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Parental Tobacco Use: Impact on Child Emotion Identification Ability

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Abstract

Although the physical effects of tobacco on an individual are well-known, the impacts that smoking has on social skills of family members are less understood. The ability for children to identify emotions is crucial for normal social functioning, and the impact of parental tobacco use during child development of this skill is not known. The proposed research compares parent-reported tobacco use to child emotion identification ability (EIA). Information regarding parental tobacco use history was gathered from a structured diagnostic interview of DSM-IV symptoms called the Composite International Diagnostic Interview. Child EIA was assessed using a paradigm called Emotional Faces, which presented photos of faces expressing different emotions at different strengths. Ability was determined based on the percentage of emotions that the child correctly identified. Exposure to parental smoking both during childhood and prior to birth was related to significantly lower child EIA compared to the EIA of children whose parents never smoked, while covariates of gender, SES, birth weight, race, and ethnicity were not significant. However, there was a significant main effect of age which, when added to the model, overwhelmed the significance of parental smoking on EIA. Upon further investigation into EIA for carrying strengths of emotion expressions, significant differences in EIA were found between children whose parents had never used tobacco, and those whose parents has used tobacco during the first decade of the child's life for child identification of moderate amounts of emotion (expression strengths of 60% and 40%), regardless of the effect of age. No significant differences were found among the groups for the stronger expression strengths of 100 and 80. The findings of this study suggest that parental tobacco use during the early years of a child's life when social skills are developing may negatively impact the child's EIA, especially in situations where they are presented with more ambiguous emotional information. As more is understood about the familial impacts from tobacco use, more effective cessation programs can be developed, and better interventions for children with decreased EIA can be explored.

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Introduction

Tobacco use continues to plague our society. As mundane and unsurprising as it may be when someone has a cigarette, the harsh reality is that each and every cigarette is contributing to the extensive consequences of continued tobacco use. The well-established findings about the physical health consequences associated with smoking are clear, yet even today, society's response is largely underwhelming. Tobacco is the second leading cause of death in the world. In 2002, the World Health Organization (WHO) estimated that smoking will be responsible for the death of more than nine million people each year as of 2030 (World Health Report, 2002). The quantity and quality of lives at risk warrants continued research.

It is unlikely that those who smoke are unaware of the nasty, painful, and deadly health consequences. The federal government spent $54 million in 2012 alone when they launched a national ad campaign against smoking (Gardiner, 2012). Every cigarette carton has a blatant warning about the negative effects. Because tobacco products are intensely addictive and because there are a myriad of reasons why people continue to smoke, it is unfair to blame someone who has yet to quit. Rather, efforts should be made to investigate factors that will better motivate someone to quit permanently and to find more effective methods for helping them quit.

While many educational campaigns have focused on personal health-related reasons to stop smoking, when individuals smoke, they are making a decision that affects more people than just themselves. Respiratory issues from inhaled secondhand smoke are the most obvious form of impact on others, with financial factors also being a common concern for loved ones. However, despite service announcements that emphasize these familial impacts, millions of Americans continue to smoke and use other tobacco products. As of 2013, approximately 17.8% (42.1 million) of Americans over the age of 18 smoked (Center for Disease Control and Prevention,

2014). Some research has been conducted on the influence that someone who uses tobacco has on his or her family, particularly that from maternal smoking. Correlations have been found between maternal smoking during pregnancy and both lower IQ and increased prevalence of attention hyperactivity disorder in children (ADHD) (Milberger, Biederman, Faraone, Chen, & Jones, 1996). Furthermore, a relationship has been found between respiratory illnesses and asthma in children whose parents smoke (Cook & Strachan, 1997). The proposed research aims to investigate an additional familial effect – the impact on a child's ability to identify emotions – which has not been evaluated. Because emotion identification is a skill that children and adults use every day and because this ability has a profound impact on children's social and emotional functioning, it is important to know if parental smoking has an impact on emotion identification ability (EIA). The hope is that this knowledge may lead to the development of interventions to help the children of smokers and to spread awareness about the importance of smoking cessation.

Known effects of tobacco use

The physical impacts of smoking are well documented. Individuals who smoke are more likely to develop a host of health issues, such as chronic obstructive pulmonary disease (COPD), atherosclerosis, lung and throat cancer, on-going low-grade inflammatory response, and more (Yanbaeva, Dentener, Creutzberg, Wesseling, & Wouters, 2007). A study that evaluated 50-year trends of deaths related to smoking in America found that the average life span of a smoker was 10 years shorter than a non-smoker (Thun et al., 2013). These studies are just a few among thousands that demonstrate how harmful smoking is for one's own health. Unfortunately, the deleterious effect of one's smoking habits on his or her loved ones have not been researched as comprehensively, and are certainly not as well publicized.

Probably the most well-known of the familial effects of smoking is the prevalence of respiratory issues in loved ones. Considering the effects of exposure to inhaled smoke, it is not surprising that a relationship has been found between respiratory illnesses and asthma in children whose parents smoke (Cook & Strachan, 1997). Cook and Strachan (1997) quantitatively reviewed 60 studies that investigated respiratory issues, including wheezing, asthma, breathlessness, and phlegm, among school age children passively exposed to parental smoking. After combining the results, the prevalence of respiratory symptoms was significantly associated with passive exposure to parental smoking, and this was consistent in different countries and after adjusting for confounds (Cook & Strachan, 1997). Additional physical effects of parental tobacco use have also been found. For example, early tobacco exposure has been found to be related to decreased autonomic regulation and reduced arousal levels in infancy (Raine, 2002). Evidently, parental smoking can have significant impacts on the physical well-being of the child.

Many of the studies that have been conducted regarding the familial impacts associated with smoking have focused specifically on the impact of maternal smoking during pregnancy. The impacts of prenatal exposure are shockingly plentiful. First of all, the likelihood of delivering a healthy infant is put in jeopardy by the increased risk of placental abruption, ectopic pregnancy, preterm membrane rupture, orofacial clefts, spontaneous abortion, and low birth weight (Castles, Adams, Melvin, Kelsch, & Boulton, 1999; Einarson & Riordan, 2009). Maternal smoking during pregnancy has also been found to reduce auditory processing and learning in children, which thereafter negatively impacts their reading and language skills (Kable, Coles, Lynch, & Carroll, 2009; Liang et al., 2006). Children’s attention, memory, and problem solving abilities have also been found to be negatively impacted (Fried, Watkinson, & Gray, 1992; Cornelius, Ryan, Day, Goldschmidt, & Willford, 2001). Furthermore, children whose mothers

smoked while pregnant have a higher likelihood of developing cancer and various chronic diseases later in life, as well as behavioral problems (Doherty, Grabowski, Hoffman, Ng, & Zelikoff, 2009; Petkovsek, Boutwell, Beaver, & Barnes, 2014). Similar results have been found by other studies looking at similar outcomes.

Although the effects of prenatal exposure have been the focus of many studies, others have looked at maternal smoking after birth. A study by Milberger and colleagues (1996) evaluated boys between six and 17 years of age, some of whom had been diagnosed with ADHD, and others whom had not. After adjusting for socioeconomic status, parental ADHD diagnoses, and parental IQ, significant associations were found between maternal smoking and lower child IQ and higher rates of child ADHD diagnoses (Milberger et al., 1996). In addition to ADHD, parental smoking has been found to be associated with other child behavioral problems. A study conducted by Pagani and Fitzpatrick (2013) investigated the impact of smoke exposure on children between the ages of 17 and 86 months regarding their aggressive and antisocial behavior. Children who had been continuously or transiently exposed during the defined postnatal period were found to be significantly more aggressive and more antisocial in the fourth grade, as measured through self-report and teacher-report (Pagani & Fitzpatrick, 2013). Parental smoking is evidently deleterious for children in both their prenatal and postnatal stages of development. Unfortunately, little research has been conducted that included how parental smoking prior to the birth of a child may be related to negative health outcomes.

Emotion identification ability

Although the current body of research regarding the associations between behavioral problems and parental tobacco use provides a good foundation of evidence for familial impacts,

an important aspect of development has not been researched. Investigation into the possible relationship between parental smoking and a child's ability to function socially has not been conducted as comprehensively. The ability to correctly identify the emotion that someone is expressing is a key aspect of social functioning (Izard et al., 2001). A first step towards appropriate communication with other children is to understand how others are feeling and interpret what they are expressing. This ability has been found to be fully developed between the ages of eight and 10 years (Bruce et al., 2000; Mondloch, Geldart, Maurer, & Le Grand, 2003). Since there is no foundation of knowledge specifically regarding tobacco exposure during the period of EIA development, the proposed research will provide useful information to fill the gap.

Emotions are typically identified by looking at one's face (Ekman, 1982). However, the importance of certain facial cues differs depending on which emotion is being expressed. For example, the eye region has been found to be more important for identifying sad and angry emotions, whereas the mouth region is more useful in identifying happy expressions (Eisenbarth & Alpers, 2011; Aviezer et al., 2008). The mouth and the accompanying frown lines have also been found to be important facial cues for pain (Roy, Blais, Fiset, Rainville, & Gosselin, 2015). Cunningham and colleagues (2005) used a stereo motion-tracking algorithm to assess which facial features were most important for expressing emotions in conversation. They found that motion of the eyes, eyebrows, and the mouth were the most crucial. With these findings in mind, the face is clearly an area that holds important clues for identifying and distinguishing emotions.

Difficulty identifying emotions is a key deficit of individuals with autism spectrum disorder (ASD) (Rutherford et al., 2015). Although it is certainly not the only social deficit associated with ASD, impairment in this area makes it especially difficult for those individuals to function independently (Mussey, Travers, Klinger, & Klinger, 2014). For example, difficulty

with social cue processing makes it challenging for children with ASD to interact with teachers or aides as effectively and productively as is needed to help manage learning challenges (Irvin, Boyd, & Odom, 2014). The prevalence of autism diagnoses and autistic trait recognition have been on the rise, especially in recent years (Schieve et al., 2012). It is important to note, however, that the field has been moving more towards recognizing autistic traits in individuals with less emphasis on a strict categorical conceptualization of an ASD. Children with disorders other than ASD, such as oppositional defiant disorder (ODD) and those with ADHD have also been found to experience social impairment (Greene et al., 2002; Tye et al., 2014). In particular, there is evidence that those with ADHD struggle with emotion processing, which is a large component of how one socially interacts (Tye et al., 2014). It is important, therefore, to better understand what factors may contribute to impairments in emotion identification to begin to work towards reducing its deleterious impact on the lives of the children and their families, regardless of distinct diagnoses.

Cessation motivation

Research about how tobacco use can impact family members is important for many reasons, but in particular, concern for loved ones has been found to be a strong motivator for cessation. A study by Bethea, Murtagh, and Wallace (2015) involved semi-structured interviews with smokers and was conducted in part to understand what factors provided the most motivation for cessation. They found that smokers were more concerned and motivated to quit when considering the impact their smoking had on friends and family members (Bethea et al., 2015). Another study also found that one of the strongest motivations to quit was an informal ban on smoking agreed upon by loved ones at home as a result of having children in the household

(Buczkowski, Marcinowicz, Czachowski, & Piszczek, 2014). The results of these studies demonstrate that familial impacts can be effective tools for helping smokers quit. Therefore, further research is warranted to better understand the familial impacts so that they can later be utilized and publicized.

Significance

The proposed research is significant because the lives of many children are being negatively affected by parental tobacco use every day. This research will aid in understanding the effects that tobacco has beyond the individual user. Specifically, it will investigate the relationship between parental smoking during child development and child EIA, which is a key aspect of children's social functioning. Children's social functioning has been demonstrated to be a critical factor in their emotional and behavioral development. Despite the importance of EIA, it has not been investigated as a familial impact of tobacco exposure. Considering the research that has demonstrated that the impacts of tobacco use on loved ones are more strongly motivating factors for cessation than are the personal physical health consequences, it is crucial to better understand the effects on the family. If the effects on the family are better understood, awareness can be spread and research can be incorporated into intervention and treatment plans. Therefore, the overall goal of this research is to investigate a previously unevaluated effect on children from parental tobacco use in order to inform the development of better methods for motivating cessation.

Hypotheses

Based on findings from ADHD and other behavioral disorders, I hypothesized that tobacco exposure during the years in which a child is developing social skills will negatively impact child EIA. I predicted that the children whose parents used tobacco prior to their birth will not have significantly different rates of correct emotion identification compared to the children whose parents have never used tobacco. Overall, I hypothesized that children whose parents have never smoked or only smoked prior to their birth will have higher rates of EIA than the children whose parents smoked during critical developmental periods. In regards to different strengths/intensities of emotional expressions, I predicted that there will be greater differences among the exposure groups for more ambiguous expressions (i.e. the lower strengths).

Methods

Participants

In order to investigate the relationship between parental smoking and child EIA, research was conducted in The Child Emotion Regulation Laboratory in the Vermont Center for Children, Youth, and Families (VCCYF). Data were collected and analyzed from participants in two IRB-approved studies titled “Factors of Emotion Regulation” (FER), and “Shared Mechanisms in Child Dysregulation, Adult Psychopathology, and Metabolic Disorders” (COBRE). The former study is no longer recruiting participants, but the data that had been collected was analyzed for this research. The latter study is still recruiting and running participants, and will continue to do so beyond the duration of this research.

The participants in the FER study were children between the ages of 8 and 13, each with one parent or guardian. The COBRE study involves participants in groups of three, all of whom

are biologically related, with either one child and two parents, or two children and one parent. The children in the COBRE study are between the ages of 7 and 17. Participants in both studies were recruited from the greater Vermont community, and through the VCCYF pediatric psychiatry clinic at the University of Vermont Medical Center. These studies recruited families based on the status of a "proband" child. These children could be community controls, clinical controls, or "dysregulated". Proband children who were categorized as "dysregulated" met the criteria for the Child Behavior Checklist Dysregulation Profile (CBCL-DP). This profile is determined by the Child Behavior Checklist/6-18 (CBCL), a questionnaire developed by Achenbach and colleagues for children between the ages of six and 18 (2001). It is completed by a parent, close relative, or teacher of a child in order to assess the child's emotional and behavioral problems, as well as his or her competencies in a number of domains.. The CBCL includes 113 items about the child's specific emotional and behavioral problems at the present time or over the previous six months, and the respondents can select zero – not true, one – somewhat or sometimes true, or two – very true or often true (Achenbach & Rescorla, 2001). A child fits the "dysregulated" profile if he or she has a score equal to or greater than 65 on the anxious/depressed, attentional problems, and aggressive behaviors syndrome subscales, or a score greater than 65 on the post-traumatic stress problem scale – a scale demonstrated to predict dysregulation in children, rather than post-traumatic stress disorder (Ayer et al., 2009). Of the child participants in the present study, 43.4% fit the dysregulated criteria.

Demographic information, including age, gender, race, ethnicity, and birth weight, was acquired from the Vermont Health Behavior Questionnaire (VHBQ) (Hudziak & Bartels, 2010). Data on socioeconomic status (measured by the Hollingshead Index) was gathered from the CBCL. The VHBQ is a survey filled by parent participants that consists of 167 questions

regarding the child's physical and mental health, including family history, education, life events, development, eating habits, substance use, exercise behavior, and suicidal thoughts and behavior.

Parental tobacco use

To collect information regarding parental tobacco use, data were extracted from a structured diagnostic interview of DSM-IV symptoms using the Composite International Diagnostic interview (CIDI) (Kessler & Ustun, 2004). The interview includes modules regarding substance abuse disorders, childhood disorders including ADHD, conduct disorder (CD), and ODD, and major mood and anxiety disorders. To administer the CIDI, each parent was interviewed by a research assistant or clinician, who asked questions verbatim from the computerized CIDI interview. Depending on what was endorsed during the screener questions, different modules were administered in the same manner thereafter. If a parent endorsed using tobacco at some point during his or her life, the tobacco module was later administered. During that module, the participant was asked when he or she began smoking regularly and when or if they had discontinued that behavior. By comparing the child birthdate with the parent tobacco use state date and cessation date, it was determined when the parent was using tobacco in relation to the child's age. From that information, the child was sorted into one of three exposure groups: 1) children whose parents had never smoked, 2) children who had at least one parent who used tobacco during the first 10 years of the child's life, and 3) children whose parents used tobacco prior to the child's birth, but not after the child was born. Ten years old was chosen as the cutoff because EIA has been found to be fully developed by that age (Bruce et al., 2000; Mondloch et al., 2003). These groups were referred to as the "Never," "During," and "Prior" groups, respectively.

Emotional Faces paradigm

To obtain data measuring child EIA, a computer paradigm called Emotional Faces was used in both FER and COBRE. The paradigm was adapted from Blair and colleagues (2001). Emotional Faces presents participants with photos of faces expressing four standardized emotions: anger, happiness, fear, and disgust. The faces were standardized Caucasian Ekman faces (Matsumoto & Ekman, 1988). Participants sat in front of a computer screen and were given a Nintendo-style game controller with four buttons, each of which corresponded to one of the four emotion options. Participants were presented with one face at a time. They were instructed to press one button when they had identified the emotion that was displayed. After 5 seconds of exposure to the face, text labels of the four different emotions appeared on the screen – always in the same positions. Participants then pressed the button that corresponded to the emotion he or she thought was being expressed. Participants completed a practice block with 17 faces, and then completed four subsequent blocks, each with 17 faces. The order of the four trials blocks was randomized for each participant. Within each block there was a neutral face, and data from those trials were excluded from this data set. The remaining 16 faces were divided into four groups of four based on strength of the emotional expression. The different expression strengths/intensities included 100, 80, 60, and 40, with the larger numbers indicating a stronger expression of the emotion. The 100-strength emotional expression was standardized such that 90% of people correctly identified the emotion (Matusmoto & Ekman, 1988). To create expressions of lower strength, Abrosoft Fantamorph software was used to morph a neutral photo of an actor with his or her 100-strength expression for a given emotion in different amounts, as depicted in Figure 1. The paradigm included two male and two female faces, all of whom were Caucasian. Each

participant's overall EIA was determined by the percentage of the emotional faces they correctly identified from all four blocks of the 16 non-neutral faces. The participant's EIA for each of the four strength categories was determined by the percentage of the emotions within each strength category that they correctly identified across all four blocks of the paradigm.

Analyses

All of the data were entered into IBM SPSS Statistics, version 22. The data were analyzed using one-way ANOVAs and univariate general linear models. A one-way ANOVA was run comparing the different exposure groups to EIA. Child birth weight, gender, age, socioeconomic status, race, and ethnicity were entered into the models as covariates. A regression was run to further evaluate the effects of any significant covariates. Univariate analyses of variance were run comparing the different exposure groups in terms of overall EIA, as well as for EIA specific to each of the four different expression strengths. In all analyses, a two-sided p-value of less than 0.05 was required for a significant finding.

Results

Demographics

There were a total of 193 child participants in this study, including 68.9% males (n = 133) and 31.1% females (n = 60). The overall mean age of the participants was 10.93 years (SD = 2.26). The overall mean socioeconomic status (measured by the Hollingshead Index) of the participants who reported it was 64.86 (n = 179, SD = 23.94). The descriptive statistics of age, percent female, and socioeconomic status (SES) for each tobacco exposure group are summarized in Table 1. The group of participants whose parents had never smoked ("Never") consisted of 62.2% (n = 120) of the participants, whereas 19.2% (n = 37) of the children had

parent(s) who had smoked in the 10 years following their births ("During"), and 18.7% (n = 36) of the children had parents who had smoked prior to their births ("Prior").

Of the participants, 73.1% (n = 141) identified their race and 53.4% (n = 103) identified their ethnicity. Of those who identified their race, 89.4% (n = 126) identified as white, 9.2% (n = 13) as being multiracial, 0.7% (n = 1) as American Indian or Alaskan, and 0.7% (n = 1) as Black or African American. Of those who identified their ethnicity, 93.2% (n = 96) identified as non-Hispanic or non-Latino, and 6.8% (n = 7) as Hispanic or Latino.

Not all participants had all of the data necessary for all analyses. For multiple reasons including participants not completing the Emotional Faces paradigm and/or technical errors with the paradigm, only 74.1% (n = 143) of the participants had emotion identification data, and 25.9% (n = 50) did not. There were a total of 33 errors made by 20 participants wherein they selected two emotions for one face, preventing distinction of which the participant believed was correct. Those data were excluded from analyses.

Overall EIA

A one-way ANOVA was run to evaluate the differences in EIA among the three exposure groups: Never (n = 91, M = 0.756, SD = 0.124), During (n = 27, M = 0.700, SD = 0.120), and Prior (n = 25, M = 0.703, SD = 0.138). There was a significant effect of exposure group on EIA at the $p < 0.05$ level [$F(2, 140) = 3.184$, $p = 0.044$]. A univariate analysis of variance was run to compare EIA among the exposure groups. The pairwise comparisons indicate that there was a significant difference in EIA between the Never and During groups (p = 0.043), and the difference between Never and Prior approached significance (p = 0.060) (Figure 2). There was no significant difference between the During and Prior group ($p > 0.05$).

This analysis was repeated with the addition of age, gender, socioeconomic status, race, ethnicity, and birth weight in the model as covariates. Because not all participants had data for all variables, the group sizes were reduced. The only covariate that was significant at the $p < 0.05$ level was age [$F(1, 40) = 13.278$, $p = 0.001$)]. None of the pairwise comparisons among the groups were significant with the inclusion of the covariates.

Because age was known to be a contributor to EIA and because of the findings that adding age to the model reduced the effects of tobacco exposure on EIA, we explored this effect further. A univariate analysis of variance was run to evaluate the differences of EIA with the main effects of exposure group and age, as well as the interaction between exposure group and age. The main effect of age was significant [$F(11, 141) = 6.708$, $p = 1.3\text{x}10^{-8}$], and the main effect of exposure was not significant [$F(2, 141) = 1.266$, $p > 0.05$], nor was the interaction term [$F(12, 141) = 0.724$, $p > 0.05$].

To further evaluate the relationship between age ($M = 11.01$, $SD = 2.358$) and EIA ($M = 0.736$, $SD = 0.128$), regardless of exposure group, a regression was run with EIA as the dependent variable, and age as the independent variable (Figure 3). The model was significant ($R^2 = 0.299$, $F(1, 140) = 59.775$, $p = 1.9\text{x}10^{-12}$), and found that age was responsible for 29.9% of the differences in EIA. The standardized coefficient for age was significant ($t(140) = 7.731$, $p = 1.9\text{x}10^{-12}$). This indicates that as age increases, EIA increases.

EIA broken down by expression strength

To assess the relationship among exposure groups in terms of EIA for each of the different expression strengths, additional univariate analyses were run (Table 2, Figure 4). First, a univariate analysis was run with the exposure groups – Never ($n = 91$), During ($n = 26$), and

Prior (n = 25) – and the EIA of only the 100-strength emotional expressions. No significant difference was found among the exposure groups [$F(2, 141) = 1.347$, $p > 0.05$]. When the analysis was repeated with the EIA of only the 80-strength emotional expressions, again, no significant difference was found [$F(2, 141) = 1.287$, $p > 0.05$].

However, when we examined the more ambiguous levels of emotion, a different story emerged. A significant difference was found when the analysis was repeated with the use of EIA data of only the 60-strength emotional expressions [$F(2, 141) = 4.173$, $p = 0.017$]. The pairwise comparisons indicate that there was a significant difference in EIA between the Never and During groups ($p = 0.012$), and the difference between Never and Prior approached significance ($p = 0.061$).

To further investigate the differences between exposure groups regarding EIA for 60-strength expressions, a univariate analysis of variance was run with custom models of age and exposure group main effects, as well as the interaction term between the two. While the main effect of age was significant, [$F(11, 141) = 3.850$, $p = 9.8\text{x}10^{-5}$], the main effect of exposure was not [$F(2, 141) = 1.892$, $p > 0.05$], nor was the interaction term of age by exposure group [$F(12, 141) = 1.155$, $p > 0.05$]. Despite the main effect of age, there was a significant difference between the Never and During groups ($p = 0.049$), and the difference between the Never and Prior groups was trending towards significance ($p = 0.080$).

Similarly, a significant difference was also found among the groups when only the 40-strength emotional expression data were used in the analysis. [$F(2, 141) = 4.173$, $p = 0.038$]. The pairwise comparisons indicate that there was a significant difference in EIA between the Never and During groups ($p = 0.019$), but none of the other pairs were significantly different. As above, custom models of age and exposure group main effects, as well as the interaction term between

the two, were added. The main effect of age was significant, [$F(11, 141) = 2.674$, $p = 0.004$], the main effect of exposure was trending towards significance [$F(2, 141) = 2.674$, $p = 0.077$], and the interaction term of age by exposure group was not significant [$F(12, 141) = 1.292$, $p > 0.05$]. With the main effects and interaction terms included, the pairwise comparisons showed a significant difference between the Never and Prior groups ($p = 0.041$), and the difference between the Never and During groups was trending towards significance ($p = 0.057$).

Discussion

As continually high rates of tobacco persist, it is important to understand the extent of the implications of parental tobacco use on children. A worldwide retrospective assessment of tobacco impacts found that in 2004, 40% of children were exposed to secondhand smoke pollutants in their homes (Öberg, Jaakkola, Woodward, Peruga, & Prüss-Ustün). The current literature provides substantial evidence that tobacco use deleteriously impacts the physical well-being of children in terms of respiratory issues and autonomic regulation, as well as their behavioral outcomes (Cook & Strachan, 1997; Raine, 2002; Petkovsek et al., 2014). However, the literature is lacking in regards to potential implications of parental tobacco use on social function deficits including trouble identifying emotions. The ability to identify emotions is crucial throughout daily life, especially the lives of children. Difficulty identifying emotions can make it challenging for one to communicate effectively, to understand what other people are feeling, to empathize, and to be an overall contributing and involved member of social situations.

It was hypothesized that tobacco exposure during the years in which a child is developing social skills would negatively impact child EIA. This hypothesis was supported by initial analyses which found that the EIA of children in the During group were significantly lower than

that of children in the Never and Prior group. However, upon the incorporation of the covariates, most critically age, the differences were no longer significant. It was also hypothesized that EIA would not be significantly different between children whose parents had never regularly used tobacco, and children whose parents had used tobacco prior to their birth. This hypothesis was not supported by the data. From the initial analyses, the Prior group had significantly lower EIA than the Never group. The overall EIA results of the Prior and During groups did not significantly differ. Further analyses with the significant covariate of age, as well as analyses conducted with different expression strengths led, to a more nuanced view of the effects of exposure.

The most important part of this view is that age was a significant covariate throughout. The results of the regression that was run to assess overall EIA with age demonstrated that age explained a significant portion of the variance in EIA. As age increased, EIA scores also tended to increase. This makes sense when thinking about the amount of exposure to and practice with different emotional expressions one gathers as he or she ages. However, the finding that the main effect of age rendered the differences in overall EIA among the exposure groups insignificant was somewhat puzzling. The exposure groups did not considerably vary in terms of the range of ages, nor the mean age of the participants within each group. Furthermore, the interaction of age and exposure was not significant, suggesting that there may be an additional factor that was unaccounted for in this study.

One possibility for the variable that was unaccounted for in this study that confounded the relationship between age and overall EIA is aggression. Parental tobacco exposure has been found to increase the likelihood that a child will exhibit aggressive behaviors (Pagani & Fitzpatrick, 2013). Additionally, maternal smoking during pregnancy has also been found to be

related to higher risk of child externalizing behaviors and conduct disorder, which involves aggression (Palmer et al., 2016). Children with conduct disorder have been found to have impaired emotion recognition ability (Short, Sonuga-Barke, Adams, & Fairchild, 2016). With these findings in mind, it may be possible that aggressive behavior was the hidden confound. Its inclusion in the study may have helped explain why the main effect of age was significant, yet the interaction of age and exposure group was not. A possible hypothesis in terms of aggression is that an interaction of age and aggression would be significant because children may develop better management strategies for their aggressive behaviors as they get older. Thus, the older children would be less socially impaired by their aggressive behaviors, and therefore, would be able to develop better emotion identification abilities. This association can be explored in future analyses.

An additional factor that was unaccounted for and that may have unknowingly impacted the results of the present study is anxiety. Interestingly, children with comorbid conduct disorder and anxiety disorder have been found to have EIA on par with normal children, and in some cases, they actually had a greater ability to correctly recognize emotions (Short, et al., 2016). Children with social anxiety disorder have been found to better recognize facial expressions that are negative compared to controls, and adolescents who are lonely have been found to be more sensitive to happy, sad, and fearful displays (Coles & Heimberg, 2005; Vanhalst, Gibb, & Prinstein, 2015). It is possible that anxiety and/or loneliness serve as protective factors for emotion recognition impairment. While some research has found that early tobacco exposure is associated with an increased risk of developing anxiety, other studies have found no correlation between exposure and rates of anxiety later in life (Hamer, Stamatakis, & Batty, 2010; Bot et al.,

2013). In the present study, EIA may have been confounded by anxiety, whether or not the anxiety disorder was idiopathic or related to tobacco exposure.

A further nuance is the findings that the level of emotion in the faces during emotion identification was a significant contributor to whether the effects of tobacco exposure were found. The univariate analyses of variance run with each subset of EIA based on different expression strengths were conducted to further investigate where the differences among exposure groups were occurring. The higher the strength, the less ambiguous the emotional expression. There were no significant differences found among the groups when the 100-strength expressions were analyzed, nor were significant differences found for the 80-strength expressions. This suggests that parental tobacco use does not significantly impair identification of strong – or more "obvious" – expressions of emotions. However, significant differences were found among the groups for the lower strength expressions, which supports the hypothesis that greater differences would be found among the groups when looking at more ambiguous expressions.

Through evaluation of the 60-strength expressions, it was determined that the Never group performed significantly better than the During group, and the difference between the Never and Prior group – with the latter having lower EIA scores – was trending towards significance. When age was included as a covariate, a significant difference remained between the Never and During group. The Never group also performed significantly better than the During group in terms of the 40-strength expressions. However, the only significant difference that was found once age was added as a covariate was between Never and Prior. It is possible that with larger group sizes, significant differences would be more evident between both the Never and During groups, as well as between the Never and Prior groups, considering that

multiple such trend-level significance values were found. Overall, these results demonstrate that parental tobacco use during the years in which a child is developing his or her social skills is related to lower ability to identify emotions when the strength of expression is low.

Ambiguity in expression is something that occurs all of the time in day-to-day life because not every emotion is displayed clearly. In fact, one could argue that these more subtle changes in emotional expression are more critical for determining the motivation and feelings of the person we are interaction with. Additionally, multiple emotions may be expressed at one time, and are thus overlapping. Studies have found that less intense/distinct emotional expressions are more difficult for both normal individuals and individuals with mild cognitive impairment to identify, with the latter having worse performance (Sarabia-Cobo, Garcia-Rodriguez, Navas, & Ellgring, 2015). The present study did not include overlapping emotional expressions – each facial image was expressing only one emotion. With this in mind, and considering that significant differences in EIA at low strengths were found regardless, the actual deficits in EIA may be more severe in normal daily life than the results of this study suggest. Even if the results of the present study accurately depict the severity of the deficits in EIA, the difference in the percentage of expressions correctly identified is significant when considering the number of interactions one has every day. The difference in overall EIA between the Never group and the During group was approximately 5%. If one cannot correctly identify the emotion being expressed in 5% of all expressions he or she sees on a daily basis, a great deal of social information is being missed. In one conversation alone, hundreds of expressions can be exchanged. Although 5% seems like a small amount quantitatively, in reality, that percentage may have a large impact on a child's life.

There are several possible biological reasons why social deficits are seen in children who have been exposed to parental smoking. One explanation is that epigenetic programming is altered through use of and exposure to tobacco (Nafee, Farrell, Carroll, Fryer, & Ismail, 2008). An example of a type of epigenetic modification is change in methylation patterns. A study conducted by Bouwland-Both and colleagues (2015) compared methylation patterns of two growth genes – IGF2DMR and H19 – in newborns whose mothers either did or did not smoke during pregnancy. These genes are associated with fetal growth and development. The researchers found that maternal tobacco use during the prenatal period was associated with decreased methylation of IGF2DMR and H19 (Bouwland-Both et al., 2015). If parental tobacco use alters epigenetic programming in the aforementioned genes, methylation patterns in genes related to social traits may also be impacted. A recent twin study found evidence that there is substantial heritability (61%) associated with face recognition abilities (Shakeshaft & Plomin, 2015). Although face recognition is different from emotion identification, it is possible that there is a similar genetic component of emotion identification skills. Further research is needed to investigate the possible genetic association, but it is possible that epigenetic alterations from tobacco use may be responsible, in part, for the EIA deficits found in children of parents who used tobacco. This is an area for future research.

Parental tobacco use has been found to have deleterious effects on children through other biological methods as well. Desensitization and activation of neuronal nicotinic acetylcholine receptors (nAChRs) can occur as the result of nicotine exposure (Dani, 2001). These receptors are widespread throughout the central nervous system, and they are involved in many functions, but of particular importance for the present study, nAChRs play an important role in neurodevelopment and neural organization (Dwyer, McQuown, & Leslie, 2009). The receptors

help regulate the release of acetylcholine (ACh), and ACh helps regulate neuronal pathfinding by inducing both extension and retraction of neurites (Myers et al., 2005; Small, Reed, Whitefield, & Nurcombe, 1995). Furthermore, prenatal exposure to nicotine has been found to negatively impact the development of both cholinergic and catecholaminergic systems, and higher rates of psychiatric disorders have resulted (Ernst, Moolchan, & Robinson, 2001). If early exposure to nicotine has widespread disruptive impacts on neurodevelopment, it is likely that the areas associated with emotion identification are not spared.

Although the perception of faces is not isolated to one cortical region, the fusiform face area is known to be particularly important (Kanwisher & Yovel, 2006). Some studies have investigated further into where the areas are that specialize in emotion identification. The amygdala – an area involved in emotion, social behavior, and visual input processing – has been found to be especially important in identifying emotion expressions, with emphasis on distinguishing overlapping emotions and fearful expressions (Adolphs, Tranel, Damasio, & Damasio, 1994; Huijgen et al., 2015). Considering that the amygdala is home to multiple types of nAChRs, and with the findings that nicotine has deleterious impacts on nAChR functioning, I hypothesize that changes to the amygdala from tobacco exposure would correlate with deficits in emotion recognition.

Limitations & recommendations

This study was limited in several regards. From a demographics perspective, the participant population had low levels of ethnic and racial diversity. The vast majority of the children identified as white, and thus the external validity was limited. While the overall size of the participant population was reasonable, the division of children into each of the three exposure

groups was unequal. Of those with EIA data (n = 143), the Never group consisted of 63.6% of the participants, while the During and Prior groups included only 18.8% and 17.5%, respectively. Larger group sizes for all three groups, with emphasis on the latter two, would improve the strength of the findings and hopefully allow more specific differences between EIA abilities to be made clear. The more specific differences may have been more apparent in this study if all the participants had data for all of the variables. The missing data limited the extent to which analyses of covariates could be conducted. Future studies should include a larger and more diverse sample, and in an effort to reduce the possible impact of age, the sample should be limited to one age.

Several limitations of the study revolve around the Emotional Faces paradigm. First of all, the paradigm only included 4 basic emotions: happy, sad, angry, and disgusted. In day-to-day life, there are many more emotions that are expressed, and sometimes multiple emotions are expressed at one time. Furthermore, only images of the faces of the individuals expressing emotions were presented to the participants. However, emotions are often expressed using more of one's body than just the face, and realistic expressions are not static and 2-dimensional. With this in mind, the paradigm used in the study limited the degree to which differences in identification of the true range of emotions could be assessed. A more dynamic emotional expression paradigm would reduce this limitation. For example, the Amsterdam Dynamic Facial Expression Set – Bath Intensity Variations uses video clips with different expression intensities to assess emotion recognition (Wingenbach, Ashwin, & Brosnan, 2016). The Cambridge Mindreading Face-Voice Battery for Children (CAM-C) assesses recognition of nine emotions, including nervous, amused, bothered, disappointed, jealous, unfriendly, loving, undecided, and embarrassed (Golan, Sinai-Gavrilov, & Baron-Cohen, 2015). The battery involves silent video

clips and audio clips of phrases with emotional intonation, and the actors are of varying ages and ethnicities. Golan and colleagues (2015) used the CAM-C to assess emotion recognition in children with ASD, and deficits were found for six out of nine of the complex emotions in both face and voice expressions. Future research investigating EIA in relation to parental tobacco exposure could incorporate more dynamic paradigms, such as the CAM-C, in order to better evaluate the severity of the emotion identification impairments in more realistic manners.

The present study was also limited in terms of parental tobacco use data. Details such as whether or not a parent smoked while the child was in the car with them or in the same room, etc., were not available. Additionally, the self-reported tobacco use dates may not have been accurate. With more specific information regarding the child's exposure, an exposure spectrum could have replaced the three distinct exposure groups that were used. Such information would allow for analyses that could better assess how the degree to which the child was exposed related to EIA performance. Overall, further studies should continue to investigate the implication of parental smoking on child social skills, including but not limited to EIA.

Conclusion

The impact of tobacco is an important area of research since use of the substance is rampant in our society, and has been for centuries. Although the initial significant difference found among the exposure groups in terms of overall EIA did not remain after the inclusion of covariates, important differences were found when assessing low-intensity emotional expressions. The significant differences between the Never group and both the During and Prior groups provide evidence that parental tobacco use both before a child is born and while the child is young can be deleterious for a child's social skills. The ability to correctly identify emotions is

a crucial skill for healthy social functioning. Although further research is necessary to more thoroughly investigate this relationship, individuals who are either considering using tobacco or are currently using tobacco should consider the diverse deleterious effects their use may have on their loved ones.

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Appendix

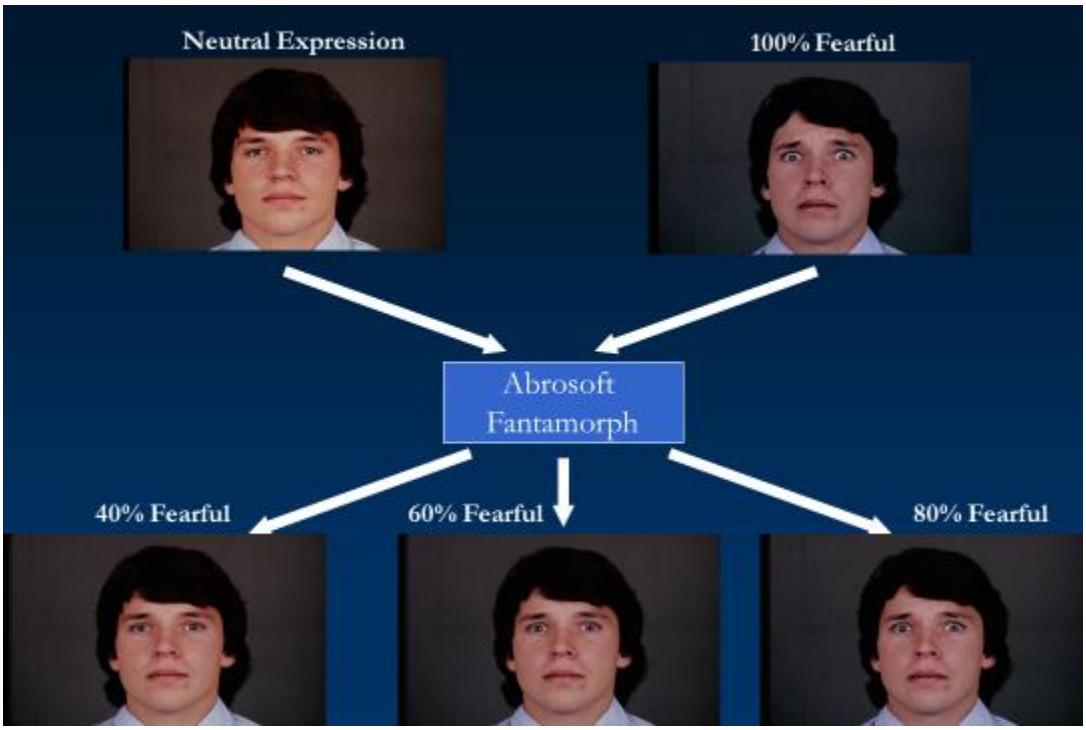

Figure 1. Creation of different expression intensities. This figure depicts the creation of lower strength emotional expressions by morphing a neutral expression and a 100-strength expression.

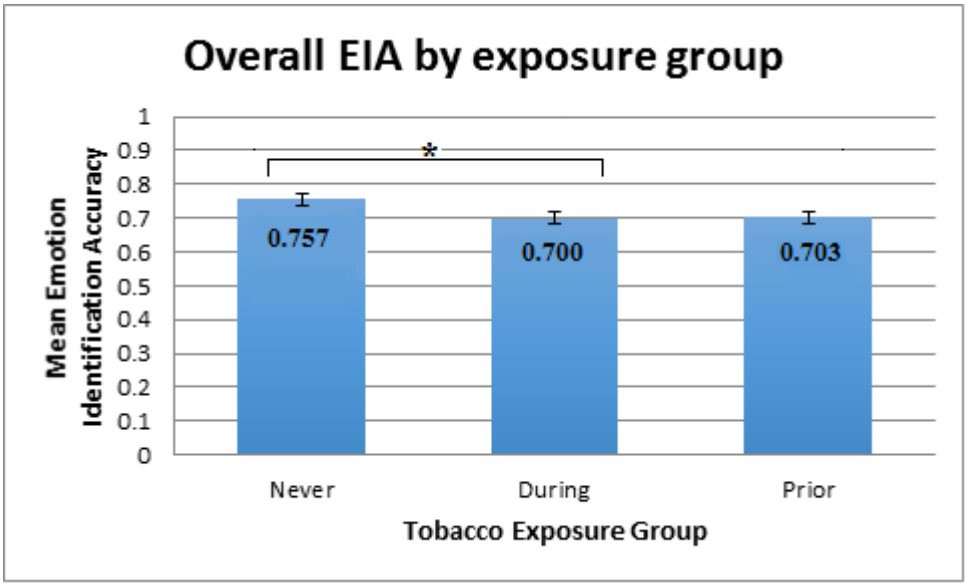

Figure 2. Overall EIA of the exposure groups. This figure includes the overall EIA of each of the three exposure groups, with the significant different between the Never and During group highlighted.

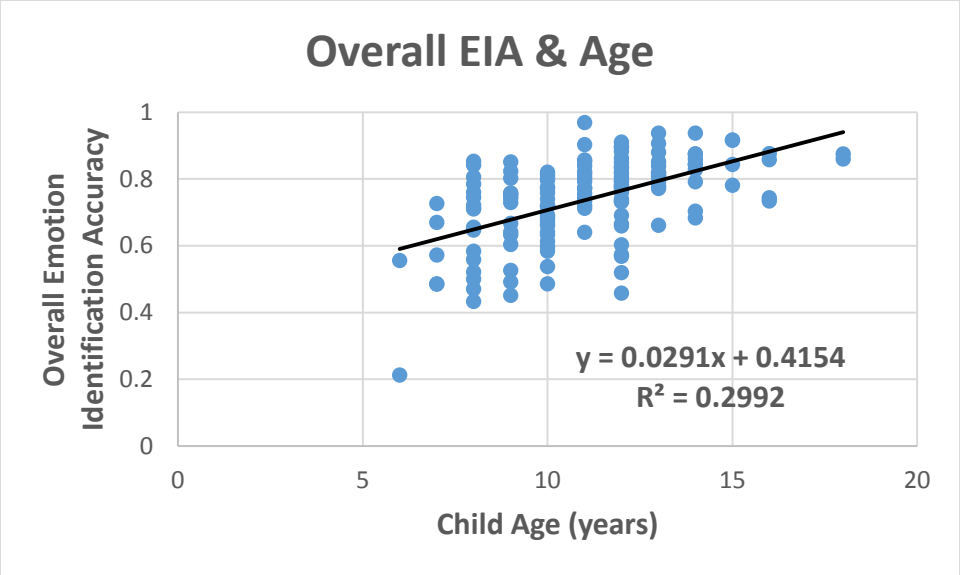

Figure 3. Overall EIA compared to age. This figure includes the regression of child age and overall EIA, with a linear trendline showing a positive relationship.

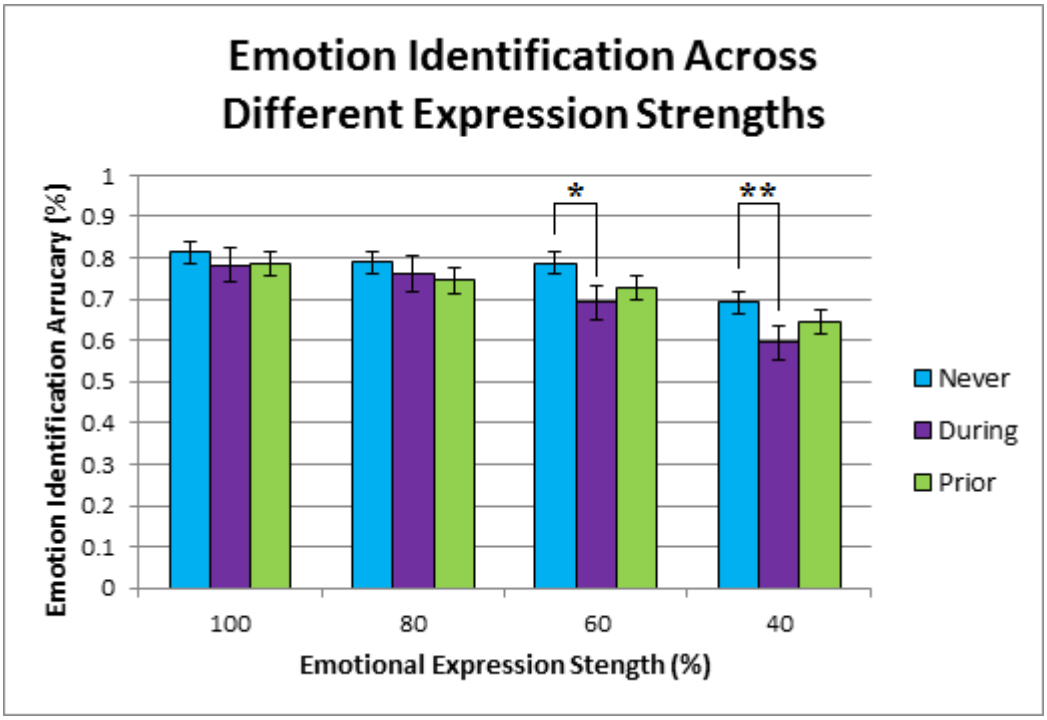

Figure 4. EIA for different expression strengths. This figure includes the EIA for each exposure group for each expression strength. There was a significant difference between the Never and During group for the 60-strength expressions, and the 40-strength expressions.

Table 1. *Descriptive statistics across exposure groups. This table includes the descriptive statistics of gender, age, and SES of the participants divided by exposure group.*

Exposure Group	N	% Female	Mean Age	Mean SES
Never	120	31.67	11.18	68.18
During	37	27.00	10.47	57.08
Prior	36	33.33	10.61	67.78
Total	193	31.09	10.93	64.86

Table 2. *EIA for across different expression strengths. This table includes the EIA for each exposure group for each expression strength.*

		Emotion Identification Accuracy			
	Expression Strength	**100**	**80**	**60**	**40**
Exposure Group	**Never**	0.814	0.789	0.787	0.691
	During	0.783	0.761	0.692	0.594
	Prior	0.784	0.744	0.726	0.643