



The link between poor quality nutrition and childhood antisocial behavior: A genetically informative analysis



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ABSTRACT

Purpose: The current study explores whether the association between poor quality nutrition and child antisocial behavior is robust to shared environmental and genetic influences.

Method: Data from the Early Childhood Longitudinal Study: Birth Cohort are employed, which includes a large, nationally representative sample of twin pairs. DeFries–Fulker (DF) analysis is used to test the current hypothesis.

Results: The results suggest that poor quality nutrition during preschool increases the extent of antisocial behavior during elementary school after the influence of genes and the shared environment are taken into account.

Conclusions: The relationship between poor quality nutrition and subsequent behavioral problems is robust to shared environmental and genetic influences, with variation in eating behaviors between twins predicting their relative likelihood of exhibiting antisocial behaviors.

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Research across multiple disciplines has suggested that nutritional factors are related to various aspects of development, including cognition (Connolly & Beaver, 2015; Gómez-Pinilla, 2008; Molteni, Barnard, Ying, Roberts, & Gómez-Pinilla, 2002) and behavior (Galler et al., 2011; Oddy et al., 2009; Woo et al., 2014). The adequate ingestion of various nutrients, vitamins, and minerals (e.g., folate, zinc, iron, magnesium, polyunsaturated fatty acids) is essential for optimal brain functioning (for a review, see Gómez-Pinilla, 2008). Conversely, poor nutrition appears to diminish neuropsychological functioning and dampen synaptic plasticity (see Molteni et al., 2002). Research has also revealed that such deficits in neuropsychological functioning may reduce self-control (Jackson & Beaver, 2013) and heighten the risk of misconduct (Espy, Sheffield, Wiebe, Clark, & Moehr, 2011; Riggs, Blair, & Greenberg, 2004; Schoemaker, Mulder, Deković, & Matthys, 2013). In short, research suggests that poor nutrition during childhood seems to predispose children to higher levels of aggression and related antisocial behaviors (Liu, Raine, Venables, & Mednick, 2004; Woo et al., 2014).

Notwithstanding this body of literature, criminologists have given little attention to the link between nutritional factors and antisocial behavior (however, see Liu et al., 2004; Liu & Raine, 2006). More specifically, the small number of relevant criminological studies to date have largely examined whether acute malnutrition and/or micronutrient supplementation are associated with behavioral outcomes. Criminological studies linking specific eating patterns to antisocial behavior, however, are sorely lacking. Perhaps even more importantly, observational studies have yet to adequately account for the role of both familial and

genetic confounding in the relationship between child nutrition and subsequent antisocial behavior. This limitation is particularly significant, as the association between nutritional factors and antisocial behavior may emerge as a statistical artifact once unmeasured familial and genetic confounding are taken into account. In light of these voids in the literature, the current study uses a within-family, genetically informative approach to test the relationship between poor quality nutrition and childhood antisocial behavior.

Childhood antisocial behavior as a predictor of crime and delinquency

A long line of research has examined the extent to which childhood antisocial behavior predicts the stability and severity of future antisocial behavior (Moffitt, Caspi, Dickson, Silva, & Stanton, 1996; Tremblay, Pihl, Vitaro, & Dobkin, 1994). When age-appropriate indicators of antisocial behaviors are employed, researchers typically find evidence that antisocial children are at risk of becoming antisocial adolescents and adults (Broidy et al., 2003; Campbell, Shaw, & Gilliom, 2000; Fergusson, Boden, & Horwood, 2014; Fergusson & Horwood, 1995; Nagin & Tremblay, 1999; Nagin & Tremblay, 2001). More specifically, elevated levels of physical aggression and associated externalizing behaviors during early childhood seem to significantly increase the odds of criminal activity during adolescence and adulthood (Broidy et al., 2003; Kokko, Tremblay, Lacourse, Nagin, & Vitaro, 2006; Nagin & Tremblay, 1999; Thompson et al., 2010). To illustrate, a seminal study by Nagin and Tremblay (1999) examined the physical aggression trajectories of males from childhood to adolescence. The authors found that subjects who exhibited high levels of externalizing behavior at age 6 tended to

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engage in high levels of delinquency at age 15. The results suggest that early oppositional, externalizing and aggressive behaviors are driven by similar developmental processes, and that this cluster of traits is one of the best predictors of adolescent delinquency (Nagin & Tremblay, 1999). A follow-up study by Nagin and Tremblay (2001) found that the odds of belonging to a “high aggression” group during high school were increased by a factor of 3 for boys who frequently exhibited hyperactivity, defiance, and aggression during kindergarten.

A number of more recent studies have corroborated these results. For example, a study by Piquero, Carriaga, Diamond, Kazemian, and Farrington (2012) found that aggression during both childhood and adolescence is associated with a greater likelihood of a criminal conviction through mid-adulthood (age 40), implying a strong degree of continuity in antisocial behavior across the life course. Recent research has also indicated that bullying and externalizing behaviors during childhood are significantly predictive of official and self-report measures of property and violent offending during adulthood (Fergusson et al., 2014; see also Schaeffer, Petras, Ialongo, Poduska, & Kellam, 2003). Ultimately, both oppositional and hyperactive behaviors during childhood appear to be predictive of crime as well as several analogous behaviors, including drug abuse (Pingault et al., 2012), gambling (Shenassa, Paradis, Dolan, Wilhelm, & Buka, 2012), and risky sexual behavior (Timmermans, Van Lier, & Koot, 2008).

The role of nutritional factors in the development of antisocial behavior

Among the studies that have examined the origins of childhood antisocial behavior, relatively few of them have considered the role of nutritional factors in the development of such behaviors (Galler et al., 2011; Woo et al., 2014). The general paucity of research in this area is somewhat surprising, considering the substantial body of literature that a) links nutritional factors to brain development (Black, 2008; Gómez-Pinilla, 2008) and b) links particular aspects of brain development to childhood antisocial behavior (Riggs et al., 2004; Schoemaker et al., 2013). Nutritional factors may be especially important to cognitive and behavioral development early in the life course, as the brain is both a) experiencing exponential growth during this time and b) placing increasing demands on exogenous nutrients to supply the building blocks (e.g., proteins) that facilitate such growth (see Benton, 2008; Georgieff, 2007).

Although a large number of studies have explored the relevance of childhood nutritional factors to healthy brain development (see Bellisle, 2004 for a review), fewer studies have specifically explored whether nutrition during early childhood is associated with the development of childhood behavioral problems (Galler et al., 2011; Liu et al., 2004). Importantly, animal research suggests that deprivation of key nutrients (e.g., omega-3 fatty acids) at critical developmental periods not only reduces synaptic differentiation and formation, but also increases aggressive behavior by disadvantageously altering serotonin levels (Hibbeln, Ferguson, & Blasbalg, 2006). The limited number of studies with human subjects suggests that similar neurological and behavioral outcomes may be related to the quality of nutrition (Galler et al., 2011; Liu et al., 2004; Sinn, 2008). To illustrate, a recent study by Raine, Portnoy, Liu, Mahomed, and Hibbeln (2015) revealed that random assignment of omega-3 consumption resulted in reductions in both externalizing and internalizing behavior in children, which was partly mediated by reductions in parental antisocial and aggressive behavior.

Ultimately, the research to date has revealed that poor nutrition during early childhood might contribute to the development of a number of behavioral problems (Galler et al., 2011; Oh, Ahn, Chang, Kang, & Oh, 2013; Park et al., 2012; Woo et al., 2014). For instance, a study by Liu et al. (2004) found that children who exhibited signs of acute malnutrition (e.g., hair dyspigmentation, hair loss, and angular stomatitis) during the first few years of life engaged in more externalizing behaviors

at ages 8, 11, and 17, implying that nutritional factors during the earliest stages of the life course may indeed play a role in the development of aggressive and hyperactive behavior. Similarly, Galler et al. (2011) found that early childhood malnutrition (defined as moderate-to-severe protein-energy malnutrition) was predictive of both deficits in executive functioning and higher parent-reported aggression toward peers at ages 9–15. Thus, scholars tend to detect quite robust associations between acute malnutrition and antisocial behaviors several years into the future (see also Liu et al., 2014).

In addition to acute malnutrition, it is possible that the actual quality of the diet, or differences in the frequency with which *specific* foods (or groups of foods) are consumed, might also influence the development of behavioral problems in children. A number of studies have investigated whether children with poorer eating habits are at an increased risk of conduct problems, including ADHD symptomatology (Benton, 2008; Howard et al., 2011; Oh et al., 2013; Park et al., 2012; Woo et al., 2014). Overall, the results indicate that a western dietary pattern may be particularly conducive to the development of conduct problems (Oh et al., 2013; Park et al., 2012; Woo et al., 2014). For example, a recent study by Woo et al. (2014) revealed a traditional-healthy pattern of eating, characterized by a diet low in fat and high in fatty acids and minerals, lowered the odds of developing ADHD, whereas a snacking pattern, characterized by high consumption of sweets, snacks, and breads, increased the odds of developing ADHD. Another study revealed that high intake of sweets during childhood significantly increases behavioral problems and deficits in social skills (Oh et al., 2013). Similar results linking poor diet to conduct problems have been obtained using adolescent samples (see Howard et al., 2011; Oddy et al., 2009).

There have also been a handful of randomized control trials examining the benefits of comprehensive micronutrient supplementation in curbing antisocial behavior (Sinn, 2008). For instance, various micronutrients, including vitamin A, iodine, iron, and zinc, seem to influence the behavioral profiles of children (Schoenthaler & Bier, 2000), adolescents (Schoenthaler et al., 1997), and adults (Gesch, Hammond, Hampson, Eves, & Crowder, 2002; Zaalberg, Nijman, Bulten, Stroosma, & van der Staak, 2010). Thus, it appears that providing nutrient-dense diets through supplementation significantly reduces various forms of antisocial behavior, including fighting, vandalism, endangering others, and other aggressive behaviors. In sum, acute malnutrition and poor dietary patterns both appear to heighten the risk of various conduct problems during childhood and even into later life stages. Conversely, there is some evidence to suggest that mimicking a well-balanced diet through the use of supplementation can reduce the frequency and/or severity of antisocial behavior across the life course.

Poor nutrition and childhood antisocial behavior: the possibility of genetic and familial confounding

Although the literature is generally supportive of the link between nutritional factors and antisocial behavior, the vast majority of prior studies suffer from two key limitations. The first of these limitations is the issue of familial confounding, or selection bias stemming from factors within the family/home environment. This shortcoming is rooted in the frequent use of observational data that are based on samples of only one child per household (for examples, see Oh et al., 2013; Park et al., 2012; Woo et al., 2014). Under such circumstances, researchers typically include a number of statistical controls for potential confounding influences within the family environment to minimize the likelihood of familial confounding. Even so, since diet quality during childhood is closely related to features of the family environment (e.g., parenting, food rules/rituals, parental education, household income, etc.), it is possible that residual confounding may render the relationship between poor quality nutrition and child antisocial behavior spurious due to omitted variable bias and/or poor measurement (see Peters, Dollman, Petkov, & Parletta, 2013). Research using a within-family design would help to address this issue, as it would be capable

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