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Review

Defining the behavioral phenotype in children with fetal alcohol spectrum disorders: A review

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Abstract

While there exists a large body of literature on cognitive functions in children with prenatal alcohol exposure, it remains undetermined if these children exhibit a unique profile of cognitive-behavioral functioning or a behavioral phenotype. Researchers have consistently found that intellectual functioning, as assessed by IQ tests, of children with prenatal alcohol exposure is deficient. There is increasing evidence that prenatal alcohol exposure is associated with slow information processing and attentional problems, in particular inattentiveness. Studies examining specific cognitive abilities such as language, visual perception, and memory in alcohol-affected children have shown performance decrements associated with increased task complexity. Children with prenatal alcohol exposure have also been found to exhibit significant deficits in daily functional skills or adaptive behavior, with deficits in socialization becoming pronounced during adolescence. The above findings point to the conclusion that a generalized deficit in complex information processing constitutes the central cognitive-behavioral characteristic of children with prenatal alcohol exposure. Researchers have consistently documented that specific brain regions are more affected by alcohol than other regions. The problem of mapping focal anomalies of the brain with a generalized pattern of deficits can be solved by taking developmental processes into consideration.

Keywords: Prenatal alcohol exposure; Fetal alcohol spectrum disorders; Fetal alcohol syndrome; Behavioral phenotype; Residual normality

Contents

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1. Introduction

It is now established that prenatal exposure to alcohol produces a range of morphological and cognitive-behavioral outcomes, commonly referred to as fetal alcohol spectrum disorders (FASD), in the offspring. Severely affected children on the spectrum display a pattern of altered growth and morphogenesis, called fetal alcohol syndrome (FAS), which is characterized by prenatal and postnatal growth retardation, craniofacial anomalies, and abnormal brain function reflected by cognitive deficits and developmental delays. The majority of children with substantial prenatal alcohol exposure (about 3 times as many children as those with FAS), however, show only some of the above features (Sampson et al., 1997) and used to be referred to as having fetal alcohol effects (FAE). Following the publication of the Institute of Medicine report on FAS (Stratton et al., 1996), the term FAE has been replaced with two new terms: alcohol-related birth defects (ARBD) and alcohol-related neurodevelopmental disorder (ARND). For convenience, I use the term fetal alcohol spectrum disorders (FASD) in this paper to refer to the full spectrum of morphological and cognitive-behavioral outcomes observed in children exposed to alcohol prenatally.

The most noticeable and devastating of these outcomes are cognitive-behavioral deficits. Over the last three decades, researchers have made considerable progress in delineating cognitive-behavioral functioning in children with FASD. Despite these advances, it remains unanswered if there is a unique pattern of cognitive-behavioral functioning or a behavioral phenotype associated with FASD. The identification of a behavioral phenotype will aid in identifying those alcohol- affected children without discernable anomalies in morphogenesis and in planning appropriate interventions for children with FASD.

1.1. Behavioral phenotype

A behavioral phenotype refers to "a characteristic pattern of motor, cognitive, linguistic and social observations that is consistently associated with a biological disorder" (O'Brien and Yule, 1995, p. 2). The task of defining a behavioral phenotype, therefore, involves comparing the FASD group with other neurodevelopmental groups having similar characteristics on a battery of tests assessing motor, cognitive, linguistic, and social functioning. In terms of causal pathways, one can conceptualize that the teratogenic effects of alcohol cause anomalous brain development, which in turn produces cognitive social, and motor dysfunction. As shown in Fig. 1, neuropsychological deficits contribute to a range of negative life outcomes, including academic, social, and emotional problems. Recognizing the direction of this causal relationship, Streissguth et al. (1998, 2004) have labeled cognitive deficits, "primary disabilities" and negative behavioral outcomes, "secondary disabilities". While neuropsychological deficits are typically assessed with specific tests designed to probe cognitive functioning, negative life outcomes are usually assessed with parent and teacher-rated questionnaires. In line with the O'Brien and Yule's definition cited above, the term 'behavioral' is used in this paper to refer to neuropsychological functioning and parent and teacher-assessed behavior in children with FASD.

It is evident from Fig. 1 that the establishment of a causal connection between prenatal alcohol exposure and cognitive-behavioral problems is methodologically challenging as environmental and genetic factors interactively introduce variability in cognitive-behavioral functioning. The severity of the effects is also known to vary as a function of exposure (e.g. quantity and frequency) and maternal (e.g. age, body weight) variables (May, 1995; Jacobson et al., 1998).

Notwithstanding the variability associated with genetic and environmental factors, there are emerging patterns of cognitive-behavioral functioning in children with FASD. The main objectives of the current paper are: to delineate these patterns and to propose a working hypothesis on the behavioral phenotype associated with FASD. Part 1 of this paper presents a review of the literature on the cognitive functioning in children with FASD, in particular on intellectual functioning, attention and information processing, executive function, language, visual-perception, number processing, and memory. Part 2 of the paper reviews the literature on adaptive behavior and parent and/or teacher-rated behavioral problems in children with FASD. Part 3 summarizes the findings from recent neuroimaging studies of FASD. The final section integrates the findings reviewed in the above sections and presents the working hypothesis on the behavioral phenotype of FASD.

2. Cognitive functions

2.1. Intellectual ability

There exists an extensive literature on intellectual functioning in children and adolescents with FASD, which was previously reviewed by Mattson and Riley (1998). Researchers have consistently found diminished intellectual performance in children with FASD (Streissguth et al., 1990; Mattson et al., 1997), with average IQs of these children ranging from mildly retarded to borderline range (Mattson and Riley, 1998). Mattson et al. (1997) found