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NEUROCOGNITIVE PROFILE IN CHILDREN WITH FETAL ALCOHOL SPECTRUM DISORDERS

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The question of whether children with fetal alcohol spectrum disorders (FASD) exhibit a unique neurocognitive profile has received considerable attention over the past three decades. The identification of a syndrome-specific neurocognitive profile would aid in diagnosing prenatally exposed children with cognitive deficits who do not exhibit clinically discernable physical anomalies. The current review of the literature, therefore, focuses on the studies of higher-order cognitive skills in children with FASDs with a view towards delineating a pattern of cognitive functioning. Researchers have documented that children with FASDs show diminished intellectual functioning, with average IQ scores falling within the borderline to low average ranges. Slow information processing and disturbances of attention have been observed from infancy through adulthood in individuals with FASDs. Clinical and experimental reports on individuals with FASD have documented marked deficits in executive functioning, particularly in tasks that involve holding and manipulating information in working memory. Studies examining specific domains of cognitive functioning such as language, visual perception, memory and learning, social functioning, and number processing in individuals with FASDs have revealed performance decrements associated with increased task complexity. The above findings converge on the conclusion that children with FASDs have a generalized deficit in the processing and integration of information. We recommend the study of developmental trajectories of both elementary and higher-order functions in future research on FASD to elucidate the development of this cognitive profile.

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Key Words: prenatal alcohol exposure; fetal alcohol spectrum disorders; neurocognitive profile; developmental trajectories

It is now established that prenatal alcohol exposure produces a range of outcomes in offspring, collectively referred to as fetal alcohol spectrum disorders (FASD). The most severely affected children on the spectrum show a characteristic pattern of anomalies called fetal alcohol syndrome, which consists of prenatal and/or postnatal growth retardation, a unique cluster of malformations on the face and anomalies in the central nervous system (CNS) [Jones and Smith, 1973]. Clinical and epidemiological studies show that the majority of children with prenatal alcohol exposure, however, do not evidence clinically discernable physical anomalies, but demonstrate significant neurodevelopmental problems [Sampson et al., 1997]. Hence the term, alcohol related neurodevelopmental disorder, is used to refer to those alcohol exposed children without dysmorphia who nonetheless display neurodevelopmental problems [Stratton et al., 1996]. Evidence from clinic-referred samples suggests that alcohol exposed children with and without dysmorphia all exhibit neurocognitive problems to a comparable degree [Mattson et al., 1997; Kodituwakku et al., 2001b].

Given that only some children with prenatal alcohol exposure exhibit clinically observable physical anomalies, clinicians have to resort to the examination of children's neurobehavioral profiles to identify those on the spectrum without dysmorphia. The neurobehavioral approach to diagnosing children without dysmorphia will however be viable, only if alcohol exposed children display a unique neurocognitive profile or a cognitive phenotype. Therefore, the question of whether children with prenatal alcohol exposure display a signature neurocognitive profile has received considerable attention over the last three decades [Streissguth et al., 1998; Nash et al., 2006].

DELINEATION OF A NEUROCOGNITIVE PROFILE

In the search for a signature profile, researchers have often employed the strategy of comparing children with FASD with a group of typical children, who are matched with respect to demographic characteristics but without prenatal alcohol exposure, on selected batteries of tests. The main objective of this strategy has been to test if the FASD group, compared with the control group, shows an uneven profile when the test scores are displayed on the same metric. In the statistical language, an uneven profile with peaks and valleys is indicated by a group × test interaction or nonparallelism of profile [Harris, 1985]. An alternative pattern that can be observed in profile analysis is what is referred to as the levels hypothesis [Harris, 1985], in which the disorder group performs at a lower level than the typical group across the board, which is indicated by two parallel lines. If the levels hypothesis is confirmed, one can argue that the disorder group has a generalized cognitive deficit.

Accordingly, the task of delineating the neurocognitive profile in FASD involves answering a number of questions: do

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individuals prenatally exposed to alcohol display an uneven cognitive profile? Alternatively, do individuals prenatally exposed to alcohol display poorer performance than the control with increased task demands across the spectrum of cognitive functions? In the first section of this article, we review the literature on higher-order cognitive functions in children with FASDs including intellectual functioning, information processing and executive functions, language, visual perception, memory, social cognition, and number processing. In the next section, we attempt to integrate the data presented in the first section and propose a hypothesis on the neurocognitive profile in children with FASDs. In the final section, we will briefly discuss future directions in the study of neurocognitive functioning in children with FASDs.

HIGHER-ORDER COGNITIVE FUNCTIONS

Although children with FASDs have been found to exhibit deficits in some elementary functions such as eyeblink conditioning [Green et al., 2000; Steinmetz et al., 2001], in this article, we will focus on the neurocognitive profile of higher-order functions in alcohol-affected children. In particular, we will focus on intellectual functioning, executive control, language, memory, and social cognition with a view to identifying patterns of cognitive competencies.

Intellectual Ability

Numerous researchers have documented diminished intellectual functioning in children with FASDs [Streissguth et al., 1990; Mattson et al., 1997], with average IQs ranging from the borderline to low average ranges. Mattson et al. [1997] found that children with heavy prenatal alcohol exposure with and without physical anomalies (dysmorphia) all displayed diminished intellectual functioning. Some researchers have found a dose-dependent decrement of intellectual ability, with exposure to 1 ounce of absolute alcohol a day being related to a decrease in nearly five full-scale IQ points [Streissguth et al., 1989].

Composed of subtests that measure a range of cognitive skills including attention, language, visual perception and visual construction, IQ tests such as the Wechsler scales offer a glimpse of overall cognitive profile of individuals with FASD. One question that can be directly addressed concerns whether the intellectual profile in children with FASDs is even or uneven. Studies that contrasted verbal and performance IQs have yielded equivocal results [Mattson and Riley, 1998], perhaps due to variability in subject backgrounds (e.g., social-ethnic) and amounts of prenatal alcohol exposure. Studies that examined intellectual functioning in children with heavy prenatal alcohol exposure have shown comparable decrement in both verbal and performance IQs [Mattson et al., 1997]. Adnams et al. [2001] reported that heavily alcohol exposed children who were diagnosed with fetal alcohol syndrome scored significantly lower than controls on intellectually more demanding tests on the Griffiths Scales [Griffiths, 1954] (e.g., speech-hearing, practical reasoning, performance), but the two groups displayed comparable performances on intellectually less demanding tests (e.g., gross motor). Therefore, children with heavy prenatal alcohol exposure seem to display deficient performance on complex intellectual tasks across the board.

Attention and Information Processing

Attention and information processing skills in children with FASDs have been extensively investigated, because attentional deficits are considered to be a common characteristic of this disorder [Nanson and Hiscock, 1990; Lee et al., 2004]. Early studies of cognitive functioning in children with FASD documented that alcohol-affected children exhibited deficient performance on tests assessing vigilance [Streissguth et al., 1986] and on tasks assessing the investment, organization, and maintenance of attention over time [Nanson and Hiscock, 1990]. Coles et al. [1997] contrasted performances of children with FASD and ADHD on a test battery assessing the components of attention proposed by Mirsky [1996]: Focus, Sustain, Encode, and Shift. These investigators found that the FASD group had greater difficulty in Encode (i.e., the capacity to hold information temporarily in memory while performing a mental operation upon it) and Shift (e.g., the ability to shift attention from one stimulus dimension to another in a flexible manner) components. In contrast, ADHD group displayed greater difficulty on tests assessing Focus (i.e., the capacity to concentrate on a particular task) and Sustain (i.e., the ability to stay on a task) components. In a subsequent study, these investigators [Coles et al., 2002] found an interaction between groups and the modality of sustained attention, with the FASD group performing worse on visual than on auditory sustained attention. Lee et al. [2004] also found that children with FASDs performed less well than controls on a visual test of sustained attention. A logistic regression analysis revealed, however, that auditory tests assessing freedom from distractibility (digit span and arithmetic) distinguished alcohol-exposed children from controls better than the test of visual sustained attention.

Thus, there is converging evidence that children with FASD are impaired at tests assessing the Encode and Shift components of attention in the Mirsky's model. A closer examination of these tests reveal that they include parts that call for the supervisory attentional system [Shallice and Burgess, 1998]. For example, reversing the aurally presented strings of digits in the head (digit span backward) and shifting of attention in response to the examiners feedback (Wisconsin Card Sorting Test), and solving mental arithmetic problems (Wechsler Arithmetic Test) all involve supervisory attention because of high cognitive demands.

A number of studies have investigated the rate of information processing in children with FASDs. Jacobson [1998] found that infants with prenatal alcohol exposure showed slower processing speed than comparison groups. Burden et al. [2005] found that tasks involving effortful processing rather than those involving automatic processing discriminated between the school-aged FASD and control groups. Consistent with this finding, Roebuck et al. [2002] reported that the FASD group exhibited greater difficulty than controls on a task that involved interhemispheric transfer of information. Thus, there is growing evidence that children with FASD have difficulty in rapidly processing relatively complex information.

Executive Functions (EF)

The term executive functioning refers to a set of abilities required to attain goals efficiently in nonroutine situations [Kodituwakku, in press]. These include planning, monitoring of goal-directed behavior in the face of external and internal distractors, shifting response sets in response to the changes in task demands, and error correction. Because these EF abilities require conscious effort or supervisory attention [Shallice and Burgess, 1998], researchers have hypothesized that children with FASDs are impaired in executive control [Kodituwakku et al., 1995; Mattson et al., 1999].

There is a growing body of literature supporting the above hypothesis [Kodituwakku et al., 2001a; Rasmussen, 2005]. Researchers have found that the FASD group performs less proficiently than controls on tests assessing cognitive planning [Kodituwakku et al., 1995; Mattson et al., 1999], conceptual set shifting [Coles et al., 1997; Carmichael Olson et al., 1998], nonverbal and verbal fluency [Schonfeld et al., 2001; Kodituwakku et al., 2006], and multiple measures of concept formation [McGee et al., 2008b].

In view of the report that children with FASD are deficient in self-regulation, Kodituwakku et al. [2001b] investigated affective set shifting in alcohol affected children using a test of visual discrimination reversal [Rolls et al., 1994]. This test is considered a sensitive measure of the orbitofrontal functioning and it requires that the examinee shift stimulus-reward associations. Results showed that the FASD group was impaired at affective set shifting and that this impairment was associated with parent-rated behavioral problems in these children.

Researchers have also obtained evidence that children with FASDs have reduced abilities in the processes underlying EF skills, namely working memory and response inhibition. Researchers have consistently found that children with FASD are markedly impaired at the Visual Working Memory Test of the Cambridge Neuropsychological Tests Automated Test Battery [Green et al., 2009; Mattson et al., 2009]. Noland et al. [2003] reported that children exposed to alcohol performed less well than controls on a tapping inhibition task. There is also evidence that children with FASDs are deficient in inhibiting reflexive eye movements (antisaccades), a function that involves executive control [Green et al., 2007].

In summary, children and adults with FASDs show deficient performance on tests assessing executive control skills. On closer examination, however, one finds that children with FASDs display greater difficulty with more complex tasks of executive functioning than with less complex ones. While Rasmussen and Bianz [2009] observed that the FASD group performed worse on the Card Sort Task than on the Tower Task from the Delis-Kaplan Executive Function System, Kodituwakku et al. [2009] found that the progressive planning test (PPT) was sensitive to the effects of prenatal alcohol exposure. It is probable that the PPT places more demands on working memory than the California Tower Task. There is evidence that the FASD group has greater difficulty with letter fluency than with category fluency [Kodituwakku et al., 2006]. Since the letter fluency requires the examinee to generate words beginning with specific letters under certain constraints it is a cognitively more demanding task than the category fluency, in which the examinee is asked to rapidly retrieve exemplars from a semantic category [Lezak et al., 2004]. Furthermore, Green et al. [2009] have reported that children with FASD were impaired at planning and working memory, with group differences becoming pronounced with increased task demands.

Language

Studies of language skills in children with FASDs have produced inconsistent results. Researchers failed to find notable language deficits in alcohol-affected children in two prospective studies [Greene et al., 1990; Fried et al., 1992]. In contrast, researchers have documented significant language deficits in clinic-referred samples of children with FASDs. These include deficits in naming [Mattson et al., 1998], grammatical and semantic abilities [Becker et al., 1990], and pragmatics [Abkarian, 1992]. Population-based studies from South Africa and Italy show that children with FASDs are markedly impaired in grammar comprehension [Adnams et al., 2001; Kodituwakku et al., 2006].

The above discrepancies in the findings from prospective and clinic referred samples could be partly explained in terms of differences in participant characteristics. It appears that the studies reporting nonsignificant results included children, on average, with lower levels of exposure compared with studies reporting significant results. It is also possible that the studies reporting positive findings employed relatively complex tests of language involving working memory. For example, the grammar comprehension test [Kodituwakku et al., 2006], and verbal fluency tasks all involved phonological working memory, which is deficient in children with FASD [Coles et al., 1997]. Coggins et al. [2007] reported that children with FASDs display deficits in social communication, which involves regulating a number of processes (e.g., retrieval of words, comprehension of nonverbal cues etc.). Thus, it appears that children with FASDs show deficits in relatively complex language tasks involving phonological working memory and social pragmatics.

Visual Perception and Visual Construction

In contrast with the areas of cognitive functioning such as attention, relatively little is known about visual perception and visual construction (e.g., building or copying patterns) in children with FASDs. Uecker and Nadel [1996] reported that children with FASD were relatively unimpaired at facial recognition, but were markedly impaired at tests assessing visual construction, such as the Beery Visual Motor Integration and Clock Drawing tests. Mattson et al. [1996] reported that children with FASDs differentially processed global and local features of visual stimuli. That is, the FASD group had greater difficulty than controls in copying and recalling local features of hierarchical stimuli, such as a large letter *D* (global) made up of small letters *y* (local features).

The above findings suggest that children with FASDs are unimpaired at simple perceptual tasks, but are impaired at tasks that require visual motor integration. The basis for the differential performance on global and local features remains unexplained.

Learning and Memory

It has now been established through animal research that the hippocampus, a region subserving memory, is specifically vulnerable to the deleterious effects of alcohol during brain development [Berman and Hannigan, 2000; Savage et al., 2002]. A number of researchers have extended the findings in animal research to humans by using tests that have been found to be sensitive to hippocampal functioning. Using a computerized (virtual) version of the Water Maze, a test that is sensitive to hippocampal functioning, Hamilton et al. [2003] found that children with FASDs demonstrated difficulty in spatial learning. In this study, researchers trained children with FASDs and typically developing controls to navigate to a hidden platform in a fixed location of the virtual pool. After 20 hidden platform trials, a single no-platform probe trial was administered. This was followed by 8 cued-navigation trials, during which the platform was visible. Results showed that the FASD group exhibited poorer performance than the control group on the hidden trials and the probe trial, but not on the cued-navigation trials.

Uecker and Nadel [1996] reported that children with FASD showed deficient performance on the Memory for Objects Task [Smith and Milner, 1989] at delayed, but not immediate, recall trial. These investigators also noted that the FASD group had difficulty with nonhippocampal visual tasks, suggesting that the FASD group had visual spatial difficulties extending beyond memory. In a subsequent study, Uecker and Nadel [1998] demonstrated that children with FASDs were impaired in spatial, but not in object memory. Aragon et al. [2008] utilized a modified version of the Lhermitte-Signoret Memory Tests [Lhermitte and Signoret, 1971] to assess learning and memory in children with FASDs. These tests included a simple spatial memory task, in which participants were required to learn the locations of nine drawings on a 3 × 3 frame, and a logical memory task, in which they were required to learn the locations of nine geometric shapes that constituted a logical pattern. Results showed that the FASD group was impaired at the logical, but not at the spatial memory task. The logical memory condition is more demanding than the spatial memory condition. Furthermore, the Lhermitte-Signoret Spatial Memory Task is simpler than the Smith and Milner Task (recall of 9 vs. 16 objects), which probably explains the discrepancy in the findings reported by Arogan et al. and Uecker and Nadel. Consistent with this pattern, Mattson and Riley [1999] found that children with prenatal alcohol exposure had greater difficulty with free recall of information than with recognition memory. Free recall of information involves the utilization of retrieval strategies and hence, is more demanding than recognition memory.

A number of investigators have investigated patterns of learning and memory in children with FASDs using standardized tests [Kaemingk and Halverson, 2000; Willford et al., 2004]. The results of these studies show that children with FASDs exhibit difficulty learning both verbal and visual materials, a pattern commensurate with diminished verbal and performance IQs. In summary, children with prenatal alcohol exposure seem to show deficits in memory processes that involve conscious effort, such as free recall and organization.

Social Cognition

On parent and teacher-rated questionnaires and adaptive behavior scales, children with FASDs are often rated as having deficits in social skills [Carmichael Olson et al., 1997; Thomas et al., 1998; O'Connor et al., 2006]. There is also evidence that social deficits in alcohol exposed children become more pronounced as they grow older [Whaley and O'Connor, 2003]. Deficits in social skills lead to numerous secondary disabilities including depression, social isolation, and failure at work place. Given that social deficits have been demonstrated in animal models of FASD [Kelly et al., 2000; Lugo et al., 2003], it is reasonable to hypothesize that alcohol-induced brain damage and environmental variables interactively contribute to social skills deficits in alcohol-exposed children.

The focus of one line of research has been on the identification of the cognitive mechanisms contributing to social difficulties in children with FASDs. Bishop et al., [2007] compared children with autism and FASD on the Autism Diagnostic Observation Schedule [Lord et al., 1989] and found that the two groups differed in social interaction and communication. Although the FASD group did not have difficulty initiating social interactions and using nonverbal communication, they displayed socially inappropriate behaviors and difficulty with peers. This study suggests that social difficulties in children with FASD may result from deficient self-regulation, rather than from deficient social sense. Schonfeld et al. [2006, 2009] have reported evidence supporting this hypothesis. These investigators found that executive functions accounted for a significant proportion of variance in parent- and teacher-rated social problems in children with FASDs.

McGee et al. [2009] et al. have demonstrated that school-aged children with heavy prenatal alcohol exposure are impaired at social information processing. In this study, participants viewed 18 video vignettes depicting children in specific social situations (e.g., group entry, provocation) and responded to specific questions tapping various social information processing measures. The results showed that children with FASDs had maladaptive processing patterns both in the generation and evaluation of responses in social situations. McGee et al. have also observed that children with FASDs exhibit deficient skills in social problem solving [McGee et al., 2008a]. These difficulties in social problem solving and social information processing can be closely linked to higher-order executive control disabilities such as decision making and strategic planning.

Number Processing

It has been well documented that children with FASDs score lower on tests assessing math than on those assessing other academic subjects [Streissguth et al., 1994]. This observation has led researchers to ask whether children with FASDs display a specific deficit in number processing. Using a test battery based on recent findings in cognitive neuroscience, Kopera-Frye et al. [1996] investigated number processing in children with FASDs. This study revealed that children with FASDs performed without difficulty on relatively simple tasks of number processing, such as number reading and number writing, but showed deficits on relatively complex tasks, that required planning and mental manipulation.

Therefore, it remains unsettled whether children with FASDs lack a number sense or they have greater difficulty with performing numerical operations than with processing basic numerical information. The findings from the Kopera-Frye et al. suggest that the main source of difficulty may be in mental manipulation of numerical information.

SUMMARY AND CONCLUSIONS

The above review of the literature on neurocognitive functioning in children with FASDs shows that alcohol-affected children exhibit diminished intellectual functioning, with average IQs ranging from the borderline to low average ranges. Comparisons of verbal and nonverbal intellectual abilities in children with FASDs have suggested that they are comparably deficient in both domains. The studies that have examined information processing in children with FASDs have consistently shown that children prenatally exposed to alcohol are significantly slower than age-matched controls. Slow information processing has been observed even in infants with prenatal alcohol exposure. Investigators have consistently found that children with FASDs are impaired in different components of executive functions, including planning, conceptual set shifting, affective set shifting, verbal and nonverbal fluency, concept formation, and error correction. There is evidence that children with FASDs show greater difficulty with the executive control tasks that require higher levels of manipulation and regulation. The results from the tests assessing different areas of functioning such as language, visual construction, memory, and number processing show that when task demands increase, the performance of the FASD group declines at a faster rate compared with controls.

The above profile of neurocognitive functioning does not indicate task × group interactions reflective of domain specific disabilities in higher-order cognitive functions. The author previously summarized this pattern of observations as indicating a generalized deficit in the processing and integration of information [Kodituwakku, 2007, in press]. This characterization of the neurocognitive profile in children with FASDs poses however an interesting theoretical problem: how do regional anomalies in the brain (e.g., cerebellum, corpus callosum, caudate, prefrontal cortex) [Riley and McGee, 2005] give rise to a generalized deficit in information processing? We have proposed that this could be explained in terms of the ontogenetic developmental processes [Kodituwakku, 2007]. As Karmiloff-Smith et al. have elegantly argued, one can not assume that undamaged regions of a damaged brain function normally during development [Karmiloff-Smith and Thomas, 2003; Karmiloff-Smith et al., 2003]. In other words, undamaged areas also may undergo atypical development since brain regions develop interdependently.

FUTURE DIRECTIONS

In view of the observation that children with FASDs display a generalized deficit in the processing and integrating information in higher-order cognitive functions, we outline below three main directions in the future neurobehavioral research on FASD.

Study of Elementary Processes

The study of intermediate phenotypes or endophenotypes has proven to be a powerful tool in the delineation of distinctive functional characteristics in neurogenetic disorders. As Gottesman and Gould [2003] point out endophenotypes represent relatively elementary processes (e.g., neuroanatomical, cognitive) that provide clues to genetic underpinnings of disease rather than the disease syndrome itself. For example, deficits in ocularmotor functions (antisaccades) and sensory motor gating have been found to be useful endophenotypes in explaining the behavioral profile of patients with schizophrenia. Researchers have observed deficits in antisaccades in the relatives of schizophrenic patients suggesting that the occularmotor deficit is a heritable trait [Radant et al., 2007].

Although FASD is not a neurogenetic disorder with heritable traits the distinction between phenotypes and endophenotypes can be fruitfully applied in the study of cognitive and behavioral profiles in alcohol exposed children. The study of some elementary processes such as eyeblink conditioning, fear conditioning, inhibition of reflexive eye movements has produced useful information on the effects of prenatal alcohol exposure on the central nervous system.

. . . cross-syndrome comparisons of developmental trajectories of both elementary and higher-order functions as well as process data may provide new insights into the neurocognitive profile of children with FASDs.

One advantage of focusing on elementary processes is that they are minimally affected by social and cultural influences and hence can be used as "biomarkers" of alcohol-induced damage. Researchers have demonstrated that deficient eyeblink conditioning in children with FASDs persists into adulthood [Steinmetz et al., 2001] and remains unaffected by motor training [Wagner and Goodlett, 2009]. Another advantage of studying elementary processes is that it allows the exchange of ideas with basic science researchers. For example, basic science research may help identify candidate elementary processes for planning studies in humans.

Process Analysis of Test Performance

An underutilized strategy to the delineation of the behavioral phenotype of FASD is the comparison of process data from test performance. The profile analyses mentioned above typically utilize achievement or end-point scores on standardized tests. Over 70 years ago, Werner [1937] forcefully argued for the importance of considering how children achieve a solution (process) in addition to the final solution itself (achievement) when evaluating test performance. Given that different processes en route to solutions are subserved by distinct neural structures, a process analysis may provide invaluable information on the brain organization of the child. The process approach has subsequently been fruitfully used in neuropsychological assessment [Kaplan, 1988] and in neurodevelopmental research [Karmiloff-Smith, 2000]. Karmiloff-Smith et al. [Annaz et al., 2009] have demonstrated that children with developmental disorders achieve end points of cognitive tasks through processes different from those employed by typically developing children. For example, Karmiloff-Smith et al. have demonstrated that children with William's syndrome perform as proficiently as typically developing children on facial recognition, but utilize an approach (e.g., feature by feature analysis) different from controls (e.g., holistic) to perform this task.

As mentioned above, children with FASDs perform as proficiently as controls on relatively simple tasks. It is unknown however if children with FASDs employ the same strategies that typically developing children use. It is possible that the strategies employed to master simple tasks are inadequate to perform complex tasks. Accordingly, process data may prove to be useful in cross-syndrome comparisons.

Study of Developmental Trajectories

The most commonly used approach to the study of cognitive profiles in FASD is the individual or group matching methodology. In this approach, a group of children with FASD is compared with age, sex, and SES matched controls on a selected set of experimental tasks. Thomas et al. [2009] have underscored the utility of studying developmental trajectories using growth models. The essence of this approach is to construct functions linking performance with age on specific experimental tasks and then to compare these functions (or developmental trajectories) of typically developing and disorder groups. This approach will avoid treating a group difference found at a specific age as a static phenomenon. To our knowledge, the developmental trajectory approach has not been used in the study of cognitive profiles in children with FASDs.

Accordingly, cross-syndrome comparisons of developmental trajectories of both elementary and higher-order functions as well as process data may provide new insights into the neurocognitive profile of children with FASDs. ■

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