Chapter 4

The Long Road From Research to Real Life

The Widening Gap

In the past two decades, several disciplines have emerged that open exciting new perspectives in child development and learning. As summarized by G. Reid Lyon, a noted researcher in child development, "An explosion of research activity in attention, memory, and executive function has occurred since the mid-1980s. Unfortunately, the literature relevant to these domains is so voluminous that the important converging trends in the data are sometimes difficult to identify and to apply to development and learning in children. This difficulty is exacerbated by the application of divergent theories, methodologies, and vocabularies that are used to identify and describe normal and atypical development…" [1]

While these comments were made in reference to particular areas of research, the problems they describe pervade the field of learning and development in general. With so much new information on so many fronts, clinicians and the public are hard pressed to absorb new developments.

This explosion of information in child development results from a variety of new technologies and methods. For example, developments in molecular biology revolutionized molecular genetics and molecular neurochemistry, permitting us to explore a variety of domains within the cell, including the human genome, and the processes of gene expression, neurotransmitter production, and cellular communication. Powerful new neuroimaging technologies, including magnetic resonance imaging and positron emission tomography (PET scans), vastly improved the understanding of brain structure. Because these technologies can selectively highlight regions of the brain that are mentally active at the time of testing, neuroimaging studies can now be used to explore the link between brain structure and function in real time.

Other critical improvements occurred in spectrometry and gas chromatography. These developments enabled scientists to measure unprecedented tiny concentrations of chemicals, permitting the identification and testing of previously unrecognized toxicants. In addition, the application of

DEFINITION - *Genome:*

The complete set of genetic information contained in the chromosomes..

new computer technologies to the study of cognition generated entirely new models for understanding how the brain processes information.

With the application of these new technologies, a variety of new, increasingly specialized fields have emerged. With increasing specialization, it is no surprise to see widening gaps between the disciplines of child development, and between the domains of research and clinical practice. Several factors may contribute to this unfortunate rift.

1. Much of the new information is so highly technical it is understood only by experts within the field from which the information originates.
2. Researchers and clinicians often have little contact. Consequently research agendas may not adequately reflect the concerns of clinicians or parents.
3. Research is often constrained by technical and methodologic concerns.
4. Funding sources may preferentially favor research with marketable technical applications rather than research relevant to less lucrative clinical concerns.
5. Busy clinicians may have limited interest in new academic topics lacking clear clinical applications.

By taking an interdisciplinary approach, this report attempts to narrow a part of the gap between research, clinical practice and public understanding. An interdisciplinary discussion on child development also supports the evolution of an over-arching bio-behavioral framework needed to integrate divergent perspectives on child development.[2]

We focus on recent findings in developmental neurotoxicology because this research readily translates into simple preventive measures to help protect children at risk. In addition to having practical applications, the research findings of developmental neurotoxicology are also of considerable academic interest. Since this research dovetails with research in other domains, particularly neuroscience and behavioral genetics, it furthers our understanding of the biological basis of development in general. In promoting a wider dialogue, we also hope to make research findings from the several "biological" domains more accessible to parents and clinicians.

Traits: A Bridge Between Divergent Disciplines (Neurotoxicology, Genetics and the Clinical Disorders)

Child development, like other behavioral sciences often uses categories to describe learning, behavior and development.[3] Categories focus on disease entities such as ADHD, autism, and other specific disorders. Categories are inherently dichotomous, meaning they imply only two possibilities: the child either has or does not have a particular disorder. Alternatively, behavior can be described using the concepts of abilities or traits, which vary as gradations along a continuum.[4 5] Short term memory, impulsivity, and attentional ability are examples of traits relevant to learning, behavior and development. There is growing consensus that a better understanding of these traits is critical to understanding the clinical disorders.[6]

Deficits in traits/abilities appear to correspond to clinical syndromes, but relationships have not been clearly established.[7] For example, deficits in the trait attention appear to correspond to the clinical syndrome ADHD, however the relationship is not straightforward. For example, studies show that boys with ADHD perform poorly on measures of sustained attention, but are not impaired in the ability to selectively focus their attention.[8 9] Other studies show that attention deficits in ADHD depend on the setting, and that the mere presence of an adult in the room at the time of testing improves attention measures.[10] While the relationship of traits and clinical syndromes is being explored, concurrent research is attempting to better define and understand the traits.[11]

Because traits are the subject of research in a variety of fields, they provide a basis for interdisciplinary dialogue. This was illustrated in the focus of a recent National Institute of Child Health and Human Development conference on attention, memory and executive function, three traits of central importance to development and learning. Focusing on traits permitted researchers and clinicians from a variety of domains, including psychology, neurology, pediatrics and special education, to exchange information on methods, concepts, and findings. Since a large body of genetic research has also focused on cognitive and behavioral traits, behavioral genetics can also be integrated into the larger discussion utilizing traits as a common denominator.

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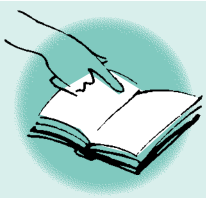
Traits As Useful Outcome Measures in Research

Aside from linking the divergent disciplines of child development, traits/abilities are well suited to research because they can be tested and quantified as specific functions. In toxicology, researchers increasingly "examine specific functions and processes rather than milestones, accumulated knowledge or general abilities."[12] For example, the effects of in-utero cocaine exposure have been detected at various stages of infancy and childhood using tests of specific function such as visual recognition memory or attentional ability. In contrast, standardized tests of general cognitive ability, (such as the Bayley Scales of Infant Development, or the Stanford-Binet Intelligence Scale) have shown little differences between exposed and unexposed children.[13] Likewise, specific tests of attention, such as the Continuous Performance Test, are more sensitive than global assessments or neurological exam to low levels of prenatal mercury exposure. As a computer-assisted neuropsychological test, the Continuous Performance Test is sensitive to "minute differences in responses…[and] therefore statistically superior in detecting subtle neurobehavioral dysfunction."[14]



THE CONTINUOUS PERFORMANCE TEST: AN EXAMPLE OF A TEST FOR ATTENTIONAL ABILITY (from Grandjean[17])

In the Continuous Performance Test, children watch a series of animal silhouettes flashed on a screen. The child's task is to press a button every time a cat appears over a 4-minute interval. The test is scored by the number of missed responses and the average reaction time during the last three minutes. This test is considered to be a measure of vigilance, a particular kind of attention.

Clinical syndromes like ADHD or Asperger's syndrome, may be problematic in research because they are categorical rather than quantitative, and because their definitions continue to change over time.[15] In addition, clinical syndromes translate poorly into animal models which are often used to study the effects of toxicants on neurodevelopment. This is illustrated by the difficulties developing animal models for autism research. As summarized by Patricia Rodier, a leading researcher in the field, "..the behavioral criteria by which autism and related disorders are diagnosed…do not invite animal experiments…Much of our most specific behavioral information… relates to behaviors that probably are exclusive to humans, such as language, associative pointing, and imitation."[16]

For all these reasons, the effects of various factors on neurodevelopment are often measured on specific behavioral and cognitive abilities rather than on clinical syndromes or global measures of development or intelligence. Focusing on traits generally provides a common denominator between different fields of research, produces more reliable and sensitive measures, and allows us to study the effects of toxicants and genetics on the "normal" population as well as on those with diagnostic labels.

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2 Taylor HG. Critical issues and future directions in the development of theories, models, and measurements for attention, memory, and executive function. In:Attention, Memory and Executive Function. Eds. Lyon GR, Krasnegor NA, Baltimore: Paul H. Brookes Publishing Co., 1996, p.400-401.

3 Mash EJ, Terdal LG. Assessment of child and family disturbance:a behavioral-system approach. In: Assessment of Childhood Disorders.Third Edition. Eds. Mash EM, Terdal LG. New York: Guilford Press, 1997, p.16-19.

4 Plomin R, DeFries JC. The genetics of cognitive abilities and disabilities. Scientific American, May, 1998:62-69.

5 McClearn GE, Volgler GP, Plomin R. Genetics and behavioral medicine. Behavioral Medicine, 22:93-101, 1996.

6 Taylor HG. Critical issues and future directions in the development of theories, models, and measurements for attention, memory, and executive function. In:Attention, Memory and Executive Function. Eds. Lyon GR, Krasnegor NA. Baltimore: Paul H. Brookes Publishing Co., 1996, p.401-405.

7 Taylor HG. Ibid. p.407.

8 Taylor HG. Ibid. p. 406.

9 Barkley RA. ADHD and the Nature of Self-Control. New York: Guildord Press, 1997, p. 10.

10 Barkley RA. Ibid, p.12.

11 Taylor HG. Ibid. p.401-405.

12 Fried PA. Behavioral evaluation of the older infant and child. In: Handbook of Developmental Neurotoxicology. Eds. Slikker W, Chang LW. San Diego: Academic Press, 1998, p.474-476.

13 Fried PA. Ibid, p. 476.

14 Grandjean P, Weihe P, White RF, et al. Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. Neurotoxicology and Teratology 19(6):417-428, 1997.

15 Mann CC. Behavioral genetics in transition. Science 264:1686-1689, 1994.

16 Rodier PM. Neuroteratology of autism. In: Handbook of Developmental Neurotoxicology. Eds. Slikker W, Chang LW. San Diego: Academic Press, 1998, p.662.

17 Grandjean P, Weihe P, White RF, et al. Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. Neurotoxicology and Teratology 19(6):417-428, 1997.