Evolution and Revolution in Child Psychiatry: ADHD as a Disorder of Adaptation

[Article]

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Abstract

Current knowledge about early plasticity and children's responsiveness to environmental modifications as well as the atheoretical nature of current nosological systems necessitate alternative models to explain the phenomena of childhood behavioral and emotional disturbances. Evolutionary biology provides one such framework. It organizes data from the behavioral and cognitive sciences and parallels similar efforts in other areas of medicine and biology. Through an evolutionary biological lens, some mental disorders are better viewed as an adaptive response to early pathogenic environments and/or reflect the optimization of brain function to some environments at the cost of poorer response to the demands of other environments. As an example, the authors examine attention-deficit/hyperactivity disorder (ADHD) in relation to evolutionary theories of psychology and biology and clarify the potentially adaptive nature of characteristics of inattention, impulsivity, and motoric hyperactivity, depending on the nature of child's environments. Reframing ADHD characteristics according to evolutionary theory has important treatment implications for clinicians and offers researchers opportunities for novel scientific discoveries. J. Am. Acad. Child Adolesc. Psychiatry, 1997, 36(12):1672-1679.

Despite the popularity and widespread use of the DSM-IV (American Psychiatric Association, 1994) [1], concerns persist among clinicians and the general public about the applicability of "mental disorder" status to some described conditions (Richters and Cicchetti, 1993; Wakefield, 1992a) [22,27]. Early environmental experiences impact structural and functional aspects of cortical development, neuronal activity, and organization (Nelson and Bloom, 1997) [18]; consequently, some DSM-defined "disorders" plausibly arise from an adaptive response to early pathogenic environments (trauma, neglect), while others result from the optimization of brain function to early environments that are inconsistent with the demands that the child must meet in later environments (Jensen and Hoagwood, 1997) [11]. Thus, straightforward symptom descriptions (as in DSM-IV) disregard the imperative of adaptation for human beings in general and, more particularly, ignore the plasticity and sculpting of our species' brain by experience (Depue et al., 1996; Greenough and Black, 1992) [6,8].

Evolutionary Biology and Human Adaptation

What alternative models might explain the phenomena of childhood behavioral and emotional disturbances, unconstrained by current nosological systems? Evolutionary biology provides one such framework, as it organizes data from the behavioral and cognitive sciences and parallels similar efforts in other areas of medicine and biology. When human mental and behavioral phenomena are viewed from this theoretical perspective, a core assumption holds that natural selection has shaped the mental mechanisms available to our species and that these mental mechanisms enhance adaptation and survival. Thus, many emotional and behavioral responses (particularly if relatively commonplace within a given species) may not just be "symptoms" of disorders, but they might instead reflect adaptive responses of the organism to environmental demands. From this vantage point, the human brain can be viewed as an "adaptation machine," evolved to fit our species to a range of environments. Indeed, non-human primate research in natural habitats suggests that a wide degree of tolerance for varied ecological conditions enables species' survival (Lindburg, 1971) [16].

Therefore, to explain the structure of a highly evolved biological system such as the brain, we must understand what adaptational problem(s) it evolved to solve. From this assumption one logically proceeds to ask, "What information would have been available in ancestral environments for solving the problem(s)?" in attempting to understand human behavior.

Application of Evolutionary Models to ADHD

This article addresses the question of how some childhood traits and behaviors construed as internal biological dysfunctions can be reframed as adaptive responses to environmental contexts. Using attention-deficit/hyperactivity disorder (ADHD) as an example, and examining this "disorder" in relation to evolutionary theories of psychology and biology, we explore the thesis that evolutionary perspectives can explain the presence of ADHD traits in some children. This model is not intended to be all-compassing, does not preclude other explanatory factors (genetic abnormalities, neurotoxins, head injury),

and may even interact with other such factors. Nonetheless, given the current estimated frequency of ADHD (3% to 5%) (Richters et al., 1995) [21], it is unlikely that such a "disorder" could be as prevalent in the human species if not maintained within the species by selection forces that conveyed certain advantages to some ADHD characteristics or other associated traits.

ADHD is characterized as a classical triad of symptoms: inattention, hyperactivity, and impulsivity. Leaving aside the co-occurrence of all three symptoms, we suggest that each of these "symptoms" can be adaptive in some instances. If this hypothesis is correct, what adaptive problems might each of these traits serve to solve, either in ancestral or modern-day environments?

Increased Motor Activity (Hyperactivity). For an organism to adapt successfully, it must constantly explore the environment for threats and opportunities. From this perspective, increased motor behavior and hyperactivity may be useful (particularly in ancestral hunter-gatherer environments) to assist in effective foraging, spotting of new opportunities, anticipating dangers, etc. Furthermore, increased motor behavior (especially during juvenile years) may serve to "wire the brain" to the external environments in a way to fit the environment, as well as to stimulate development of muscle and motor skills. Is this in the service of exploratory behavior, serving to develop a reservoir of experiences upon which the animal later draws? If this hypothesis is correct, one would theorize that animals adapted to food-scarce environments would show high degrees of motor behavior, perhaps even in the young who are not yet responsible for foraging (a testable assumption, both within and across species).

Yet does the juvenile animal always show increased motor behavior, or only under conditions where such motoric activity subserves adaptation? Consistent with our thesis, increased exploratory motor behavior usually occurs only in the context of proximity to the care-taking animal (hence, presumed safety), and a frightened animal (or child) who is characteristically highly motorically active will suppress motor activity during periods of separation from caregivers, during periods of danger, or in situations with a high degree of novel stimuli (Bowlby, 1973) [4]. These straightforward observations illustrate the simple yet elegant premises of adaptational theory-motor behavior is expressed when it subserves adaptation and survival and is suppressed when it does not, given sufficient time for evolutionary and selection forces to encode the behavioral repertoire within the species' genome. It is not surprising, then, that empirical studies of animals suggest that activity level involving speed, proportion of time active, and foraging effort is associated with resource acquisition among varying species (Werner and Anholt, 1993) [29] and that speed and time activity are reduced in the presence of predators (Lima and Dill, 1990) [15].

Attentional Processes (Scanning and Rapidly Shifting Attention). Vigilance is necessary to monitor dangers and threats. Overfocused attention could be quite maladaptive in high-threat or highly novel environments, yet it could be a productive use of cognitive capacities to allow for future planning when environmental threats or novel stimuli are minimal. Thus according to our conceptualization, animals who are preyed upon or are in

environments with a high ratio of predators to prey are more likely to have increased scanning behaviors. If the scanning strategy is malleable and "wired" during early development to fit the local environment in an organism-specific manner, within a given species animals that are raised in low-threat environments will show fewer scanning behaviors. In contrast, animals raised in higher-threat and/or high novel stimulus-rich environments (where scanning is adaptive, learned, and in part species-specific) should show high scanning levels, even when this is no longer necessary during later development. Thus, while there may exist evolved, adaptive reasons for the behavioral potentials existing within the species' genome, the environment shapes the tendencies of particular organisms within that species to express responses such as increased scanning behaviors, i.e., "inattention" to a single, repetitive stimulus. Moreover, definitions of over- versus underattention are sensible only when are situated within a given context and for specific classes of stimuli (e.g., those requiring active versus passive listening) (Shibagaki and Yamanaka, 1990) [24].

Impulsivity. How about "impulsivity"? For purposes of our thesis, we define impulsivity as an organism's quick response to environmental cues while not considering alternative responses to the cues. We hypothesize that some responses are relatively automatic or reflexive, but a given organism can learn to adjust the threshold and timing of response based on the likelihood of a "payoff" as a result of immediate, delayed, or non-response, and whether the response is a correct one. The animal (or species) without ability to adjust this timing-dependent, payoff-dependent, response threshold is less able to adapt to different environments and/or pass its genes to the next generation. The organism that does not quickly pounce on a potential prey or dodge a potential predator may not get another chance. The relative danger of false-positive responses (e.g., mistaking a neutral cue for a threat, and responding defensively) could be easily outweighed by the "downsides" of missing a critical cue in dangerous or resource-scare environments. In such environments an organism may learn (through early neuroplastic and sculpting processes) to respond with a relatively low threshold for an action response. On the other hand, such "impulsive" hair-trigger responsivity may be less adaptive as the organism moves into other, less time-critical settings over its life course.

Nature of Ancestral Environments

Converging evidence from anthropology and archeology indicates that the human species diverged from forebears by living for a few million years in hunter-gatherer societies. Foraging was essential. Not uncommonly, resources may have been scarce (or at least only intermittently plentiful), and threats abounded. Yet human culture and society have changed dramatically in the last 10,000 years, more rapid by far than the pace of evolution of the human genome. A lag in remodeling the genome means that our species' brains still retain the propensity to adapt to environmental features as these were before the emergence of recent civilizations. Thus, to understand behavioral repertoire of modern-day humans, consideration of our ancestral environments is instructive. Relevant to the traits characteristic of persons with ADHD, we suggest that ancestral environments ranged along several continua, including safe versus not safe, resource-rich versus impoverished, and time-optional versus time-critical. At one end of these three continua

(which we will term "response-ready"; see Figure 1), humans' survival depended on being (1) hypervigilant, including the ability to retrieve and integrate information through all senses at once-somewhat akin to parallel processing; (2) rapid-scanning; (3) quick to pounce (or flee); and (4) motorically "hyperactive" (foraging for food, moving toward warmer climes as seasons and ice ages come and go, etc.). The "response-ready" individual would likely have been advantaged under the brutal or harsh circumstances of the frozen steppe or humid jungle, whereas the excessively contemplative, more phlegmatic individual would have been "environmentally challenged."

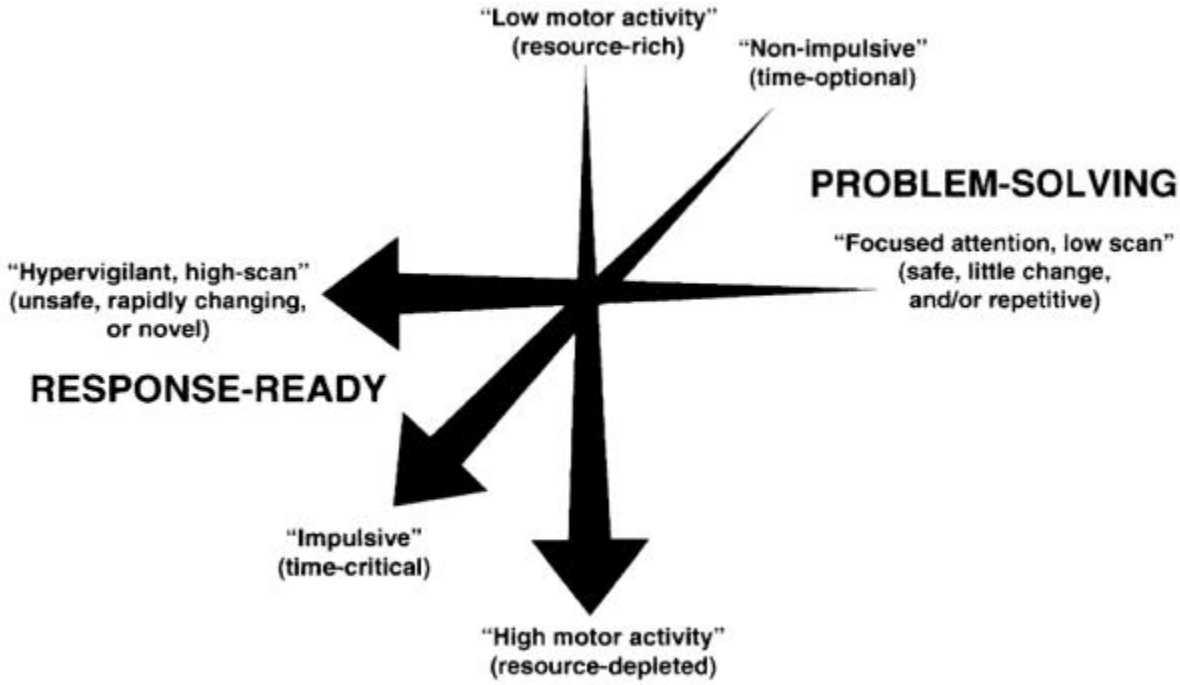

Figure 1. Attention-deficit/hyperactivity disorder dimensions and environtypes. Personal characteristics in quotes; environmental dimensions in parentheses.

Yet not all ancestral environments would have been this harsh, so variability of these traits within the genome would also have been useful for species survival. Within a given hunter-gatherer society, individuals with more of the "response-ready" characteristics would likely have been successful warriors on a primitive battlefield, while those with more contemplative characteristics may have been valued for longer-term planning, strategic operations, or perhaps development of novel solutions to long-standing or even fairly immediate environmental problems. As society has become increasingly industrialized and organized, "response-ready" characteristics may have become less adaptive, to the extent that current-day environments are more resource-rich and safe and a "hair trigger" time-action response to environmental cues is less critical (even counter-productive). Success in such environments becomes increasingly measured by the ability to demonstrate (1) problem-solving and analytic strategies, (2) restraint of impulsivity,

and (3) the controlled deployment of energies. For purposes of our argument, such an individual will be termed "problem-solving."

Is Everything Adaptive?

Evolutionary adaptational models cannot be all-inclusive, since there are likely many pathways through which children elaborate specific behavioral patterns. In some instances ADHD may reflect the effects of perinatal anoxia, maternal cigarette smoke exposure in utero, traumatic brain injury, child abuse, or a combination of a host of environmental experiences coupled with susceptibility genes. Yet the importance of an evolutionary model of ADHD rests with its ability to better explain discrepant findings in the research literature, elaborate novel (and testable) hypotheses that shed new light on ADHD phenomena, lead to more effective models of intervention, or clarify the relations between health and disease.

Clinical Implications

Viewed from an evolutionary, adaptational perspective, our current school environments could hardly be more difficult for the "response-ready" child. Most of them demand attentional focus and motoric passivity, while presenting complex stimuli. They offer many distractions (e.g., large class size), yet funnel information in through one modality only, as in passive listening or reading. They limit opportunities for shifting attention and for motor response and demand delay of recognition for efforts. Most school environments favor the "problem-solving" individual, able to maintain intellectual activity with motor quietness, screen out distractions, sustain attention, and delay response until all aspects of a situation have been analyzed. Individual variations along the dimensions of "response-ready" versus "problem-solving" may coincide with environmental variations in a way that produces either good or bad fit for a particular child. It is not surprising that many parents and clinicians note that a "response-ready" child may struggle greatly with a given classroom or teacher, but do much better in another setting, simply by accommodation to the child's abilities (seating placement, smaller classroom size, more "hands-on" learning opportunities, teacher-pupil rapport). Thus, alterations in the environment may reduce the adaptive strain on a child's nervous system whose set-point may be at the other pole from the environment in which he or she finds himself or herself. Done systematically and strategically over time, could such interventions modify the "response-ready" child's biological substrate and brain-behavior relationships (e.g., see Baxter et al., 1992 [3])?

In reframing the child who has ADHD as "response-ready," experience-seeking, or alert and curious, the clinician can counsel the child and family to recognize situations in modern society that might favor such an individual, both in terms of school environments, as well as future career opportunities, e.g., athlete, air-traffic-controller, salesperson, soldier, or entrepreneur. Also, the clinician can "frame" the effects of behavioral treatments as teaching the "response-ready" child to extend his or her range of skills toward increased task focus, motor and impulse inhibition, self-awareness, and problem-solving. In addition, the parent and child can adopt the reasonable goal to assist

the child through school without allowing his or her difficulties in that setting to erode self-esteem and motivation to do well in more adaptive societal niches. The child and parents are encouraged to seek situations and potential success areas where "response-ready" traits are more adaptive.

Specialized classroom environments tailored to the "response-ready" child seem potentially beneficial. Swanson (1992) [25] has described special school classrooms and instructional systems designed to shape children's on-task behaviors and maximize their learning. These systems involve individual and group-based contingencies, tailoring of assignments to a given child's needs, self-paced computer learning, skill-building, active self-monitoring, etc. The current premium on "mainstreaming" all children, without regard for the child's personal strengths and weaknesses, seems ill-conceived for many ADHD children, since many ADHD children experience problematic school and vocational outcomes, partly in response to early adverse school experiences (Richters et al., 1995) [21]. Inadequate societal investments in school resources, large classroom sizes, and lack of specific teacher training for "response-ready" ADHD children seem likely to perpetuate these difficulties.

In considering treatments for a given child, clinicians should be aware that the child's ADHD "symptoms" may be adaptive in some settings but not others. From this perspective, the complaints of some children and parents that stimulant medications make the child seem too sedated, less social, or "not himself" are understandable. Clinicians should be appropriately cautious when treating one aspect of the child's behavior (e.g., reducing hyperactivity and increasing attention span at school) if the same treatment interferes with the child's functioning in other settings. Such possibilities should not be too quickly discounted, since research studies have documented medication effects across a range of environments and situations (e.g., parent-child interactions [Barkley and Cunningham, 1979] [2]; peer relations [Whalen et al., 1979] [30]; and across structured and unstructured school settings [Gadow et al., 1990; Hinshaw, 1991; Hinshaw et al., 1989; Kaplan et al., 1990] [7,9,10,12]).

To the extent that we conceptualize ADHD symptoms as traits with adaptive value in specific settings, and that we determine the malleability and environmental triggers of these traits, more specific treatments can be developed that take into account the context dependency of children's symptoms. Furthermore, better awareness of how children's brain systems unfold and consolidate during development may catalyze discovery of novel medications that increase the brain's plasticity to new environmental cues.

An evolutionary perspective on the adaptive nature of children's symptoms should not be confused with a statement against the use of medications or even making a diagnosis. Instead, this perspective draws attention to the need for better assessment of the nature of children's environments, the interactive exchanges between children's behaviors and their environmental fits, and environments' potential adverse sculpting of children's behaviors. Such assessments are necessarily complex, must draw information from multiple sources, and must take the child's environments into account in treatment planning. In many

circumstances, medications may be the only available or most effective way to help a given child.

Research Implications

A major implication of the above ADHD model suggests that more study of the individual components (attention, motor activity, and impulsivity) as specific traits may be warranted. Breaking the syndrome into its specific behavioral components might more easily allow cross-species comparisons of these traits, with animal and experimental models, including examination of the neurobiological underpinnings of these systems. In addition, more research is needed to explore how such traits may be beneficial in some settings while nonadaptive in others.

While "response readiness" may be adaptive in some settings, how should such settings be characterized? As others have noted (Boyce et al., in press; Jensen and Hoagwood, 1997) [5,11], a typology of contexts ("environtypes") may facilitate study of the interfaces between organisms and their environments. Conceptualizing environments seems complex, but within an evolutionary framework this complexity can be reduced by considering the critical functions enabling the organism to survive and thrive. Our three-part characterization of environments as safe/nonsafe, resource-rich/impoverished, and time-optional/time-critical provides understanding of the adaptive nature of ADHD symptoms in some cases. Other environmental descriptors may be needed to understand the potentially adaptive circumstances for symptoms of depression, anxiety syndromes, or conduct disorder.

We need further study of the effects of children's early environments on the development of "response-ready" traits, as well as the malleability of these characteristics. In this context, what is the impact on children's attentional systems of watching television and playing video games? Compared with many school-related tasks that emphasize logic, sequence, discipline, and detachment, television emphasizes imagery, narrative, immediate gratification, and rapid emotional response (Postman, 1993) [20]. When images flash across video screens every few seconds, when children use primarily a passive or reactive form of attention, what attentional skills are being developed? Some research exists concerning related questions (e.g., Landau et al., 1992) [13], but we have been able to locate none that address these issues directly. How might such play differ from activities where the child directly controls the pace of visual, auditory, and tactile stimuli (e.g., playing with toys in a sandbox or exploring a creek in a neighborhood park)?

We hypothesize that scanning or shifting attentional systems can be "up-regulated" as a function of externally driven stimuli during early development (i.e., set on "high scan"), possibly at the expense of attentional systems for focusing and selecting. Such a child is less prepared to cope with attentional tasks such as reading, listening to a story in a quiet circle, or sitting at a desk for long periods of time. "Cohort" effects (increasing prevalence of disorder in later-born generations) have not been demonstrated in the prevalence of ADHD symptomatology, as they have in depressive disorders, both in

children and adults, but this possibility as a function of changing societal environments warrants systematic study.

If attentional regulatory systems are indeed malleable, we need to determine the periods of greatest plasticity, and ascertain which children are most susceptible to "up-regulation." Once attentional systems have been "up-regulated," does that person or animal continue to select environments that are either relatively novel, risky, or otherwise highly stimulating? And does further experience in these settings strengthen or consolidate the biological substrate that led to their selection? Using a combination of functional neuro-imaging and greater anatomic specification of the neural systems that subserve these regulatory systems, specific tasks may need to be developed that retrain an attentional, motor, or inhibitory system that is maladapted to environmental demands (e.g., Merzenich et al., 1996; Tallal et al., 1996) [17,26].

Clearly, it would be incorrect to "romanticize" the child with ADHD as simply mismatched with his or her environment, since many (but certainly not all) ADHD children suffer from impairments across home, school, and neighborhood settings. Furthermore, once we humans began to settle in cities, we certainly had institutions that required children to focus attention, sit passively, and delay response, whether in primitive schools (for the privileged few) or in religious ceremonies. Of note, however, Postman (1993) [20] has noted our current schools are a very recent invention, largely in the past 400 years, due to the information explosion made possible by the printing press.

Better functional understanding of "response-ready" traits will enable investigators to study their emergence, persistence, or desistance in longitudinal and environmental contexts. In other words, are there critical tasks in the life of the developing organism for which a given trait is adaptive, but only within a specific time period of the life course of that species? Thus, does impulsivity or excessive motor behavior generally decline over the first two decades of life, because such traits serve an important function early on (e.g., exploration, learning), while the caretaker can provide the necessary protections from radical missteps?

Understanding these specific traits may also require anthropological studies and cross-cultural comparisons. ADHD has been described in most Western societies, but actual differences in prevalence are unknown, particularly in non-Western societies. We urge cross-cultural studies of the effects of cultural and environmental factors as these shape the expression of various ADHD-like traits.

Our hypothetical model of ADHD suggests that more studies of the boundaries between illness and health, and what constitutes a "disorder," are needed. Indeed, recent findings from the largest genetic twin study of ADHD conducted to date suggest that ADHD is best characterized as a trait distributed normally throughout the population (Levy et al., 1997) [14]. But at which point should a mismatch between persons and environments be designated as a medical psychiatric disorder, particularly when neuroscience findings are increasingly blurring the boundaries between normal and abnormal? As we expand our scientific knowledge, pressure for "medicalizing" many manifestations of human distress

may increase and may be seen as beneficent, particularly if society is only willing to pay for "medical" illnesses and not for what are perceived as "problems in living" (Sadler et al., 1994) [23].

In a recent series of articles, Wakefield (1992a,b) [27,28] has elaborated the construct of "harmful dysfunction" which focuses on the identification of a pathological process or function per se, as well as the determination that this pathophysiological process within the individual results in some impairment or harm for that individual within a given society. Both components (harm and dysfunction) must be present to identify a mental disorder. This promising approach may nevertheless present problems to the extent that a "dysfunction" of a natural process cannot be understood outside of the context in which the function evolved. Some presumed biological "dysfunctions" are best conceptualized as the displacement of the organism from its original ecological niche.

We suggest that evolutionary biology provides a useful framework for understanding a range of psychiatric phenomena, just as it does for almost all areas of medicine. Our proposed hypotheses are testable through cross-cultural and cross-species comparisons, experimental animal models, and various research strategies appropriate and generally accepted among evolutionary scientists. While these ideas may seem speculative, Popper has suggested that new ideas must be nursed, particularly when one paradigm becomes too dominant, too much like a monopoly, or an entrenched ideology-a "fashion of science" (Popper, 1994) [19]. In the case of ADHD, where the current ideology is supported by the scientific infrastructure and by economic incentives (treatment programs, school systems, and the pharmaceutical industry), attempts toward progress may not always be welcome. However, as new theory, these ideas can lead to different hypotheses and novel approaches, compared with the currently dominant theories. Understanding ADHD symptoms within the context of their adaptive functions is a promising alternative strategy for discovering and understanding gene-environment and brain-behavior interactions and offers the eventual possibility to develop more effective preventive and treatment interventions.

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