

Causal Models of Attention-Deficit/Hyperactivity Disorder: From Common Simple Deficits to Multiple Developmental Pathways

Edmund J.S. Sonuga-Barke

Until recently, causal models of attention-deficit/hyperactivity disorder (ADHD) have tended to focus on the role of common, simple, core deficits. One such model highlights the role of executive dysfunction due to deficient inhibitory control resulting from disturbances in the frontodorsal striatal circuit and associated mesocortical dopaminergic branches. An alternative model presents ADHD as resulting from impaired signaling of delayed rewards arising from disturbances in motivational processes, involving frontoventral striatal reward circuits and mesolimbic branches terminating in the ventral striatum, particularly the nucleus accumbens. In the present article, these models are elaborated in two ways. First, they are each placed within their developmental context by consideration of the role of person $\times$ environment correlation and interaction and individual adaptation to developmental constraint. Second, their relationship to one another is reviewed in the light of recent data suggesting that delay aversion and executive functions might each make distinctive contributions to the development of the disorder. This provides an impetus for theoretical models built around the idea of multiple neurodevelopmental pathways. The possibility of neuropathologic heterogeneity in ADHD is likely to have important implications for the clinical management of the condition, potentially impacting on both diagnostic strategies and treatment options.

Key Words: Attention-deficit/hyperactivity disorder, causal models, executive function, delay aversion, development, dopamine

Attention-deficit/hyperactivity disorder (ADHD)¹ is a debilitating childhood psychiatric condition characterized by severe and persistent impulsiveness, inattention, and overactivity, resulting in significant long-term educational and social disadvantage (Swanson et al 1998). Despite considerable scientific interest regarding the underlying psychopathophysiology of the condition, ADHD remains poorly characterized in this sense. Traditionally, explanations of ADHD have been based around simple causal models of single, common core dysfunctions. In this review, we begin by contrasting two such models that have been influential: 1) executive dysfunction due to deficient inhibitory control; and 2) impaired signaling of delayed rewards arising from disturbances in motivational processes. We highlight the potential limitations of these simple causal paradigms and the need for them to be elaborated further if they are to provide full accounts of the clinical phenomenology of ADHD. One way to achieve this is to place them into a framework that highlights the role of the child's social environment in shaping neurodevelopmental pathways to ADHD. Recent evidence of neuropsychologic heterogeneity in ADHD supports the likelihood that multiple neurodevelopmental pathways underpin this disorder and highlights the need for theoretical models of ADHD to combine motivational and cognitive elements.

From the Developmental Brain-Behaviour Unit, School of Psychology, University of Southampton, Southampton, United Kingdom; and the Child Study Centre, Department of Psychiatry, New York University, New York, New York.

Address reprint requests to Edmund J.S. Sonuga-Barke, Ph.D., University of Southampton, School of Psychology, Southampton SO17 1BJ, United Kingdom; E-mail: ejb3@soton.ac.uk.

Received May 26, 2004; revised August 30, 2004; accepted September 14, 2004.

¹In this review, the term ADHD is used to indicate ADHD combined type, so that the theoretical challenge is to account for co-occurring symptoms of inattention, hyperactivity, and impulsiveness.

The Quest for Common Core Dysfunctions in the Science of Psychopathology

Philosophers of science have observed that the practice and progress of science is shaped by the assumptions held by scientists about the nature of the phenomena of interest (Sonuga-Barke 1998). Although such assumptions are essential to science, in that they provide a common set of meanings that allow communication between scientists themselves and with their audiences, they also constrain research by determining legitimate scientific questions and acceptable ways of providing answers. In this way, the classic disease model of mental disorders has been pivotal in shaping the scientific paradigm and defining the aims and objectives of scientists in the field of child psychopathology (Sonuga-Barke 1998). Implicit in this model is the assumption that mental disorders are discrete disease entities, qualitatively different from the normal range of functioning, which result from a dysfunction of neuropsychologic/biologic mechanisms within the patient. Indeed, DSM-IV translates the assumption of dysfunction into a defining feature of mental disorders (American Psychiatric Association 1994). Given this, it is not surprising that much scientific psychopathology seems motivated by a quest to identify the site of the core dysfunctions that "cause" disorders.

Common Core Dysfunction in Causal Models of ADHD

In the neuroscience of ADHD, this has meant that one question above all has provided the ultimate challenge for researchers: where, within the brain/mind of the ADHD child, is the site of the common core dysfunction that "causes" ADHD (Sonuga-Barke 1994)?

A Cognitive Dysfunction Model of ADHD: The Mediating Role of Inhibitory-Based Executive Deficits

Figure 1 illustrates one version of what, until recently, has been considered the most useful (and is therefore the dominant) class of explanations of ADHD psychopathology (i.e., cognitive dysfunction models). This model is described with the notation of the developmental causal modeling framework proposed by John Morton and Uta Frith (Morton and Frith 1995). Because this framework encourages us to think systematically about the causal processes underpinning disorders, it aids the comparison

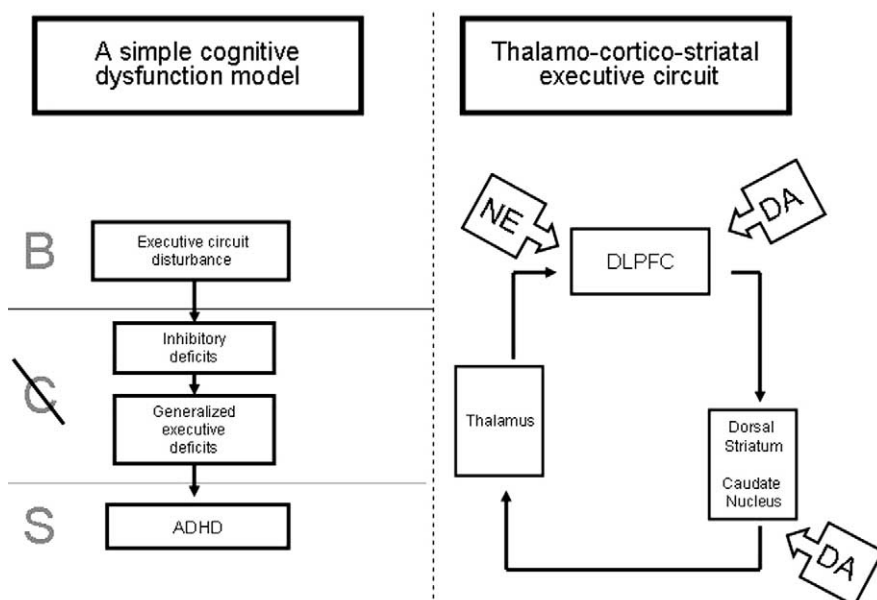


Figure 1. Schematic representation of a simple cognitive deficit model of attention-deficit/hyperactivity disorder (ADHD) (adapted from Barkley 1997) and a simplified account of associated frontostriatal circuitry (adapted from Alexander et al 1990). B, C, and S represent biology, cognition, and symptoms, respectively (Morton and Frith 1995). The slashed C represents cognitive deficit. NE, norepinephrine; DA, dopamine; DLPFC, dorsolateral prefrontal cortex.

of the distinctive characteristics of, and therefore the specific predictions made by, different causal models of ADHD. At the same time, it must be recognized that the model is not theoretically neutral, in that it reflects certain metatheoretical assumptions about the nature of disorder. These assumptions can be seen in the ground rules set out by Morton and Frith, which include the requirement to start at the neurobiologic level and proceed to build causal chains across intermediate cognitive or neuropsychologic and behavioral levels of analysis (e.g., symptoms of ADHD). Morton and Frith also emphasize the importance of ensuring a full account of the disorder in question by explaining all core clinical characteristics. The particular cognitive dysfunction model presented is adapted from Barkley's unified theory of ADHD (Barkley 1997), in which symptoms of the disorder are considered to be caused by the disruption of neurocognitive control systems, with brain-behavior relations fully mediated by deficits in inhibitory-based executive processes. Executive functions are higher-order, top-down, cognitive processes that allow appropriate set maintenance and shift and that facilitate the flexible pursuit of future goals. Deficits on tasks thought to measure these processes are a frequently observed characteristic of children with ADHD (Barnett et al 2001; Bayliss and Roodenrys 2000; Clark et al 2000; Cornoldi et al 1999; Pennington and Ozonoff 1996; Seidman et al 1997; Sergeant et al 2002), with the substantial amount of evidence implicating response inhibition deficits thought to be especially compelling (Nigg 2001). Problems with working memory, planning, and set shift have also been identified (Karatekin and Asarnow 1998; McLean et al 2004; Nigg et al 1998). Executive dysfunction is also implicated in the processes involved in the distribution of cognitive-energetic resources (i.e., effort) to activation and arousal systems that are required to meet the changing demands of different situations and settings and that seem to be disrupted in ADHD (Douglas 1983; Sergeant 2000; van der Meere 1996; van der Meere et al 1999). Barkley (1997) argues that the general pattern of executive impairment associated with ADHD is grounded in more specific early-appearing deficits in response inhibition (Nigg 2001; Oosterlaan et al 1998). Response inhibition refers to the ability to inhibit an inappropriate prepotent or ongoing response in favor of a more appropriate

alternative. It is regarded as a prerequisite for self-control (Murray and Baumeister 2000), emotional regulation (Eisenberg 2002), and cognitive flexibility (Arbuthnott and Frank 2000). As a domain of competence, response inhibition seems to be fractionated into conceptually related clusters of functions, with each cluster sharing common elements but also having key distinctive features (Nigg 2001; Olson et al 2002; Winstanley et al 2004a).

At a neurobiologic level, there is growing evidence that inhibitory control and other executive functions are underpinned by one of a number of the functionally segregated but anatomically proximate basal ganglia-thalamocortical circuits first proposed by Alexander et al (1990; Christakou et al 2004). As shown in Figure 1, this executive circuit links the prefrontal cortex (Aron et al 2004a, 2004b) to the dorsal neostriatum (preferentially, the caudate nucleus; Eagle and Robbins 2003) via excitatory glutaminergic cells. Reciprocal pathways pass via inhibitory connections through a complex of basal ganglia foci to the dorsomedial thalamus with excitatory glutaminergic cells connecting back to the prefrontal cortex (Heyder et al 2004). Data from structural and functional neuroimaging studies support the hypothesis that deficits in inhibitory-based executive functions in ADHD are associated with disturbances in this circuit (Bush et al 1999; Casey et al 2001; Castellanos 1997; Castellanos et al 2002; Hesslinger et al 2001; Rubia et al 1999). Dopamine, which is implicated in ADHD on the basis of pharmacologic and genetic studies (Levy and Swanson 2001), is a key neuromodulator of this circuit (Nieoullon and Coquerel 2003). Two distinct branches seem to be involved. The mesocortical branch originates in the ventral tegmental area of the rostral portion of the brainstem and terminates in the prefrontal cortex, whereas the second branch originates in the substantia nigra and terminates in the dorsal striatum.

An Alternative Motivational Dysfunction Model: Disrupted Signaling of Delayed Reward

A number of motivation-based dysfunction models have been proposed as alternatives to cognitive theories of ADHD. These models shift the focus from core deficits in inhibitory control to suboptimal reward processes, with the links between neurobiologic processes and ADHD symptoms being mediated by deficits

Download English Version:

<https://daneshyari.com/en/article/9377548>

Download Persian Version:

<https://daneshyari.com/article/9377548>

[Daneshyari.com](https://daneshyari.com)