

Greek Mind/Geek Mind

The roles of Χηαος (Chaos), Complementarity & Consciousness in ADHD

Advanced Study often requires a conceptual retreat to fundamental issues of epistemology to ensure that advances toward difficult issues are firmly grounded. *Attention Deficit and Hyperactivity Disorder* (ADHD) is a complex phenomenon, with neuroscientific, educational, parental, policy, and budgetary implications. Platonic and Aristotelian perspectives on knowing can provide solid ground from which investigators may redeploy the most modern equipment of genetic, neural and behavioral technologies.

Plato likened our knowledge of the world to that of prisoners in a cave, chained to look only at a wall on which fell the shadows of real objects (Figure 1). In studying a phenomenon we must necessarily abstract certain dimensions for scrutiny: Any one characterization of an object is a projection into a lower dimensional space – the wall of our cave. The dimensions left behind might later be crucial for identifying features that matter. At the CAS we may stand back from the press of habit, talk to others who see the phenomenon from different perspectives, and invest the time necessary to develop the implications of a

Professor Peter Killeen

Department of Psychology,
Arizona State University, USA
peter.killeen@asu.edu
CAS Fellow 2004/2005

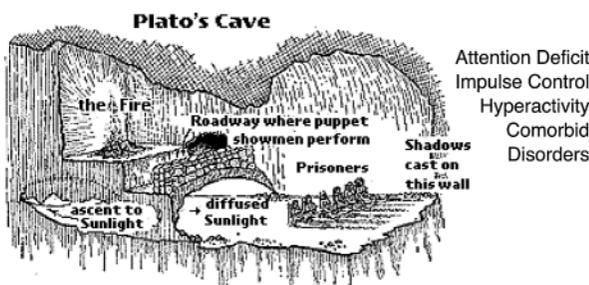


Figure 1. Plato's Cave. The Prisoners are scientists, trying to infer the nature of the objects held up by the showmen from the shadows they cast. Our shadows are the symptoms of ADHD. Are they cast by one real object, by three, or by many overlapping objects? Convergent information from alternate sources of light – alternate theoretical perspectives – can elucidate the object.

new formulation. The odds are against any one new formulation, but with time to come back at the phenomenon again and again, we turn the odds in our favor.

Our group seeks to understand *Attention*

Deficit and Hyperactivity Disorder (ADHD), characterized as a disorder of attention, of self control, of ability to settle into a task. These dimensions are measured by standard psychological instruments, carefully calibrated by expert statisticians. Yet what the parents or teacher wish to know –

whether the child is “normal” or has a psychological or biological problem – requires that the rich multidimensionality of every child first be abstracted into scores on 3 or 4 factors – and those factors further reduced to a binary decision of “ADHD” or “normal”. This Solomonic division of children is pragmatic; yet as scientists we look at the graded shadows on the wall of the cave, and ask whether they are thrown by the same object or by different objects – whether they really justify different names, and if so where to draw the category boundaries. Hyperactivity, inattention, and impulse control are meliorated by the same stimulant drugs, which supports the pragmatic lumping. Absent a solid theoretical taxonomy and pedagogic and biomedical protocols for dealing with the many varieties of ADHD that may exist, can we assume that the shadows on the wall are cast by an “ADHD disorder” and leave it at that? Our task at the Centre is

Aristotle's 4 beCauses (aition)

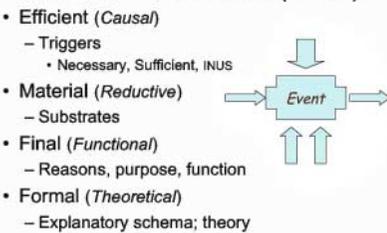


Figure 2. Aristotle identified four things (*aition*) we should know about an object to understand it. *Aition* was translated as ‘cause’, but a better translation might be “because”. A fifth “cause”, involving feedback was also identified by Aristotle

it (necessary causes). We must know what the object is made of: The material basis of a statue may be granite; of a man flesh and bones and neurons. The final cause of an object is what has brought it about. The final cause of a telephone is to communicate over a distance; of a heart to pump blood. The fourth thing we need to know about a phenomenon is its essential form: Remove all the arbitrary, “accidental” parts and what is left? We represent the essence of a phone with words, circuit diagrams, equations. Representation is a key activity of all science; scientists continually shuttle between the representation and the thing represented, adjusting first one then the other, seeking continually to improve the correlation between them.

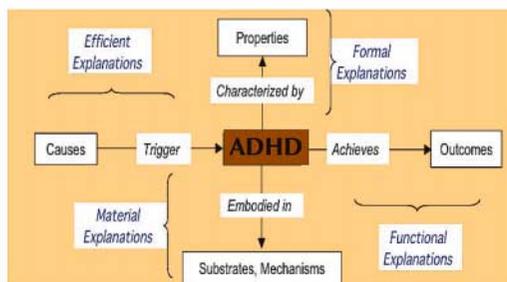
What are the 4 “causes” of ADHD (Figure 3)? Our answers must be tentative – hypotheses rather than conclusions. We believe

to throw light on the phenomenon from new directions, to see finer distinctions where they exist, greater commonalities where they are latent.

One hundred years after Plato, Aristotle set the mold for careful scientific classification of phenomena. He recognized that we must know at least 4 things about a phenomenon in order to understand it (Figure 2). We must know what causes it: The efficient causes of a phenomenon are those which, if present will bring it about (sufficient causes); or if absent will obviate

Figure 3. Sagvolden’s group applies Aristotle’s template to clarify the nature of Attention Deficit/Hyperactivity Disorder (ADHD).

A beCausal Analysis of ADHD



the material cause may be a weakness in the energetics of dopamine transport. Dopamine is a neuromodulator that serves many functions in the body. One of these appears to be to signal that a positive state of affairs has occurred – a reinforcer – increasing the conductivity of the neurons active at that time, and thus possibly responsible for the reward. Insufficiency of this neurochemical may hinder the association of chains of productive activity with their eventual reward, thus making it difficult for children to learn sedulous tasks. Several genes have been associated with ADHD, moving our knowledge of its material causes even deeper.

The efficient causes are uncertain, but it is known that prenatal insult can cause ADHD symptoms; some scholars at the CAS are especially concerned with the role of PCBs as possible triggers. Efficient causes also operate on a faster timescale: Children with ADHD sometimes act quite normal; at others disruptively distractable. What are the circumstances in which their disability is most likely to manifest?

It seems strange to ask what function a malady such as ADHD serves: ADHD appears to be a failure mode, analogous to a broken bone, serving no function. But that could be misleading. Think of another disruptive event, pain. Pain is a sign of a failure somewhere in the system, but it is highly adaptive. Given the severe problems ADHDers can have as adults, and its relatively high (~5%) prevalence and heritability, we must ask what are the circumstances that maintain it in the population. The adventurer, the risk-taker, those easily distracted by novelty would not last in Henry Ford's factories. But perhaps some will find ways to eliminate the boring tasks, leap to visualizing other modes of transport, discover their own continents. Or perhaps they will be attractive enough or assertive enough to leave more offspring than the more careful, providential individual. Many roads lead to Rome, and the citizens that built it. The problem child may be just too far along otherwise useful dimensions, an extension that tips the balance into the problematic. How is such a boy best protected from extremes, while protecting what is valuable and unique in him?

The fourth Aristotelian question asks how we might represent the essence of the phenomenon. The group leader, Terje Sagvolden, has promulgated one of the most encompassing theories of ADHD, involving both neurophysiological and behavioral mechanisms. Other members of the research team pursue other hypotheses, such as the heightened delay aversion shown by the ADHD child. None of these hypotheses, or others current in the field, are definitive. One of our purposes here is to test these theoretical structures and ascertain which one, or which parts of several, provides the best modern interpretation.

Aristotle also mentioned a fifth causal structure, circular causality. A man who exercises becomes more healthy, and thus is able to exercise

Functions compromised by ADHD

- Function is the *raison d'être* of behavior and cognition
- Effects modify input → Attention
- Effects modify substrate → Learning
- Effects modify model → Framing

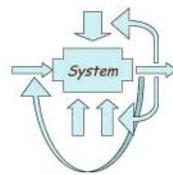


Figure 4. Aristotle's 5th Cause – the feedback of action back into the system – affects the crucial higher functions of intellect: The objects we attend to, the things we learn about them, how we represent them and give them meaning by context.

more, becoming more healthy, Such feedback loops also exist in the behavior of organisms. It is this feedback which is particularly compromised in ADHD. Figure 4 shows how the output of a system feeds back to change it. If we are interested in an object we focus our attention on it, and thus come more strongly under the control of its nuances. But as the first letter of the disorder suggests, attention is one of the most severely compromised functions of afflicted individuals. When behavior has good results, it is reinforced, and we learn to engage in the behavior more effectively and regularly. This is learning. Learning is compromised in ADHD,

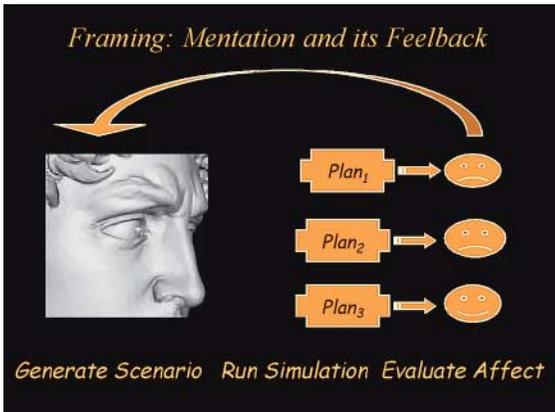


Figure 5. Generating alternative action plans, evaluating their likely emotional impact, and then selecting among them, is a singular human activity. In their rush to action, such deliberation is often severely compromised in ADHD children. We seek ways to give them back this gift of foresight.

as extended endeavors cannot be maintained without much higher rates of reinforcement than those that work for normal kids. When we lay plans to achieve goals, to do good, to enjoy goods, or to avoid harm, we may then be rehearsing the optimal scenario. This process greatly enhances our ability to achieve those

goals (Figure 5). ADHDers routinely fail to plan adequately, take precautions, or be guided by long-term goals.

Plato’s Cave reminds us of the multiple perspectives that are necessary to resolve our shadows into a real form. Aristotle’s model of comprehension identifies five of those perspectives which contribute to a complete understanding. It takes time and concentration to step back, pull apart, clarify, then re-weave these causal threads, time that we have found at the CAS. When Queen Victoria asked Michael Faraday of what use was the awkward toy device he was fabricating – something he called a “dynamo” – Faraday replied: “Madame, of what use is a baby?” Not all babies turn out well, nor do all ideas; but given a nurturing environment, both have enormous potential.