Assessment & Diagnosis of ADHD:

Current Perspectives on Auditory Processing and ADHD

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Etiological Factors

- Environmental factors associated with ADHD
  - lead poisoning (other toxins)
- Chromosomal anomalies associated with ADHD
  - Fragile X, XYY syndromes
  - Turner's syndrome (45 X0)
- Neurofibromatosis
- Food additives -
  - studies have not held up
- Central nervous system infection
- Low birth weight
- Thyroid disorder
Family History

- considerable support for genetics
- often not noticed by family
- FAS
- Maternal consumption of alcohol; heavy smoking
Definition of ADHD

A persistent pattern of inattention or hyperactivity/impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development;
Some symptoms must present before age 7;

• There is some evidence that this is not necessarily valid
• Particularly for girls
Some impairment present in at least 2 settings:

- Home
- School
- Work
- Testing situation (?)
Clear evidence of interference with developmentally appropriate behaviors

- social,
- academic or
- occupational functioning;
Exclusivity

• Does not occur exclusively during course of PDD, psychotic disorder or better accounted for by another mental disorder.
3 Sub-types

- hyperactive-impulsive
- inattentive
- mixed
Symptoms: Inattention/Disorganization

- MORE DIFFICULT TO IDENTIFY: GOOD BEHAVIOR
- Often fails to finish things
- Does not seem to listen
- Easily distracted
- Difficulty concentrating
- Difficulty organizing work, projects
- Needs a lot of supervision
- Frequently shifts activities
Symptoms:
Motor hyperactivity/impulsivity

- FREQUENTLY DIAGNOSED DUE TO CONTROL/MANAGEMENT ISSUES
H-I symptoms...

- Excessive running and climbing
- Excessive fidgeting
- Difficulty staying seated
- Motor restlessness
- Always on the go
- Acts before thinking
- Blurts out answers
- Difficulty waiting turn
Associated problems

- Academic underachievement (especially with inattentive type)
- Problematic peer relationships
- Low self-esteem
- Conduct problems
- Negative interactions with parents/teachers
Behavioral Variability

- Not evident in all situations
- Sustained attention
- Structured situations
  - first noticed in school transitions
- Primary problem:
  - INABILITY TO REGULATE BEHAVIOR
  - new situations (including changes in reinforcement schedules)
Physiological and Cognitive

- Attention is both
- A sensory response system
- A cognitive operation on those responses
Neuropsychological Basis of ADHD

• much research to point to frontal and interconnecting subcortical circuits
• models of attention also implicate frontal lobes
• convergence of evidence points to frontal lobe dysfunction
  • neuroanatomy
  • neuroimaging
  • neurochemistry
  • stimulant meds
ADHD Diagnosis reflects more than attention

- Physiological arousal
- Neurological attention
- Cognitive executive function
Arousal, Attention, and Executive Functions

- DSM-IV diagnosis confounds these constructs
- Barkley argues that the dx. Reflects executive dysfunction
- NP studies have attempted to differentiate specific functions
  - All 3 are involved
Arousal

- Also called vigilance
- Changes in brain that affect overall state
- Readiness to respond to any external or internal event
Neuroanatomy of arousal

Two systems regulate arousal levels:

- Thalamus
- Brain-stem reticular formation
Attention

- Modulation of information processing within a particular sensory modality
- Indication that changes in neuronal response (neural activity) reflect effortfulness vs automatic processing
Frontal & parietal involvement

- Associative and polymodal cortices regulate modulations of sensory input
  - Cortico-cortico interactions
Right hemisphere dominance

Ventrolateral prefrontal cortex and frontal eye fields involved in auditory and visual-spatial attention
Visual Domain

• Overlap between networks for visual-spatial orienting
  • (right parietal cortex)
• and oculomotor control
  • (frontal eye fields)
Auditory Domain

- Attention modulation in primary auditory cortex (most studies)
- Paus’ studies indicate ventrolateral prefrontal cortex, parietal cortex and secondary auditory cortex (superior temporal gyrus)
  - Not primary auditory
  - Possible confound with baseline task
Auditory Attention

- similar processing as visual
- location experiments: visual dominates
  - visual pre-cues effected RT to localize both vis. & aud. targets
  - auditory pre-cues effected only RT to auditory targets
- when vis. & aud. cues conflict, visual dominate
  - Ward, 1994
Executive Function: Barkley’s Model

- deficiencies in regulation & maintenance of behavior by rules and consequences
- problems inhibiting, initiating, sustaining responses to tasks
- problems adhering to rules or instructions
  - esp. when response contingencies are weak
Four Processes

- interactive
- alter probability of occurrence of subsequent behavioral responses
  - SELF-REGULATION
  - direct behavior toward future
1. separation of affect
2. prolongation
3. internalization
4. reconstitution
Components of the Executive System

- Gioia & Isquith
  - Awareness of one’s strengths/weaknesses
  - Set realistic goals for oneself
  - Plan and organize behavior to achieve goals
  - Initiate behavior in pursuit of goals
  - Inhibit behavior incompatible with goals
  - Monitor performance in relation to goals
  - Flexibly and strategically, shift behavior with obstacles that interfere with goal pursuit
Functional Domains of The Executive

- **Initiate**: begin task, activity, attention, language
- **Sustain**: persist for age appropriate time
- **Inhibit**: stop an action or not react to impulse
- **Shift**: move from one task or situation to another
- **Plan**: anticipate future events and develop steps
- **Organize**: establish, maintain order
- **Self-monitor**: attend to behavior/output; revise
Frontal Lobe Functions

- orbito-frontal, limbic structures
- mediates delayed responding & object permanence
- language:
  - lengthened pathways lengthens response time, provides parallel systems
  - internalized symbols expresses cognitive info (not just social communication); allows hindsight & foresight
Mirsky’s Studies: Behavioral & Psychophysiological Markers of Disordered Attention (1987)

- Factor analysis of NP tests
- 4 FACTORS FROM 10 NP TESTS
  - different brain regions support different functions
  - shared responsibility: specialization is not absolute
The factors:

1. Perceptual-motor speed: focus & execute (Trails, letter cancel, digit symbol, Stroop)
2. Vigilance - sustaining focus (CPT errors & RT)
   • Stabilize - variability of RT & commission errors
3. Numerical-mnemonic - encoding (Digit Span, Arithmetic)
4. Flexibility - shifting (WCST)
Replication of Mirsky’s model of attention with children

Mirsky’s model:
- shift (dorsolateral prefrontal)
- sustain midline thalamus, upper brainstem, reticular)
- focus-execute (superior parietal, superior temporal, basal ganglia)
- encode (hippocampus, amygdala)
Kelly’s Extension of the Mirsky Model

somewhat different than Mirsky’s factors

- although the Mirsky model also fit the data well
  - included errors
  - demonstrated significant developmental trends
    - shifting showed most growth
    - likely due to developmental changes in prefrontal cortex
Tests

- WISC-III VIQ, PIQ
- Symbol Search, Digit Span, Arithmetic, Coding
- Number Cancellation
  - hit rate, time
- CPT (Vigil/w)
  - hit rate, omissions, commissions, av. RT
- WCST
  - # correct, categories, #psv error
- Stroop Test (Golden)
  - time and errors
- Trails A & B
  - time and errors
Kelly’s 4 Factor Model

Element of Attention
- Speed of Response
- Impulsivity
- Sustain
- Shift

Factor Identity
- Information processing
- Errors in Processing
- Vigilance
- Flexibility
Speed of Response

Factor: Information Processing

Tests:
- Cancellation time,
- Coding score,
- Trails total time,
- Symbol Search score,
- Arithmetic score,
- CPT RT,
- Stroop total score
Stroop test

Appears to tap orbitofrontal
• Also implies impulse inhibition

Read the words:
Orange, purple, white

Say the colors:
XXX XXX XXX

Say the colors:
Purple, white, orange
Impulsivity

Factor: Errors in Processing

Tests:
- Symbol Search errors,
- Cancellation errors
Sustain

Factor: Vigilance

Tests:
- CPT Hit Rate,
- CPT % Errors of Commission
Shift

Factor: Flexibility

Tests:

- WCST % error
- WCST Categories

- WCST taps dorsofrontal
- Also relates to abstraction ability
Summary

- 4 factor model appears to represent attentional dysfunction in children
- Likely neurological correlation with Mirsky
Do NP Tests Identify ADHD?

Predictive Power of Neuropsychological Tests for ADHD in Children
Perugini et al, 2000
The predictive power of specific test battery

- 21 ADHD boys ADHD Combined or HI/I
- 22 normal controls
- ages 6-12
- IQ >80
Tests Administered

- thought to assess frontal lobe integrity
- consistent with theories of ADHD implicating frontal lobes in ADHD
  - Hand movements (KABC)
  - Stroop
  - COWAT - FAS
  - Trail Making A & B
  - Arithemtic & Digit Span
  - CPT (Conner’s)
Results

- only 1 test showed differences between groups:
  - CPT
- 2 of 7 tests in battery > 1.s.d. below mean
- impaired score indicated ADHD
- unimpaired score does not rule out ADHD
- 3 most sensitive tests
  - Trails B
  - Digit Span
  - CPT Index
    - multiple scores
Diagnostic Efficiency: Sensitivity

- moderate sensitivity (.62)
  - proportion who have disorder who have a positive score (indicating deficit)
  - of those who have disorder (21), how many impaired scores (13)
  - high true ‘positives’ (impaired scores)
Diagnostic Efficiency: Specificity

- strong specificity (.91)
  - non-disordered who do not have positive test score
  - of the controls, how many did not have impaired scores (did OK on test) (22)
  - high true ‘negatives’
Positive Predictive Power

- strong positive predictive power (.87)
  - proportion who receive impaired score who have disorder
  - of the impaired scores (15) how many were from ADHD (13)
- moderate overall predictive power (.77)
  - proportion correctly classified by a test score
Negative Predictive Power

- strong negative predictive power (.71)
  - proportion who do not have impaired score and who do not have disorder
  - of the non-impaired scores (did OK on test - 28), how many were in the control group (20)
- odds ratio of 16.25
  - ratio of odds of disordered individual getting impaired score to non-disordered who receive non-impaired score
Graph of Sensitivity/Specificity Stats

Diagnosis Utility

Number of Subjects

ADHD

Control

Groups

ok scores

impaired scores
Predictive Power Stats

![Predictive Power Chart]

Scores

- Impaired scores
- OK scores

Number of Subjects

- Control
- ADHD
Bottom Line...

- An OK score is not informative
  - can still have the disorder
  - a false negative
- An impaired score is a pretty good indication of ADHD (H/I or Mixed)
Summary

- CPT is most sensitive to disorder
- obtaining 2 impaired scores in battery of (these) 7 tests is good indication of the disorder
Co-Occurrence of ADHD with CAPD

- ADHD (especially sustained attention deficits) is multimodal
- to the extent that ADHD represents an inability to regulate behavior, CAPD represents a more specific dysfunction
  - deficient auditory processing can cause attention problems
- structural deficits in ADHD do include auditory processing areas
  - PT, aud. area of CC, possibly Heschel’s gyrus
Study of Comorbidity of CAPD & ADHD

- Riccio, et al. 1994
- Previous studies have shown that many kids with ADHD have CAP deficits
- 30 kids with CAPD
  - 18 had ADHD
  - Not all CAPD met criteria for ADHD
  - 26 (87%) from sample had been identified as learning disabled
  - Difficult to determine if ADHD behaviors were due to poor auditory function
Differentiating ADHD and CAPD

- Both can have attention deficits
- ADHD are an output disorders
  - Reduced rate of information processing
    - as measured by output
    - Executive dysfunction
- CAPD is an input disorder
  - Executive dysfunction as a secondary source of listening problems
<table>
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<th>ADHD</th>
<th>CAPD</th>
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<tbody>
<tr>
<td>Inattentive</td>
<td>Difficulty hearing in bckgrnd. noise</td>
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<tr>
<td>Distracted</td>
<td>Difficulty following oral instructions</td>
</tr>
<tr>
<td>Hyperactive</td>
<td>Poor listening skills</td>
</tr>
<tr>
<td>Fidgety/restless</td>
<td>Academic difficulties</td>
</tr>
<tr>
<td>Hasty/impulsive</td>
<td>Poor auditory association skills</td>
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<tr>
<td>Inteerrupts</td>
<td>Distracted</td>
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<tr>
<td></td>
<td>Inattentive</td>
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Differences in Auditory Function

- See Chermak
- Possible differences in auditory functions:
  - Ear differences
  - Noise interference response
  - Word recognition errors based on acoustic or semantic properties
  - Response latencies and variability
ADHD Diagnosis rests on:

- Good history of symptoms
- Evidence across domains and/or
- Neuropsychological data
But...

- ADHD is a categorical diagnosis that does not reflect etiology;
- And does not rule out other disorders
- In fact, ADHD dx. May be secondary to many other problems/disorders
Thank you

This presentation is posted at:
www.dartmouthpsychiatry.org/healthinformation.htm
Some References