Paying Attention to Attention

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Gail Eskes, Ph.D.
Department of Psychiatry
gail.eskes@dal.ca

DALHOUSIE UNIVERSITY

Learning Objectives

- To increase understanding of the different forms of attention and the underlying brain networks
- To improve knowledge of how these networks are related to attention pathologies

Disclosure

- Grant Funding
  - CIHR, Heart & Stroke Foundation
  - Centre for Aging & Brain Health Innovation/Nova Scotia Health Research Foundation
  - Brain Repair Centre
  - NSHA, Dalhousie Dept. Psychiatry Research Fund
- Advisory/consultant role
  - Heart & Stroke Foundation
 - NovaResp
  - HomeExcept

Road Map

- What is attention?
- Attention Networks
  - Function
  - Localization
  - Neuromodulators
- Attention Network Test
- ADHD and attention networks
- Summary

What is Attention?

Everyone knows what attention is. It is the taking possession by the mind in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of it's essence. It implies withdrawal from some things in order to deal effectively with others…"
        --*William James, Principles of Psychology, 1918*

Pay Attention!
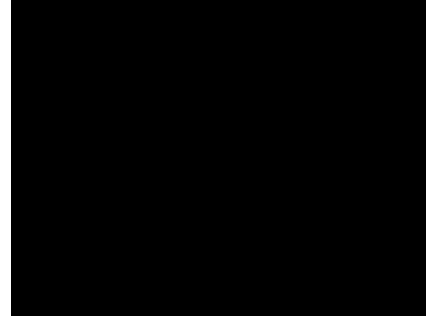
Attention networks

Vigilance/Sustained attention
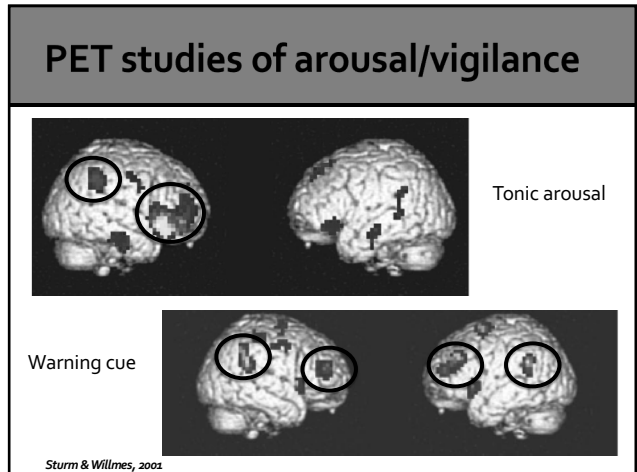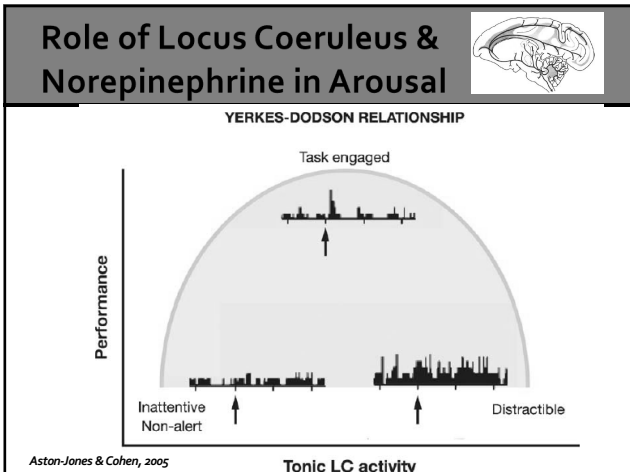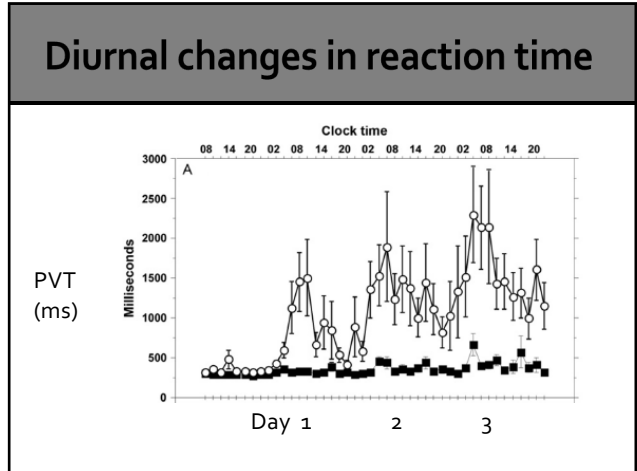
Orienting/Selection

Executive Control

Petersen & Posner, 2012, Annual Review of Neuroscience

Attention Networks

- Attention systems are anatomically separate from processing systems
- Attention uses multiple networks
- Each network carries out different functions
  - Independent, but normally interacting
  - Domain general, regardless of content
- Most clinical tests of attention don't discriminate among them

Vigilance/ sustained attention

- Achieving and maintaining the readiness to respond (phasic vs tonic)
- Tonic: arousal, sustained vigilance over long periods of time (e.g., air traffic controllers)
  - Diurnal/circadian rhythm in reaction time
  - Tested by reaction time on continuous performance tasks
- Phasic: alerting response to external or internal warning cue
  - Preparation for detecting, responding
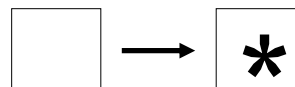 - Improves reaction time to expected event

Diurnal changes in reaction time

PVT (ms)

Day 1   2   3

Role of Locus Coeruleus & Norepinephrine in Arousal

YERKES-DODSON RELATIONSHIP

Task engaged

Performance

Inattentive Non-alert   Distractible

Aston-Jones & Cohen, 2005

Tonic LC activity

PET studies of arousal/vigilance

Tonic arousal

Warning cue

Sturm & Willmes, 2001
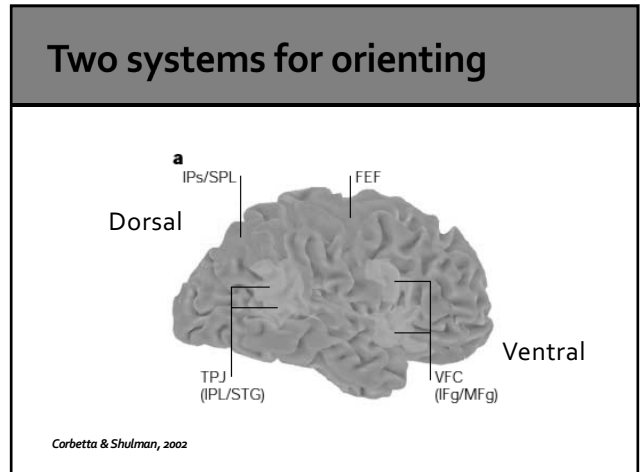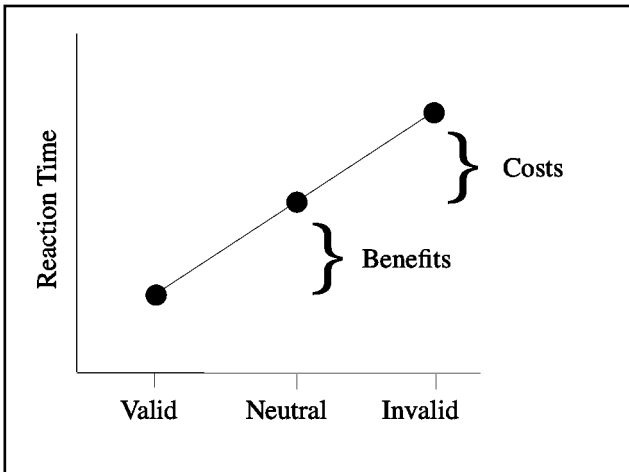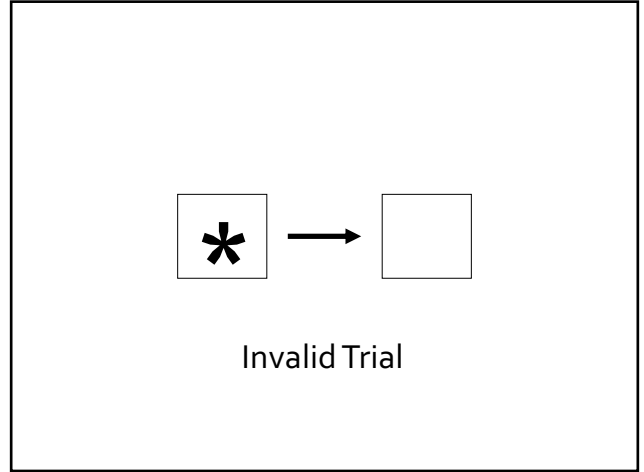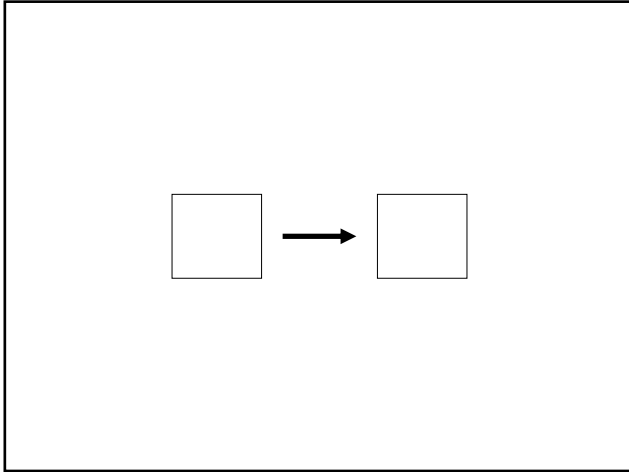
Orienting and selection

- Giving priority to sensory input by selecting a modality or location
- Two systems: Dorsal and ventral
- Dorsal: Strategic control over selection
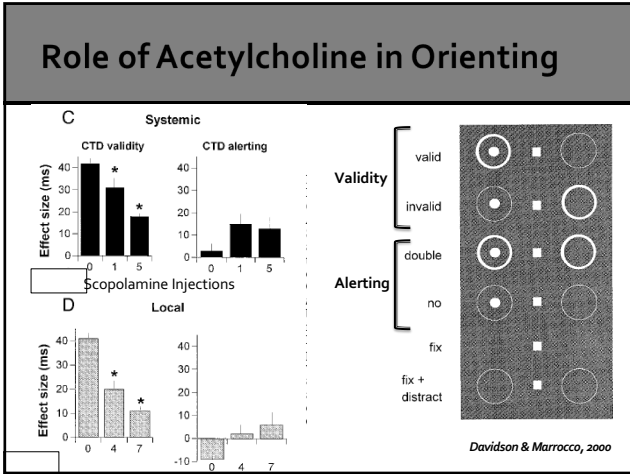- Ventral: Interrupt bottom up signal to switch priority

Orienting -
Posner Cued Reaction Time Task

Valid Trial

Invalid Trial

Reaction Time

Costs

Benefits

Valid   Neutral   Invalid

Two systems for orienting

a
IPs/SPL   FEF

Dorsal

Ventral

TPJ   VFC
(IPL/STG)   (IFg/MFg)

Corbetta & Shulman, 2002
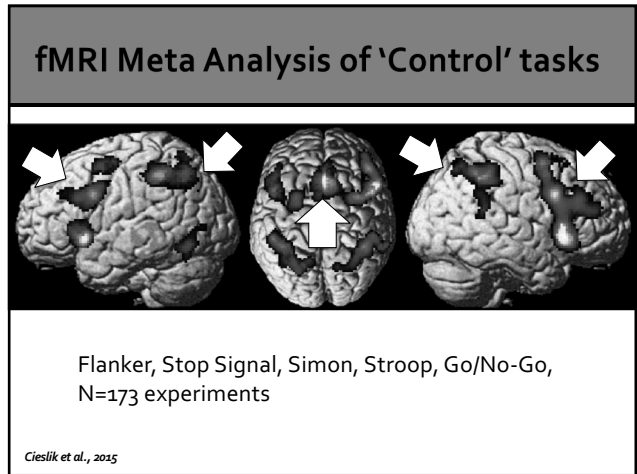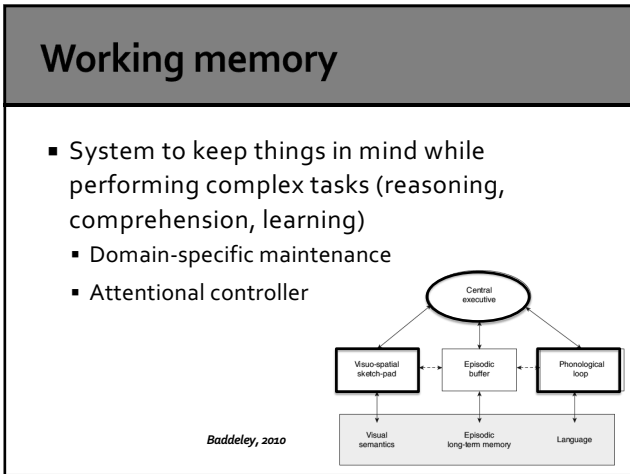
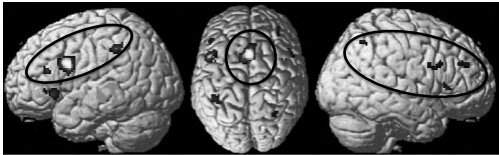## Role of Acetylcholine in Orienting

Davidson & Marrocco, 2000

Executive control

- Attention = limited capacity system overall
- Regulation of attention = 2 systems
- Top-down control system (initiation, switching, adjusting, resolving conflict)
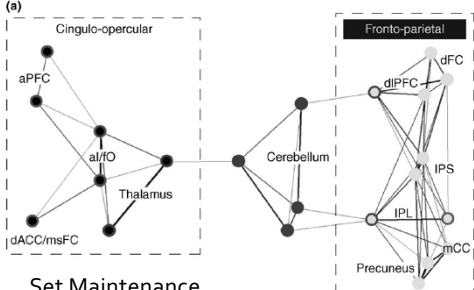- Maintenance and monitoring system

Working memory

- System to keep things in mind while performing complex tasks (reasoning, comprehension, learning)
  - Domain-specific maintenance
  - Attentional controller

Baddeley, 2010

fMRI Meta Analysis of 'Control' tasks

Flanker, Stop Signal, Simon, Stroop, Go/No-Go, N=173 experiments

Cieslik et al., 2015

Working memory core network

Includes n-back, Sternberg, verbal and non-verbal tasks
Meta-analysis of 189 experiments

Rottschy et al., 2012
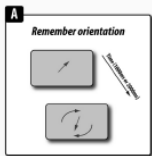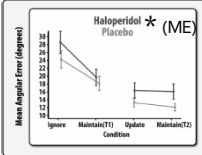
Resting state networks of executive control systems

Set Maintenance

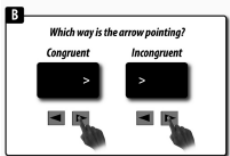*Dosenbach et al., 2008*

Initiate, adjust
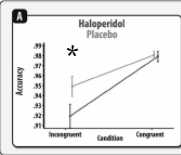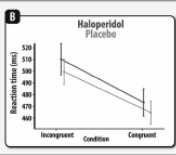
Dopamine is involved in executive control tasks (Fallon et al., 2019)

Working Memory   **Simon Conflict Task**
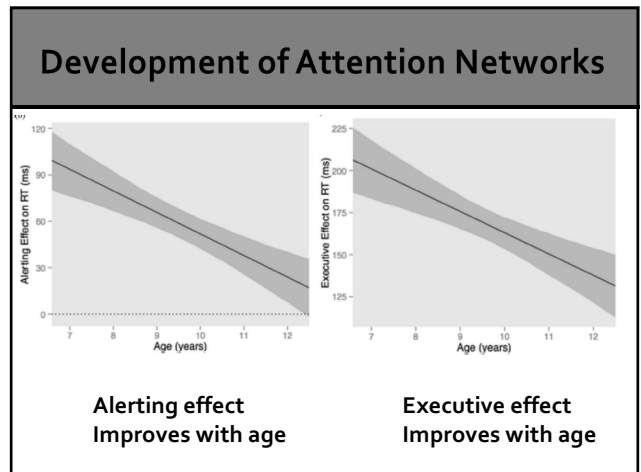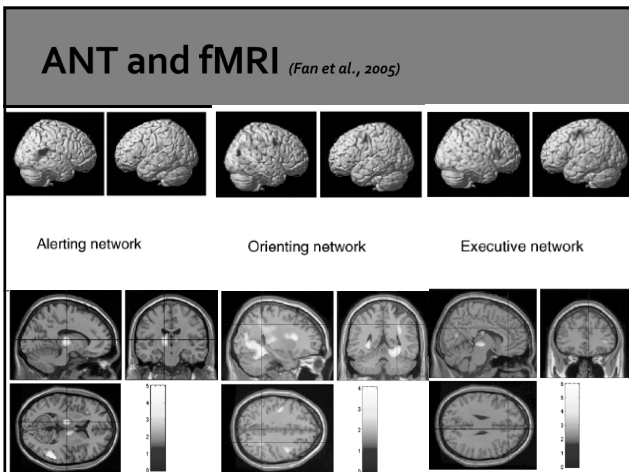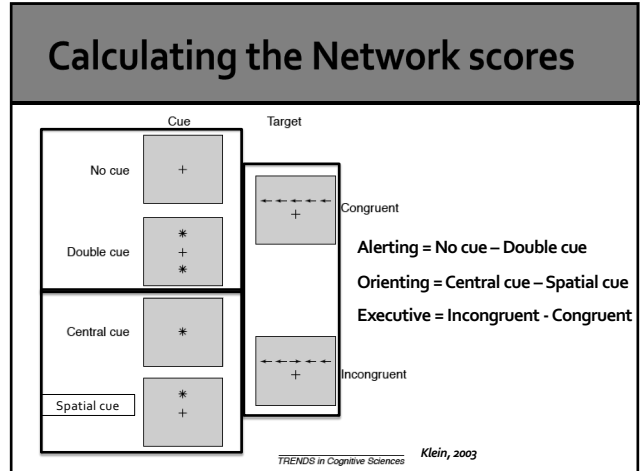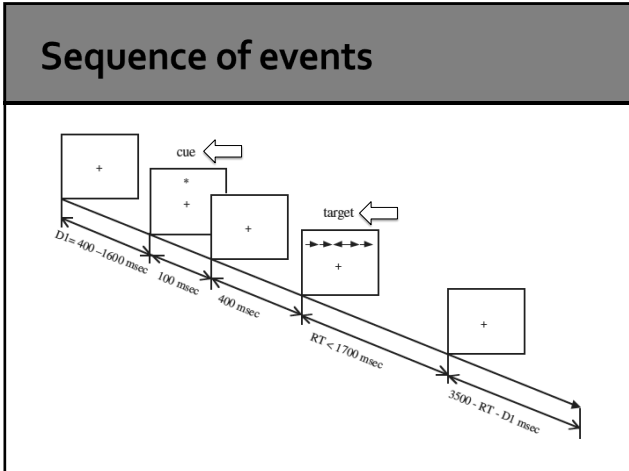

Testing the Networks of Attention

Testing the Efficiency and Independence of Attentional Networks

Jin Fan, Bruce D. McCandliss, Tobias Sommer,
Amir Raz, and Michael I. Posner

Abstract

■ In recent years, three attentional networks have been defined in anatomical and functional terms. These functions involve alerting, orienting, and executive attention. Reaction time measures can be used to quantify the processing efficiency within each of these three networks. The Attention Network Test (ANT) is designed to evaluate alerting, orienting, and executive attention within a single 30-min testing session that can be easily performed by children, patients, and monkeys. A study with 40 normal adult subjects indicates that the ANT produces reliable single subject estimates of alerting, orienting, and executive function, and further suggests that the efficiencies of these three networks are uncorrelated. There are, however, some interactions in which alerting and orienting can modulate the degree of interference from flankers. This procedure may prove to be convenient and useful in evaluating attentional abnormalities associated with cases of brain injury, stroke, schizophrenia, and attention-deficit disorder. The ANT may also serve as an activation task for neuroimaging studies and as a phenotype for the study of the influence of genes on attentional networks. ■
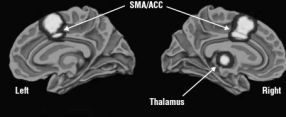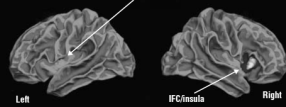
Fan et al., 2002

Sequence of events

Calculating the Network scores

Alerting = No cue – Double cue

Orienting = Central cue – Spatial cue

Executive = Incongruent - Congruent

Klein, 2003

ANT and fMRI *(Fan et al., 2005)*

Alerting network   Orienting network   Executive network

Development of Attention Networks

Alerting effect
Improves with age

Executive effect
Improves with age

ANT and ADHD

Attention in ADHD
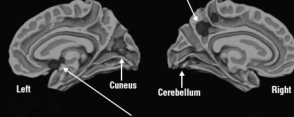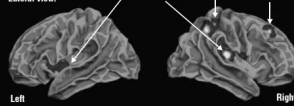
Inhibition tasks = decreased activation
In Vigilance and Medial Executive networks

Combined attention tasks = decreased
Activation in Dorsal Executive network

Summary

Network	Function	Brain Location	Neuromodulator
Alerting/Vigilance			
Orienting/selection			
Executive Control			