From Pat Cavanaugh

The graph shows the relative number of publications across different decades for various topics:

- **Attention**
- **Memory**
- **Cognition**
- **Perception**
- **Learning**

The x-axis represents the decades from 1960 to 2000, and the y-axis represents the relative number of publications. The baseline for 1960s is set at 100.
COGNITIVE NEUROSCIENCE of ATTENTION

INTRODUCTION    Michael I. Posner, Editor

COGNITIVE MODELS    Cavanaugh..Klein..Fuentes..Carr...Cohen...Botvinick

IMAGING          Duncan..Corbetta..Reynolds..Nobre..Hillyard
Naatanen...Bush..Luu

SYNAPTIC AND GENETICS STUDIES     Parasuraman..Grandy..Deth..Robbins
Koch..Marrocco

DEVELOPMENT     Colombo...Richards...Pollack....Ridderinkhof

DEFICITS          Ladavas.....Swick....Robertson....Raz.....Swanson
ITS NETWORKS

SOME NETWORKS CONTROL OTHER NETWORKS

NETWORKS CHANGE
ANATOMY
**Attentioal Networks**

**Figure.** Functional anatomy of the attentional networks.

**Alerting.** Right frontal and parietal areas are active when people maintain the alert state.

**Orienting.** The pulvinar, superior colliculus, superior parietal lobe and frontal eye fields are often found active in studies of the orienting network.

**Conflict.** The anterior cingulate gyrus is an important part of the executive network.
<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>STRUCTURES</th>
<th>MODULATOR</th>
<th>SITES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orient</td>
<td>Superior Parietal</td>
<td>Acetylcholine</td>
<td>V1, A1,S1</td>
</tr>
<tr>
<td></td>
<td>Temporal parietal</td>
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<td></td>
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<tr>
<td></td>
<td>Junction</td>
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<td></td>
<td>Frontal eye fields</td>
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<td></td>
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<tr>
<td></td>
<td>Superior Colliculus</td>
<td></td>
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<tr>
<td>Alert</td>
<td>Locus Coruleus</td>
<td>Nor epinephrine</td>
<td>Orient System</td>
</tr>
<tr>
<td></td>
<td>Right frontal and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>parietal cortex</td>
<td></td>
<td></td>
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<tr>
<td>Exec. Attn.</td>
<td>Ant. Cingulate</td>
<td>Dopamine</td>
<td>All brain areas</td>
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<tr>
<td></td>
<td>Lateral ventral</td>
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<tr>
<td></td>
<td>Prefrontal</td>
<td></td>
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<tr>
<td></td>
<td>Basal Ganglia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Pattern 1</td>
<td>Pattern 2</td>
<td></td>
</tr>
<tr>
<td>------------</td>
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<tr>
<td>Congruent</td>
<td><img src="image1.png" alt="Pattern" /></td>
<td><img src="image2.png" alt="Pattern" /></td>
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<tr>
<td>Incongruent</td>
<td><img src="image3.png" alt="Pattern" /></td>
<td><img src="image4.png" alt="Pattern" /></td>
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<tr>
<td>Neutral</td>
<td><img src="image5.png" alt="Pattern" /></td>
<td><img src="image6.png" alt="Pattern" /></td>
<td></td>
</tr>
</tbody>
</table>
• **Spatial conflict**: Picture targets were presented in three different locations, left, center, right.

- **Congruent**
- **Incongruent**
- **Neutral**

The participants' task was to indicate the target's identity by pressing the matching key regardless of location.
COMPARISON OF THREE CONFLICT TASKS

Flanker task  Color Stroop task  Spatial conflict task

FAN ET AL, 2003
CONJUNCTION OF
THREE TASKS
INDIVIDUALITY
(b) Three target conditions

- Congruent
- Incongruent
- Neutral

(c) Timeline

D = 400 - 1600 ms
100 ms
400 ms

RT < 1700 ms
3000 - RT - D ms

(a) Four cue conditions

- No cue
- Center cue
- Double cue
- Spatial cue

(d) Three subtractions

Alerting = No Cue RT - Double Cue RT
Orienting = Center Cue RT - Spatial Cue RT
Conflict = Incongruent Target RT - Congruent Target RT
Attention Network Test  ANT

RESULTS

![Graph showing reaction times for different conditions: neutral, congruent, incongruent. The y-axis represents reaction time (msec) and the x-axis represents target conditions (neutral, congruent, incongruent). The graph includes lines for no, center, double, and spatial conditions.](image)
fMRI results of the attentional networks

Alerting Network
(center cue – no cue)

Orienting Network
(spatial cue – center cue)

Conflict Network
(incongruent – congruent)

FAN ET AL, SUBMITTED
DEVELOPMENT
### NT

<table>
<thead>
<tr>
<th>Age</th>
<th>Alerting</th>
<th>Orienting</th>
<th>Conflict</th>
<th>Conflict (error rates)*</th>
<th>Overall RT</th>
<th>Overall Error Rates</th>
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</thead>
<tbody>
<tr>
<td>6</td>
<td>79 (75)</td>
<td>58 (76)</td>
<td>115 (80)</td>
<td>15.6</td>
<td>931 (42)</td>
<td>15.8</td>
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<tr>
<td>7</td>
<td>100 (75)</td>
<td>62 (67)</td>
<td>63 (83)</td>
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<td>833 (125)</td>
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<td>8</td>
<td>73 (67)</td>
<td>63 (66)</td>
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<tr>
<td>9</td>
<td>79 (47)</td>
<td>42 (48)</td>
<td>67 (38)</td>
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<td>734 (68)</td>
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<td>10</td>
<td>41 (47)</td>
<td>46 (44)</td>
<td>69 (44)</td>
<td>2.1</td>
<td>640 (71)</td>
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<tr>
<td>Adults</td>
<td>30 (32)</td>
<td>32 (30)</td>
<td>61 (26)</td>
<td>1.6</td>
<td>483 (36)</td>
<td>1.2</td>
</tr>
</tbody>
</table>

### 1NT

| 10 | 78 (61) | 60 (56) | 156 (76) | 3.9 | 710 (90) | 2.8 |
| Adults | 40 (34) | 52 (35) | 131 (62) | 4.7 | 532 (54) | 2   |

* Incongruent % error – congruent % error.

**RUEDA ET AL, 2004**
EXECUTIVE ATTENTION RELATED TO EFFORTFUL CONTROL

EFFORTFUL CONTROL RELATED TO:
- ABILITY TO DELAY REWARD
- THEORY OF MIND
- DEVELOPMENT OF CONSCIENCE

DURING ADOLESCENCE

EFFORTFUL CONTROL AND EXECUTIVE ATTENTION NEGATIVELY RELATED TO ANTI SOCIAL BEHAVIOR
Broad Dimensions of Temperament.
CBQ: 6-7 Years

**Extraversion/Surgency**
- Activity
- Smiling & Laughter
- High Intensity Pleasure
- Impulsivity
- Shyness (-)
- Positive Anticipation

**Effortful Control**
- Attentional Shifting
- Attentional Focusing
- Inhibitory Control
- Low Intensity Pleasure
- Perceptual Sensitivity

**Negative Affectivity**
- Fear
- Anger
- Sadness
- Discomfort
- Soothability (-)
Candidate Gene for ADHD: DRD4 on Chromosome 11p15.5

[Diagram showing molecular structure of DRD4 gene]
CONFLICT

ALERTING

ORIENTING

REACTION TIME

FOSSELLA ET AL, 2002
Mapping the genetic variation of executive attention onto brain activity

fMRI results: N=16

Behavioral results: N=200

MAOA promoter (4-repeat) > (3-repeat)

DRD4 promoter (insertion-allele) > (deletion-alleles)

ATTENTION
TRAINING
ATTENTION TRAINING
<table>
<thead>
<tr>
<th></th>
<th>Overall %</th>
<th>Conflict %</th>
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<tr>
<td></td>
<td>RT</td>
<td>errors</td>
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<tr>
<td>EXPTAL</td>
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<tr>
<td>PRE</td>
<td>1733</td>
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<td>POST</td>
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</table>
ERP time courses of the conflict resolution

Incongruent - congruent

Time (msec)

-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

-200 0 200 400 600 800

References for EEG-Voltage:

- 70.0 ms
- 370.0 ms

Voltage scale:

- 0.10 μV / step
- 0.20 μV / step

Difference: incongruent - congruent
ERP data

Trained group

Pre-test

Control group

Post-test

Mid-frontal channel (Fcz)
4 YEAR OLD POSTTEST

ADULTS
<table>
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<tr>
<th></th>
<th>IQ</th>
<th>VOC</th>
<th>MAT</th>
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<td><strong>EXPTAL</strong></td>
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<td>4,5</td>
<td>-1,4</td>
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LITERACY
INTERVENTIONS

Word Building

sat  tot  past
sap  pot  pat
tap  pat  pot
stop sat pop
stop spat stop
stop pats stop
PSYCHOPATHOLOGY

ALERTING
  AGING
  ADHD

ORIENTING
  AUTISM

EXECUTIVE
  ALZHEIMER
  SCHIZOPHRENIA
  BORDERLINE PERSONALITY
ALZHEIMER

FERNANDEZ-DUQUE & BLACK
NETWORK SCORES FOR CONTROLS AND SCHIZOPHRENIC PATIENTS

WANG, FAN ET AL, IN PROCESS
Frequency distributions of conflict effect for normal controls and schizophrenic patients

Conflict effect (ms)

Frequency distributions show that normal controls have a higher frequency of conflict effects in the 51-100 and 101-150 ms range compared to schizophrenic patients. The graph indicates a significant difference in the frequency distributions between the two groups, with normal controls having a higher frequency of conflict effects in the 101-150 ms range.
ANT Scores for Patients & Controls

DEVELOPMENT OF ATTENTIONAL NETWORKS

ATTENTION OPERATES THROUGH SPECIFIC NETWORKS

NETWORKS ARE DEVELOPED IN EARLY LIFE

SPECIFIC GENES INFLUENCE ATTENTIONAL NETWORK DIFFERENCES

TRAINING MAY INFLUENCE THESE NETWORKS

PATHOLOGIES ALTER ATTENTIONAL NETWORKS