Attentional Disorders and Their Rehabilitation

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ATTENTION
Posner and Petersen (1990)

• Alerting/Vigilance

• Selection

• Switching/control
Parietal cortex: Spatial awareness/shifting (right particularly associated with neglect)

Right prefrontal cortex – ‘alertting’ sustained attention

Anterior cingulate “target selection”
Test of Everyday Attention for Children (TEA-Ch)
The Test of Everyday Attention for Children (TEA-Ch)
The Test of Everyday Attention for Children (TEA-Ch)

Map Mission
Tone counting
Lottery ticket task

PG749
LM182
HJ018
QW387
RT291

LN155 → LN

KV472
Sustained Attention Performance and Noradrenaline in ADHD

SART

1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3

Greene et al, 2011, Bellgrove et al, 2009
DBH Noradrenergic Gene Predicts Vigilant Attention Performance in Healthy Young and in ADHD

Repeating Regular Series of Numbers – Press to all except 3

1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3

Greene, Bellgrove, Gill and Robertson, 2009 Neuropsychologia

Right inferior frontal gyrus role in SART (random) commission errors
Mohlenberg and Vandenberghe, 2009
LC stimulation improves spike timing in tactile stimulation

Human noradrenergic Markers?

Rajowksi et al 1993

Murphy, Robertson and O’Connell 2012
Awareness and Sustained Attention
Poor sustained attention – poor self-awareness in normals

- Self and close other ratings on FRSBE –
- eg I tend to speak only when spoken to”
- “I tend to mix up a sequence, getting confused when doing several things in a row.”

Hoerold and Robertson
Exp Br Res Research, 2008
Traumatic Brain Injury

Fig. 2. Interaction between TBI High SA, TBI Low SA and Control Group on three composite awareness scores.
Tau-opathies

ACC activation was equivalent for both errors subjects were aware of and those they were not aware of making.

Explicit awareness of error was associated with bilateral prefrontal and parietal brain activation.

Hester et al., 2005; NeuroImage
Impaired error processing TBI and ADHD

Fig. 1. Mean skin conductance responses for each group to no-go targets as a function of no-go response (withhold vs commission error).

O’Connell, Bellgrove and Robertson, 2004; O’Keeffe and Robertson 2004
Awareness Correlates

Healthy Controls

• Slow/fast wave activity in the EEG spectrum correlates 0.61 with error awareness (O’Connell ..and Robertson, Eur J Neuroscience 2008)

Traumatic Brain Injury

• Skin Conductance Response to Aware Errors correlates 0.62 with error awareness. (O’Keeffe .. and Robertson, Brain Research 2004)
Insight and the damaged right frontal lobe

- *Alzheimer’s Disease:* ‘Inaccurate insight and right DLPFC after controlling for global cognitive dysfunction’ (Harwood et al, 2005)

- *Stroke* – *anosognosia for hemiplegia,* right frontal regions strongly associated (Pia et al, 2004)

- *Fronto-temporal dementia,* ‘Loss of insight is associated with hypoperfusion/hypometabolism in the right hemisphere, particularly the frontal lobe. (Mendez and Shapiro, 2005)
Accuracy of self evaluation was significantly correlated with functional activation of the right dorsolateral prefrontal cortex in TBI (Schmitz, Rowley, Kawahara, & Johnson, Neuropsychologia, 2006)
REHABILITATION
Plastic reorganization depends on attention to stimuli

Experience-Dependent Adult Cortical Plasticity Requires Cognitive Association between Sensation and Reward

David T. Blake,1,* Marc A. Heiser,2 Matthew Caywood,2 and Michael M. Merzenich3

Yoked behavior. The guide animal performs an operant discrimination of Frequency Discrimination. The yoked animal hears the same sounds and receives the same rewards, but does not play a causal role.
• Neurorehabilitation requires many hundreds if not thousands of repetitions of key stimuli to which attention must be sustained

• Hence the ability to sustain attention over time to relatively unchanging stimuli is the key aspect of attention for neurorehabilitation

• AROUSAL AN ESSENTIAL PARTNER OF SUSTAINED ATTENTION
Sustained attention and motor recovery after RH stroke (9 hole peg test)

Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness

Ian H. Robertson*, Jason B. Mattingley*, Chris Rorden*† & Jon Driver†
Self-instructed arousal
Sustained attention task -

Self-instructional techniques

Neglect task (baking tray test) -
Effects of External Alerting on SART performance – REDUCES right dorsolateral prefrontal cortex activation

significant activations associated with SART condition compared to Control condition, including (A) right middle frontal gyrus (B) bilateral thalamus.

During SART, irrelevant alerting tone DECREASES RIGHT FRONTAL ACTIVATION

O’Connor, Robertson and Levine, in press, Neuropsychology
Fig. 2. The number of component tasks attempted within the 15 min of the Hotel Test, for patients under control and alerted conditions and for neurologically healthy matched control volunteers.

Fig. 3. Deviation from optimal time allocation in the Hotel Task, for patients under control and alerted conditions and for neurologically healthy matched control volunteers.

Fig. 2. Phone call performance as a function of cue status and day of experimental phase—composite measure.

Manly, Robertson et al, Neuropsychologia, 2002

Fish et al 2007 Neuropsychologia
Volitional Control of Arousal: O’Connell et al, 2008, Neuropsychologia

Mean Commission Errors

SAT
Placebo

Pre
Post

Volarional	Control	Arousal:	O’Connell	et	al,	2008,	Neuropsychologia
Text-based alerting TBI

* Check “mental blackboard” to prevent absentminded errors.
* Use text messages as opportunity to “STOP”, stop, think, organise, plan.
  • Think about things to do
  • Fish, Manly et al, Neuropsychologia do
Results

Composite Score

Uncued  Cued

Proportion Score

Uncued  Cued
Self-Alert Training to improve attention and impulsivity in adults with ADHD: A Randomized Controlled Trial

Simona Salomone
Supervisor: Prof. Ian Robertson
Training sessions 

(one hour and a half per session)

Biofeedback training group

Materials
Two examples of participants’ biofeedback session with several successful alerts. The red dots indicate the start of a self-alert episode, which is followed by a clear increase (peak) in participants’ SCR.
Significant results

CAARS A = Inattention Memory Problems

Time 1 x Time 2:
Interaction: F(1,34)=5.370, p=.027

Time 1 x Time 3: n.s.

CAARS C = Impulsivity/Emotional Lability

Time 1 x Time 2:
Interaction: F(1,34)=9.068, p=.005

Time 1 x Time 3:
Interaction: F(1,28)=5.287, p=.029

Self-report CAARS A scale

Self-report CAARS C scale
CAARS D = Problems with self concept

Time 1 x Time 2:
Interaction: F(1,34)=5.324, p=.027

Time 1 x Time 3:
Interaction: F(1,28)=9.231, p=.005

CAARS E = DSM-IV Inattentive Symptoms

Time 1 x Time 2:
Interaction: F(1,34)=9.726, p=.004

Time 1 x Time 3:
Interaction: F(1,28)=4.27, p=.048
CAARS G=DSM-IV Symptoms Total

Time 1 x Time 2:
Interaction: F(1,34)=6.090, p=.019

Time 1 x Time 3: n.s.

CAARS H= ADHD Index

Time 1 x Time 2:
Interaction: F(1,34)=6.570, p=.015

Time 1 x Time 3:
Interaction: F(1,28)=10.623, p=.003
Self-Efficacy Scale

Time 1 x Time 2:
Interaction: $F(1,33)=3.073$, $p=.089$ (trend)

Time 1 x Time 3:
Interaction: $F(1,24)=4.335$, $p=.048$

Beck’s depression Inventory (BDI)

Time 1 x Time 2: n.s.

Time 1 x Time 3:
Interaction: $F(1,26)=4.454$, $p=.045$
HOME TECHNOLOGY FOR COGNITIVE FUNCTION?
Alertness – Training for Focussed Living
GSR graphs – total sessions – One participant

### Grand total of all GSR data:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Average pp</th>
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</thead>
<tbody>
<tr>
<td><strong>N=17</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total days used:</td>
<td>84</td>
<td>4.9</td>
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<tr>
<td>total sessions:</td>
<td>145</td>
<td>8.5</td>
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<tr>
<td>total time: (hh:mm:ss)</td>
<td>17:04:26</td>
<td>01:00:16</td>
</tr>
<tr>
<td>average session time:</td>
<td>00:07:04</td>
<td></td>
</tr>
<tr>
<td>total number of self alert attempts:</td>
<td>901</td>
<td>53.0</td>
</tr>
<tr>
<td>average amount of alerts per session:</td>
<td>6.2</td>
<td></td>
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RCT Trial (Single blind RCT, 20 per group, healthy elderly with self-reported absent-mindedness.

**Category Fluency**

- **Training:**
  - Pre: 13.45
  - Post: 14.82

- **Control:**
  - Pre: 13.8
  - Post: 11.8
Auditory version of SART results

VAAT Commission Errors

- Pre: Training = 0.74, Control = 1.47
- Post: Training = 0.59, Control = 1.83
Training Attentional Filtering in Patients with Traumatic Brain Injury
Dundon, Dockree, et al
Study 1: Results

Proportion of story content remembered as a function of distraction level in unattended ear

1 = baseline (unattended story not audible)
5 = Both stories (attended and unattended) of equal volume

<table>
<thead>
<tr>
<th>Neuropsychological test</th>
<th>Control Mean (s.d.)</th>
<th>TBI Mean (s.d.)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Memory – immediate recall</td>
<td>11.25 (1.74)</td>
<td>10.25 (3.31)</td>
<td>P=0.24</td>
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<tr>
<td>Logical Memory – Delayed recall</td>
<td>10.60 (2.23)</td>
<td>10.60 (2.56)</td>
<td>P=0.99</td>
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<tr>
<td>Backward Digit Span</td>
<td>10.75 (2.55)</td>
<td>10.95 (5.71)</td>
<td>P=0.89</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>11.10 (2.45)</td>
<td>9.75 (2.40)</td>
<td>P=0.086</td>
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<tr>
<td>Elevator Counting</td>
<td>6.95 (0.22)</td>
<td>6.60 (0.82)</td>
<td>P=0.07</td>
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<tr>
<td>Elevator Counting with distraction</td>
<td>10.85 (2.08)</td>
<td>7.90 (3.02)</td>
<td>P=0.001</td>
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<tr>
<td>Elevator Counting with reversal</td>
<td>10.55 (2.26)</td>
<td>3.00 (2.62)</td>
<td>P=0.005</td>
</tr>
<tr>
<td>Hayling 1</td>
<td>6.10 (0.55)</td>
<td>5.55 (1.05)</td>
<td>P=0.045</td>
</tr>
<tr>
<td>Hayling 2</td>
<td>6.15 (0.75)</td>
<td>5.20 (1.64)</td>
<td>P=0.024</td>
</tr>
</tbody>
</table>

* Elevator Counting with distraction & Proportion correct MCQ: $r = 0.448$, $p = 0.048$
* Elevator Counting with reversal & Proportion correct MCQ: $r = 0.553$, $p = 0.011$
Study 1: Summary

- Healthy controls show efficient perceptual adaptation in the face of a interfering speech stream.

- By contrast, TBI patients are impeded under such conditions and fail to adapt.

- The TBI show selective impairments on tests of auditory selective attention in the face of distraction; these impairments correlate with our experimental test of speech-in-noise.
26 TBI patients recruited to date

Adaptive Training Group (n = 9)

Non-Adaptive Training Group (n = 8)

Non-Experimental Control Group: (n = 9)

Training was based on a modified version of Attention Process Training (Sohlberg & Mateer, 2001) in which participants were required to monitor stimuli and identify infrequent auditory targets.

Training blocks were administered in two weekly one-hour sessions conducted over a four-week period.
Improvements on Dichotic Listening task

Training benefits for speech comprehension in noise

Baseline normed scores on auditory comprehension task

Pre Training | Post Training

AG | NAG | Overall Training | Control
Changes in neuropsychological function

Sig differences from pre- to post-training in both experimental groups

No reliable differences from time 1 to time 2 in non-experimental control
Pre-training stress and distractibility & training outcome

Participants reporting higher levels of pre-training self-reported stress and distractibility appeared to benefit more from training, as measured by pre-post change in baseline normed dichotic listening scores.
Selective changes in brain potentials during target & distracter processing
Summary & Conclusions

• We found that patients showed significant gains after training (under both the adaptive and nonadaptive conditions) in a dichotic listening task. In this task, auditory comprehension improved in the context of distracting and irrelevant speech.

• Those patients who reported higher pre-training levels of distractibility and stress responded more strongly to training by showing greater improvements in auditory comprehension in the context of noise.
“My ability to read for longer increased. e.g. 15 to 20 pages instead of 5 to 10 pages. I am not as easily distracted by noise when I am concentrating on something. This would be the most satisfying aspect for me. I think follow up sessions would be good. My reading benefit is starting to diminish.”

(Headway client -6 Months following adaptive training)
Reading

Robertson IH and O’Connell RG (2013) Rehabilitation of Attention. In The Oxford Handbook of Attention
Edited by Anna C. Nobre and Sabine Kastner
Oxford Library of Psychology