A CHALLENGING LOOK at "EXECUTIVE FUNCTIONS" and THE FRONTAL LOBES: ANYTHING NEW after THIRTY YEARS of RESEARCH?

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Section 1

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Baycrest Enriching Care Enhancing Knowledge Enlightening Minds

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FORMAT

- A historical journey of 30 years of research on the role of the frontal lobes

A HIGH SCHOOL TEACHER TURNING PSYCHOLOGIST

- Early 1970s in Ontario, Canada: Report on education:
  - Current neuroscience emphasized left brain – right brain
  - Report: education was too much directed to “left brain” (rote learning)
  - Solution: release the right brain (creativity, insight)
  - Outcome: Almost chaos

VYGOTSKY – LURIA – NAUTA/PANDYA

- Vygotsky: Russian educational psychologist
- Luria: Social/Neuropsychologist. Hierarchical brain organization
- Nauta/Pandya: All roads lead to Rome: frontal lobes only brain region with connections to all other parts of the brain
  - and only region in which these are (almost totally!) reciprocal

Real Solution: Teach and use the frontal lobes

THE CONCEPTUAL/EXPERIMENTAL DILEMMA

- How do you study the "Highest" abilities like "self"?
- If the frontal lobe are used in novel or complex situations, how do you tease apart the various experimental factors?
- The frontal lobes constitute 25-35% of the human brain: How do you map answers to 1 and 2 onto this large expanse of brain?

OVERALL GOAL

- To increase understanding of the functions of the frontal lobes, a region covering from 1/4 to 1/3 of the brain, which is still considered unitary functional domain

PRIMARY OBJECTIVES

- Identify four categories of distinct processes within the frontal lobes identified by recent lesion research, with an emphasis on two categories related to attention
- Understand the impact of task complexity and context on brain attentional systems
- Introduction to the role of the frontal lobes in sustained control of behaviours: staying on the job!

SECONDARY OBJECTIVES

- To provide current information on fractionation of frontal lobe functions
- To suggest different research approaches on how such fractionation can be achieved
- To increase knowledge of the use of clinical measures of frontal lobe functioning

THREE SECTIONS to the WORKSHOP

- Definition and Models
- Attention and Memory – New Findings
  - Value of Current Measures of Frontal Lobe Functions
- Clinical Applications

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SECTION ONE: DEFINITIONS and MODELS

A. Definition of Executive Control

1. **Highlights of different models**
2. **The modified Supervisory System**

B. An Approach for Localization of Function within the frontal lobe

1. **The "standard" group localization approach**
2. **The architectonic localization: "lesion functional imaging"**

MY BRAIN HURTS

- **Is Executive Function (EF) related to Frontal Lobes (FL)?**
  - **Is EF *necessarily* related to FL?**
  - **Is EF *uniquely* related to FL?**
- **What really is (are) "EF(s)"**

DEFINITION OF EXECUTIVE DYSFUNCTION

Impairments:

- **Initiation**
- **Planning**
- **Sequencing**
- **Inhibition**
- **Flexibility (Shifting)**
- **Monitoring**

Cause:

- **Most common after frontal lobe damage**
- **Therefore, "Executive Dysfunction" and "Frontal Lobe Dysfunction" are often used interchangeably**

BUT…

- Classic cases often have many more problems, including significant personality changes
- Many of these classic cases have notable amount of brain damage, and often caused by trauma or hemorrhage
- How many of the observations were based on large studies of individuals with circumscribed lesions?
- What about frontal “dysfunction” in the normal population?

DEFINITION OF EXECUTIVE DYSFUNCTION

- Moreover, “executive dysfunction” can be found in many other types of patients with varying amounts of frontal lobe involvement.
  - Alzheimer’s disease
  - Vascular Injury to deep circulations
  - Multiple Sclerosis
  - Traumatic Diffuse Axonal Injury
  - Psychiatric Disorders

SOME INITIAL COMMENTS

- Frontal lobe, central executive, executive dysfunction CANNOT be used interchangeably
- What people call frontal lobe behaviour or dysfunction can be found in the “normal” population
- “Executive dysfunction”, central dysexecutive syndrome, are psychological constructs not neuroanatomical

ONE APPROACH
FOCUS on the FRONTAL LOBES

- Are there lawful distinctions (anatomical and functional) within the frontal lobes?
- How do "frontal systems" fit in the picture?
- What's the interaction of frontal regions with posterior brain regions?

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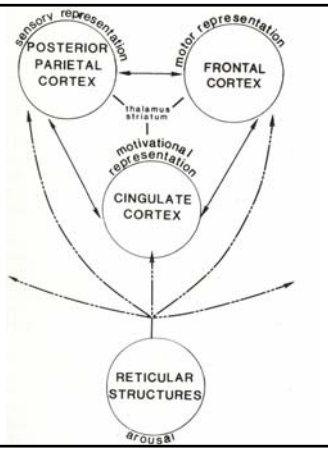
THEORETICAL MODELS

1. Posner & Petersen
2. Mesulam
3. Normal & Shallice
4. Modified supervisory system
   (Stuss, Shallice, Alexander, & Picton, 1995)

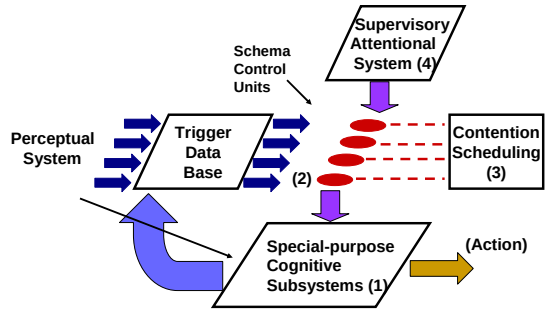
POSNER & PETERSEN

The attention system:

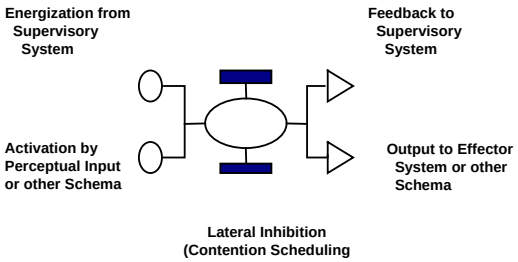
- **Own identity, but interacts with other parts of brain**
- **A network of different functional anatomical regions**
- **An anterior attentional system (in particular the midline) interacts with a posterior attentional system**



ANTERIOR ATTENTIONAL SYSTEM Shallice (1991)



DEFINITION of FRONTAL LOBE DYSFUNCTION

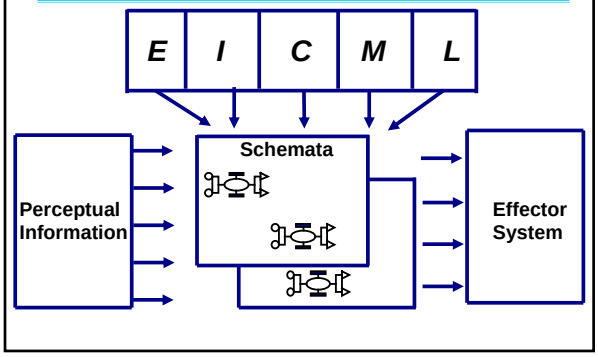


ANTERIOR ATTENTIONAL SYSTEM: Five Postulated Frontal Component Processes

E	I	C	M	L

- Energize a Schema
- Inhibit a Schema
- Adjust Contention Scheduling
- Monitor Goal Fulfillment
- If-then Logic

ANTERIOR ATTENTIONAL SYSTEM
Stuss, Shallice, Alexander, & Picton, 1995



SUSTAINING ATTENTION

Definition:

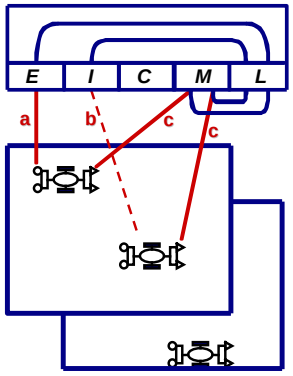
Attention to relevant events occurring at a relatively slow rate over prolonged periods of time

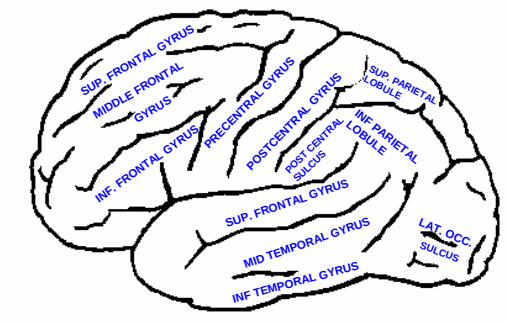
SUSTAINING ATTENTION

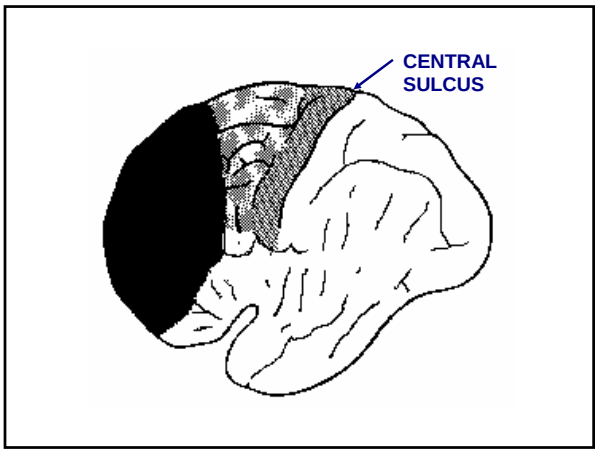
a energize task schema

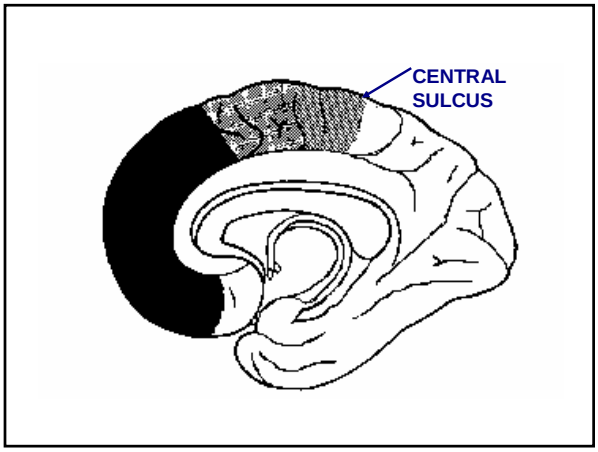
b inhibit competing schema

c monitor responses on and off tasks






CENTRAL
SULCUS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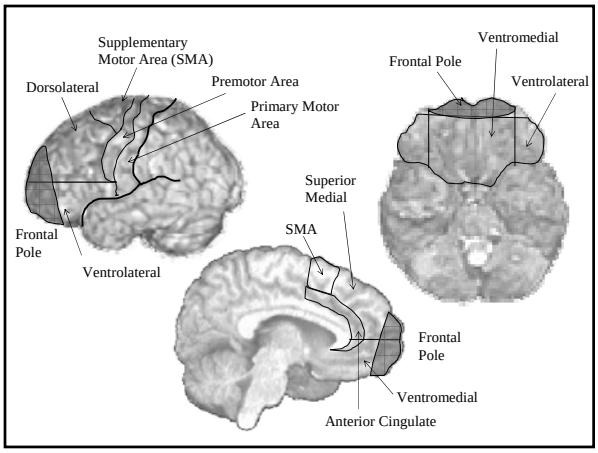
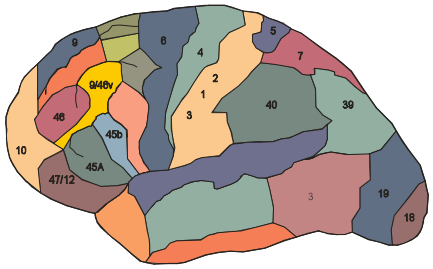
SULCUS


Supplementary
Motor Area (SMA)
Dorsolateral
Premotor Area
Primary Motor
Area
Frontal
Pole
Ventrolateral
Superior
Medial
SMA
Frontal
Pole
Ventromedial
Anterior Cingulate
Ventromedial
Frontal Pole
Ventrolateral



SURFACE	REGION	CYTOARCHITECTURE
POLAR	Superior	10
	Inferior	10
ORBITO-FRONTAL		14, 11, 13, 47/12
LATERAL	Dorsolateral	9, 46, 9/46d, 9/46v, 8b, 8ad, 8av, 6a, 4
	Ventrolateral	47/12, 45a, 45b, 44, 6b, 4
SUPERIOR MEDIAL	Superior Anteromedial	8b, 9
	Superior Posteromedial	6a, 4
	Paracingulate	32
	Cingulate	24
INFERIOR MEDIAL	Ventromedial	14
	Paracingulate	32
	Cingulate	24, 25

METHODOLOGICAL NOTES

- **Focus of functions of the frontal lobes**
- **Focal single lesions; vascular if possible but understanding that need other etiologies under specific conditions to get adequate representation of the different brain region**
- **Chronic stage of recovery, so as not to confuse recovery with brain-behaviour relation**
- **Brain-impairment relation**

METHODOLOGICAL NOTES

- Isolate Processes:
  - construct single tests, and then use this as a scaffolding
- "Localize" Brain-Behaviour Relation:
  - architechtonic "hotspotting": lesion for each patient mapped onto P&P architectonic template
  - for a particular measurement, performance of individuals who have damage in a particular region compared to all those who do not

METHODOLOGICAL NOTES

- Criticism of Approach:
  - Type I error
- Response: REPLICATION
  - across tests that require same process
  - across modalities (e.g., memory vs RT)
  - across different patient groups

INTRODUCTION/BACKGROUND

A. <u>Neuroanatomical Approach</u>

1. Classic anatomical classifications
2. Backward Engineering – start with performance and search for anatomical

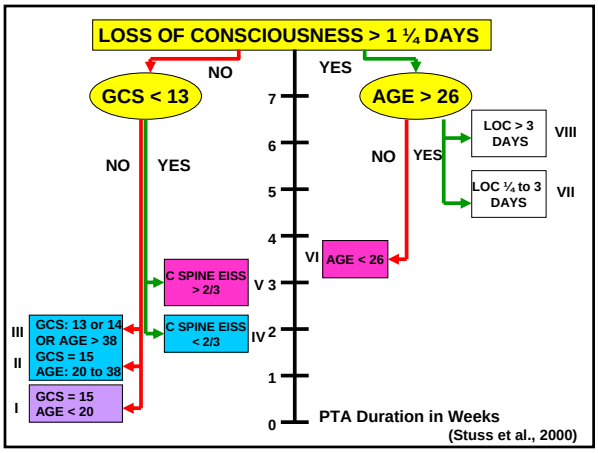
   i. Split half
   ii. Control is base; divide patients based on how different from controls
   iii. Classification and Regression Tree
   iv. Correlation of performance with defined anatomical region

C.A.R.T.
CLASSIFICATION and REGRESSION TREE
(Brieman et al., 1984)

- A regression technique that separates by extremes of performance
- Using performance as the independent variable enables investigation of which factor(s) contributes to the separation

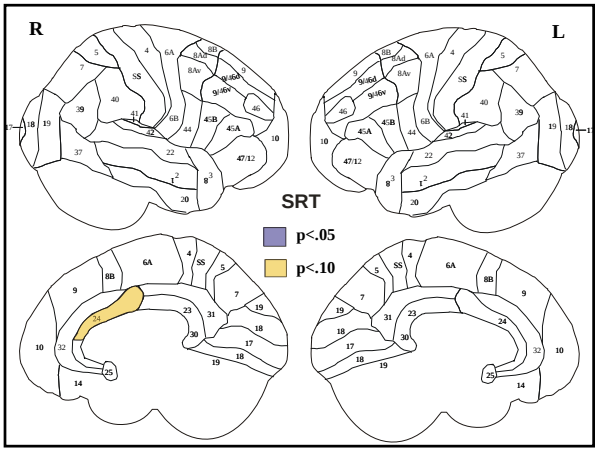
C.A.R.T.

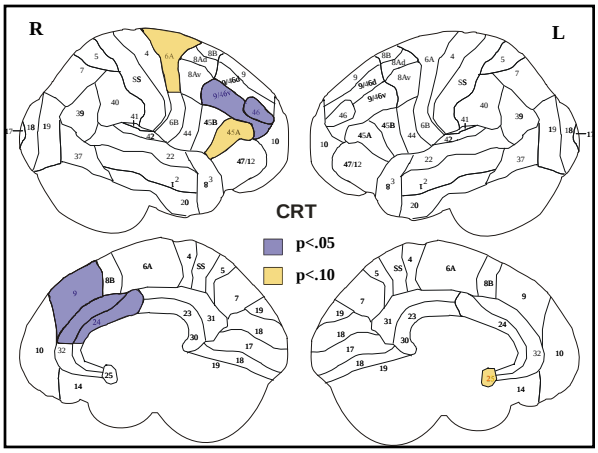
- Variables can be re-introduced at each iteration
- Process re-iterative until each subject is classified into new anatomical groupings (n>5) that provide the most separable performance-based categories



ARCHITECTONIC CORRELATIONS

- **Identified areas within the frontal lobes that were damaged for each patient using Petrides and Pandya (1994) architectonic divisions of the frontal lobes**
- **If an individual patient's lesion involved a defined architectonic region, it was coded as 1 for damaged; if not, it was coded as 0**
- **For abnormal slowing, for each P & P area, we identified all patients who had a lesion in that area and compared their RT by a t-test analysis to all patients who did not have damage in that area**





SUMMARY of SECTION 1

- No matter what we do, research or clinical, we have to have precise operational definitions of our concepts, anatomy, and processes
- There are many different ways to study specific brain-behaviour relations
- Lesions studies tell you which brain regions are Necessary to perform any task

TELL THEM WHAT… INTRODUCTION to SECTION TWO

- There are separate processes within the frontal lobes, each related to a different frontal region
  - Energization
  - Executive Functioning
    - Task setting
    - Monitoring
  - Metacognitive Processing
  - Behavioural Self-regulation

ASSESSMENT: FOUR DOMAINS

A. Energization/regulation: superior medial

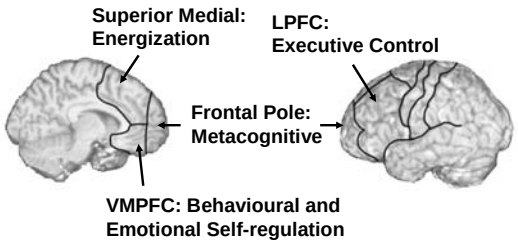
B. Executive/cognitive: lateral

C. Metacognitive: frontal poles, primarily right

A. Behavioural Self-regulatory: orbital/ ventromedial

RATIONALE for FOUR FUNCTIONAL DOMAINS

- Two major divisions based on evolution of cortical architectonics (Stuss & Levine, 2002)
  - Dorsolateral: from hippocampal, archicortical trend
    - Spatial and conceptual reasoning: executive cognitive
  - Ventral(medial): from olfactory, paleocortical trend
    - Emotional processing: behavioural self-regulatory
- Network connectivity – add action regulation
- Metacognitive – recent research



TELL 'EM THAT YOU TOLD 'EM

- Damage in different frontal regions result in distinct attentional deficits; three (at least)
- There is no generic frontal lobe dysexecutive syndrome
- The implied processes are "supervisory" in that they control lower order processes
- There is no overarching supervisory system, no "ghost in the machine", higher in the hierarchy

THREE SECTIONS to the WORKSHOP

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- **Attention and Memory – New Findings**
  - **Value of Current Measures of Frontal Lobe Functions**
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FEATURE INTEGRATION TEST

Test	Target	Distractors
Simple	△	none
Easy Choice	✚	□ ○ △
Complex Choice	blue	red yellow blue
Redundant Choice	yellow	red green blue

ROBBIA

ROTMAN
BAYCREST
BATTERY TO
INVESTIGATE
ATTENTION

ROBBIA

Reaction time tests involving manipulations of:

- **Timing of stimulus presentation**
  - **Rate**
  - **ISI (Inter-Stimulus Interval)**
- **Stimulus complexity**
- **Context of stimulus presentation**

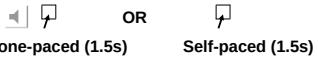
ROBBIA

Test	Target	Distractors
Simple RT	A	none
Choice RT	A	B C D
Prepare RT	+ WS A	B C D
NoGo	A then B,C,D	B,C,D then A
Suppress	X O	X O H J T

ROBBIA

Test

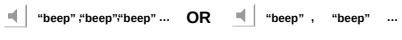
Tap



Tone-paced (1.5s) Self-paced (1.5s)

Concentrate

Count



Fast (230-280 ms) Slow (2500-3500 ms)

STUDY/PATIENT OVERLAP

	Feature Integration Test	Neuropsychological Tests	ROBBIA
# of Frontal Patients	25	33-56	43
# of Shared Patients	16	3	
	0		

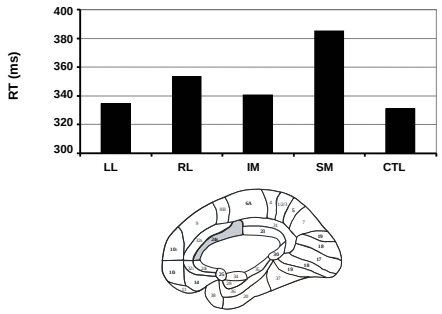
STRUCTURE of DATA PRESENTATION

- TOP: Bar graph by coarse lesion localization:
  - RL – right lateral;
  - LL – left lateral;
  - SM – superior medial;
  - IM – inferior medial
- BOTTOM: Architectonic localization

TELL THEM

- ENERGIZATION
  - "The process of initiation and sustaining of any response made"

ENERGIZATION – SIMPLE RT (ROBBIA)



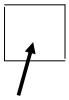
ENERGIZATION – CHOICE RT (ROBBIA)

Target

A

Distractors

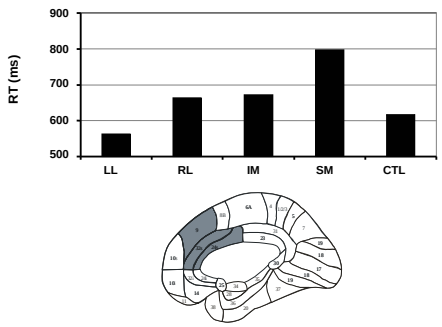
B C D



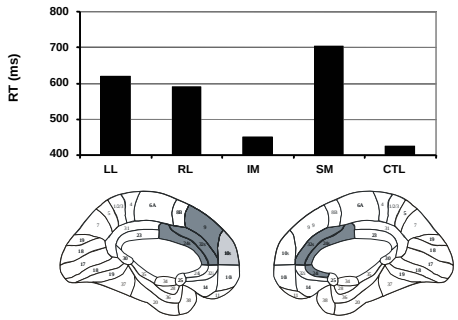
Press Button 1

Press Button 2

ENERGIZATION – CHOICE RT (ROBBIA)



ENERGIZATION – CHOICE RT (FIT)



ENERGIZATION – PREPARE RT (ROBBIA)

\+ ← Warning Signal

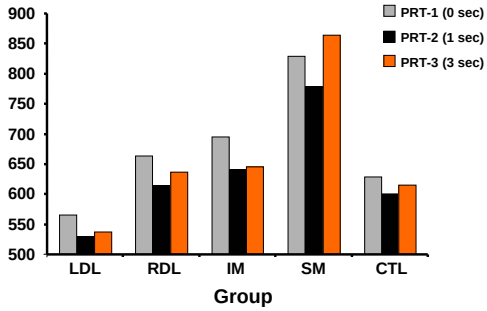
3 seconds
or
1 second

before stimuli….

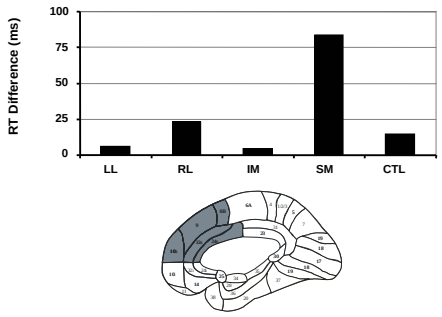
Target	Distractors
A	B C D

Press Button 1 Press Button 2

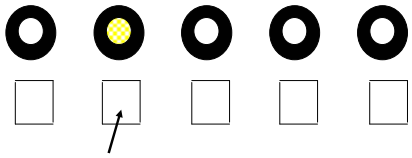
PREPARE ACROSS BLOCKS



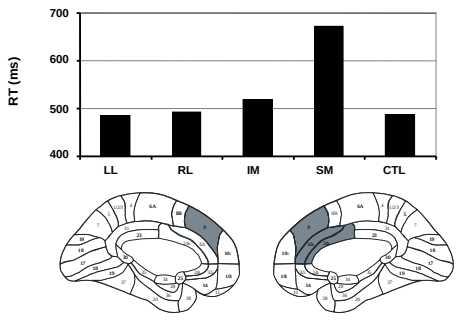
ENERGIZATION – PREPARE RT (ROBBIA)



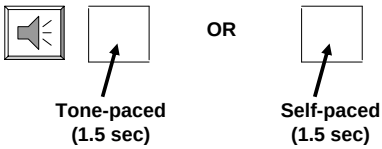
ENERGIZATION – CONCENTRATE (ROBBIA)



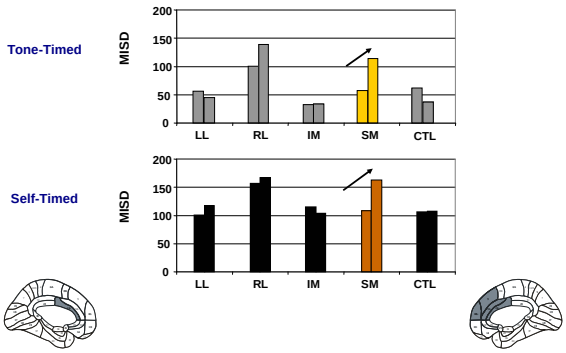
ENERGIZATION – CONCENTRATE (ROBBIA)



MONITORING – TAP (ROBBIA)



ENERGIZATION – TAP (ROBBIA)

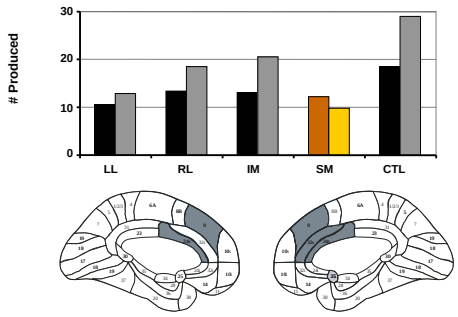


ENERGIZATION – VERBAL FLUENCY

- **Letter Fluency: generation of words (no proper names) beginning with F, A, and then S, over a one minute duration per letter. Production was analyzed in the first 15, and the last 45, seconds.**

	F	A	S
15 sec	fun fast forest first flag fern flower fable famous fan		
30 sec	fruit from fall frown find		
45 sec	fruit from fall		
60 sec	fragrant		

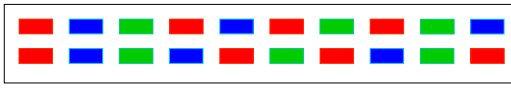
ENERGIZATION – VERBAL FLUENCY



Word Reading

RED BLUE RED GREEN BLUE RED GREEN BLUE
RED GREEN BLUE RED GREEN RED BLUE GREEN

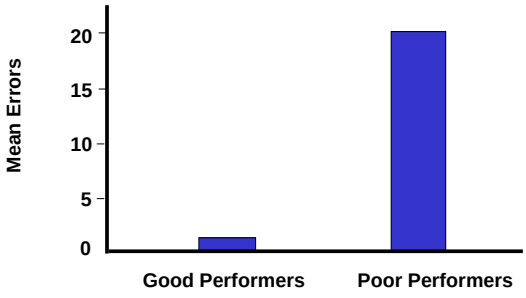
Colour Naming



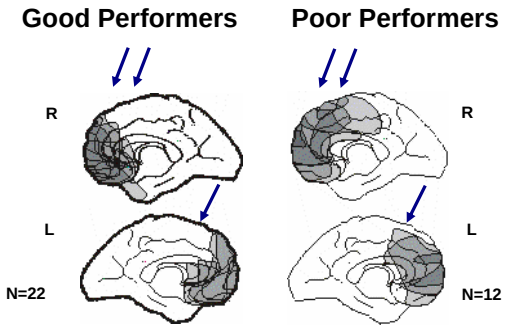
Incongruent Condition

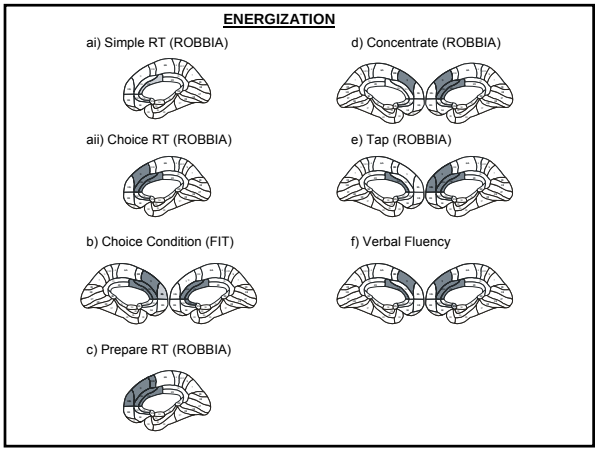
RED BLUE GREEN RED BLUE RED GREEN GREEN
BLUE BLUE RED BLUE GREEN BLUE RED GREEN

STROOP - INCONGRUENT ERRORS



STROOP - INCONGRUENT ERRORS





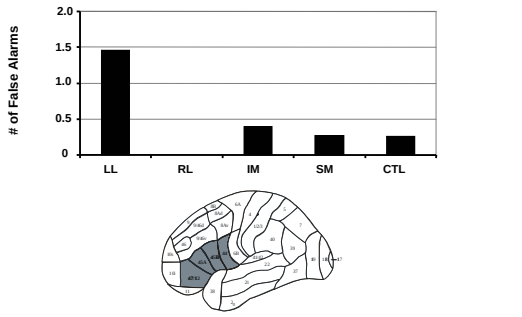
SUMMARY - ENERGIZATION

- **SM deficits demonstrated by prolonged simple and choice RT, inability to sustain preparation to respond, inability to maintain consistent short time intervals, diminished output in verbal fluency, and Stroop errors**
- **SM frontal lesions results in decreased facilitation of the neural systems to make decisions and initiate responses**

TELL THEM

- **TASK SETTING**
  - **"The ability to establish a stimulus-response relationship", requiring formation of a criterion to respond to a defined target with specific attributes, organization of the schemata to do a task, and adjustment of contention scheduling**

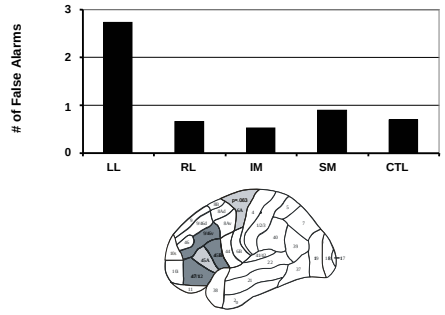
TASK SETTING – CONCENTRATE (ROBBIA)



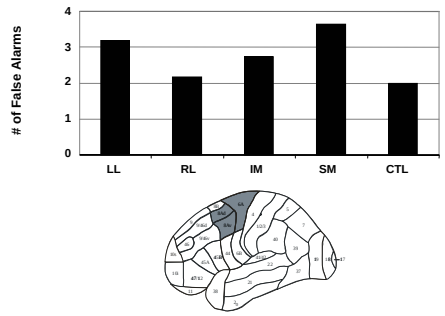
TASK SETTING – SUPPRESS (ROBBIA)

Target: RED	Target: BLUE	Distractor: BLUE	Other: RED
X	O	X	H
1 2	**1** 2	1 **2**	1 **2**

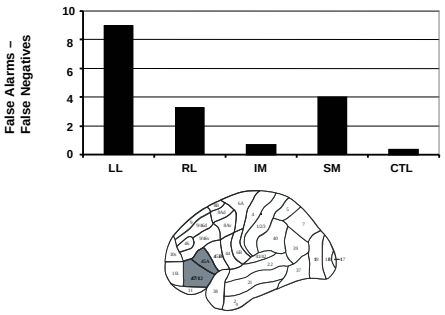
TASK SETTING – SUPPRESS (ROBBIA)



TASK SETTING – NOGO (ROBBIA)



TASK SETTING – COMPLEX (FIT)



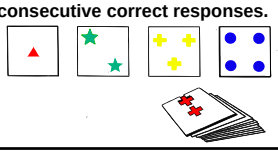
TASK SETTING – WCST 128

Wisconsin Card Sorting Test, Three Conditions

i. **128 Cards: Milner Administration.**

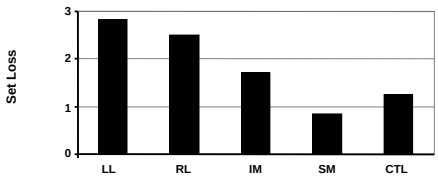
ii. **64 Cards (64A): administered after the 128. Subjects told the three sorting criteria.**

iii. **64 Cards (64B): administered after 64A. Subjects were again told the three sorting criteria and informed that colour was the initial criterion. Also told that the criterion would change after 10 consecutive correct responses.**



Stuss et al., 2000

TASK SETTING – WCST 128



TASK SETTING – CVLT

- **Five learning trials, 20 minute delay, recognition trial**
- **False Alarms are those words during the recognition trial that are incorrectly identified as words presented during the learning trials.**

drill
plums
vest
parsley
…
…
…
…

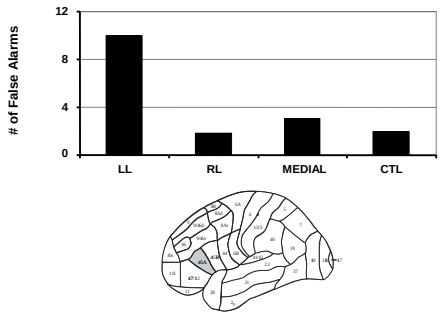
Learning Trials

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
drill plums vest				

Recognition

	Y	N		Y	N	
sweater			pepper			apricots
oregano			jacket			…
flounder			aspirin			…
rug			wax			
tires			drill			

TASK SETTING – CVLT



TASK SETTING

a) Concentrate (ROBBIA)

b) Suppress (ROBBIA)

c) NoGo (ROBBIA)

d) Complex Condition (FIT)

e) WCST 128

f) CVLT 2003

SUMMARY – TASK SETTING

- **Task setting deficits were observed in different RT tests, WCST, and list learning**
- **Left lateral frontal damage impairs ability to use task-instructions to direct behaviour (Luria, 1966)**

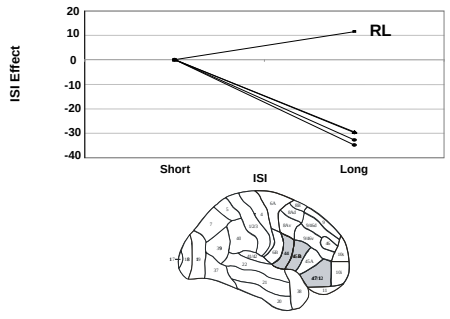
TELL THEM

- **MONITORING**
  - **"The process of checking the task over time for `quality control' and the adjustment of behaviour "**

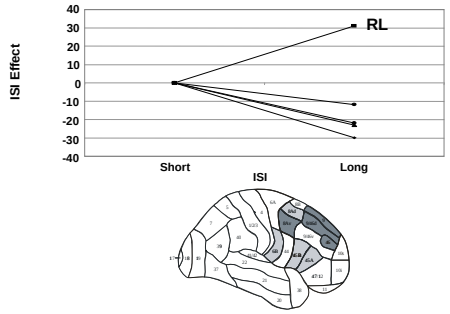
MONITORING – SIMPLE & CHOICE RT (ROBBIA)

- **5 different Inter-stimulus Intervals (ISI) (3,4,5,6, or 7 seconds), each occurring 10 times randomly**
- **Short ISI = 3 and 4 seconds**
- **Long ISI = 6 and 7 seconds**

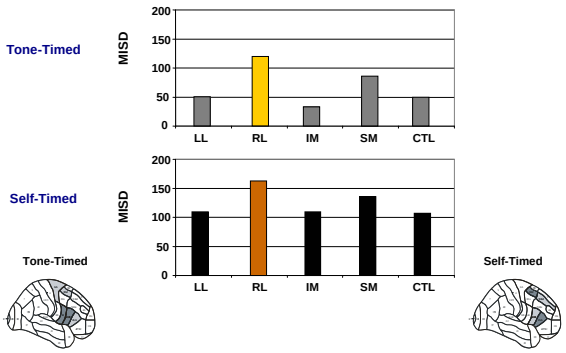
MONITORING – SIMPLE RT (ROBBIA)



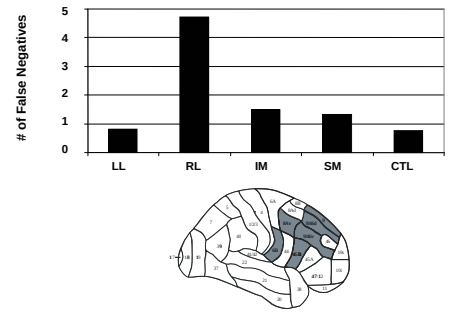
MONITORING – CHOICE RT (ROBBIA)



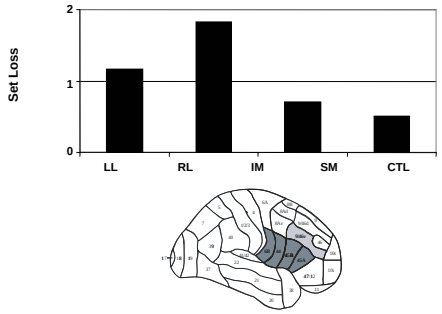
MONITORING – TAP (ROBBIA)



MONITORING – COMPLEX (FIT)



MONITORING – WCST 64B



MONITORING – CVLT

- **A list of words was presented and then immediately recalled by subject for five trials. After a 20 minute delay, another free recall trial without further stimuli presentation and a recognition trial were administered. The dependent measure was the number of False Alarms during the recognition trial.**

drill
plums
vest
parsley
...
...
...
...

Learning Trials

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
drill plums vest				

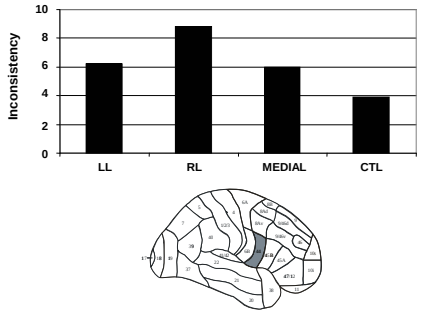
Recognition

Y	N		Y	N	
sweater		pepper			apricots
oregano		jacket			…
flounder		aspirin			…
rug		wax			
tires		drill			

MONITORING – CVLT

- **Inconsistency:**
  - **the failure to recall a word on a trial when it had been recalled on the previous trial**

MONITORING – CVLT

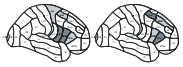


MONITORING

ai) Simple RT (ROBBIA)

aii) Choice RT (ROBBIA)

b) Tap (ROBBIA)



c) Complex Condition (FIT)

d) WCST (64B)

e) CVLT 2003

SUMMARY – MONITORING

- **RL frontal lesions produce impairments in monitoring and checking of performance over time.**
- **Demonstrated in failure to show decrease in RT in variable foreperiods, to note errors and adjust performance.**

SECTION 2

Pacific Northwest
Neuropsychological Society

March 2009

Section 2

Donald T. Stuss, Ph.D.
Rotman Research Institute at Baycrest
University of Toronto

Baycrest Enriching Care Enhancing Knowledge Enlightening Minds

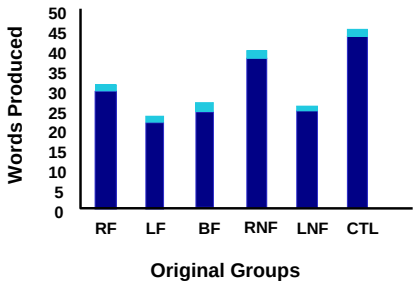
U of T Neurology

A CLOSER LOOK at SOME of the "STANDARD" FRONTAL LOBE TESTS

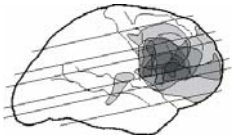
Validity and Methods of Scoring

1. **Verbal Fluency**
2. **Wisconsin Card Sorting Test**
3. **Stroop**
4. **Trail Making Test**

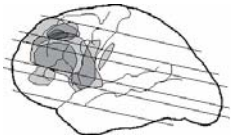
LETTER-BASED FLUENCY



Right Dorsolateral - Lateral

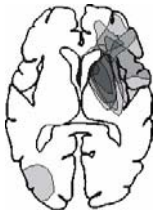


Left Dorsolateral - Lateral

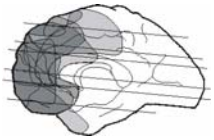


Right Dorsolateral - Striatal

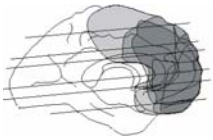
Left Dorsolateral - Striatal



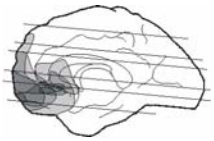
Superior Medial - Right



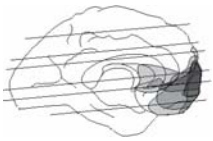
Superior Medial - Left



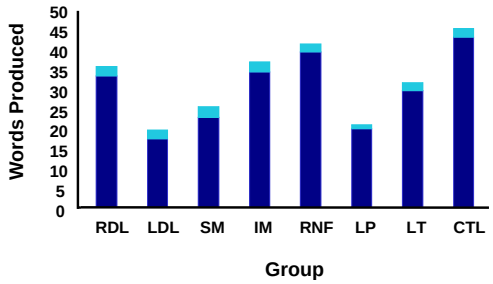
Inferior Medial - Right



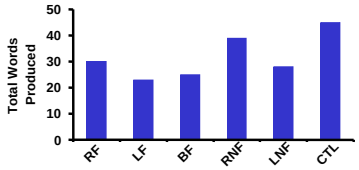
Inferior Medial - Left



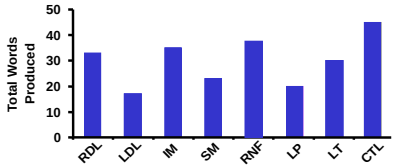
LETTER-BASED FLUENCY



STANDARD LESION CLASSIFICATIONS



RESTRUCTURED GROUPS



VERBAL FLUENCY CONCLUSIONS

- **CART procedure provided more precise functional-anatomical distinctions**
- **Use of task analysis and correlation with other measures provides a means for differentiating separate processes**

VERBAL FLUENCY CONCLUSIONS

- **Different frontal letter fluency processes appear to contribute**

• Initiation and activation (first 15 seconds)	SM & possibly LDL
• Direct semantic to lexical (correlation with naming test)	LDL
• Verbal articulatory rehearsal (correlation with digit span backwards)	LDL; IM
• Higher level associations semantic retrieval (hypothesized)	LP
•Sustained production (last 45 seconds)	LDL; SM

WCST - THREE LEVELS OF ADMINISTRATION

128: Standard administration of all 128 cards

THREE LEVELS OF ADMINISTRATION

64A: Ss informed of the three sorting criteria only, regardless of performance

Standard administration of 64 cards

THREE LEVELS OF ADMINISTRATION

64B: Ss informed of the following:
- 3 sorting criteria
- told to start with colour
- warning each time criterion changed (but actual sorting criteria NOT mentioned)

WCST DEPENDENT MEASURES

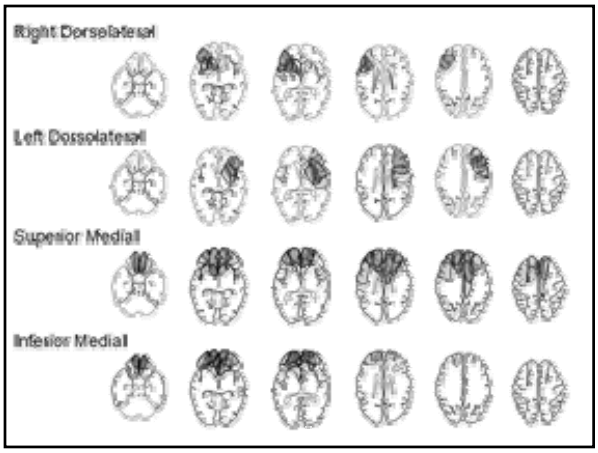
- **Categories:**
  - the number of categories sorted with 10 consecutive correct responses

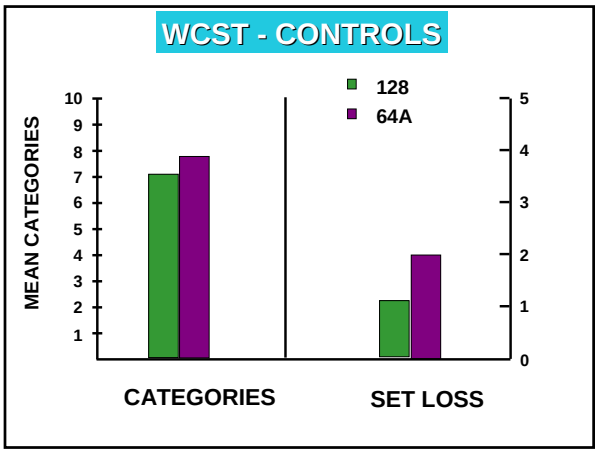
- **Perseveration of the Preceding Criterion (PPC):**
  - all incorrect responses that contained a match to the preceding criterion

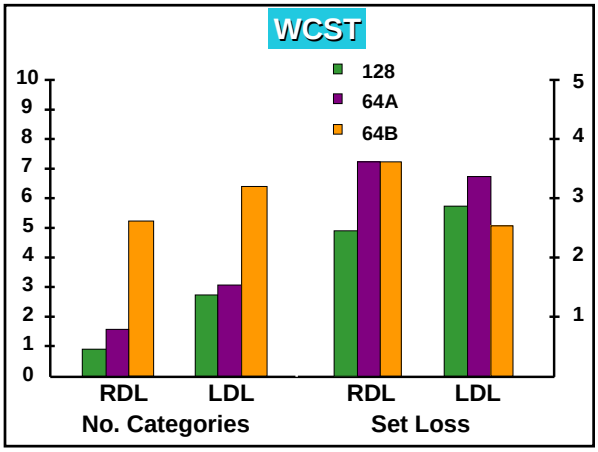
WCST DEPENDENT MEASURES

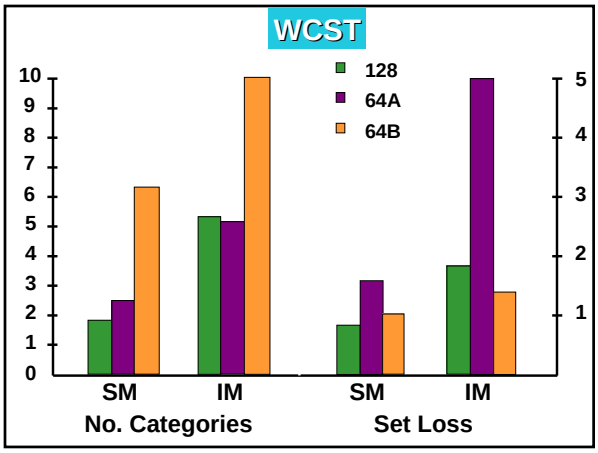
- **Perseveration of the Preceding Response (PPR):**
  - exact repetition of the immediately preceding incorrect response

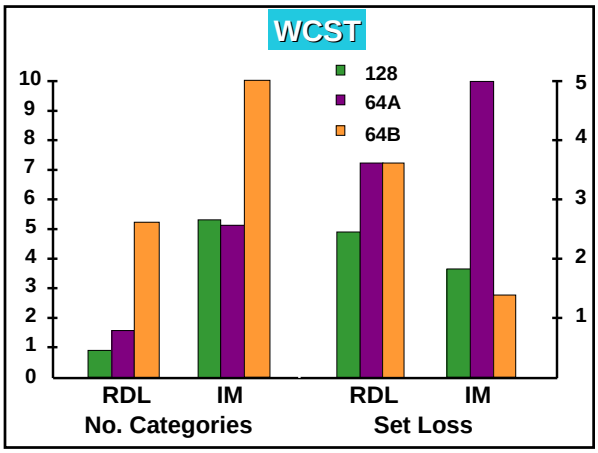
- **Set Loss:**
  - the number of times an incorrect response occurred after three or more consecutively correct responses




WCST - CONTROLS
128
64A
MEAN CATEGORIES
10
9
8
7
6
5
4
3
2
1
5
4
3
2
1
0
CATEGORIES
SET LOSS


WCST
128
64A
64B
10
9
8
7
6
5
4
3
2
1
0
5
4
3
2
1
RDL
LDL
RDL
LDL
No. Categories
Set Loss


WCST
128
64A
64B
10
9
8
7
6
5
4
3
2
1
0
5
4
3
2
1
SM
IM
SM
IM
No. Categories
Set Loss

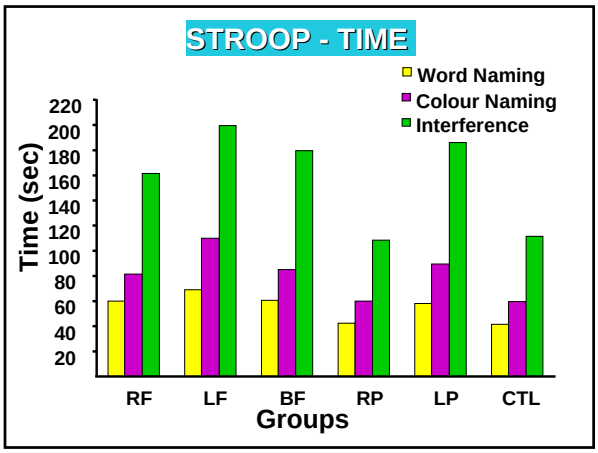


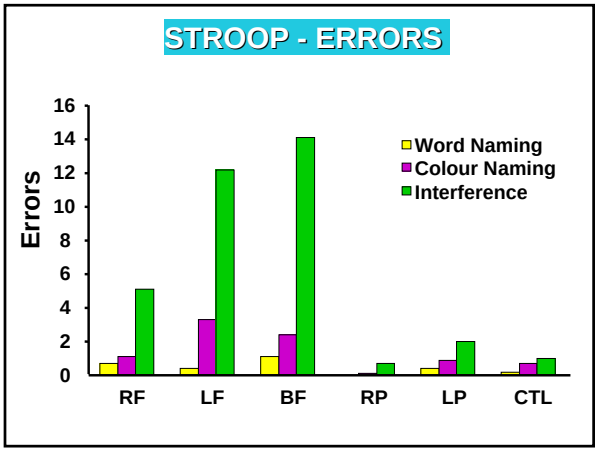
WCST IMPLICATIONS

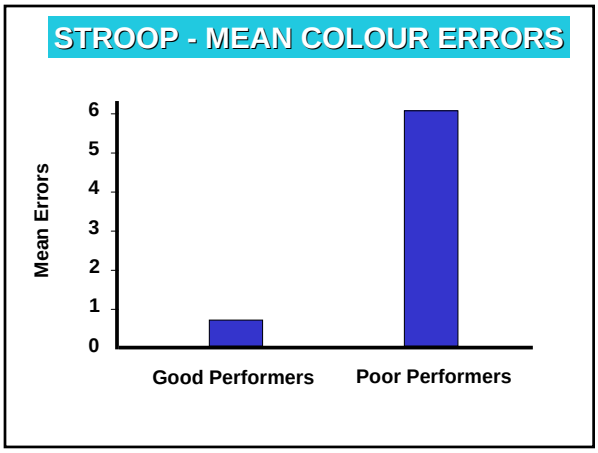
- Support can help
- And you can use support to test how severe the impairment is
- You can inform too much or too little

WCST IMPLICATIONS

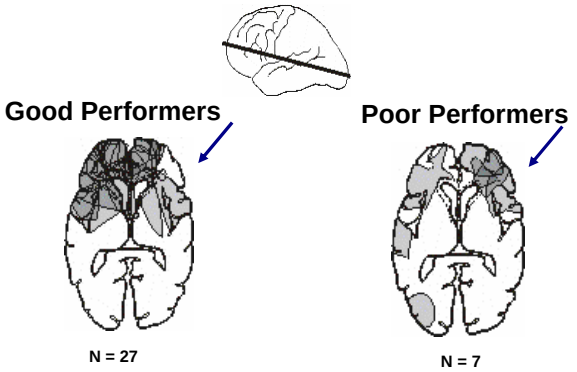
- IM lesions did not affect WCST performance for most measures
- SM AND DL groups significantly impaired
- Patterns of performance differ


STROOP - TIME
Word Naming
Colour Naming
Interference
Time (sec)
220
200
180
160
140
120
100
80
60
40
20
RF
LF
BF
RP
LP
CTL
Groups

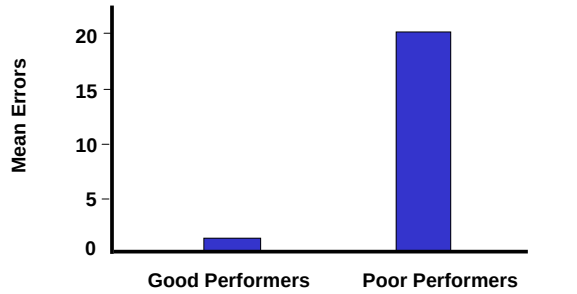

STROOP - ERRORS
Errors
16
14
12
10
8
6
4
2
0
Word Naming
Colour Naming
Interference
RF
LF
BF
RP
LP
CTL


STROOP - MEAN COLOUR ERRORS
Mean Errors
6
5
4
3
2
1
0
Good Performers
Poor Performers

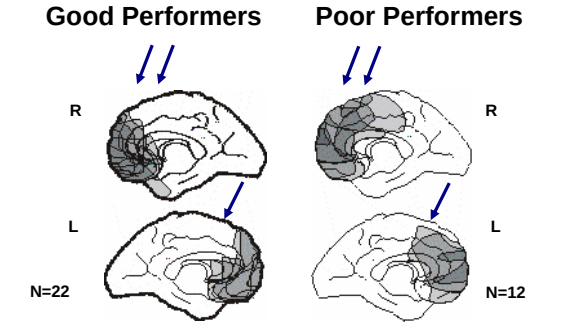
STROOP - MEAN COLOUR ERRORS

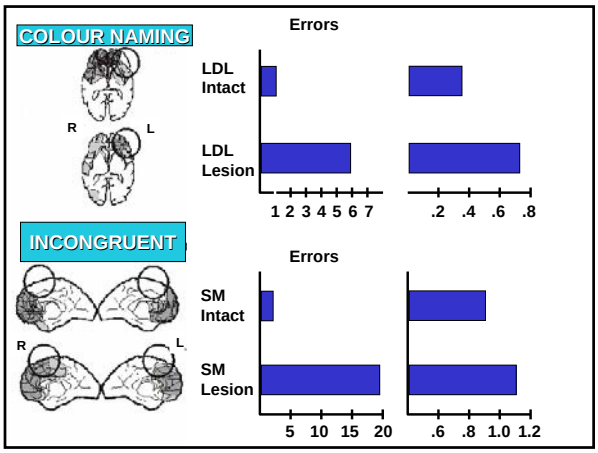


STROOP - INCONGRUENT ERRORS



STROOP - INCONGRUENT ERRORS



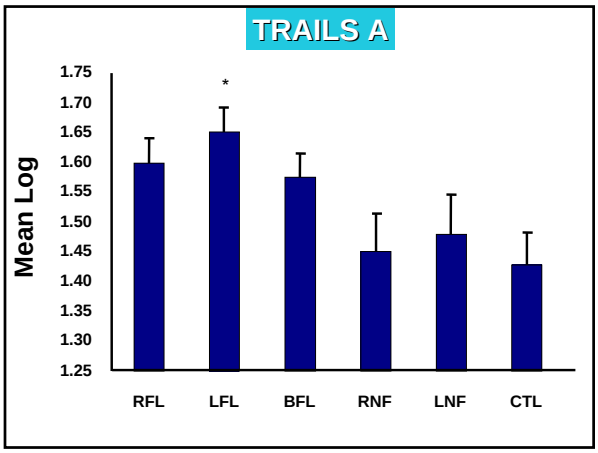


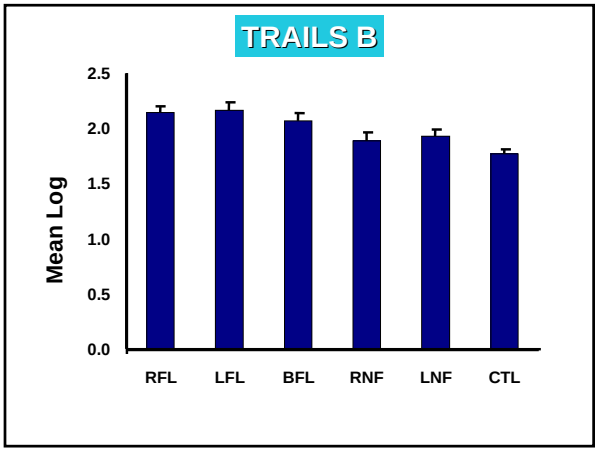
STROOP TEST CONCLUSIONS

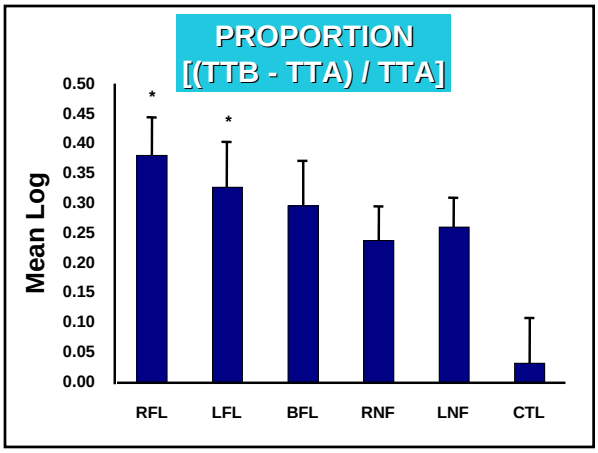
- Left frontal lesions impaired direct colour naming, complicating any interpretation of a Stroop effect.
- Previous studies claiming left frontal association with exaggerated Stroop effect did not control for direct colour naming

STROOP TEST CONCLUSIONS

- Exaggeration of the Stroop interference effect was observed in patients with superior medial frontal lesions, usually bilateral but some right sided alone
- Superior medial frontal region essential for initiation, activation, and spontaneity


TRAILS A
Mean Log
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
*
RFL
LFL
BFL
RNF
LNF
CTL


TRAILS B
Mean Log
2.5
2.0
1.5
1.0
0.5
0.0
RFL
LFL
BFL
RNF
LNF
CTL


PROPORTION
[(TTB - TTA) / TTA]
Mean Log
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
*
*
RFL
LFL
BFL
RNF
LNF
CTL

TRAIL MAKING TEST: PERFORMANCE GROUPINGS

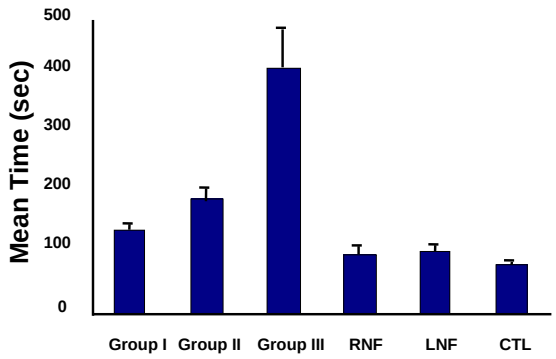
Trails B:

GROUP 1: 0-1 ERRORS

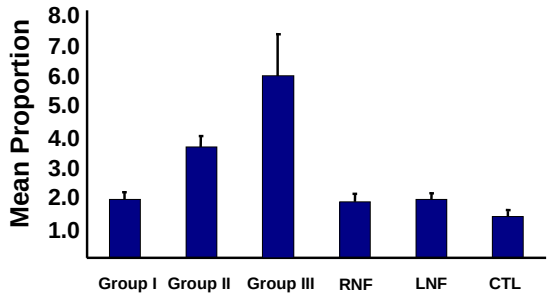
GROUP 2: 2-3 ERRORS

GROUP 3: >3 ERRORS

ERROR GROUPS TRAILS B



TRAIL MAKING TEST: PROPORTION TIME (TTB-TTA)/TTA



TRAIL MAKING TEST CONCLUSIONS

- CART did not work; TMT too multi-factorial?
- Used categorical analysis of errors, and correlated specific lesion location to number of errors using gamma, a measure of ordinal association

TRAIL MAKING TEST CONCLUSIONS

- Use errors and/or a proportion (ratio) measure
- IM lesions did not significantly impair TMT performance (lowest errors and fastest time for frontal patients) (see also lobectomy research)
- Greatest errors occurred with right superior posteromedial damage, although not significant (p=.11)

MUSINGS on ASSESSMENT of FRONTAL LOBE ABILITIES

- Provided you isolate the processes, it doesn't seem to matter what test you use to identify an impairment.
- Standard clinical tests can give you the same type of information as do the experimental tests. However, because they are often complex, isolating the processes may be difficult.

TRAIL MAKING TEST CONCLUSIONS

- CART did not work; TMT too multi-factorial?
- Used categorical analysis of errors, and correlated specific lesion location to number of errors using gamma, a measure of ordinal association

SECTION 3

Pacific Northwest
Neuropsychological Society

March 2009

Section 3

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Baycrest Enriching Care Enhancing Knowledge Enlightening Minds

U of T Neurology

THREE SECTIONS to the WORKSHOP

- Definition and Models
- Attention and Memory – New Findings
  - Value of Current Measures of Frontal Lobe Functions
- Clinical Implications

SECTION THREE: CLINICAL IMPLICATIONS

The Role of Context in Assessment

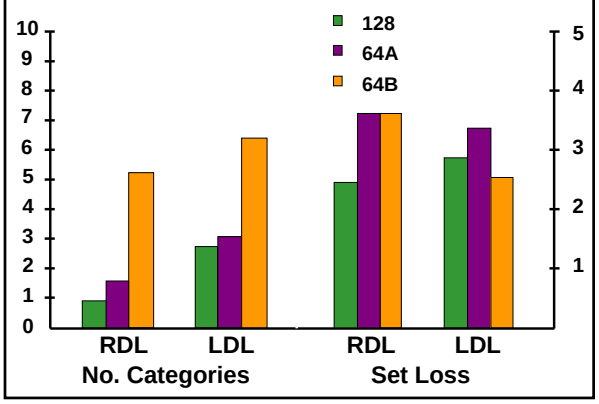
1. **Lessons from the WCST**
2. **Variability in performance**
3. **Effects of minimal changes in task demands**

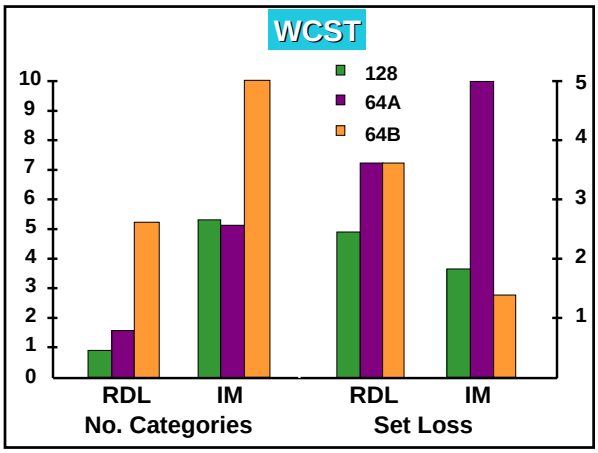
SECTION THREE: CLINICAL IMPLICATIONS

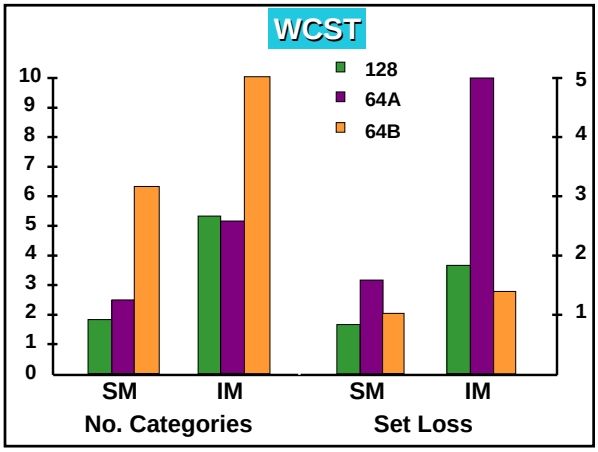
The Role of Context in Assessment

1. **Lessons from the WCST**
2. **Variability in performance**
3. **Effects of minimal changes in task demands**

WCST







SECTION THREE: CLINICAL IMPLICATIONS

The Role of Context in Assessment

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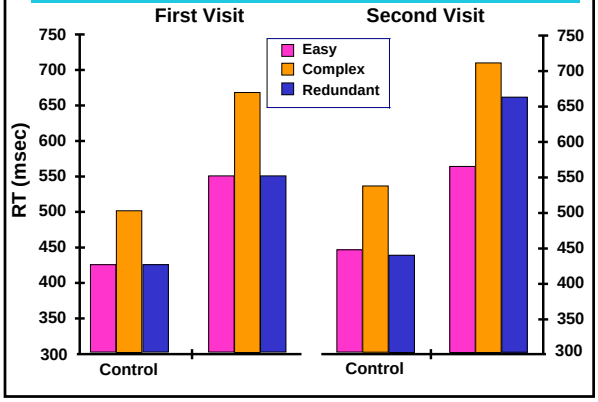
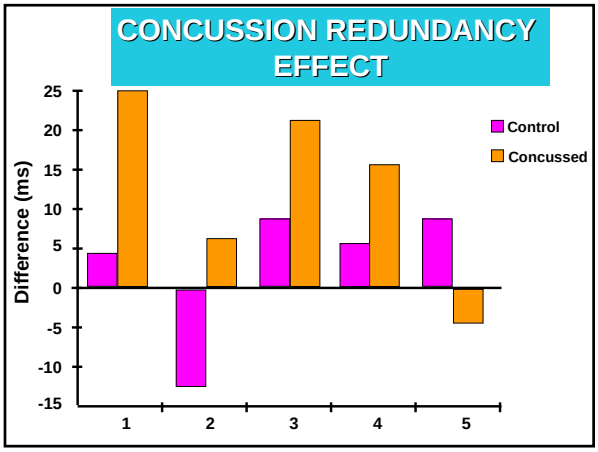
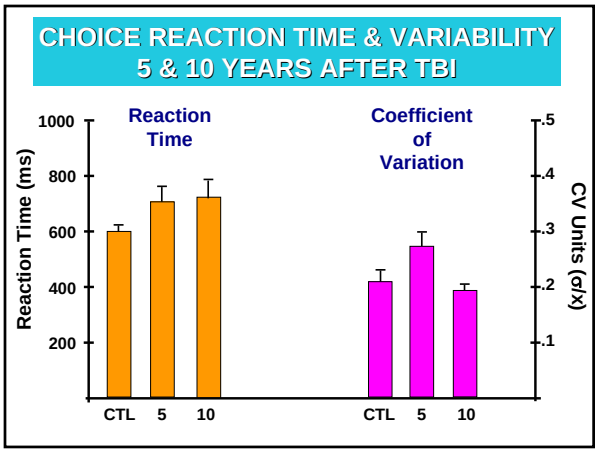
CRT TARGET CORRECT RESPONSES



CONCUSSION REDUCTION EFFECT



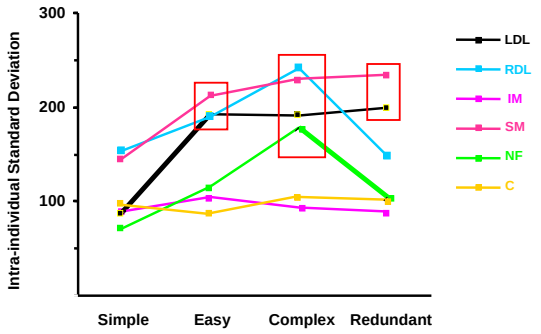
CHOICE REACTION TIME & VARIABILITY 5 & 10 YEARS AFTER TBI



TYPES of VARIABILITY

Group Variability (inter-individual variability):
- the differences in performance of different members of the group around the mean of the group

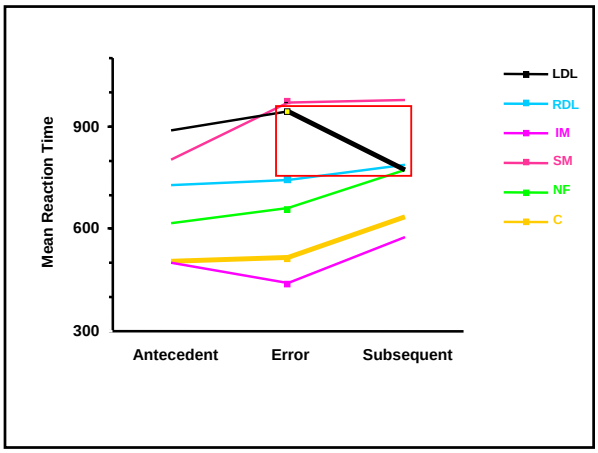
Individual Variability (intra-individual variability - IIV):
- the differences in performance of an individual
  - Dispersion - the oscillation of performance during a single continuous task
  - Consistency - the degree of variability of an individual between administrations of the same test either within the same testing session (e.g., different blocks of the same test) or over separate sessions of testing



EFFECT of ERRORS

General Effect:
- In the RL group, the association of errors with intra-individual variability was significantly different from the control group

Local Effect:
- Change in RT before and after an error indexes executive control



INCONSISTENCY OVER REPEATED ASSESSMENT

	Simple	Easy	Complex	Redundant
Mean RT	DL	DL		DL SM
ISD & ICV		DL	DL NF	DL SM

REFLECTIONS

- Our initial approach to rehabilitation emphasized strategic processes.
- If these processes can be fractionated, does that mean that our rehabilitation should be targeted to these specific processes?
- Determining the ecological validity of these approaches is a key next step.

MAIN RESULTS in VARIABILITY

- The frontal lobes have several non-domain specific control mechanisms:

  i. Superior and lateral (perhaps in particular) frontal regions - inconsistency of performance

  ii. Superior medial - maintenance of activation to respond and of energization of various schemata in the response set, not related to errors or speed

  iii. RDL - IIV affected by errors

  iv. LDL - IIV related to establishment of criteria for functional responses

SECTION THREE: CLINICAL IMPLICATIONS

The Role of Context in Assessment

1. Lessons from the WCST
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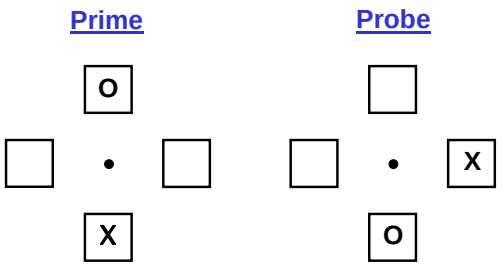
INTEGRATED SYSTEMS and TASK DEMANDS

- **Demonstrating fractionation of frontal lobe functions does not imply a set of independent processes.**
- **Processes are flexibly assembled in response to context, complexity and intention over real time into different networks within the frontal regions, and between frontal and posterior areas.**

SPATIAL SELECTION TASKS

- Three spatial selection tasks:
  "Select-what / respond-where"
- Identify and locate a defined target stimulus and move a joy stick in same direction
- Tasks varied:
  Presence of distractor
  Content of identification
  Level of complexity

ONE TRIAL = TWO PRESENTATIONS



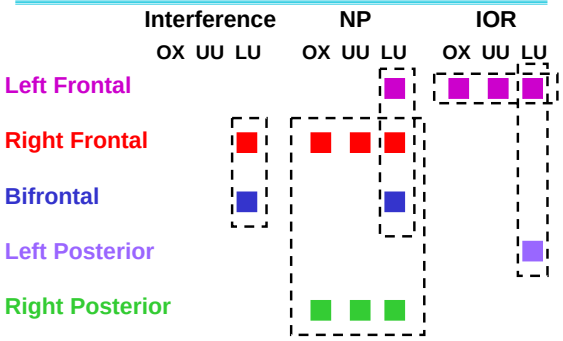
STIMULI

	Centre	Target	Distractor
LU	a	A	D(E,G)
UU	A	A	D(E,G)
OX	•	O	X

TASKS

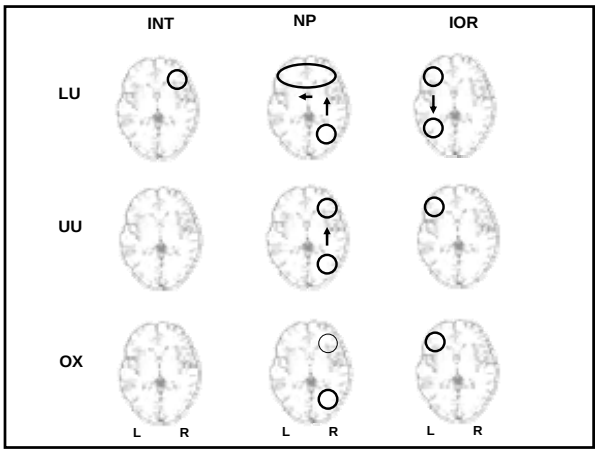
Task	Matching	Characteristics
LU	Letter	•Variable mapping •Central letter Identification •Literal Identification (e - E)
UU	Letter	•Variable mapping •Central letter Identification •Perceptual Match (E - E)
OX	Symbol	•Constant mapping

PATIENTS: RESULTS COMPARED TO CONTROL SUBJECTS



SUMMARY of SPATIAL SELECTION STUDY

- Apparent small changes in task demands can alter the role of brain areas and brain systems
- Lesion studies can be used to identify brain systems

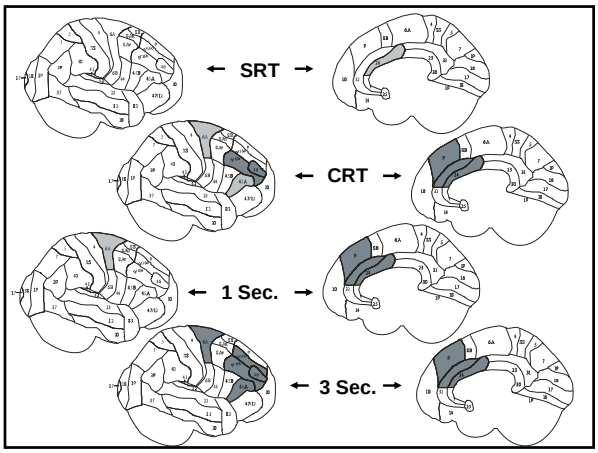


ANTERIOR/POSTERIOR NETWORKS

- There are top-down and bottom-up anterior/posterior networks.
- These networks depend on the specific process and task demands.

LET'S RETURN to the RT TASKS

- Simple RT
- Choice RT
- Prepare RT



SYSTEMS

- **Demonstrating fractionation of frontal lobe functions does not imply a set of independent processes.**
- **Processes are flexibly assembled in response to context, complexity and intention over real time into different networks within the frontal regions, and between frontal and posterior areas.**

CLINICAL IMPLICATIONS

- **The case example: how to capture inability to stay on the job**
- **One assessment of a frontal patient may not capture dispersion or inconsistency**
- **Potential treatments**
  - **i. Dextroamphetamine (Bleiberg et al., 1993)**
  - **ii. Verbal self-regulation (Stuss et al., 1987)**
  - **iii. Target treatment to the mechanism, not the symptom? E.g., RDL - develop feedback to monitor their performance to distinguish correct from incorrect responses**

TASK COMPLEXITY

- Complex tasks may not be the best way to understand frontal lobe functions
- Effect of task complexity is not necessarily step-wise; different frontal regions respond differently

TASK CONTEXT

- Apparent small changes in task instructions can affect performance, at least for some groups
  - **WCST:** IM
  - **Spatial Selection Task:** Lesion location by task interactions

BRAIN SYSTEMS

- Move from brain regions to effect of lesions on brain systems
- Brain systems may mean top-down OR bottom-up interactions

VARIABILITY

- Fluctuations of individual performance are not error variance: “the noise is the data”
- Increased intra-individual variability may be caused by damage to specific brain regions
- Disorders of stability of performance reflect top-down control. Since there are different types of intra-individual variability, there are multiple mechanisms of control

CONCLUSIONS

- Many patients with frontal lobe damage perform well on many attentional tasks
- There are several components within the anterior attentional system. More will likely be differentiated

CONCLUSIONS

- Testing many patients and precise lesion localization is a key step, along with task dissociations, in differentiating the components
- Lesion research can help dissociate component structure of tasks