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Cognitive recovery after brain damage
Problems associated with the long-term effects of neurological change represent the largest demand on long-term NHS Services.

In the aging population, neurological changes very often associated with gradual degenerative alteration in brain function:

• Alzheimer’s
• Parkinson’s
• Healthy aging

In other cases you may have sudden step changes associated with brain injury or stroke.
In general screens of the acute stroke population (even up to 3 months post stroke), cognitive deficits have been documented in at least 50% of the patients (Adunsky et al., 2002).

Cognitive status at admission is reliably related to rehabilitation outcome (Galsky et al., 1993).

Thus it is important to measure cognitive problems following stroke, and important to assess the optimal way(s) to rehabilitate such problems.
Here I will discuss our work in developing a screen for cognitive deficits after stroke.

Using tests that are applicable in acute stroke, that do not exclude patients with some of the more common cognitive problems ('aphasia friendly' and 'neglect friendly')

The screen aims to pin-point specific problems that can be addressed through appropriate re-learning/rehabilitation strategies.

I will then go on to discuss how our understanding of the rehabilitation process can be aided by brain imaging functional recovery in patients.
Previous studies have typically used either:

**General (non-specific) measures of cognitive function:**
- Mini-mental state examination (Lawrence et al., 2001)
- Clock drawing (Friedman, 1991)

**Measures of single cognitive functions:**
- Expressive aphasia (Kauhanen et al., 2000)
- Neglect (Cassidy et al., 1999)
- Executive functions (Leeds et al., 2001)
- Visuo-spatial abilities (Adunsky et al., 2002)
Some attempts to measure multiple cognitive functions, but:

(i) few have been applied in acute stroke

(ii) few have measured executive processes alongside ‘modular’ cognitive processes such as language, memory, spatial processing

yet executive processes [sustained attention, reasoning, working memory] may pervade many cognitive abilities and be important predictors of outcome
Aim:

(1) to develop a 'broad but shallow' screen of multiple cognitive processes in acute stroke

(2) to assess which tests (and cognitive functions) are impaired in different patient groups, and which factors predict cognitive deficits & recovery

(3) to assess the utility of general (single test) measures of cognition relative to finer-grained analyses
Birmingham University Cognitive Screen (BUCS)

Part 1:
Broad but shallow screen to give a general picture of abilities, including measures that predict outcome

Part 2:
Application of finer-grained tests that pin-point a specific deficit that can be linked to rehabilitation
Phase 1 screen: 1 hr to administer, at bedside

Broad cognitive functions:

- Language (comprehension & production, written & spoken)
- Memory (short and longer-term, recognition & recall)
- Attention (spatial & controlled & working memory)
- Praxis (action recognition, production and multi-step sequencing)
- Numbers (number operations and money)
Example **Part 1** test: Controlled attention

Measuring sustained attention, selective attention & working memory

Hear a series of words and respond to ‘no’, ‘hello’, ‘please’

BUT do not respond to ‘yes’, ‘goodbye’ or ‘thanks’
Selective attention = tapping to targets and not distractors

Sustained attention = compare performance blocks 1 & 3

Working memory = practice to learn words, and how many remembered at end
Test uses short, high frequency words, suitable for aphasics

Uses auditory not visual material – closer to everyday life suitable for neglect patients
Tests administered to 200 acute stroke patients (within 1 month of lesion)

Follow-up at 9 months, including measures of activities of daily living

All tests validated against other standardised (but often much longer) tests in the literature

Age-matched norms developed for each test
Frequency of occurrence of deficits relative to controls

Frequency of occurrence of impairment - Left patients

- ATTENTION - controlled
- ATTENTION - spatial
- LTM - episodic
- LTM - orientation
- PRAXIS - ideomotor
- PRAXIS - visuo-constructive
- NUMBER - calculation
- NUMBER - writing
- NUMBER - reading
- LANGUAGE - writing
- LANGUAGE - reading
- LANGUAGE - speech

Legend:
- impaired
- unsure
- spared
In general:

Patients are impaired on tests that ‘load’ on aspects of executive function – measures of controlled attention

Left hemisphere patients fare worse than right hemisphere patients, even on some ‘non-language’ tasks

even with variance due to language factored out, left hemisphere damage predicts measures of selective, controlled attention
On follow-up:

Good ADL outcome predicted by ‘functional memory’, & non-verbal reasoning (executive function)

(no effect of age)

BUCS is currently being rolled-out across the West Midlands (from 2 to 7 hospitals) - opening up the study to look at other factors, such as genetic predictors of recovery from stroke
The ‘broad but shallow’ approach can add to general measures of cognition (MMSE) – particularly by incorporating results on executive functions – without significantly increasing testing requirements on patients.

Aim of the approach – to use the tests to target rehabilitation to the specific in the specific patient.

Is this an effective approach?
AH: 51 year old patient
Left posterior cerebral artery stroke

BUCS revealed: general word finding problem, and a specific reading problem leading to ‘letter by letter’ reading

This led to us targeting her reading problem using computer-based reading therapy, with words presented for decreasing durations
AH - effects of rehabilitation on letter-by-letter reading

AH - effects of rehabilitation on letter-by-letter reading

- LF (pre)
- HF (pre)
- LF (pos)
- HF (post)

Word length

RT (ms)

0 1000 2000 3000 4000

3 5 7 9
Recently this functional approach to understanding cognitive recovery after brain damage has been added-to with the study of the neural basis of recovery using functional brain imaging.
AH - scanned prior to and subsequent to the rehabilitation
AH reading
(2004 & 2005)

AH 2005 > 2004

Evidence for right hemisphere recruitment
Functional brain imaging here adds to our knowledge of how recovery is taking place.

Evidence suggests the recruitment of new brain regions for the task, in this instance.

Highlights the need to develop rehabilitation procedures that target the brain structures sensitive to rehabilitation.
So in sum, to assess cognitive recovery after brain damage means that it must be measured, and measures need to be applicable and sensitive.

These measures should be designed to guide therapy to the critical problem in individual patients.

Measures of functional recovery can be added to by functional imaging, which charts the neural basis of recovery.
The End