Cognitive Functioning in Individuals with Spinal Cord Injury (SCI)

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Outline

- Defining Cognition
  - Cognitive domains
- SCI and Cognitive Functioning
- Potential Sources of Cognitive Deficits in SCI

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Cognition

- "the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses."
  - Conscious and unconscious
  - Concrete and abstract
  - Intuitive and conceptual

Cognition

- Includes the concepts of
  - Knowledge
  - Attention
  - Memory
  - Judgment and evaluation
  - Reasoning and "computation”
  - Problem solving and decision making
  - Comprehension and language production

Cognition

- Cognitive processes use existing knowledge and generate new knowledge
- Ongoing changing *process.*
- *We rely on cognition EVERY day.*
- Central to who we are and what we do with our lives.

Impact of Cognition on Daily Life

- Cognitive deficits lead to:
  - Depression, anxiety
  - Decreased participation
  - Increased unemployment
  - Decreased quality of life

In SCI specifically…

- Cognitive deficits are associated with:
  - Less functional gains during rehabilitation
  - More aggressive behaviors
  - Higher likelihood of re-hospitalization
  - Limited acquisition of novel, day-to-day skills required for community re-integration

Negative Impact

- Rehabilitation efforts and social integration
- Associated with poor self-perception / QOL

Patient Perspective

- Persons with SCI report significant decreases in cognitive functioning from before to after injury
- Patient perceptions of their cognitive challenges:
  - *"I learn things more slowly"*,
  - *"I have difficulty … remembering things"*

So What?

- Age of onset and career productivity
  - Career development may slow or stop
- Physical and cognitive impairments lead to early retirement
- Biggest Obstacles to maintaining employment
  - Information processing deficits
  - Memory deficits

What does this mean?

- MUST identify cognitive deficits when they present and treat them effectively
- First step: Reliably identify the deficits

Cognitive Domains

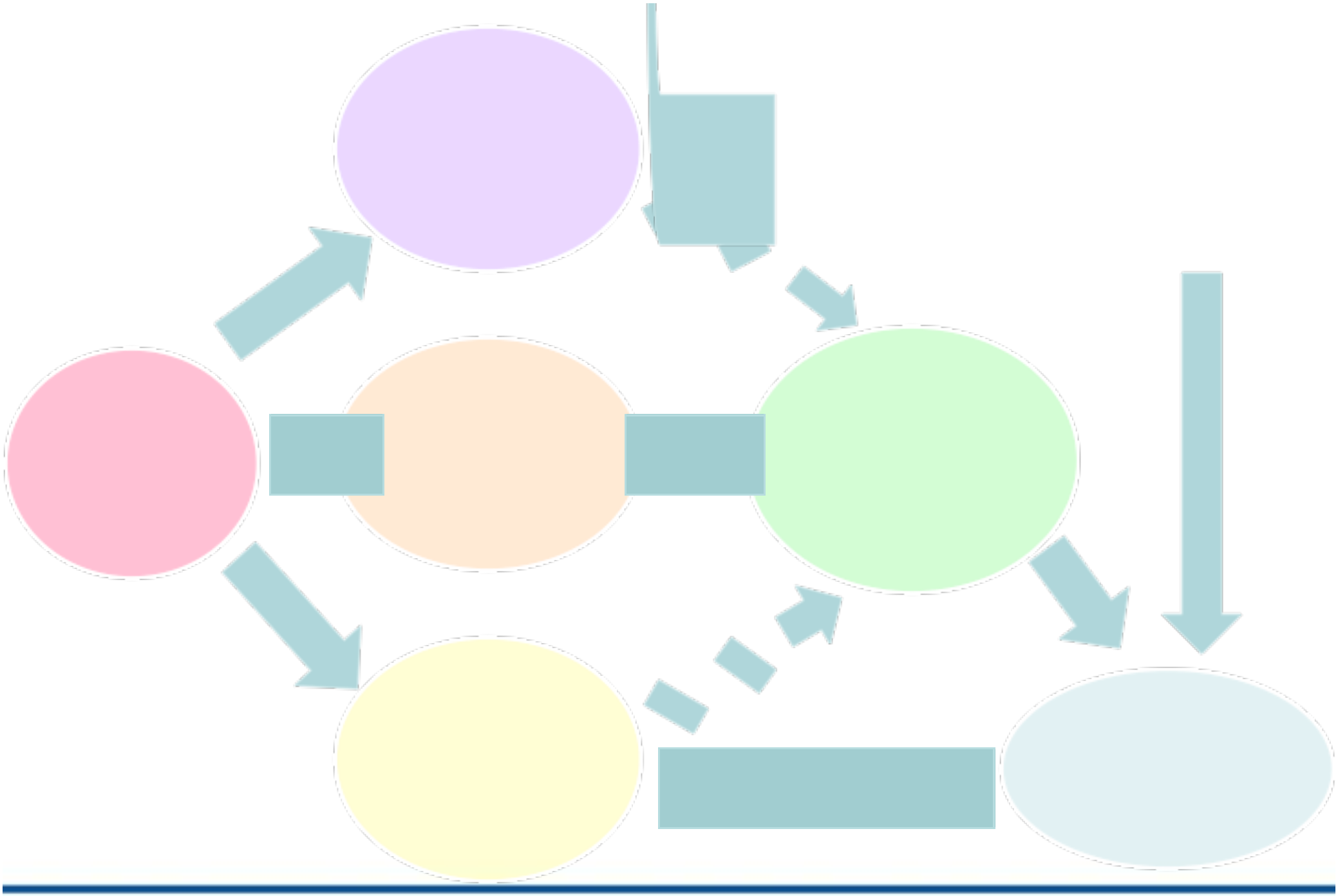
- Attention
- Working Memory
- Processing Speed
- Visuospatial processing
- Long Term Memory
- Executive Functioning

Intelligence - not a cognitive domain, culmination of cognitive abilities

Breaking Down the Domains

- Attention
  - Simple
  - Sustained
  - Divided
- Working Memory
  - Maintenance
  - Manipulation

- Long Term Memory
  - Verbal and Non-verbal
  - Episodic, procedural
  - Retrospective, Prospective
  - Encoding, Consolidation, Retrieval
- Executive Functioning
  - Fluency
  - Mental flexibility
  - Disinhibition
  - Problem Solving
  - Abstract Reasoning



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- Potential causes / sources of Cognitive Deficits in SCI

In the Literature…

- Cognitive deficits have been noted
  - Attention
  - Concentration
  - New learning and memory
  - Abstract reasoning
  - Verbal learning
  - Processing speed

*even in relatively young SCI cohorts (28-45 years)

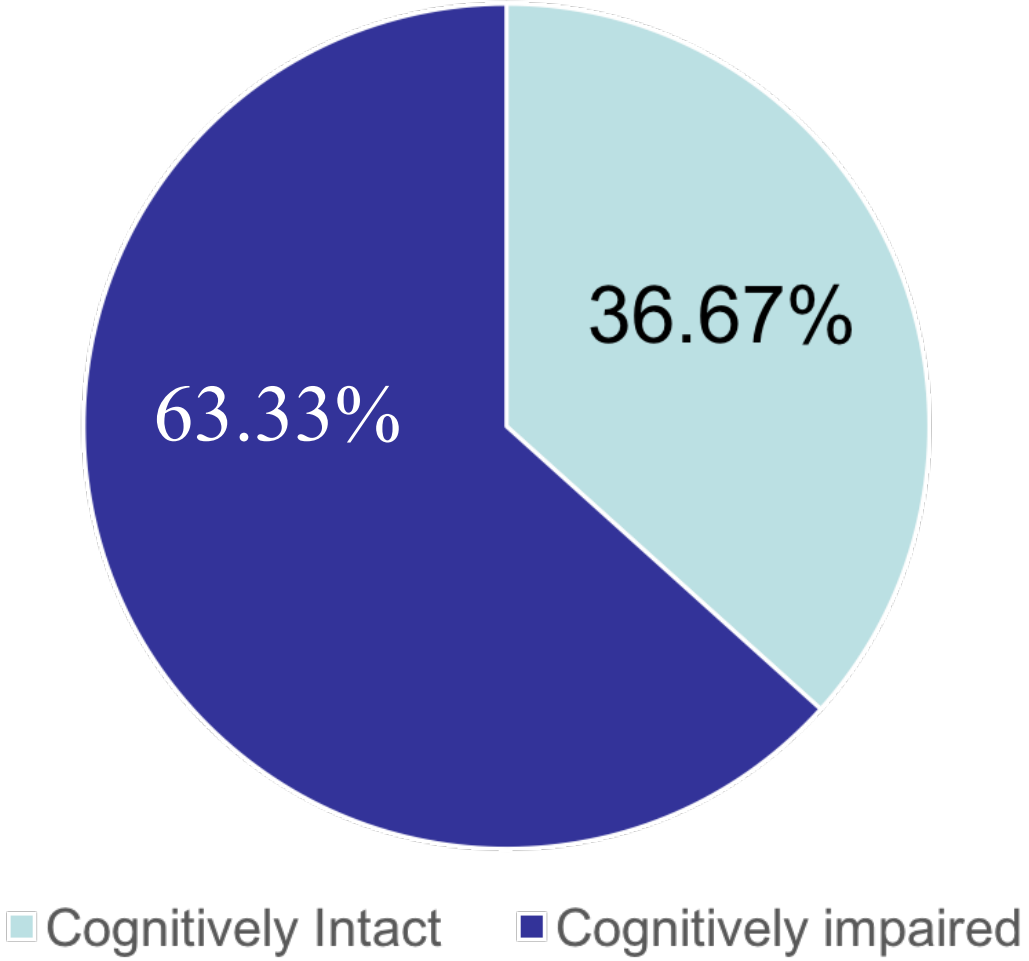
Our data…

- Similar pattern with specific deficits in
  - New Learning and Memory
  - Processing Speed
  - Executive functioning / Working Memory
    - cognitive flexibility

Sample Characteristics

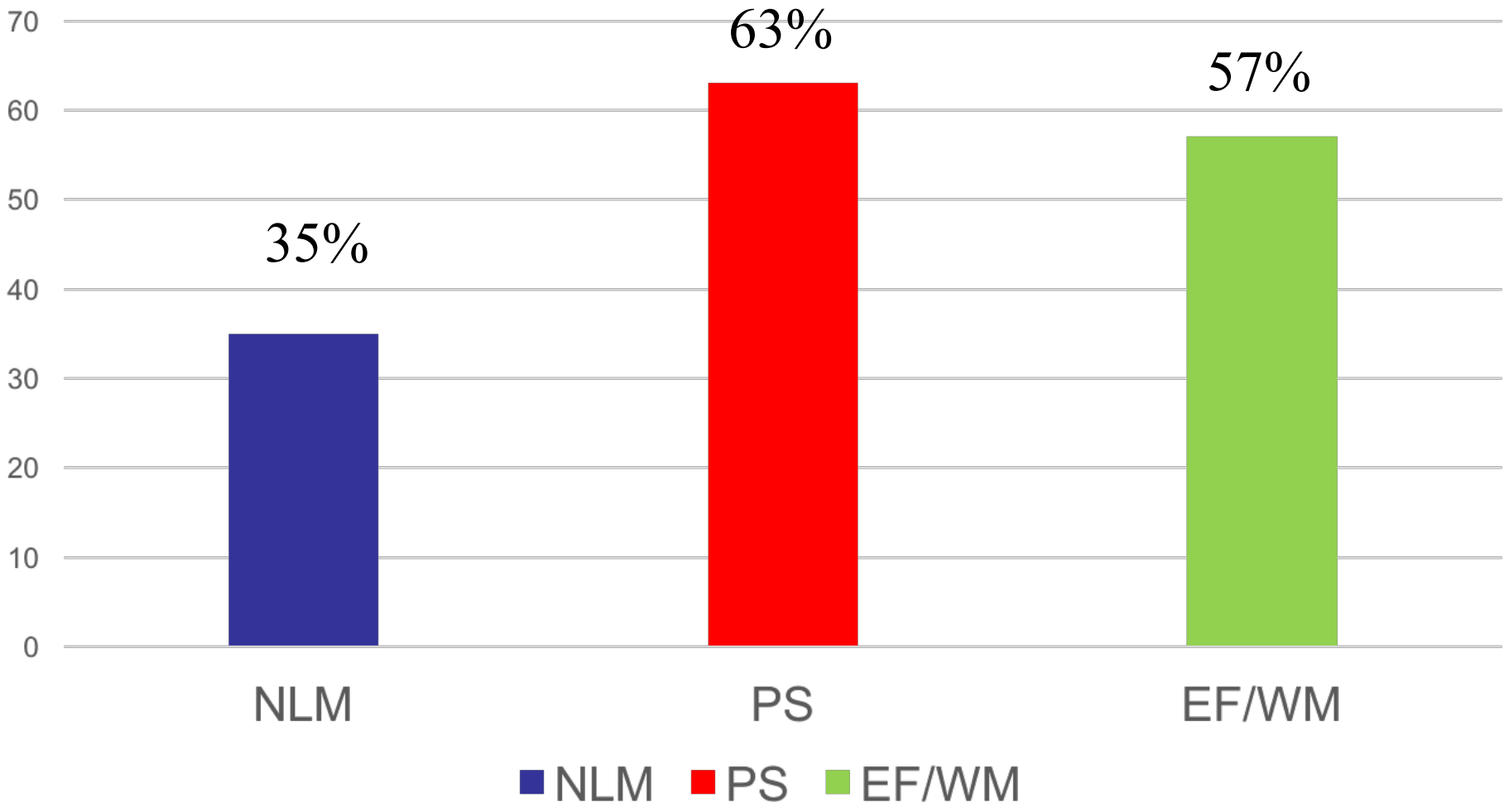
	SCI N=60	Healthy Controls N=50
Age	35.38 (7.01)	45.58 (13.49)
Education	13.65 (2.24)	15.76 (2.04)
Time since injury	9.83 (7.32)	n/a
Level of Injury	C1-8: n=31 T1-5: n=6 T6 and below: n=23	n/a

Cognitive Impairment in SCI



Global Impairment: Performance >1 SD below HC on 2 or more tests

Impairment by Cognitive Domain



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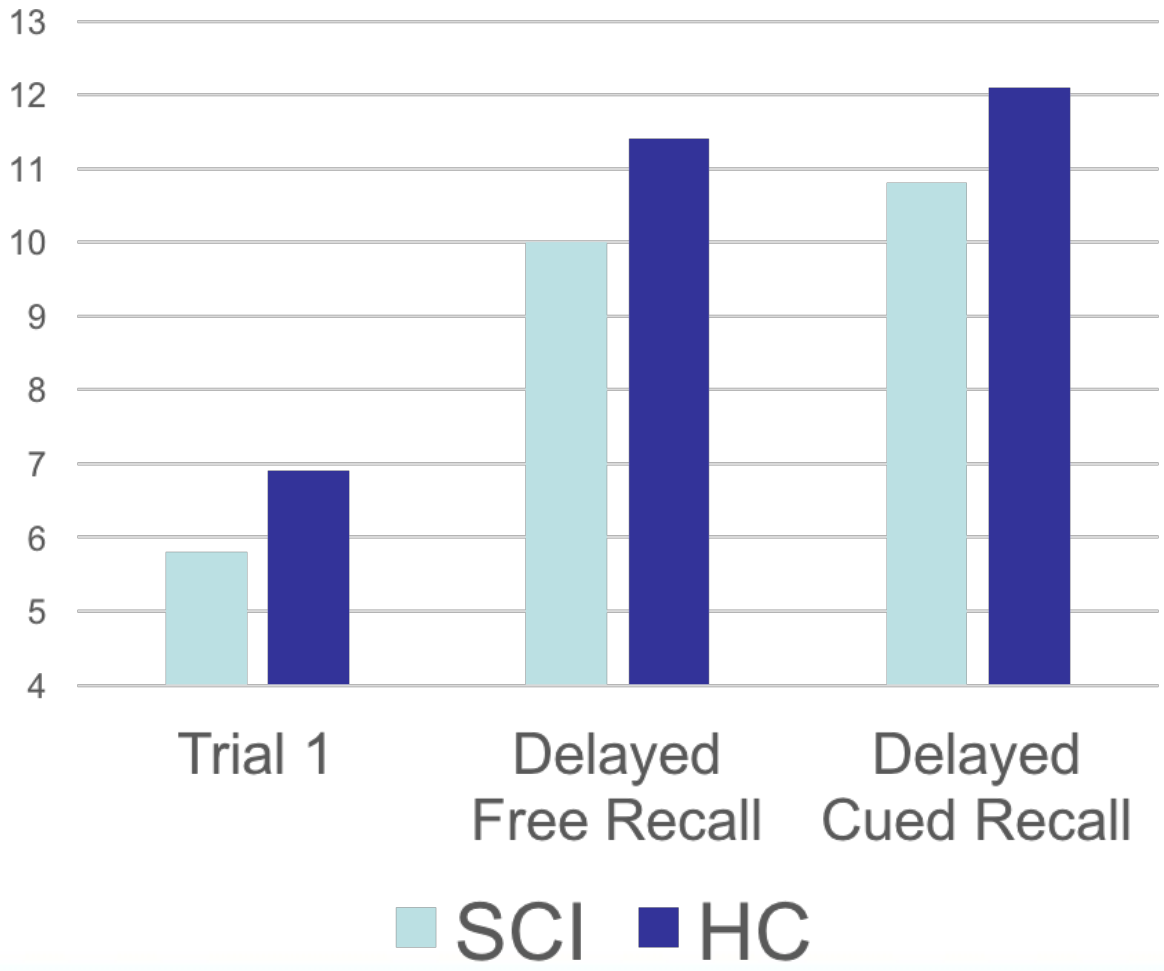
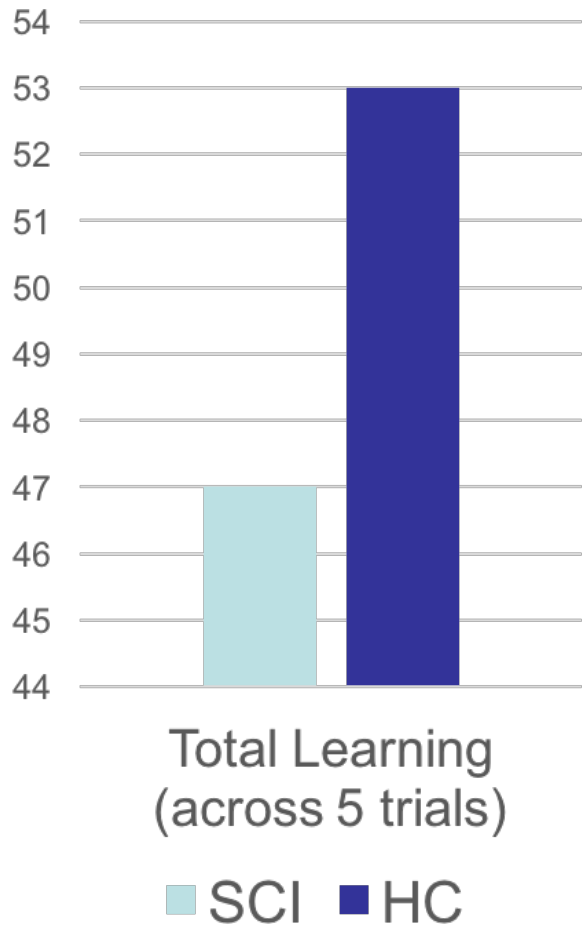
Novel Approaches to the problem

- Break down NLM
  - One trial learning
  - Learning over repeated trials
  - Recall after different delays
  - Procedural learning
- Are there neuroimaging changes?
- Role of level of injury

Learning and Memory Performance





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Correlations between NLM and QOL

	CVLT-long delay free recall	CVLT recognition discriminability
SCI-QOL Cognition	0.195	0.328*
SCI-QOL Fatigue	0.146	0.323*
SCI-QOL Positive Affect & Well Being	-0.396*	-0.461*
SCI-QOL Resilience	-0.425**	-0.365*

* $p<0.05$

**$p<0.01$

Implicit Procedural Learning

- Bloch et al
  - 10 persons with acute SCI in T1-T11
  - 10 HC participants
  - serial reaction time task
    - examines implicit motor sequence learning

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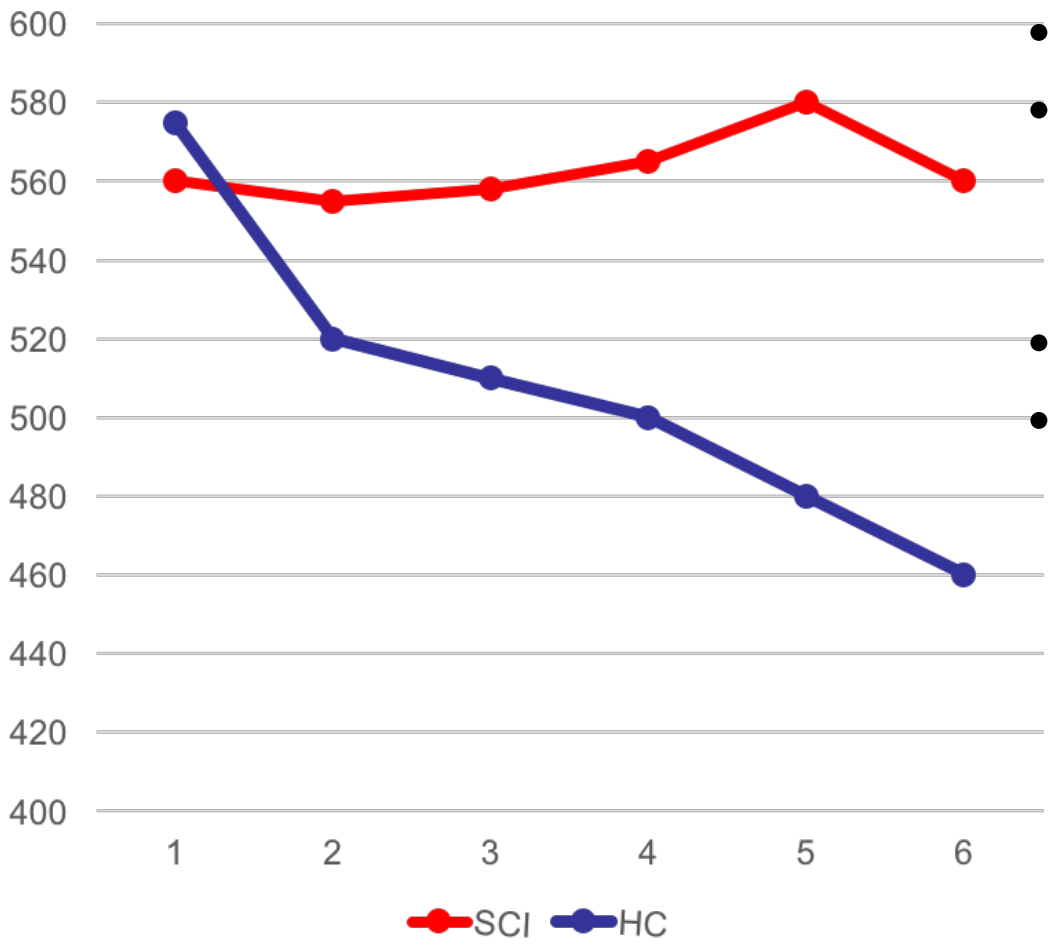
Performance of IPL task in SCI vs HC



SCI group

no decline in reaction time over blocks

HC group

Expected decline in reaction time over the 6 trials

*No differences between groups on other cognitive measures.

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Study Implications

- Rehabilitation and everyday life functioning
  - Rehab is heavily reliant on IPL due to the emphasis on motor learning
  - Deficits in IPL will result in a substantial limitation in benefit from rehabilitation

- Preliminary due
  - Small sample size
  - Inclusion of only acute patients
  - Follow-up study under review

Neuroimaging

- Not yet been used to examine cognition post SCI

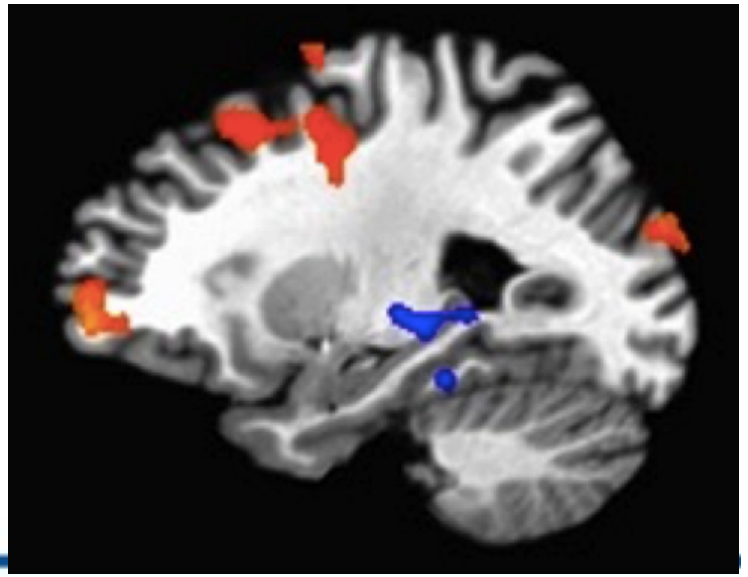
- Our pilot data:
  - cognitive changes present with changes on functional neuroimaging

fMRI of the brain during explicit memory task

- Recognition memory test, persons with paraplegia vs HCs
  - SCI performed more poorly
  - more activation in frontal and parietal regions, but less activation in explicit memory (hippocampus)

*NLM tasks require more cerebral resources in those with paraplegia as compared with HCs

*Dedicated more cerebral resources but not effective at improving performance

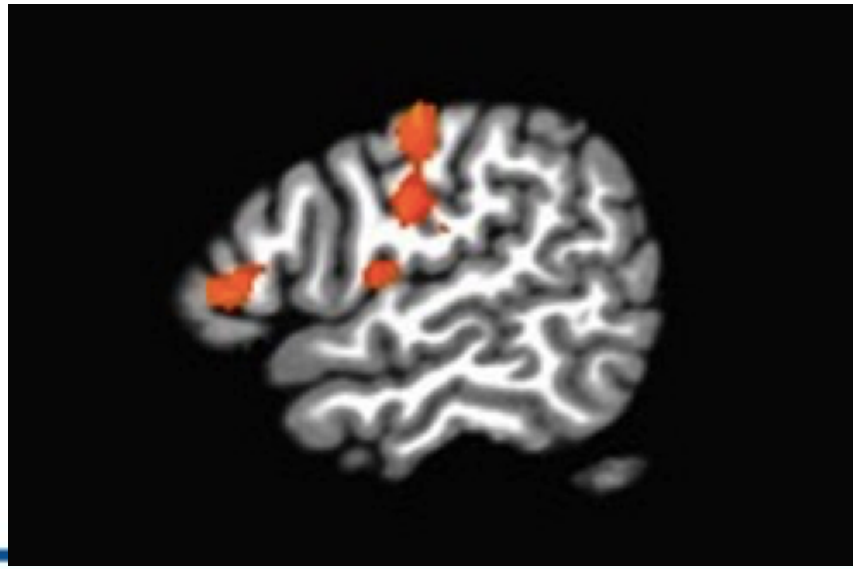


fMRI of the brain during PS task

- PS task, persons with tetraplegia
  - performed more poorly than HC
  - Showed more activation in frontal and motor regions than HCs.

*PS tasks require more cerebral resources in those with tetraplegia as compared with HCs

*Dedicated more cerebral resources but not effective at improving performance



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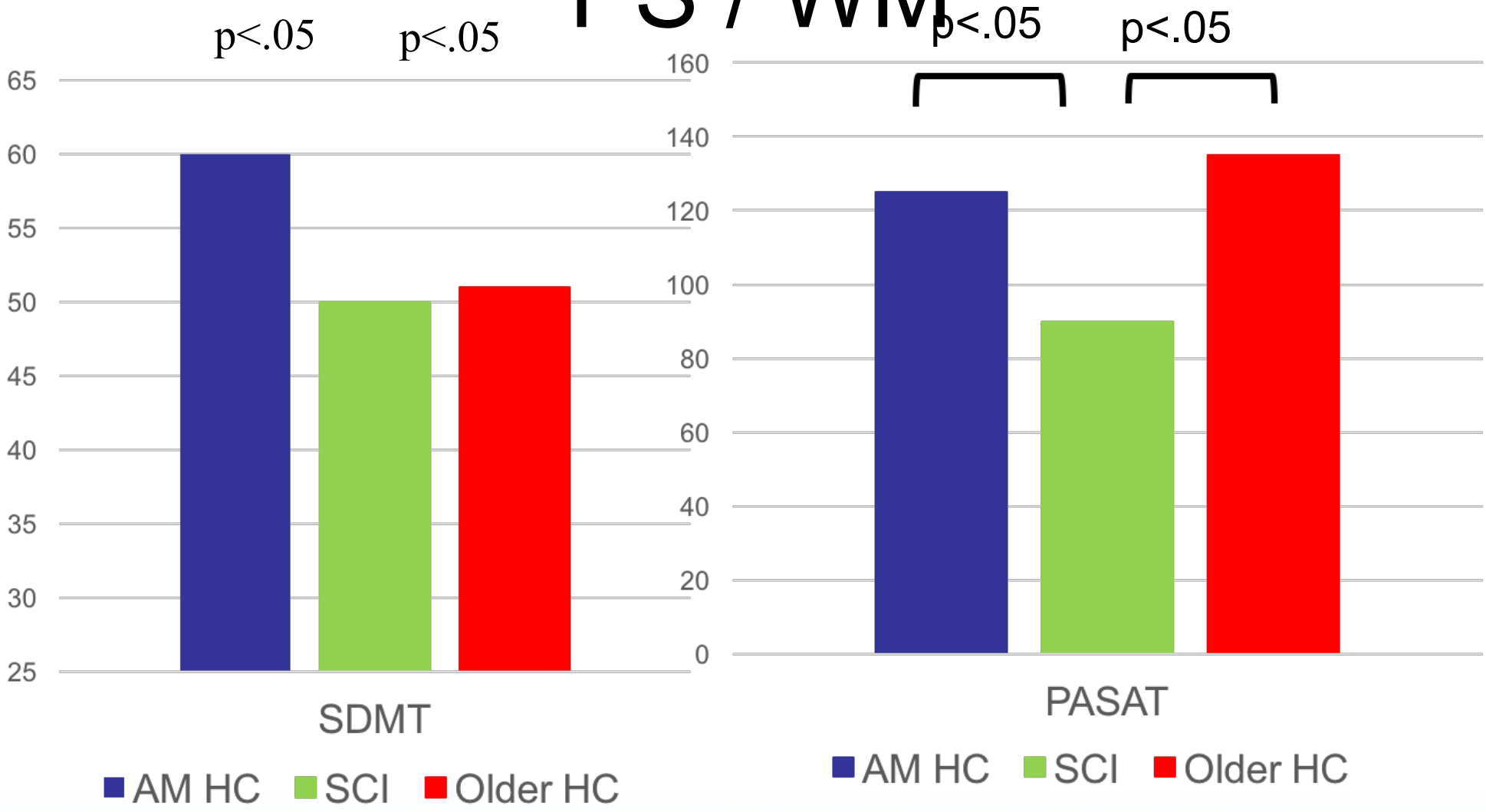
Level of Injury

- Are there differences in cognition depending on level of injury
  - Cardiovascular role?
  - Risk of concomitant TBI

Sample Characteristics

	Tetraplegia N=18 C3-C8	High Para N=5 T1-T5	Low Para N=14 T7-T12	Older Controls N=14	Age Matched Controls N=18
Age	38±8	39±6	34±6	60±3	36±8
Duration of Injury	14.2±8.9	13.6±5.1	8.4±4.5	n/a	n/a
Education	14.1±2.8	13.8±1.5	13.3±2.2	16.3±2.5	15.9±2.0

SCI vs Young and Older HC PS / WM



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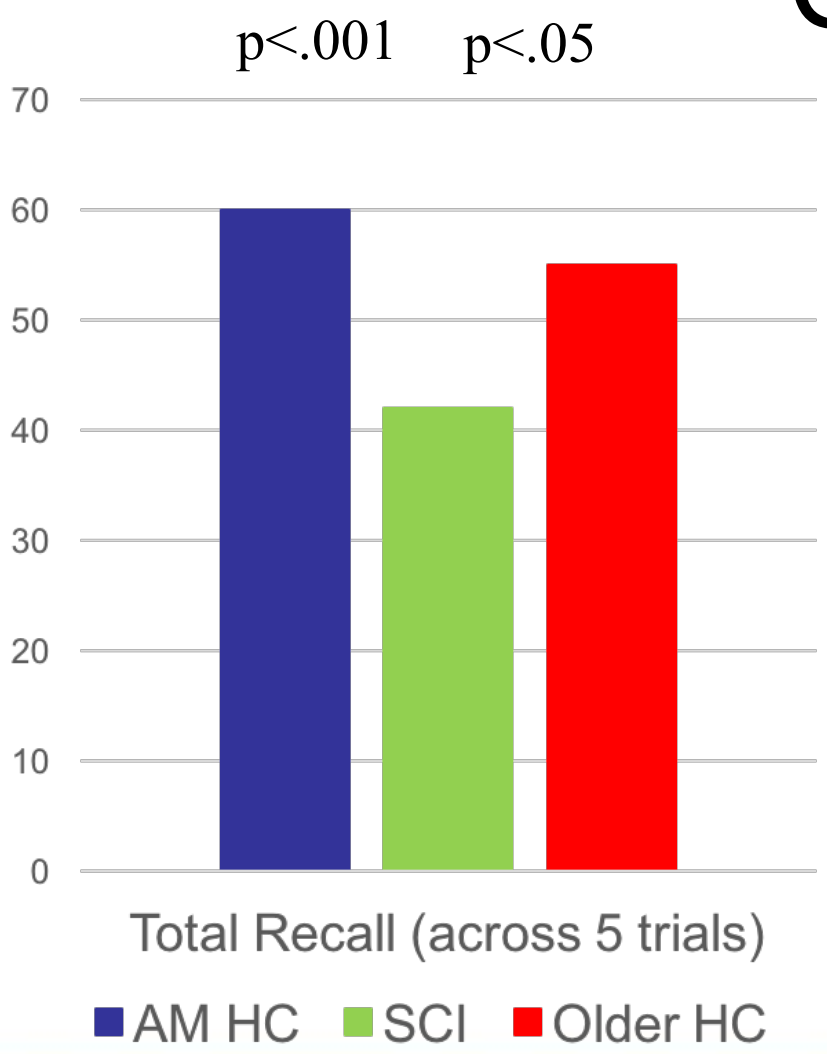
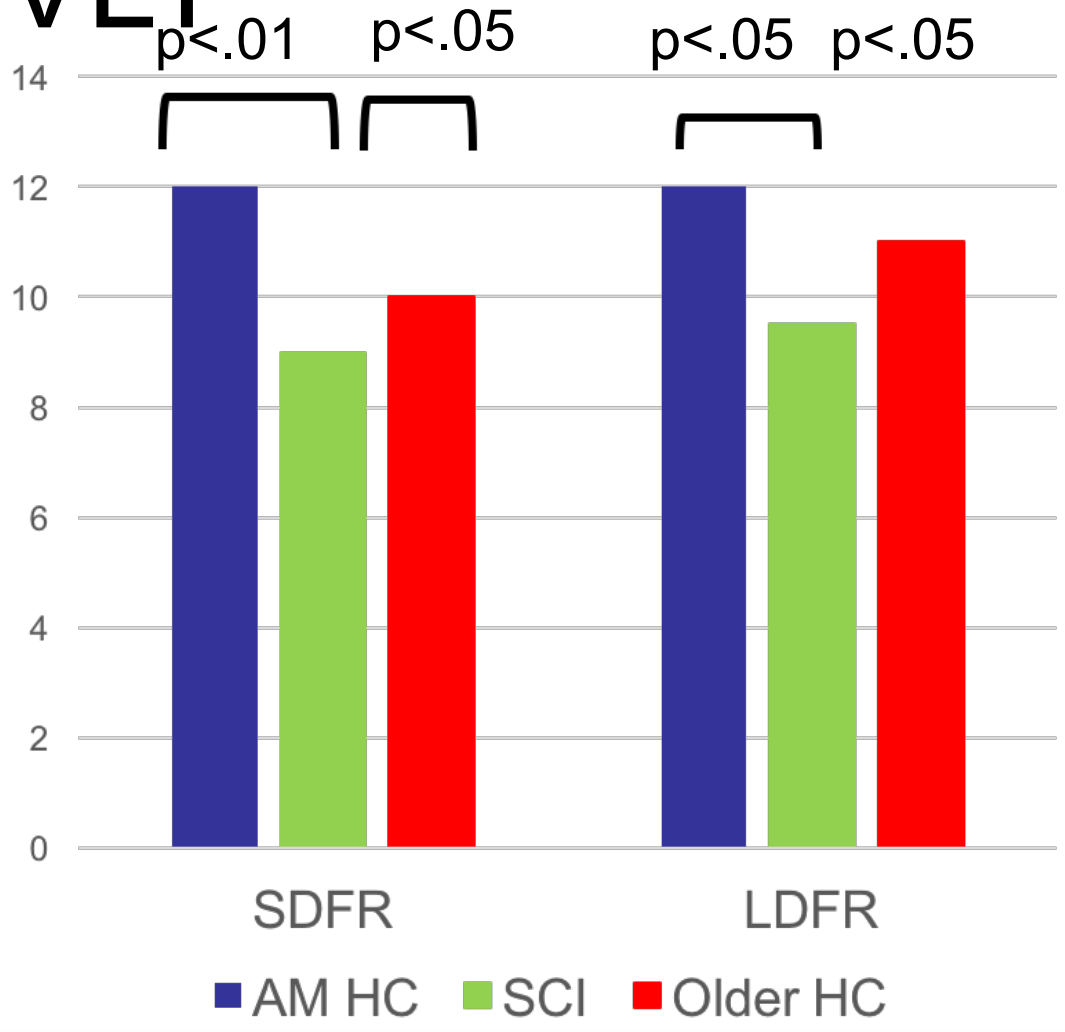
SCI vs Young and Older HC CVLT





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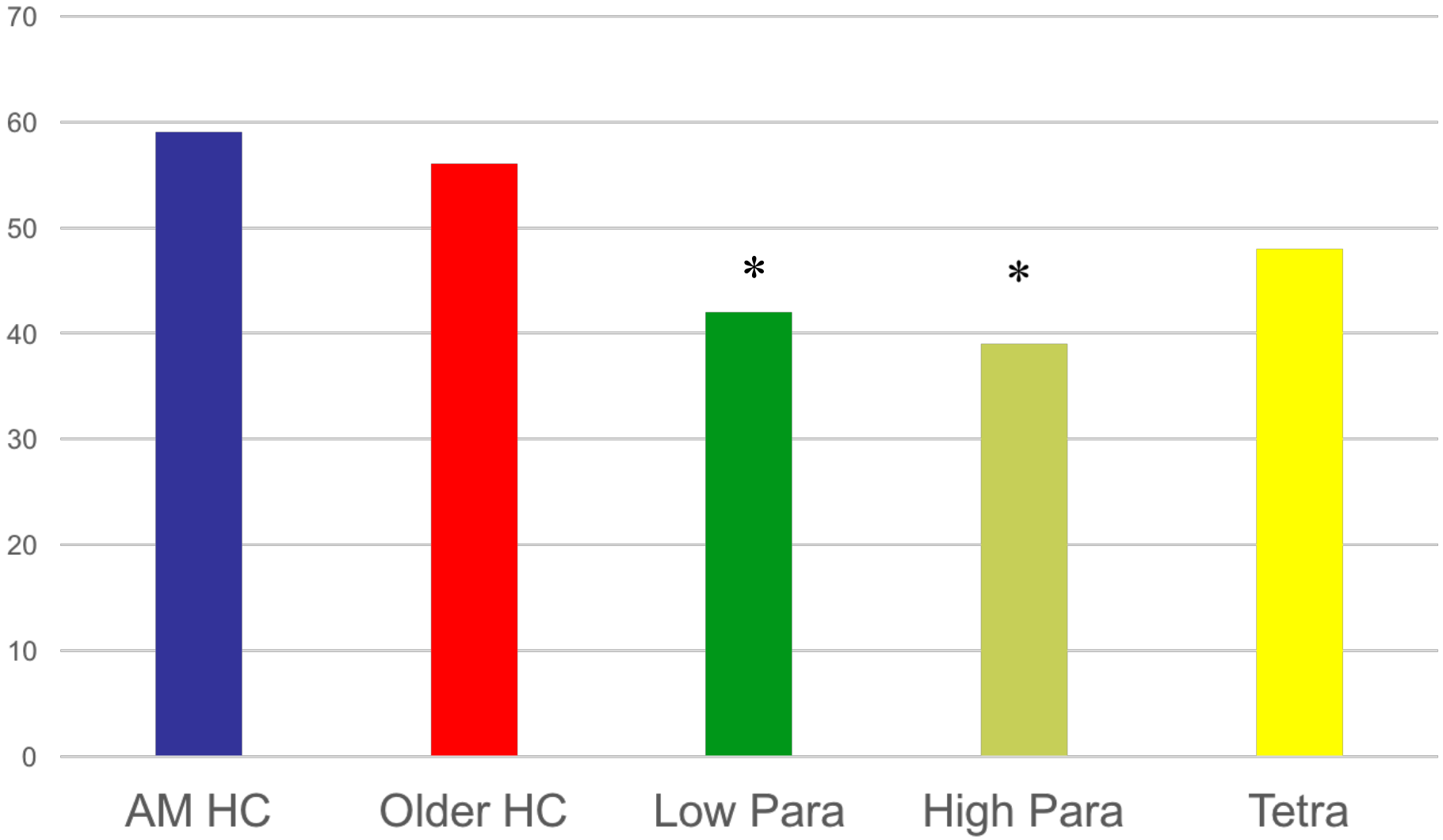
CVLT by level of Injury



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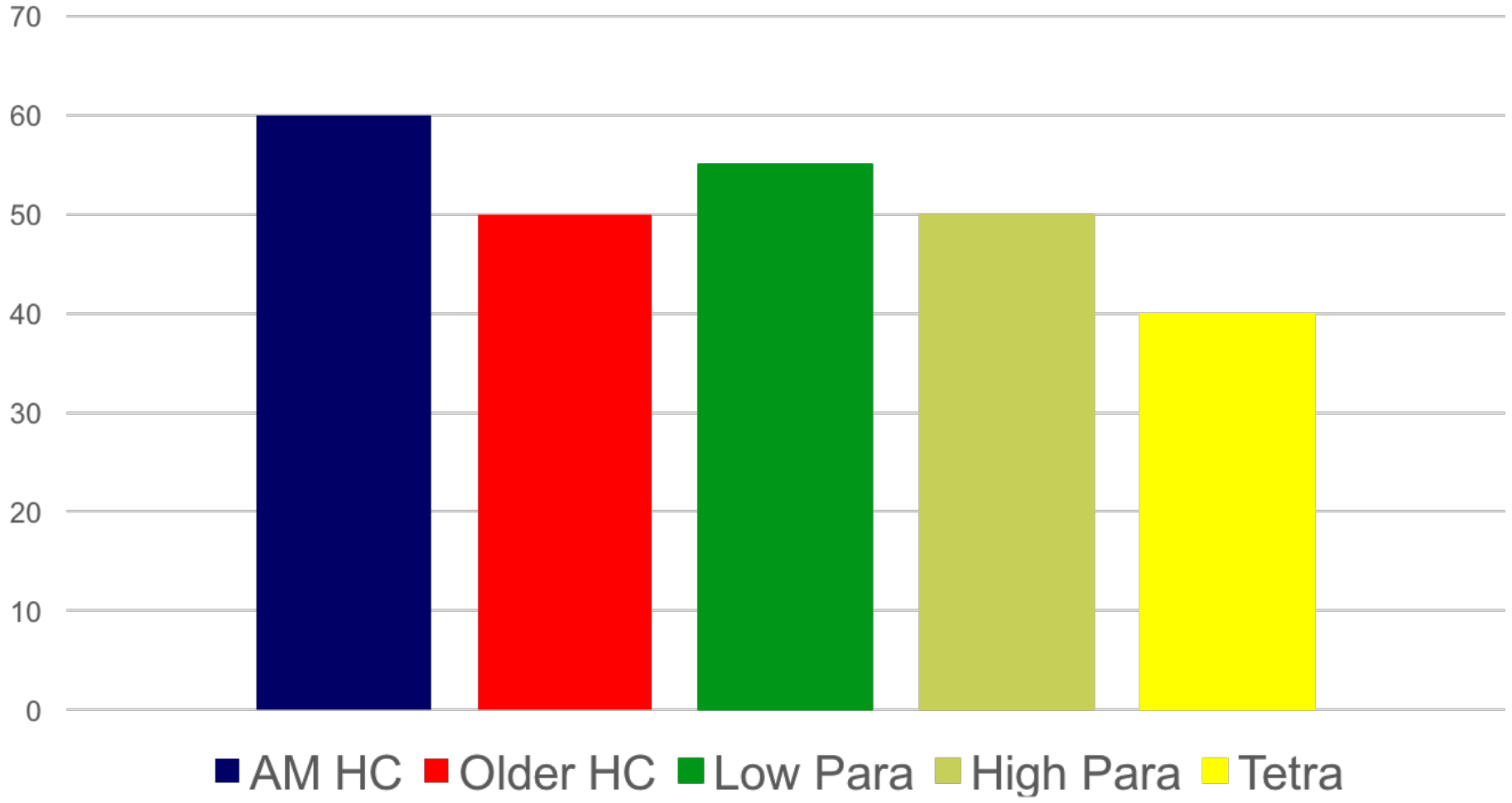
* p<.05 vs age matched HC

SDMT by level of injury

* p<.01



Summary of Deficits

- Overall SCI:
  - New Learning & Memory
  - Processing Speed
  - Working Memory
- Para
  - New Learning & Memory
- Tetra
  - Processing Speed

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Etiology

- Several potentially contributory factors
- Concomitant traumatic brain injury (TBI)
  - Frequently "blamed"
  - Bombardier et al (DATE)
    - The number of patients reporting deficits consistent with TBI far exceeded physician-rated presence of TBI by 80% in their sample of 105 persons with SCI.
    - Factors other than concomitant TBI are involved
- Secondary trauma as a result of cerebral edema, hypoxia and anoxia
- Cardiovascular and cerebrovascular dysfunction

Other Factors in Expression

- Physical factors may play a role
  - sleep apnea
  - temperature dysregulation
  - medications

Methods for Determining Cause

- Cerebrovascular testing during cognitive performance
- Imaging
  - Brain
  - DTI, fMRI
- Observing trajectory of change
- Ongoing work – still much to do!

Take Home Message

- Cognitive Function following SCI is important to consider
- Impact can be significant!
  - rehabilitation efficacy
  - Daily life functioning
  - Social re-integration
  - Quality of Life
- Recognize and consult - identification is key!

Treatment on the horizon

- We have data indicating a contribution of cerebrovascular insufficiency
  - Treat low BP and observe cognition
    - Ongoing study with Midodrine
    - Observing immediate and long term effects
- Also observing fMRI abnormalities
  - Early Cognitive Rehabilitation?
    - Ongoing cognitive rehab trial in SCI
    - Data in other populations – treatment for more mild deficits most promising

Collaborators

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