PROMOTING SOCIAL ENGAGEMENT BY UNDERSTANDING, AND ENHANCING, EMOTIONAL RESPONSITIVY IN PERSONS WHO HAVE EXPERIENCED ABI

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Harnessing the Power

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PSYCHOSOCIAL OUTCOMES & BRAIN INJURY

Psychosocial outcomes for individuals who have experienced an acquired brain injury (ABI) are more limited relative to age-appropriate cohorts.

While cognitive and physical gains have permitted return to activities and engagement when assessed ***10 years*** later***, socioemotional factors continue to influence community integration and quality of life satisfaction*** (e.g. Draper, Ponsford, & Schonberger, 2007; Hoofen, Gilboa, Vakil, & Donovick, 2001)

PSYCHOSOCIAL OUTCOMES & BRAIN INJURY

Individuals, and others who know them, report ***continuing and high rates of depression, anxiety, and loneliness***; and successful social interactions and relationships are compromised as a function of ***social challenges, not the least of which includes the person's aggression or anger.***

PSYCHOSOCIAL OUTCOMES & BRAIN INJURY

Our studies demonstrate ***that individuals are***, in fact, ***physiologically underaroused*** prior to a triggering event and are ***less able to interpret emotional signals*** from themselves or others.

As a result, ***social personality variables of aggression or anger are actually reactive*** in nature – not a 'state' of being.

Incompatible social responses, or reduced social contact in the community arise, in part, due to a lessened ability to experience emotional responses in one's self or detect the emotional reactions of others.

PSYCHOSOCIAL OUTCOMES & BRAIN INJURY

Social judgments and risky decisions result from limited emotional markers (e.g. Koenigs et al, 2007) that typically guide behaviour to alert us to safe or less safe choices.

Improving the arousal/stress response in persons who have experienced an ABI has been shown to ***ameliorate these emotional*** indicators and provide us with an ***intervention to enhance*** or promote improved ***social engagement*** and outcomes.

The Real World

- Persons with traumatic brain injury have been compromised in:
  - Social decision making (Ciaramelli et al., 2007)
  - Moral decision making (Koenigs et al., 2007)
  - Emotional functioning (Barbas, 2003; Stuss et al., 1992)
- Also present with attenuated physiological responses (i.e., underaroused status) (Tranel & Damasio, 1994)
- All which are subserved by a complex network of brain areas involved in both emotional and cognitive processes, especially the orbitofrontal cortex (OFC) region

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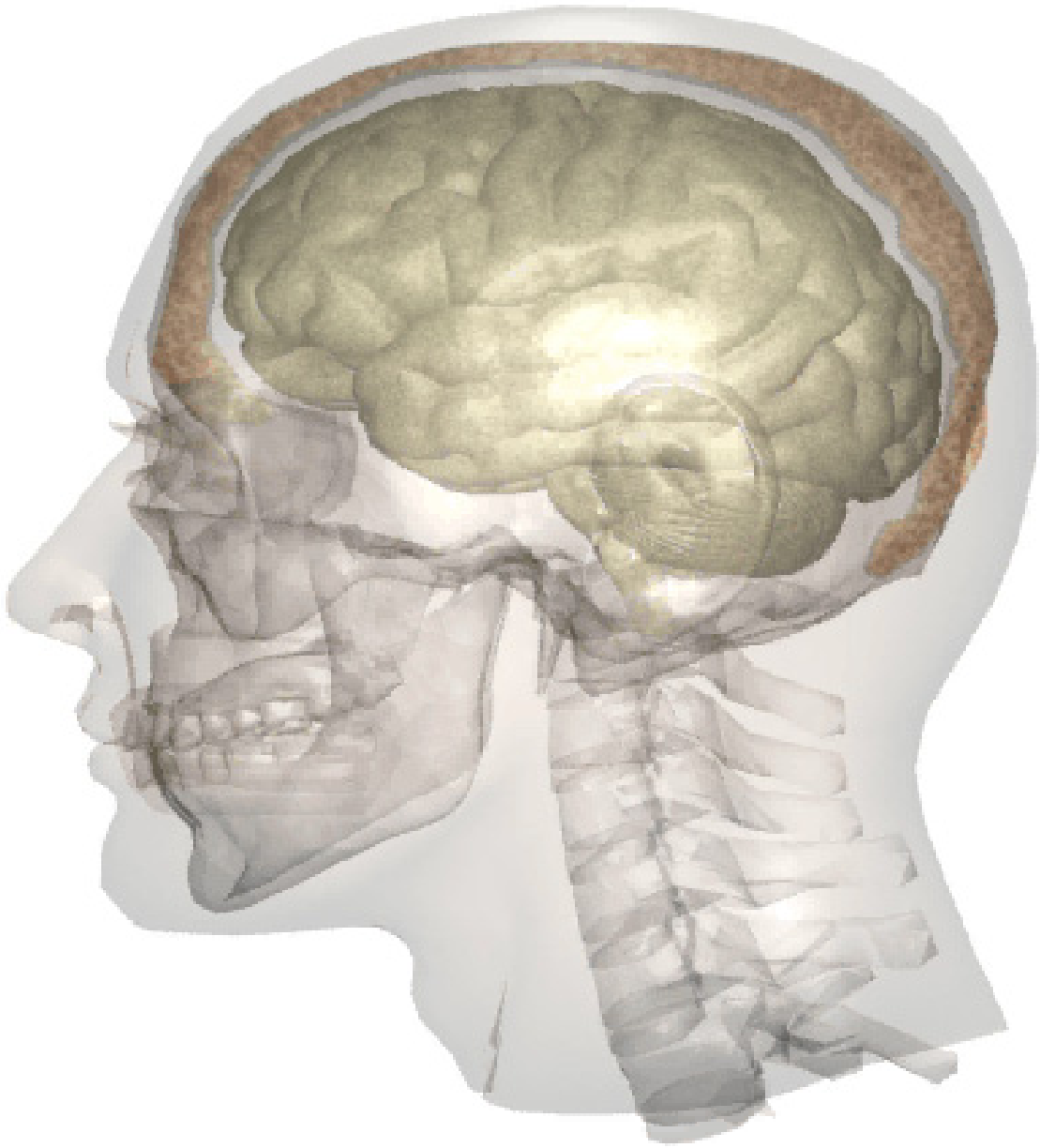

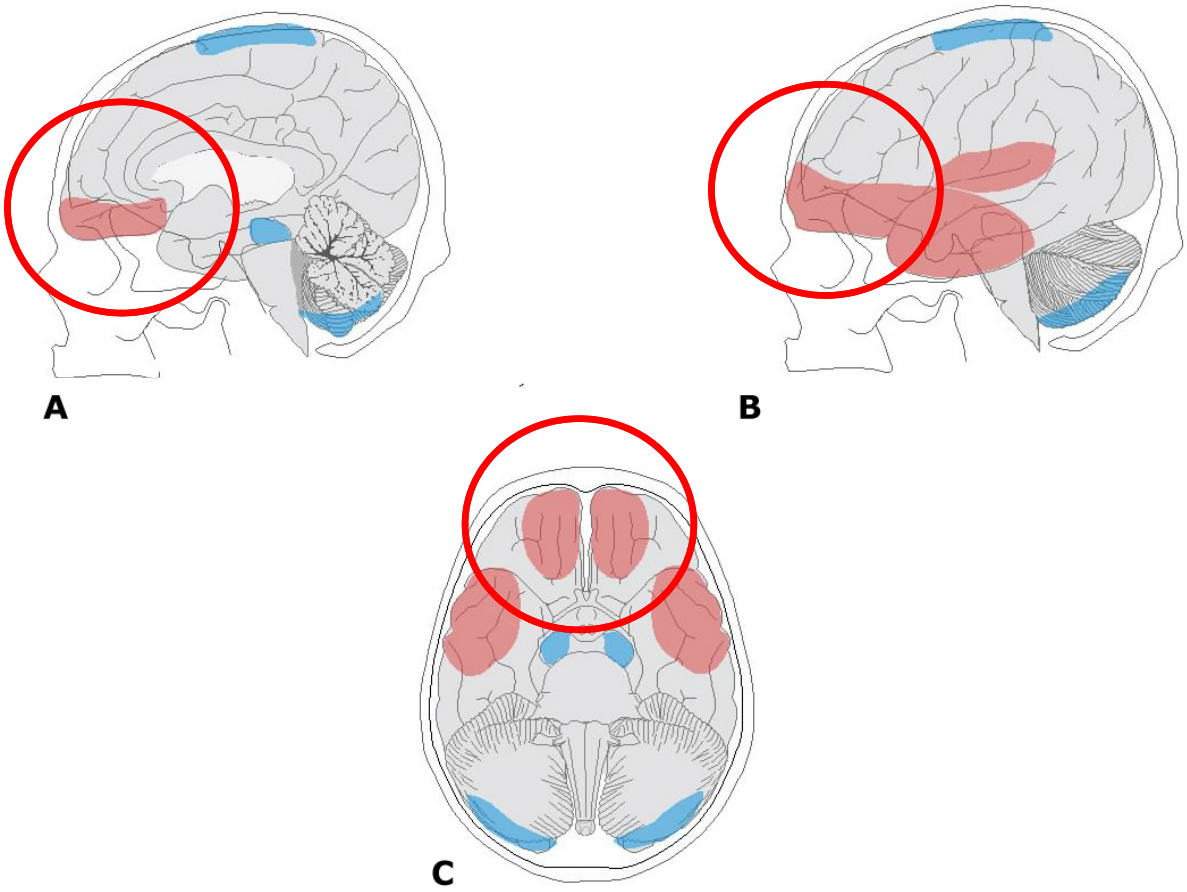

Schematic diagrams of contusion most commonly affected by contusions (red) and those that are occasionally affected by contusions (blue). Areas that are predominantly affected by contusions include the ***orbitofrontal cortex***, anterior temporal lobe, and posterior portion of the superior temporal gyrus area, with the adjacent parietal opercular area.

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Injury to the Frontal Lobes

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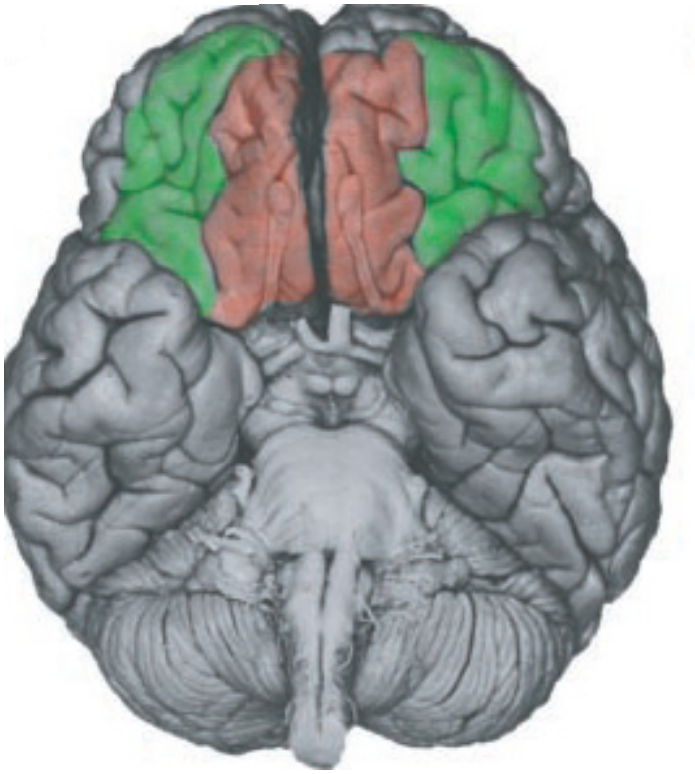
- Persons with injury to the OFC/VMPFC:
- ***Cognitive impairments*** (inflexibility, etc.)
- ***Social deficits*** (poor decision making, etc.)
- ***Differential emotional arousal*** via disrupted reciprocal connectivity between subcortical and OFC strucuters
  - → possible differential autonomic responsivity (dysregulation)



See Wallis (2007) for review

PHYSIOLOGICAL FEEDBACK

- And these behaviours are likely all reflective of OFC connectivity:

  e.g. limits on decision making may reflect lack of physiological/emotive feedback indicating 'caution'

  i.e. the relationship between

  - "Gut Reaction"/Arousal and the decision 'not' to do something

(Bechara, Damasio, &Damasio, 2000)

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CONSEQUENCES OF PFC/OFC INJURY: KNOWING VERSUS DOING

- Global intellect intact, but unable to apply social knowledge (e.g., Phineas Gage - Harlow, 1848).
- Cognitively competent, but *in vivo* decision-making impaired (e.g., E.V.R. - Eslinger et al., 1985; Saver et al., 1991).
- Understand problem and possible solutions, but inability to execute properly (Robertson et al., 2008).

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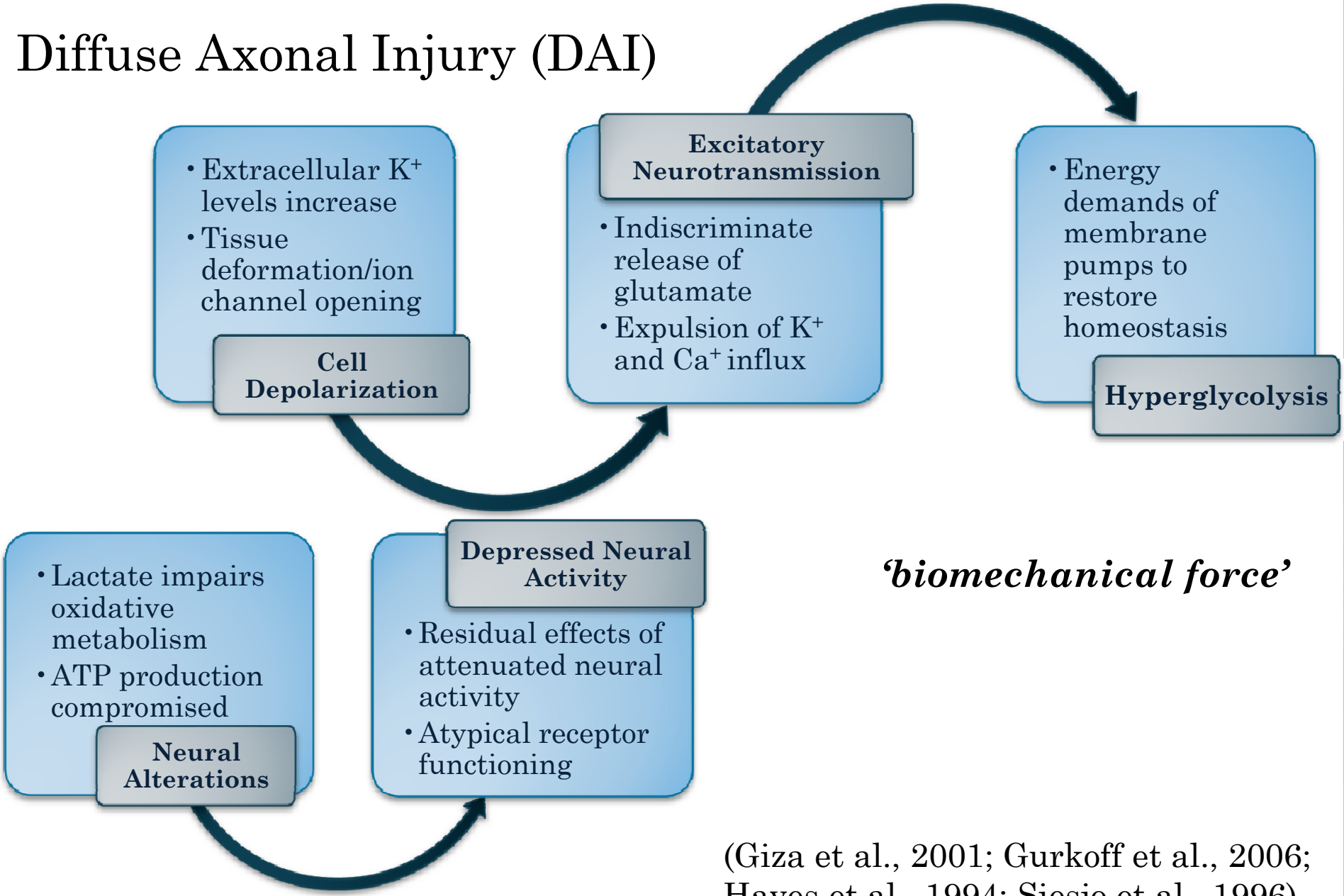
What is the Mechanism? And Factors that influence outcome – and can do so by examining Individuals with milder injuries

Prevalence of ***head Injury***

- Globally, 57 million hospitalizations per year (Langlois et al., 2006)
- 1/3 sustain injury before 25 (McKinlay et al., 2008)
- 70-90% classified as 'mild' (Cassidy et al., 2004)

Pathophysiological Consequences of Injury

- Diffuse Axonal Injury (DAI)



'biomechanical force'

(Giza et al., 2001; Gurkoff et al., 2006; Hayes et al., 1994; Siesjo et al., 1996)

Mild Head Injury

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- Kay et al. (1993):
  - physical trauma to the head via ***biomechanical force*** sufficient to produce an ***alteration*** **in consciousness** (e.g., dizziness, dazed, disoriented)
  - loss of consciousness not required

Previous studies have shown the prevalence of MHI in university students to be ~37% (Chuah et al., 2004; Segalowitz & Lawson, 1995)

- Sustained MHI primarily due to:
  - Accidental falls
  - Sports activities
  - Motor Vehicle Collisions

    (Belanger & Vanderploeg, 2005; Cassidy et al., 2004)

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Mild Head Injury & Personality

- Interpersonal relationships rely on personality
- Personality factors:
  - Socially unacceptable behaviours
  - Aggression
  - Impulsivity

Research question

Is mild head injury associated with maladaptive personality characteristics? If yes then which ones?

MHI Indicator

Questionnaire:

- Demographics

Have you ever had a head injury resulting in an altered state of consciousness (including: vomiting, dizziness, seeing stars, confusion)?

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Mild Head Injury & Personality

- Participants
  - 87 undergraduate university students (70% women)
  - 47 reported sustaining a mild head injury (54%)
  - On average 20 years old for both groups

	No MHI	MHI	Total
Men	9 (21%)	18 (38%)	27
Women	34 (79%)	29 (62%)	63
Total	43	47	90

Chi-Square = 3.23, $p > .05$

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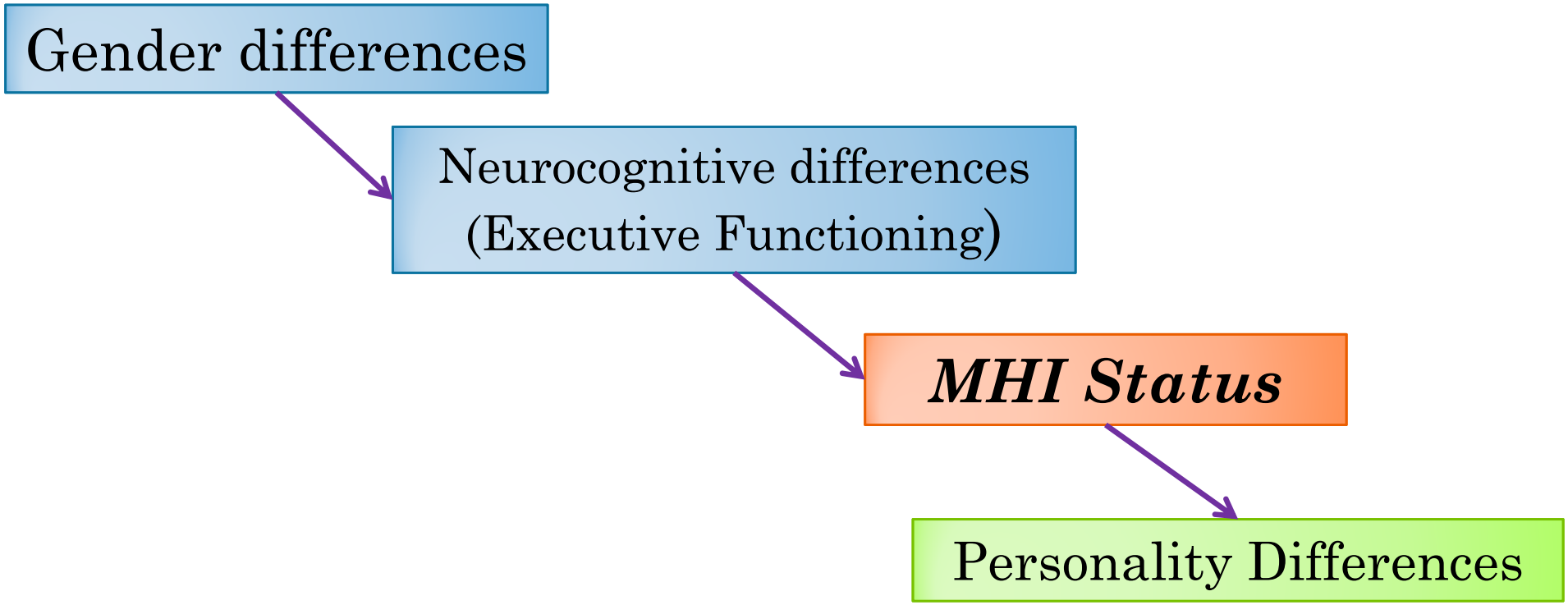
Mild Head Injury & Personality

- Personality
  - Aggression Questionnaire (Buss & Perry, 1992)
    - Physical aggression, Verbal aggression, Hostility, Anger
  - SRP Checklist (Paulhus et al., in press)
    - Erratic lifestyle, Socially unacceptable behaviours, Callous affect, Interpersonal manipulation
  - Barratt's Impulsiveness Scale (Patton, Stanford, & Barratt, 1995)
    - Attentional impulsivity, Non-planning, Disinhibition
  - Delay discounting/gratification task (Kirby, Petry, & Bickel, 1999)

Mild Head Injury & Personality

- Executive function
  - Reasoning
    - CTONI (1996)
  - Cognitive flexibility
    - Trails (DKEFS, 2002)
  - Sustained attention
    - NEPSY (NEPSY-2nd Ed., 2007)
  - Working memory
    - Mental Control (WMS-III, 1997)
    - Letter number sequencing (WMS-III, 1997)

MHI and Personality: Expectations



- MHI status would predict personality differences even after gender and executive functioning differences have been taken into consideration
  - *Higher levels socially unacceptable behaviour and erratic lifestyle*
  - *Higher levels of reactive aggression*
  - *Higher levels of disinhibition (impulsivity)*

MHI AND PERSONALITY: RESULTS

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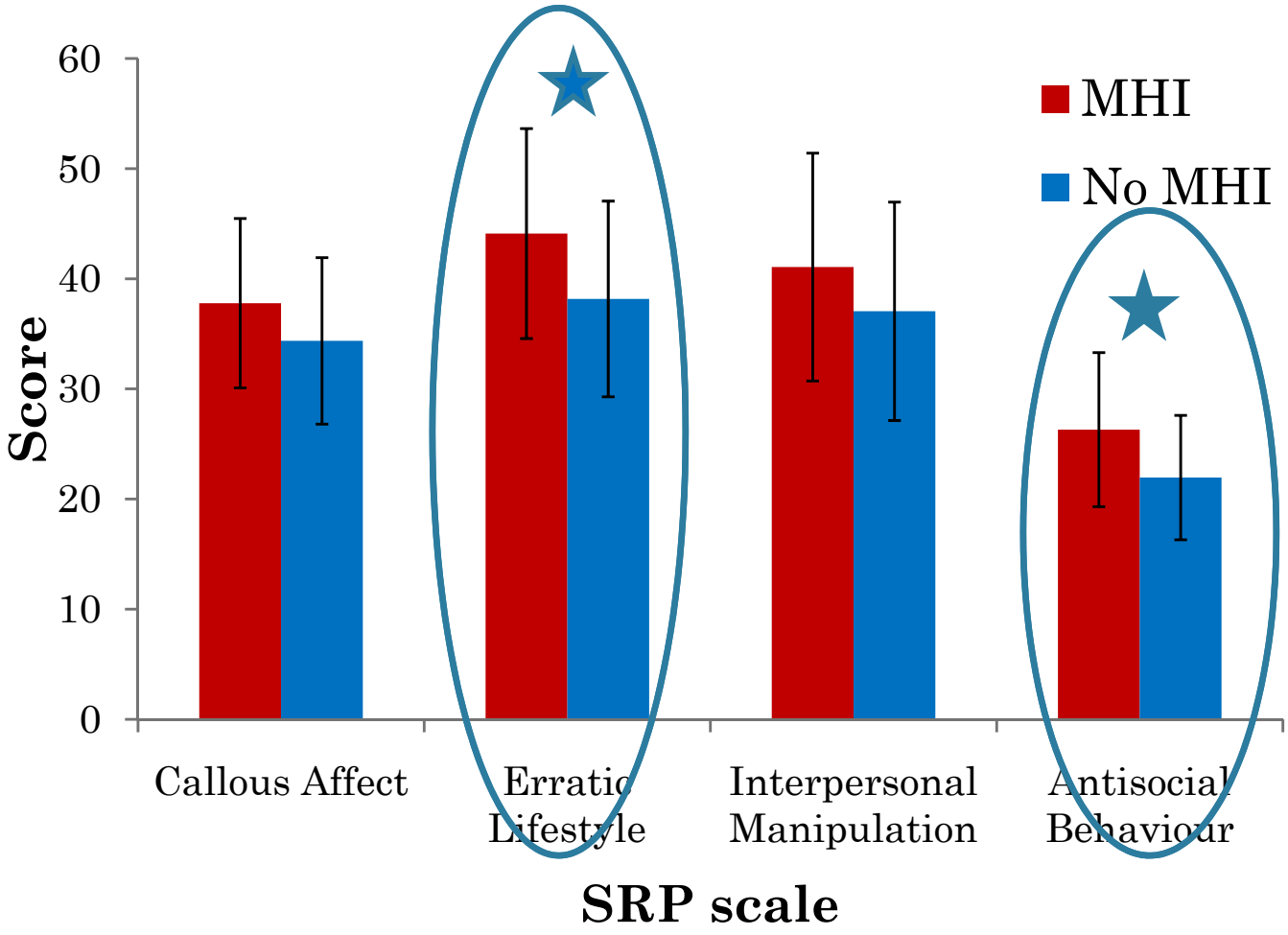
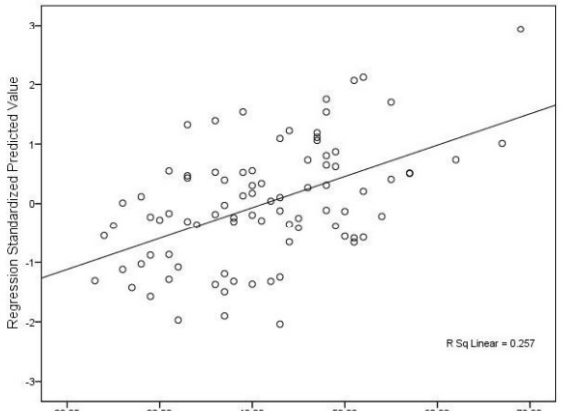
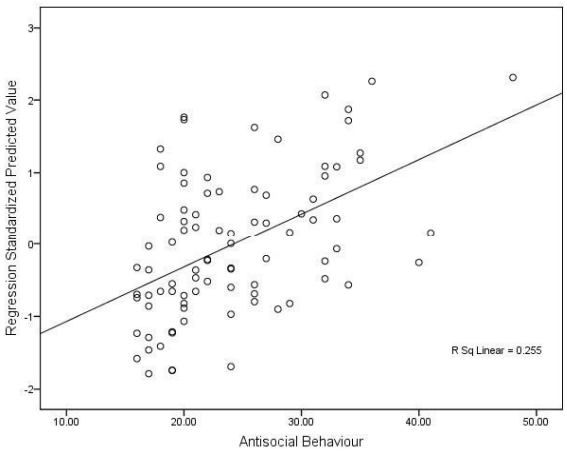
- Only erratic lifestyle and socially unacceptable behaviour were associated with MHI





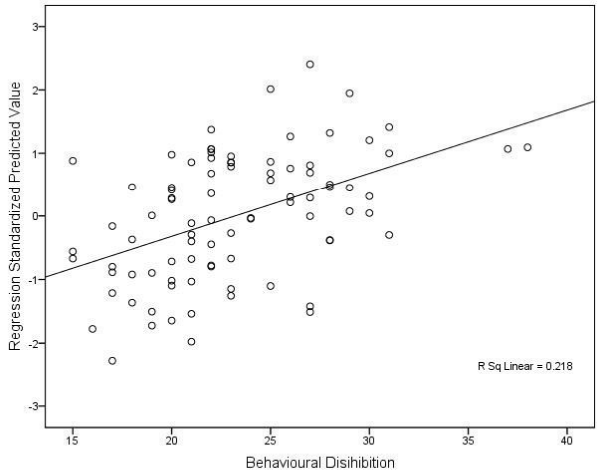
Erratic Lifestyle: R^2=.26, F (8,78) = 3.37, p=.002



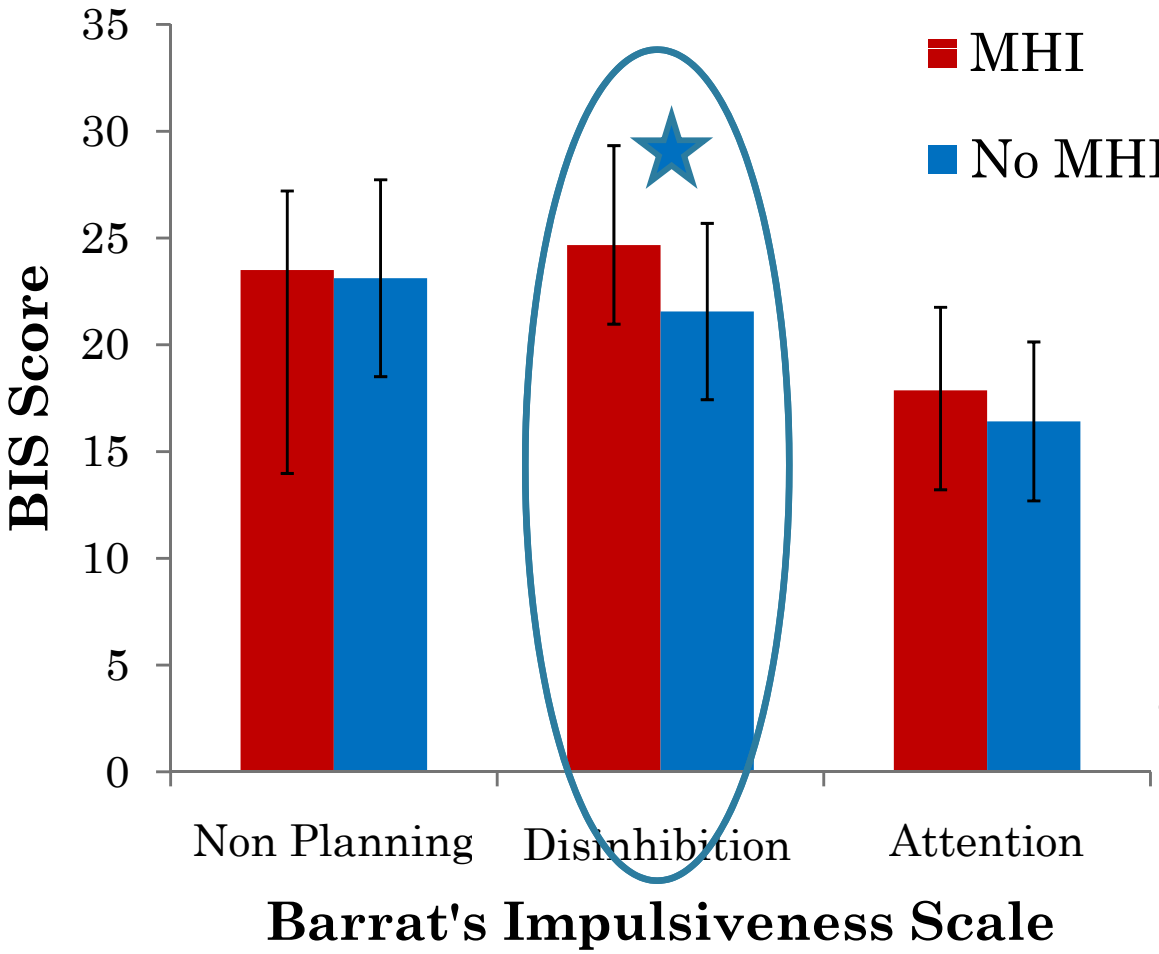
Antisocial behaviour: R^2=.26, F (8,78) = 3.33, p=.002

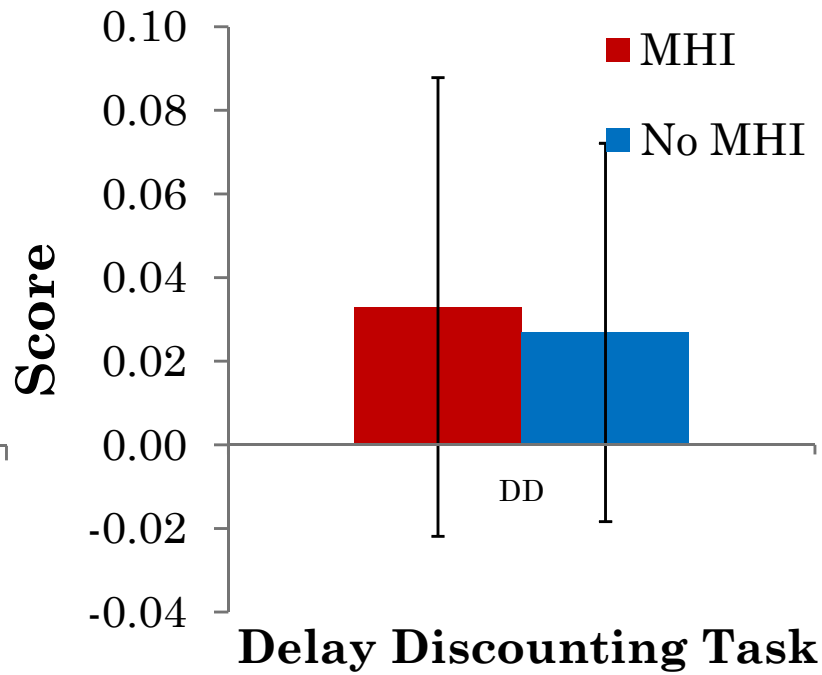
MHI and Personality: Results

- Impulsivity:
  - Only behavioural disinhibition was predicted by MHI



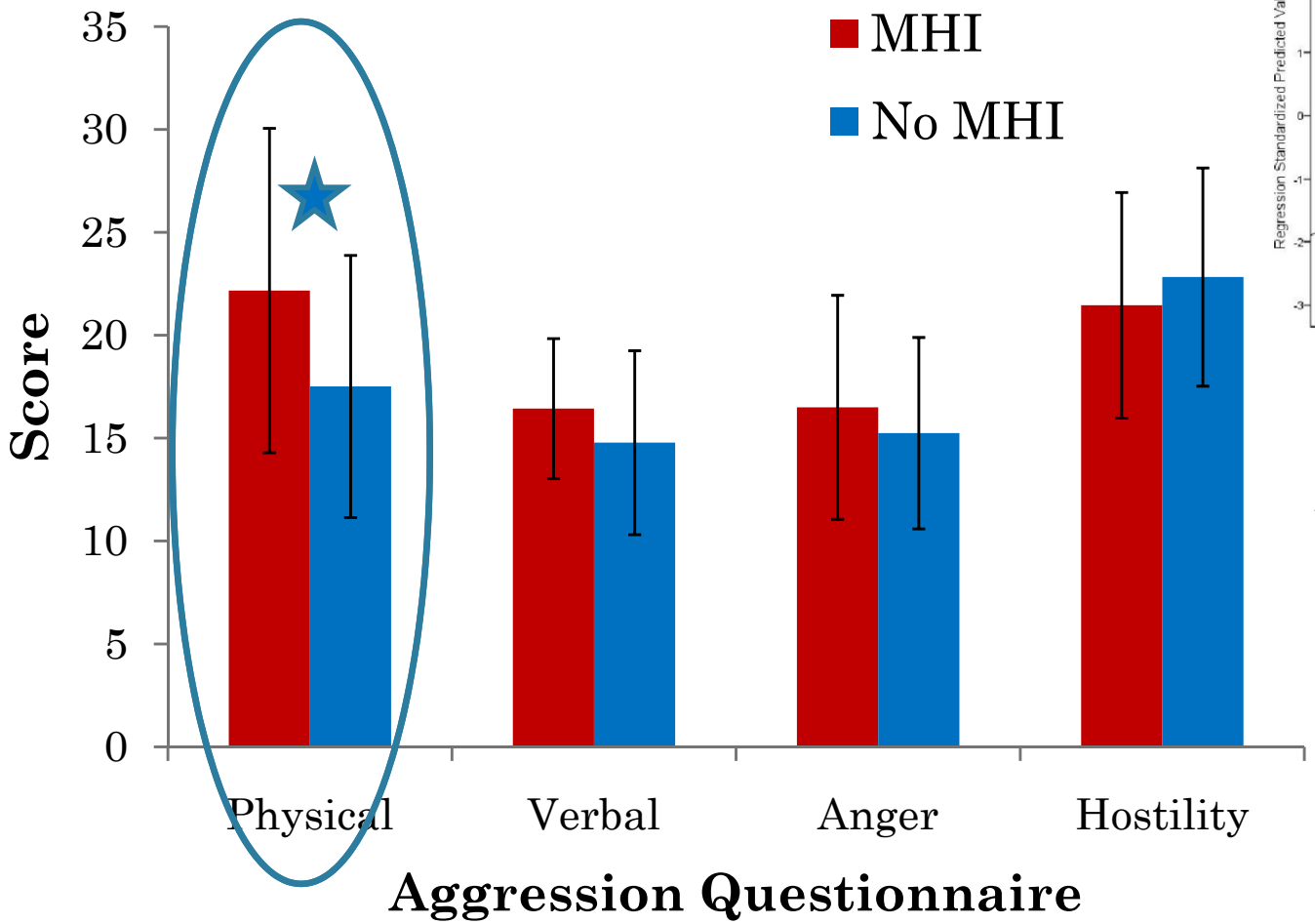
Behavioural Disihibition: R^2=.22, F (8,78) = 2.72, p=.011

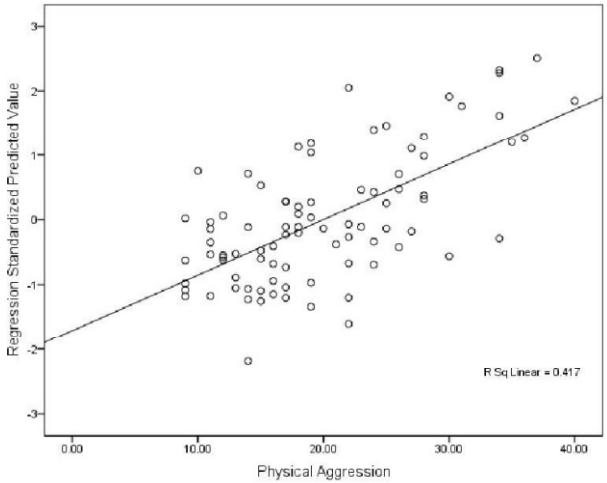




MHI and Personality: Results

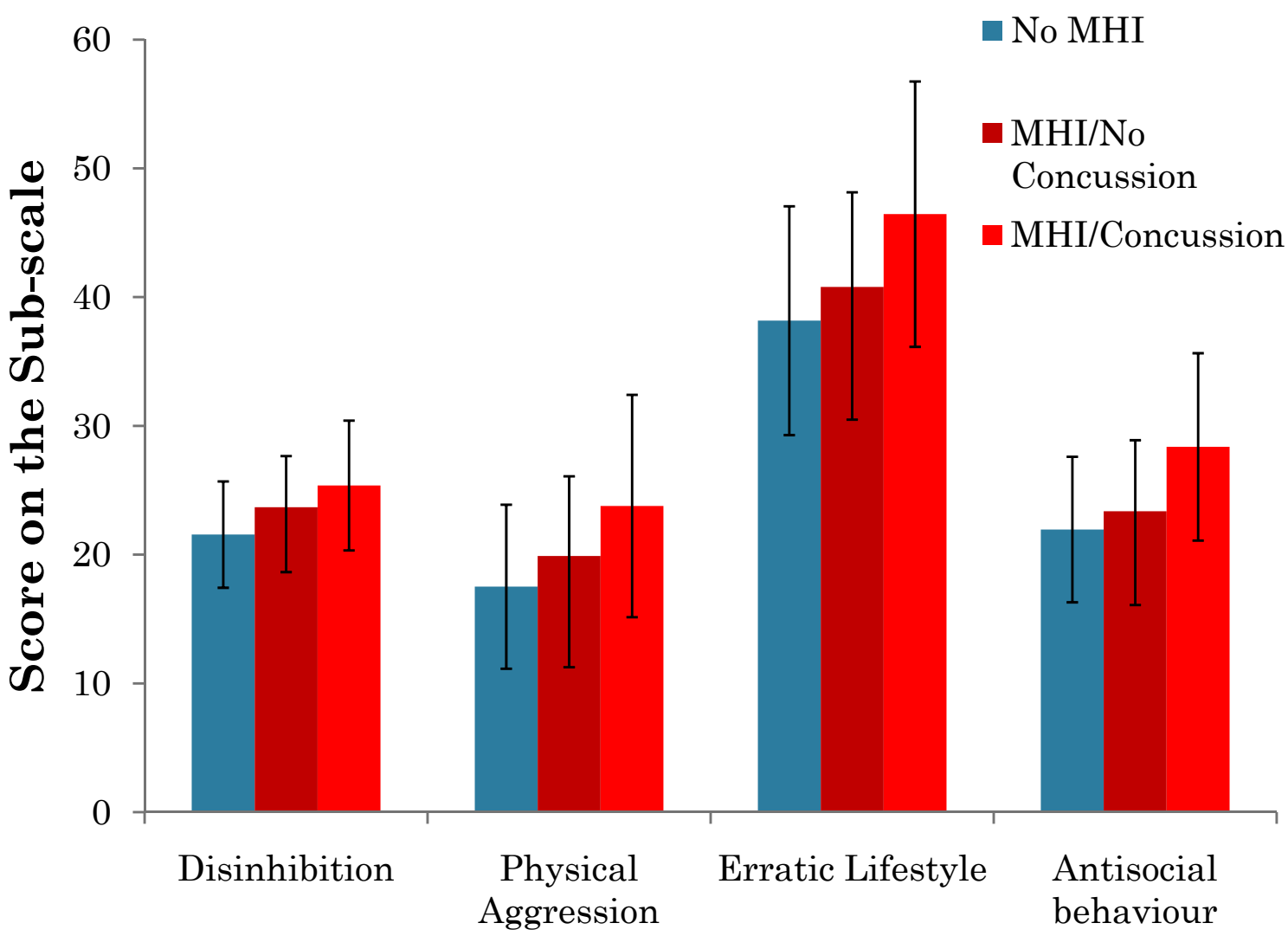
- Aggression:
  - Only physical aggression was predicted by MHI



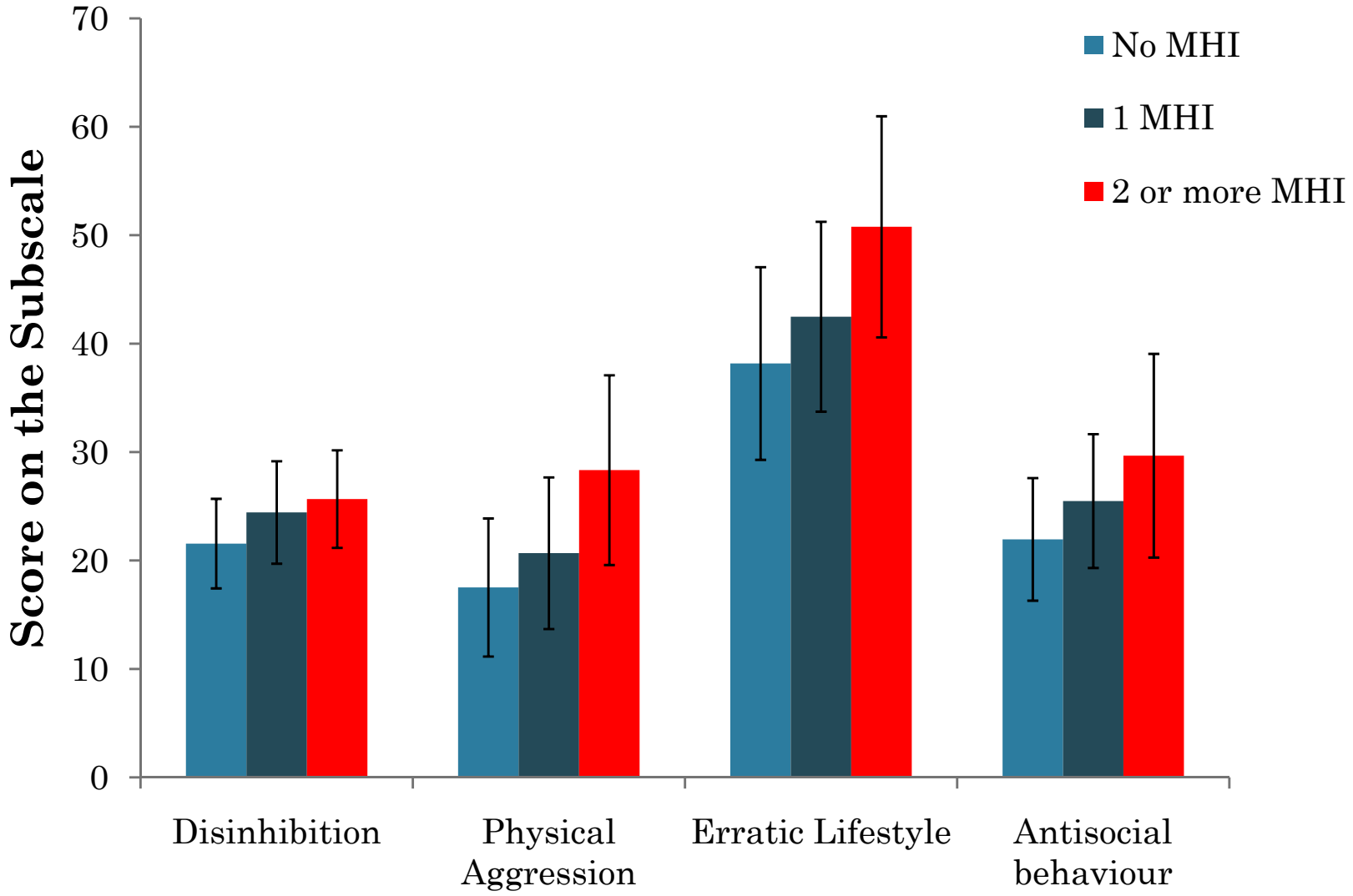


R^2=.417, F (8,78) = 6.97, p<.001

Severity of Injury and Personality



Number of Injuries and Personality

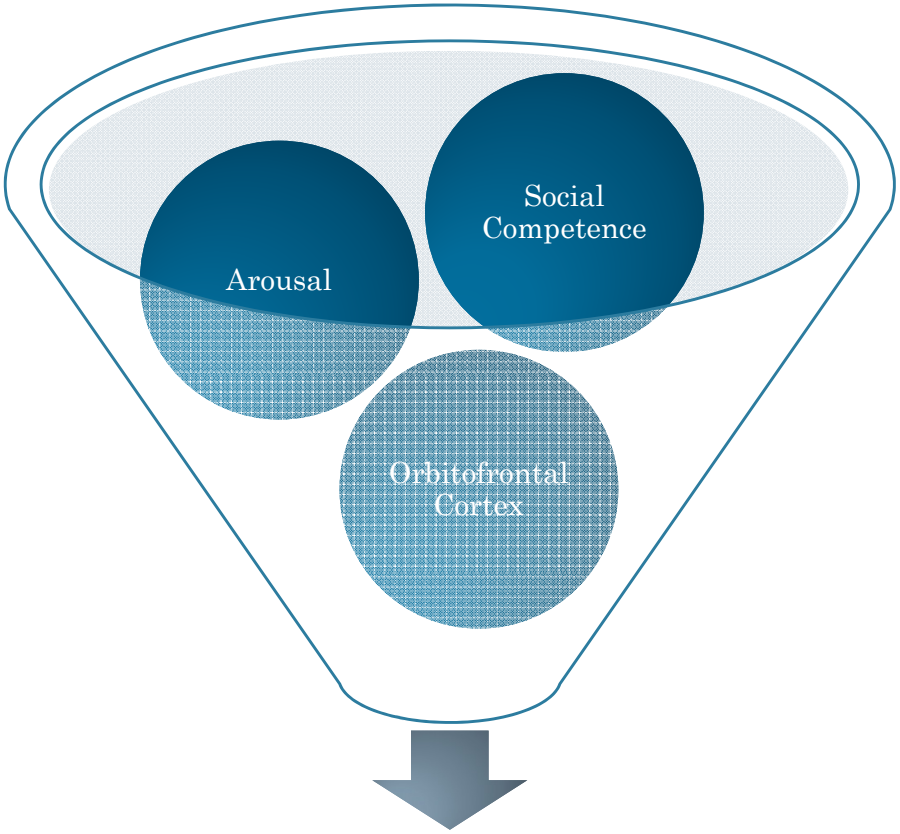


MHI AND PERSONALITY: SUMMARY

- Mild head injury was associated with
  - Higher levels of behavioural disinhibition but not other types of impulsivity
  - Higher levels of physical aggression but not other types of aggression
  - More socially unacceptable behaviour and erratic lifestyle
- Furthermore:
  - Behavioural disihibition was associated with MHI even after lifestyle and socially unacceptable behaviour were taken into consideration (Dzyundzyak, Good, & DeBono, 2008)

MHI and Personality: So What?

- Mild head injury is associated with inability to withhold responses and reactive physical aggression
- These effects present as impulsive and aggressive personality characteristics, which in turn have a negative impact on interpersonal relationships
- However, these responses are triggered by the environment and, thus, can be anticipated and prevented



- Social competence in terms of decision making can be a function of OFC through:
  - Trauma or maturation
  - Arousal levels
  - Injury to the OFC

(Yeates et al., 2007)

Social Decisions: Moral Behaviours

- Previous research demonstrates that persons who have incurred a head injury may lack social awareness demonstrated through self-report social problem solving skills (Kendall et al., 1997)

- Persons who have experienced injury to the VMPFC are more likely to agree with a socially unacceptable choice relative to persons who have not incurred a head injury (Ciaramelli et al., 2007; Koenigs et al., 2007)

- Persons who had not incurred a head injury were more reluctant to make decisions that resulted in personal transgressions compared with impersonal, whereas persons with injury to the VMPFC took equally as long (Ciaramelli et al., 2007)

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Does mild injury increase the propensity for more socially unacceptable behaviour ?

HYPOTHESES

- Individuals with MHI would rate themselves as having similar social problem solving skills as individuals with no MHI

BUT…

- When individuals with MHI consider social/moral decisions, we expect their performance to reflect different processes:

  Persons with MHI will make less socially acceptable choices, and be quicker to do so, compared to no MHI counterparts

MHI Indicator

Questionnaire:

- Demographics

Have you ever had a head injury resulting in an altered state of consciousness (including: vomiting, dizziness, seeing stars, confusion)?

Demographics

- Recruited 47 University Students with and without MHI

	No MHI	MHI	Total
Males	6	6	12
Females	21	14	35
Total	27	20	47

($\chi^2 = .37$, $p = .55$)

- 12 participants reported a loss of consciousness (60% of MHI group)
- 8 participants reported seeking medical treatment (40% of MHI group)

Measures

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Demographic Questionnaire

- Indicator of head injury

Moral Judgment Task

- Social situation
- Presents a situation in which a social dilemma is required

Social Problem Solving Inventory

- Describe how they believe they make choices

SOCIAL PROBLEM-SOLVING INVENTORY- REVISED

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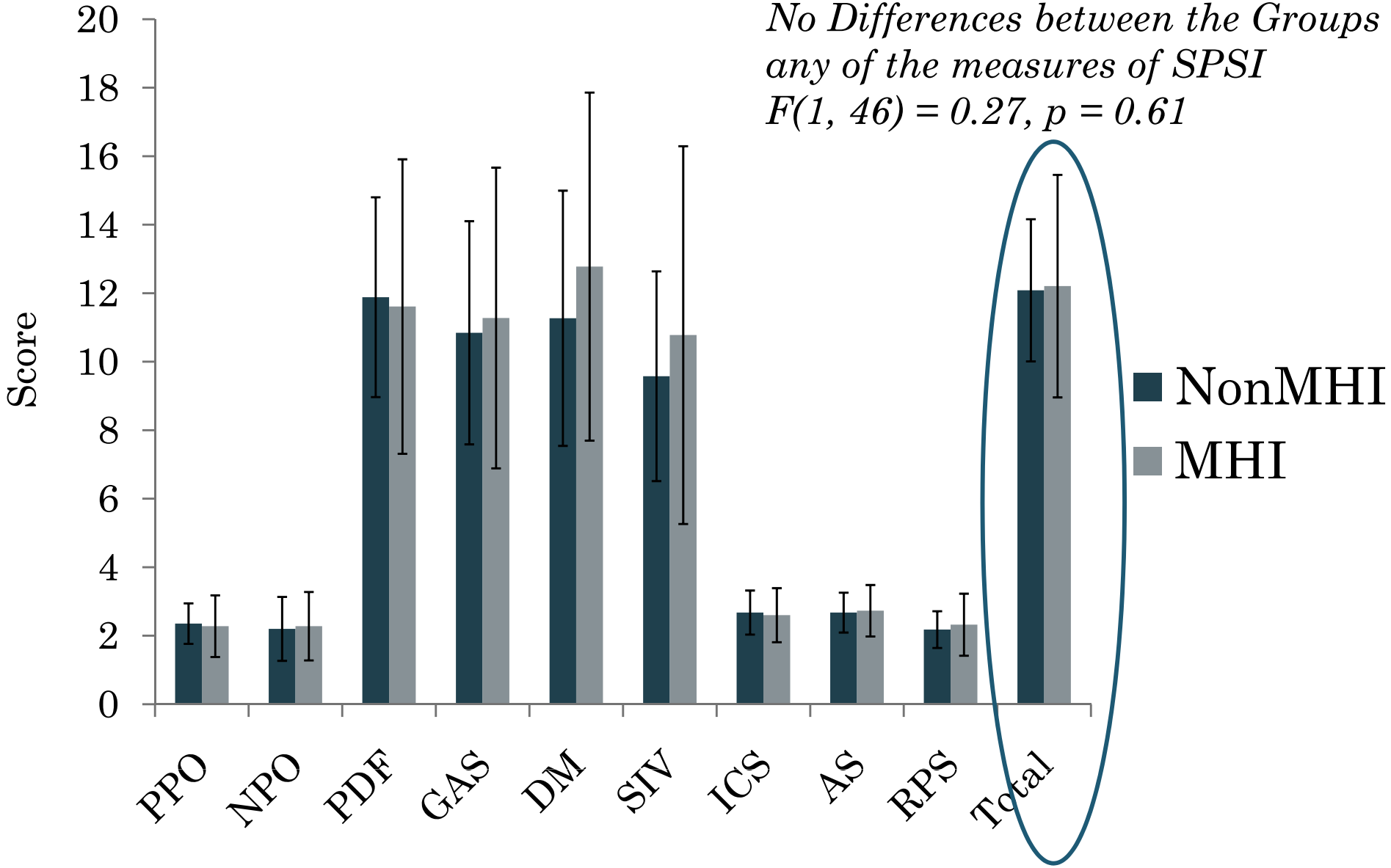
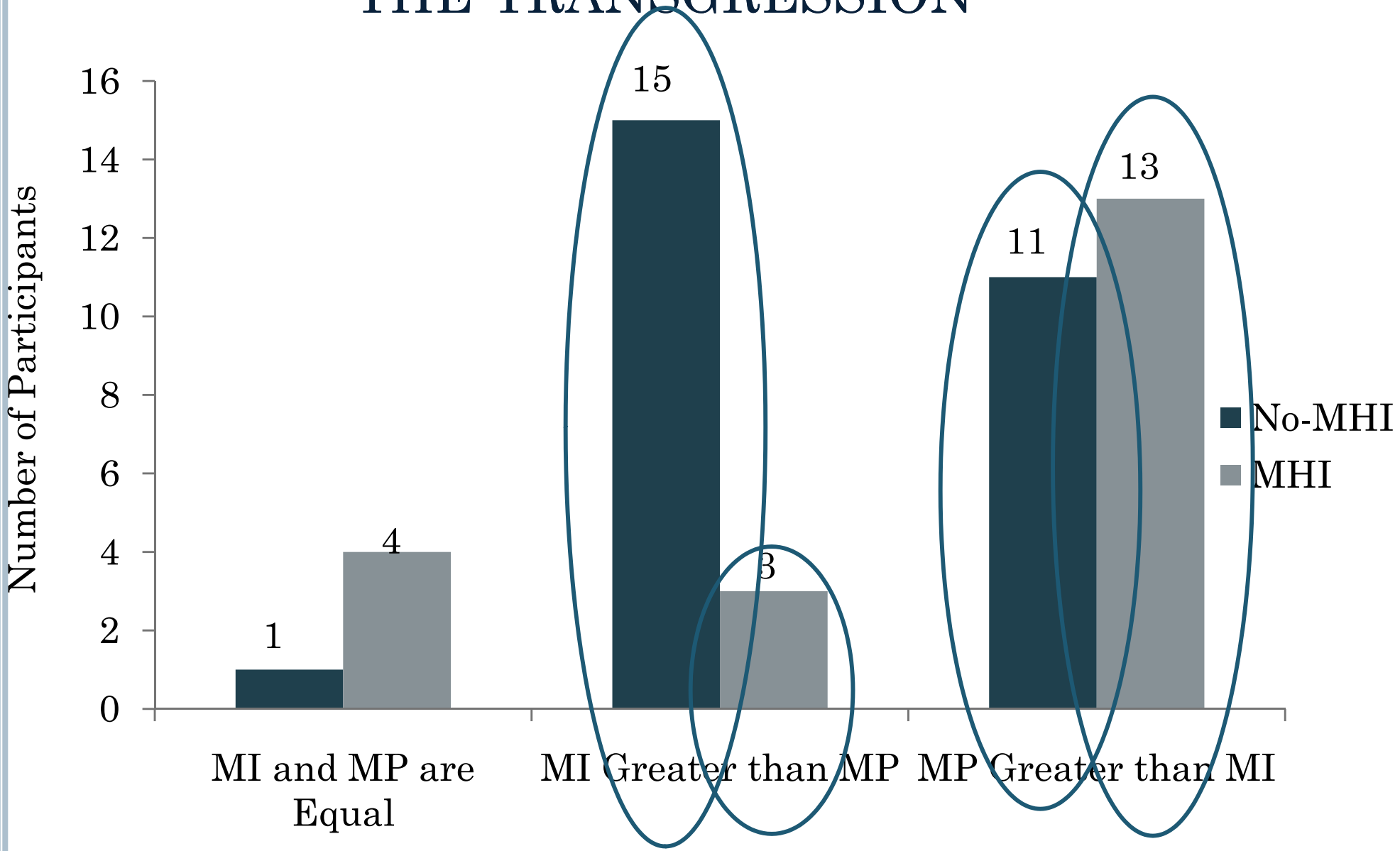
No Differences between the Groups on any of the measures of SPSI
$F(1, 46) = 0.27$, $p = 0.61$

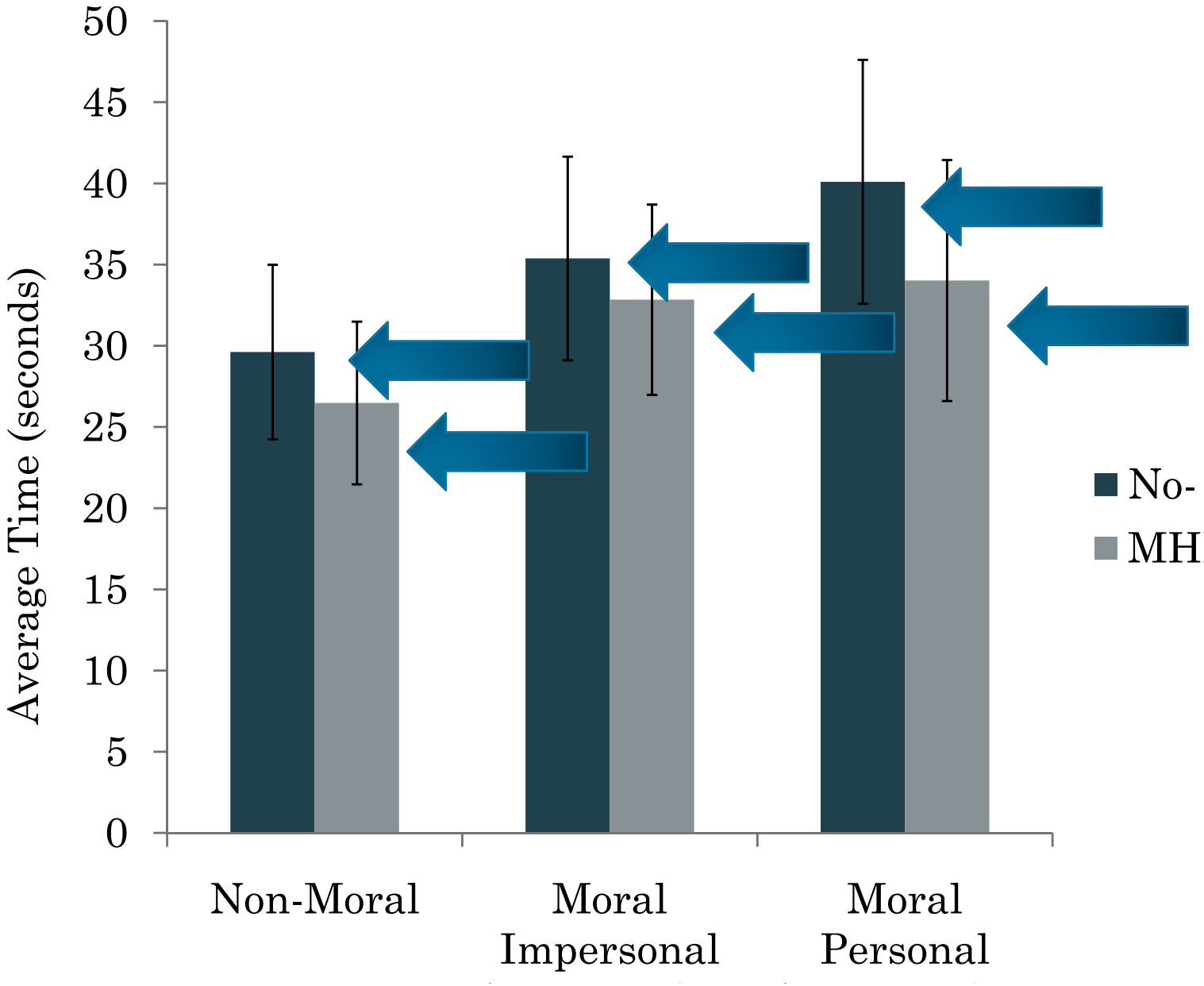


RELATIVE LIKELIHOOD OF COMMITTING THE TRANSGRESSION



($\chi^2 = 9.13$, $p = .01$)

Time Data

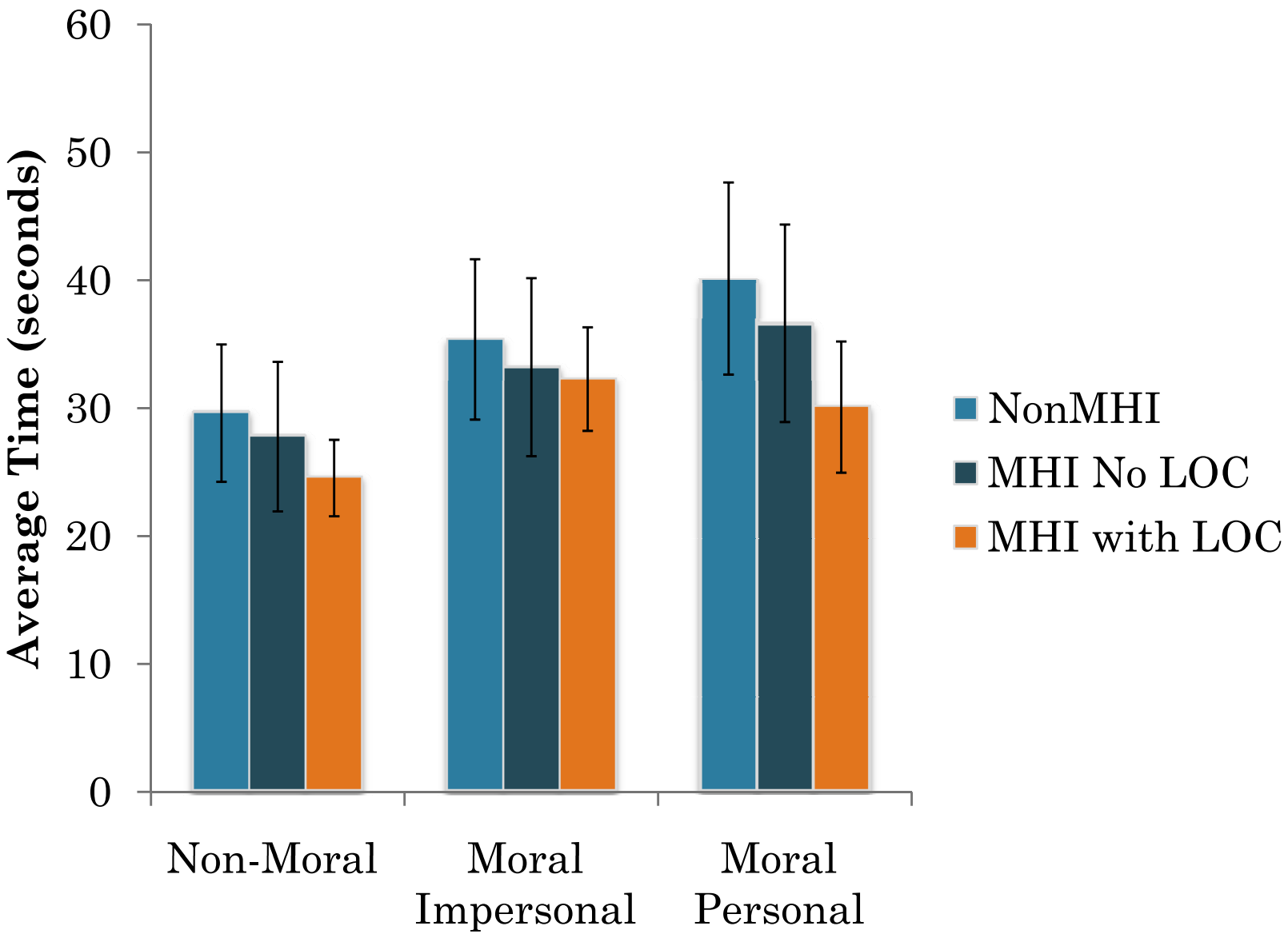


NonMHI:
NM < MI < MP

MHI:
NM < MI = MP

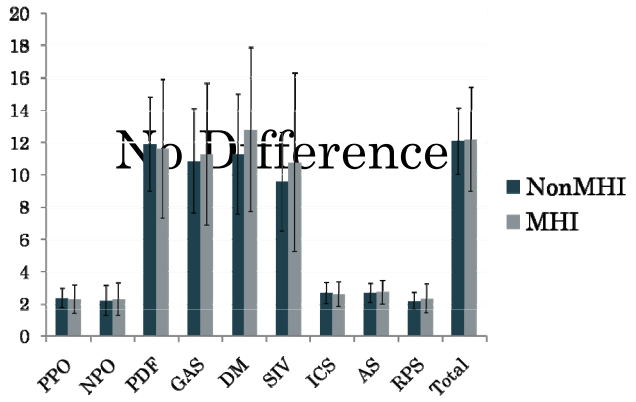
($F(1,45) = 5.37$, $p = .03$)

Severity Measure

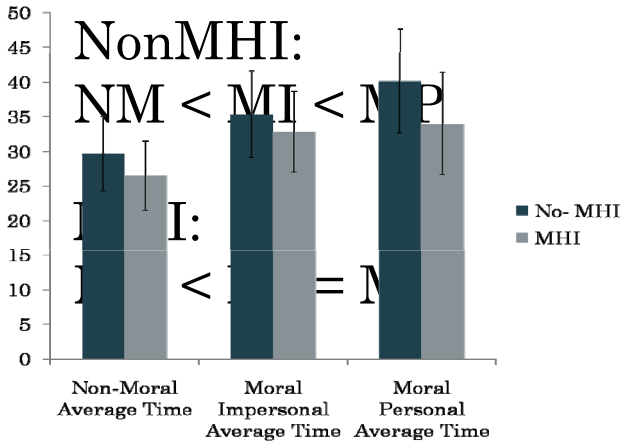


SUMMARY

1. NonMHI and MHI approached problem solving skills in a similar fashion



2. MHI group made less socially acceptable choices, and were quicker to do so, compared to the nonMHI group



❖ Persons who have incurred a MHI may have disrupted emotional feedback from the viscera and orbtiofrontal cortex, therefore, they are not interpreting or receiving social information in the same way

Decision making, emotional markers and learning

- Emotional feedback to consequences of decisions signals a discrepancy between one's expectation and what actually happens (Nieuwenhuis et al., 2004; Oya et al., 2005; Santesso et al., 2009)

- Affect (valence) associated with an outcome provides basis for adaptive learning (Bechara, 2004; Rudrauf et al., 2009) – i.e. negative feelings = learn to avoid, or anticipate the negative consequence in future situations

- Anticipation of potential future consequences via somatic marker activation (Damasio, 1996; Denburg et al., 2007)

Consequences of OFC Injury

- Have the capacity to emotionally respond to the environment, but have limited activation of anticipatory emotional responses

- Limited affective markers compromise emotion recognition in oneself and others (Heberlein et al., 2008; Hopkins et al., 2002; Ietswaart et al., 2008)

- Insensitive to the potential of future consequences to decisions (Bechara et al., 1996; 2000)

HYPOTHESES

- Might those with MHI, even though competent, be emotionally uninformed when making decisions?

- Do mild head injuries in university students relate to measurable differences in the ability to generate and interpret emotional signals from oneself and others?

- How might variable physiological and neuropsychological mechanisms influence social decision making?

- University students with MHI are expected to perform competently on general cognitive tasks
- University students with MHI are expected to have attenuated physiological responses during the anticipatory stages of decision-making
- University students with MHI are expected to be less successful in discriminating facial expressions of emotion
- Compromise community reintegration and healthy interpersonal relationships

Methods: Participants

	Study 1		Study 2	
	MHI	Non-MHI	MHI	Non-MHI
n	16 (40%)	24 (60%)	18 (41%)	26 (59%)
Mean Age	19	19	20	19
n Males	9 (56%)	6 (25%)	5 (28%)	6 (23%)
n Females	7 (44%)	18 (75%)	13 (72%)	20 (77%)
Education (Yrs.)	13	13	13	13

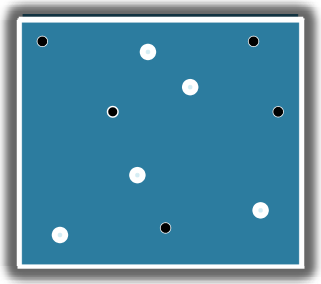
Methods: Participants

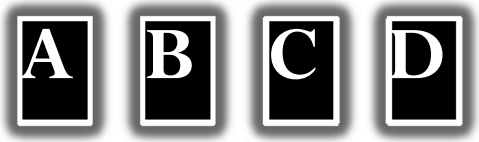
	Study 1	Study 2
	MHI (n = 16)	MHI (n = 18)
Medical Attention	7 (44%)	7 (39%)
Stitches	4 (25%)	2 (11%)
Loss of Consciousness	5 (31%)	11 (61%)
Multiple MHI	8 (50%)	5 (28%)
Mean Age of Injury	15	13

MEASURES

Neuropsychological Tasks:

- General cognitive abilities:
  - Design Fluency (Delis et al., 2001).





- Behavioural decision-making:
  - Iowa Gambling Task (IGT; Bechara, 2007).

- Emotion discrimination:
  - Affect Recognition (Korkman et al., 2007).

ELECTROPHYSIOLOGICAL EQUIPMENT

- Electrodermal Activity (EDA)
  - Index of autonomic arousal through continuous measurement of skin conductance (Lykken, 1961; 1971; Fowles et al., 1981)
  - Variations in perspiration signal sympathetic activity
  - ***Represents a measure of Emotional Arousal***

Physiological Equipment

Electrodermal Electrode

Finger Pulse

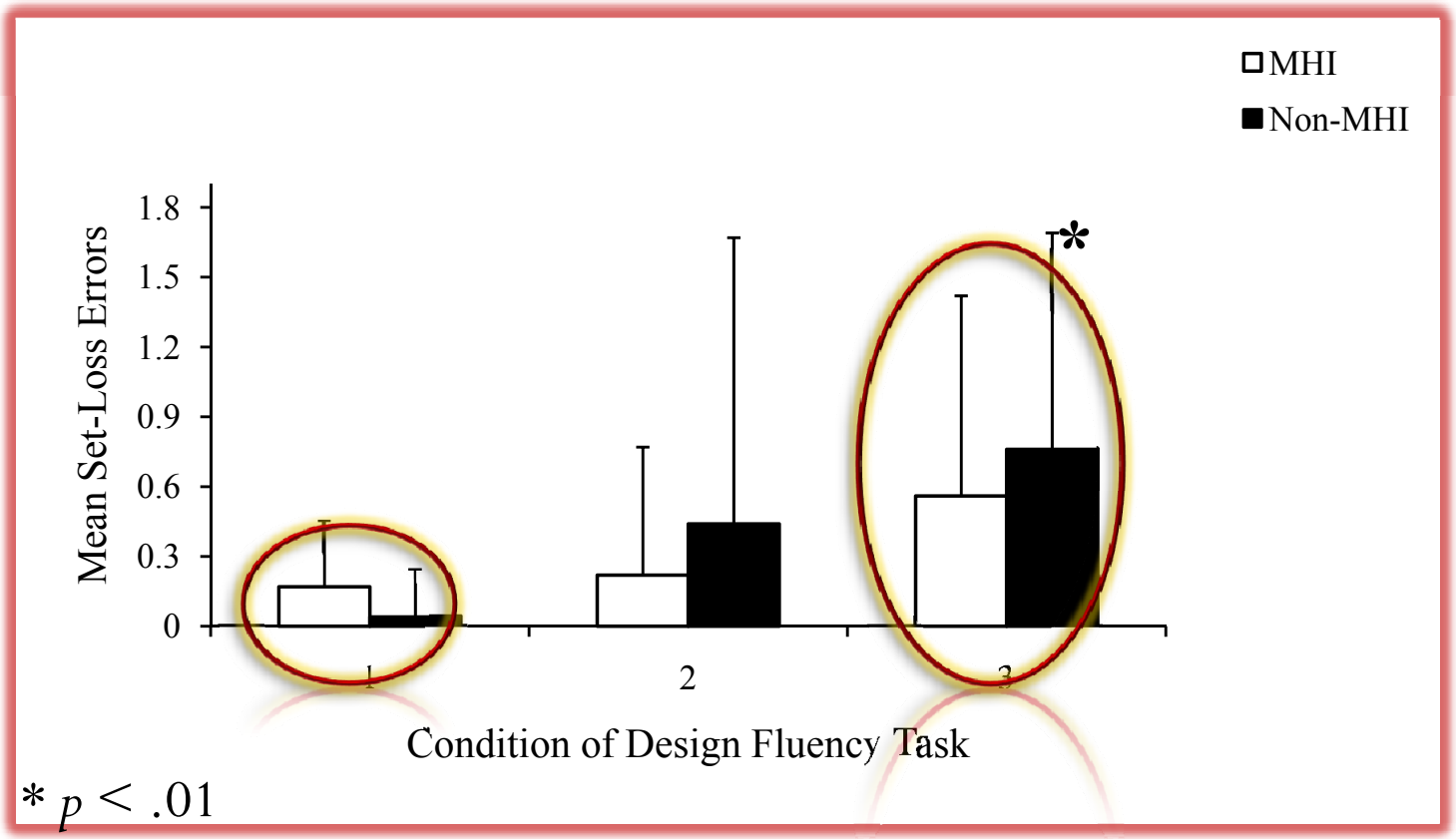
MHI Indicator

Questionnaire:

- Demographics

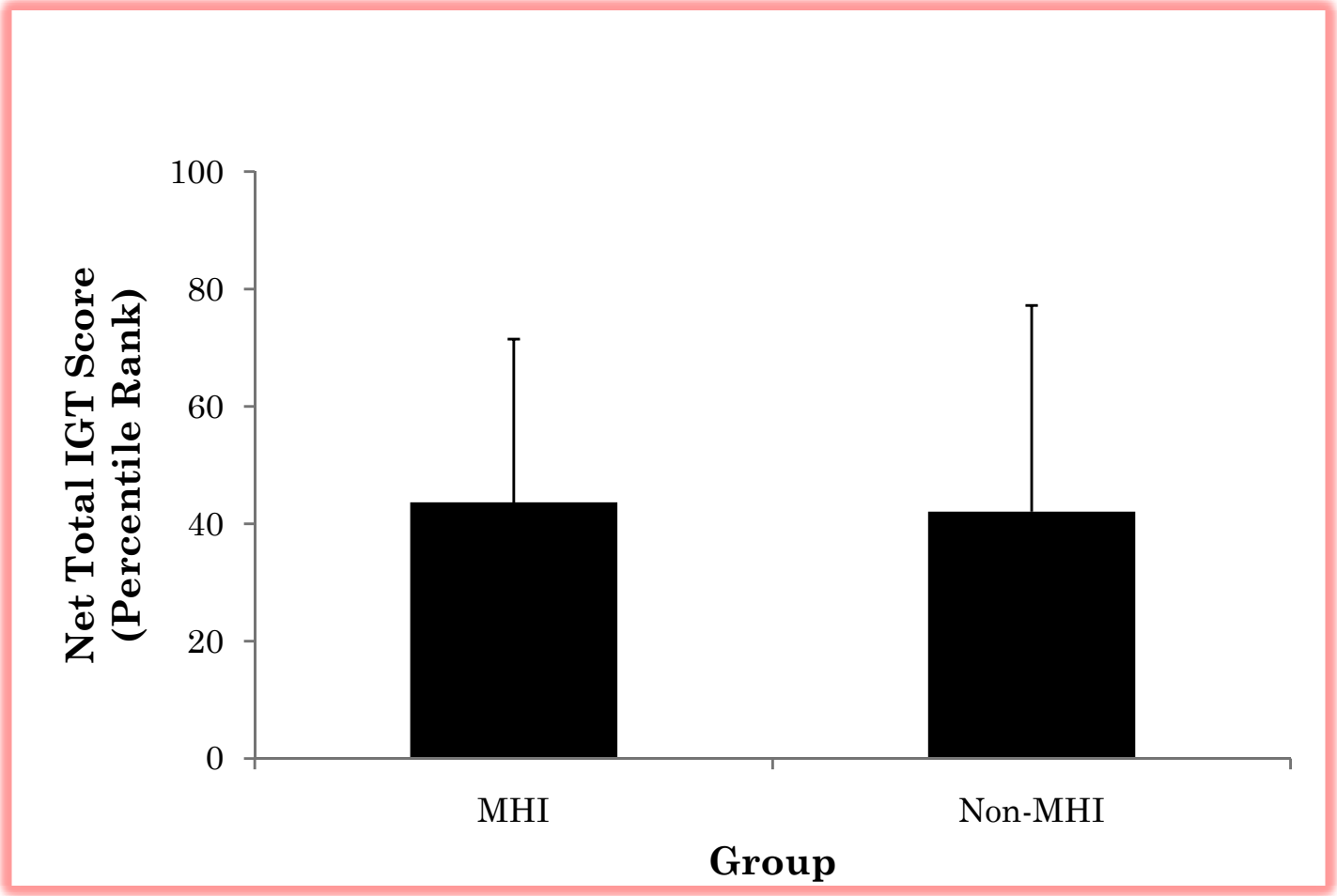
Have you ever had a head injury resulting in an altered state of consciousness (including: vomiting, dizziness, seeing stars, confusion)?

General Cognitive Ability



- MHI (n = 18) and non-MHI (n = 25) groups perform comparably on the Design Fluency Task; with more challenging task demands resulting in more errors for both groups.

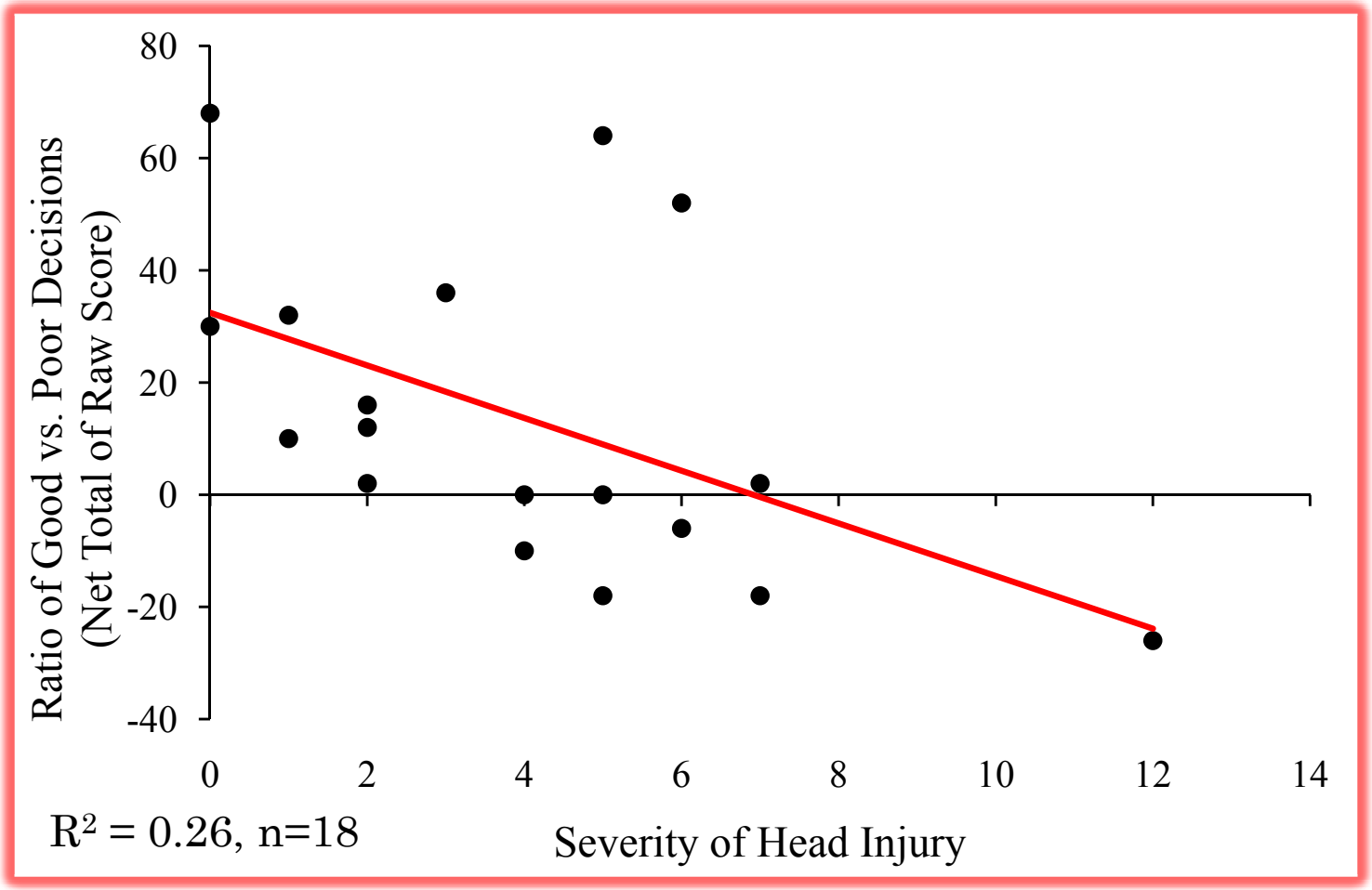
Decision-Making Success



No difference in overall decision-making performance.

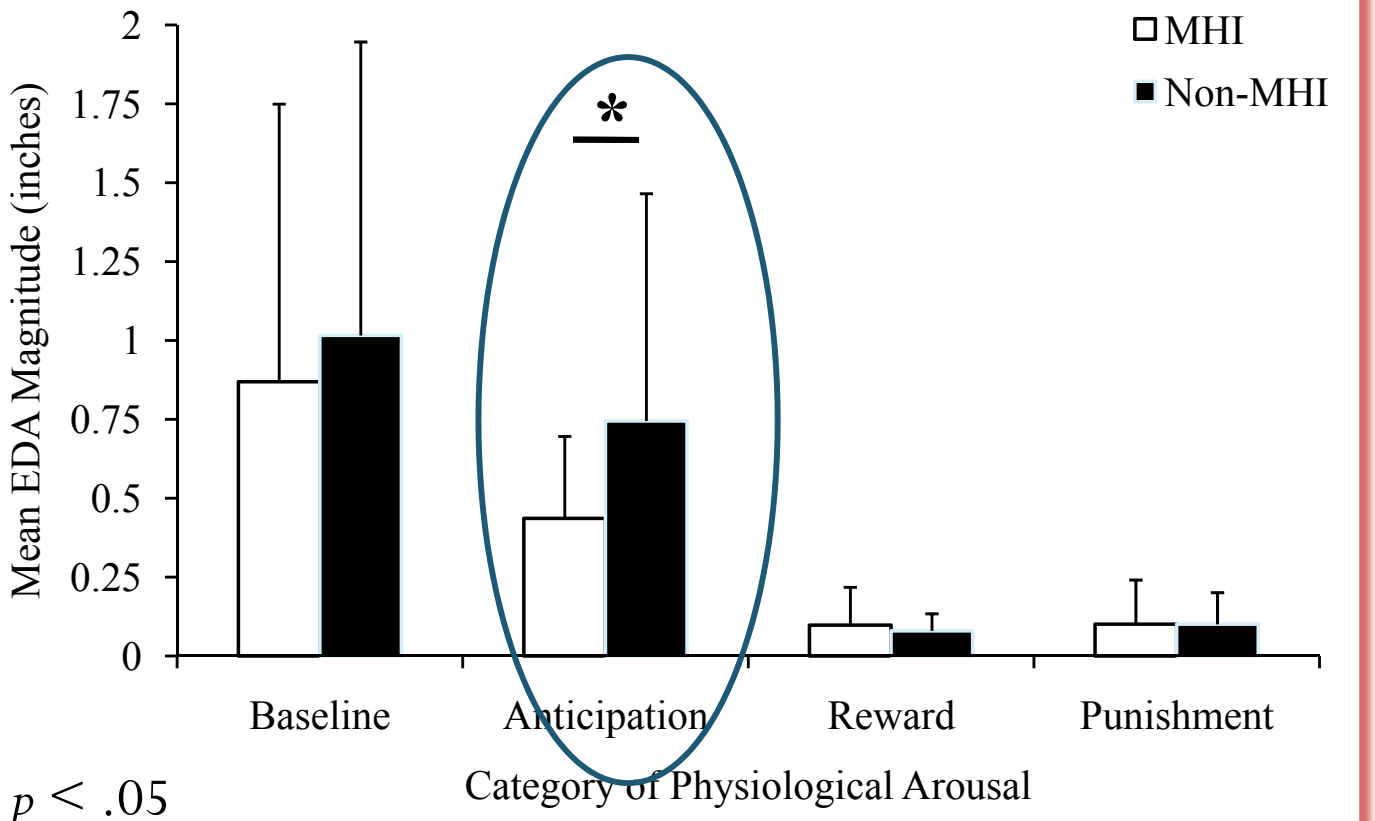
- MHI (n = 17) and non-MHI (n = 26) groups made equally risky decisions overall.

Severity of MHI and Decision-Making Success



- Correlation between reported severity of mild head injury and net raw score on IGT, $r = -.51$, $p = .03$.

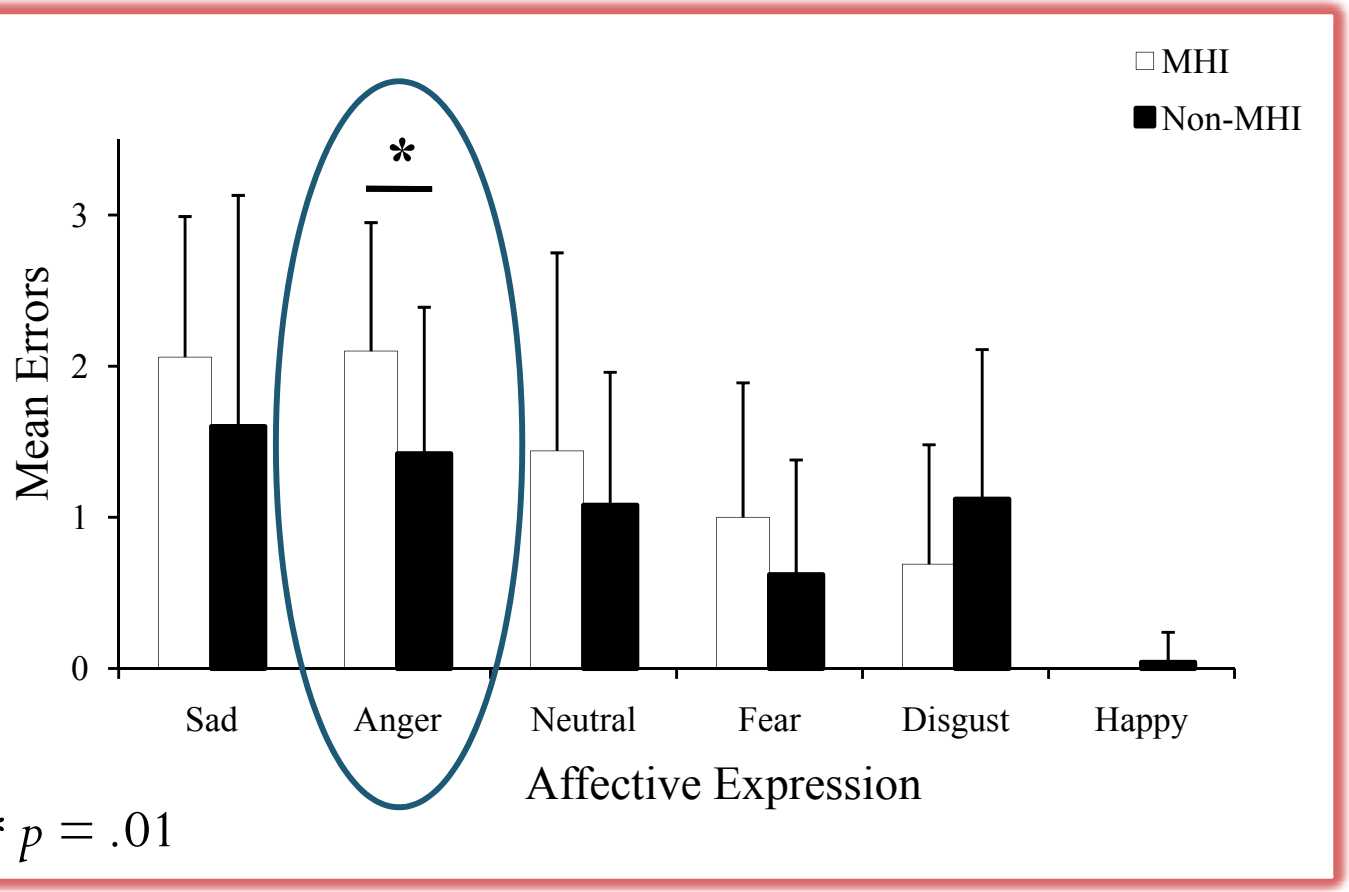
Autonomic Arousal – Emotional Physiological Feedback



- Individuals reporting MHI were significantly less aroused only during the anticipation of a triggering event.

- Comparison of mean electrodermal conductance amplitude for baseline, anticipatory, and feedback between the MHI and non-MHI groups.

Emotion Facial recognition – Emotional Feedback from Others



- After controlling for abstract and social reasoning skills, history of MHI significantly predicted the success in discriminating facial expressions of anger, $p < .05$

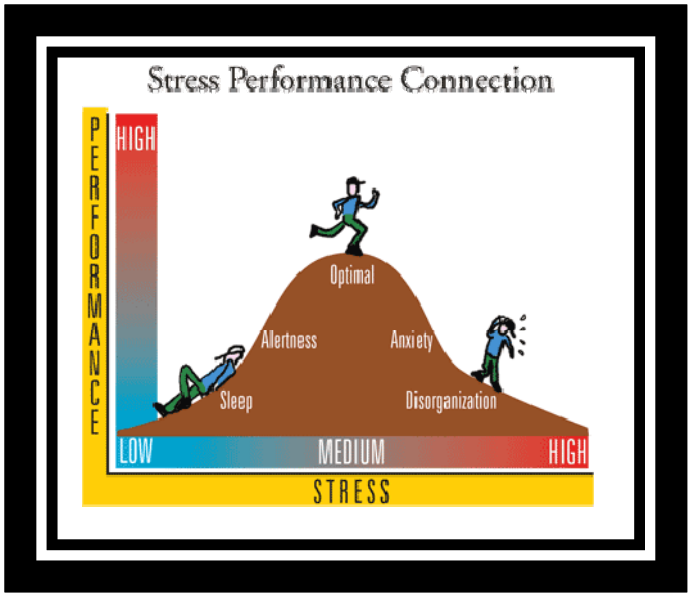
- Comparison of mean errors made in discriminating various facial expressions of emotion between the MHI and non-MHI groups.

Summary of Findings

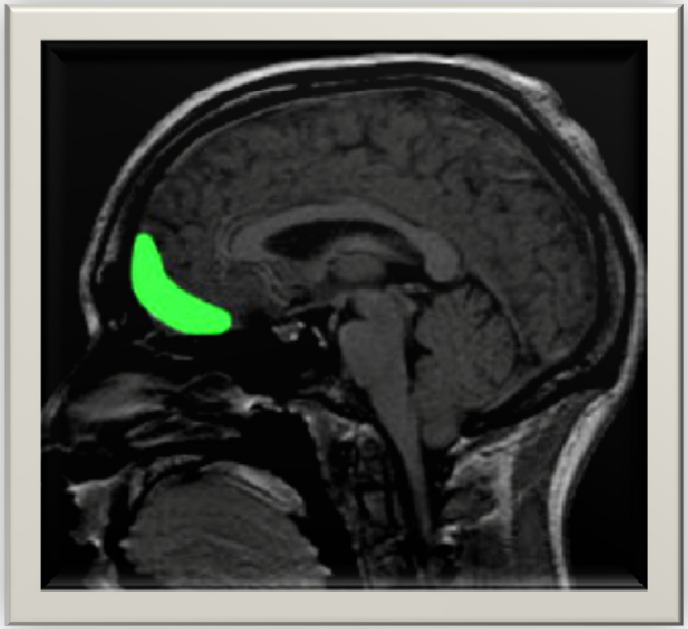
- Intact intellect, emotionally responsive
- Self-reported MHI severity is marker of underlying metabolic/neural disruption
- Limited emotional markers during anticipatory stages of decision-making
- Individuals with MHI are limited in successful emotional discrimination (particularly expressions of anger)
- Social decision-making behaviour in the MHI group is constrained by limitations in processing socio-emotional feedback

Underarousal Hypothesis

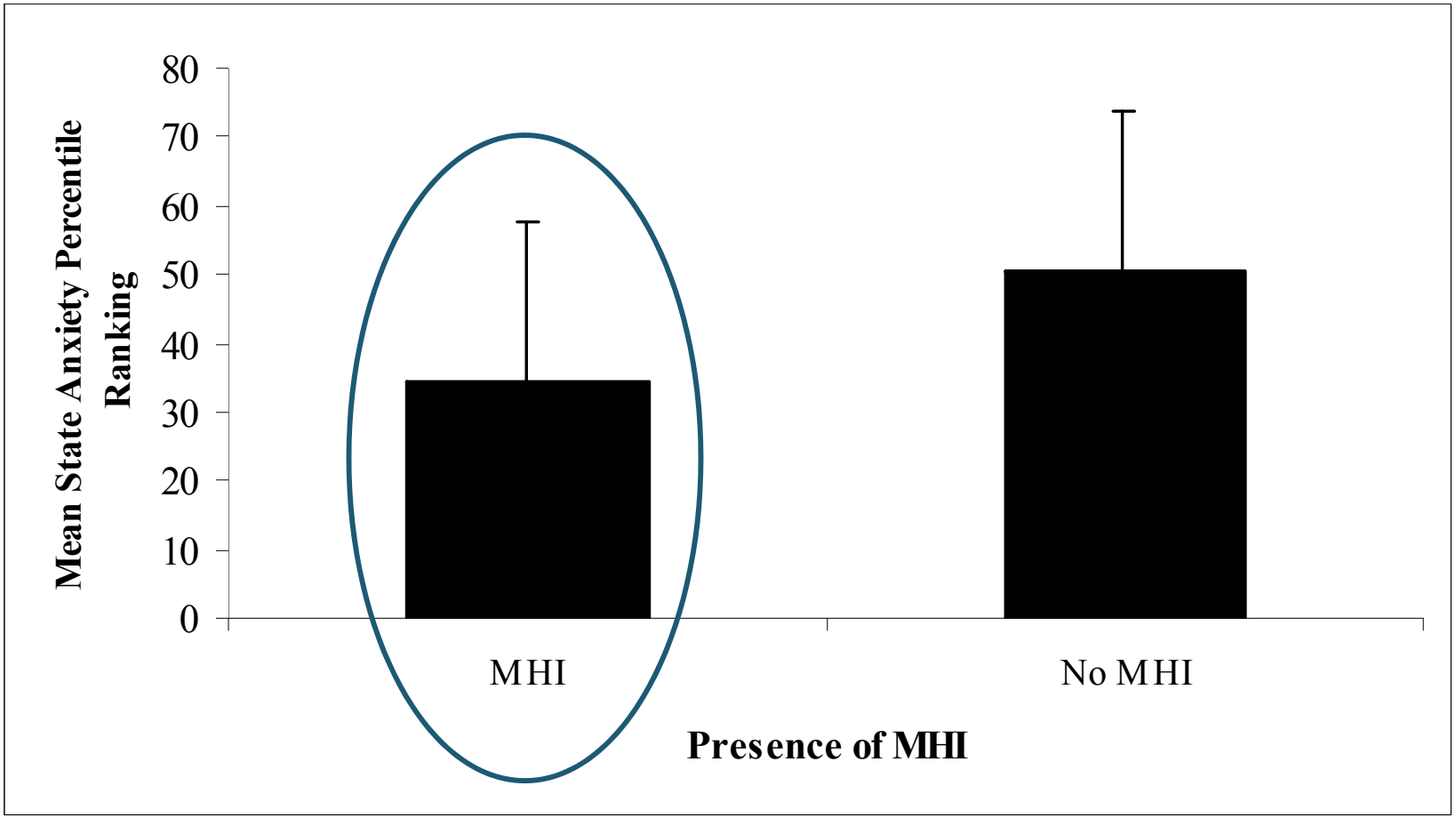
- Students with MHI are relatively emotionally and physiologically underaroused compared to no-MHI counterparts
- May benefit from being activated to a higher level of arousal



- Since the OFC /VMPFC manages emotional responses, disruption to this area could explain the differential emotional and physiological arousal state



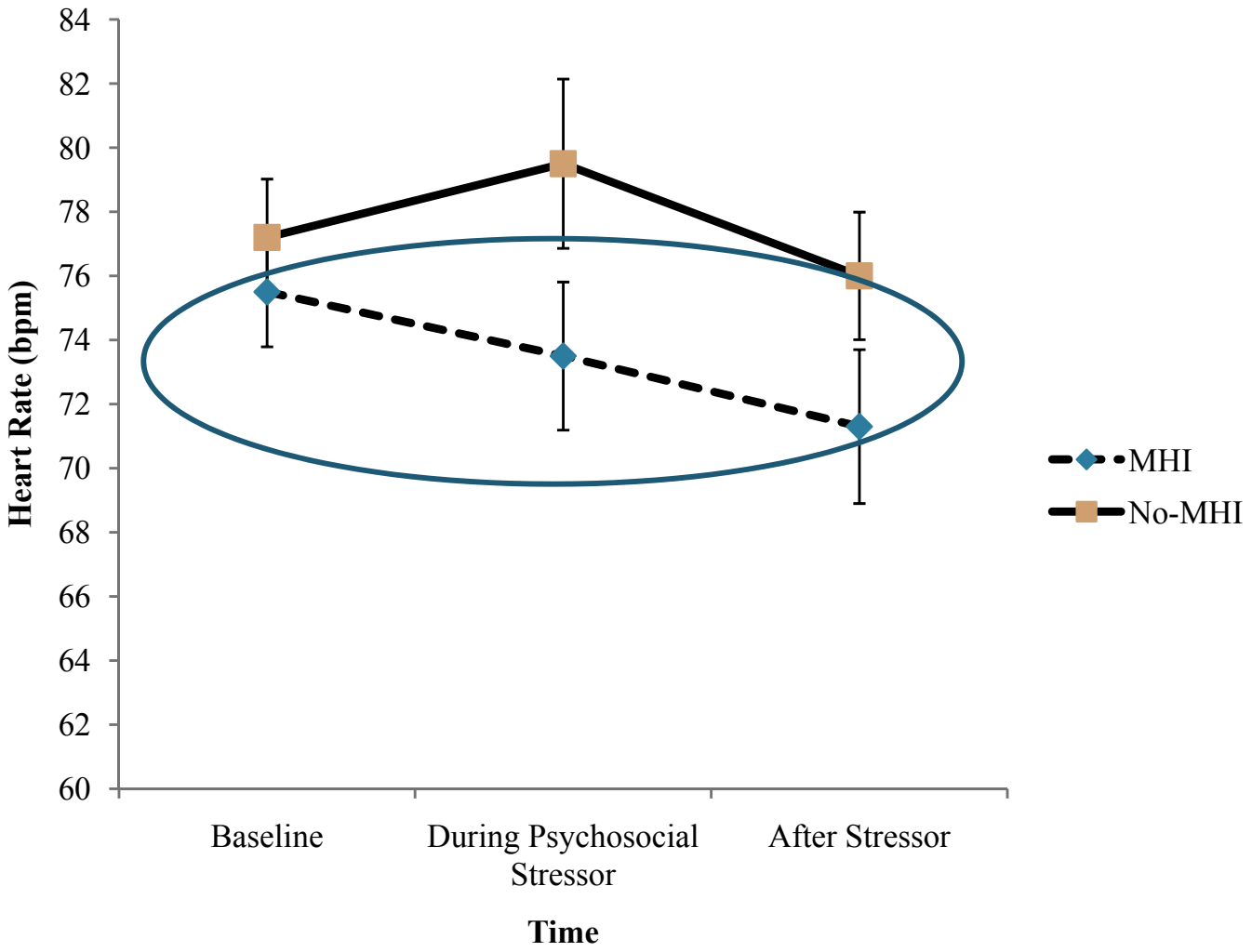
AFFECT



Persons with MHI presented with less anxiety than persons without MHI.

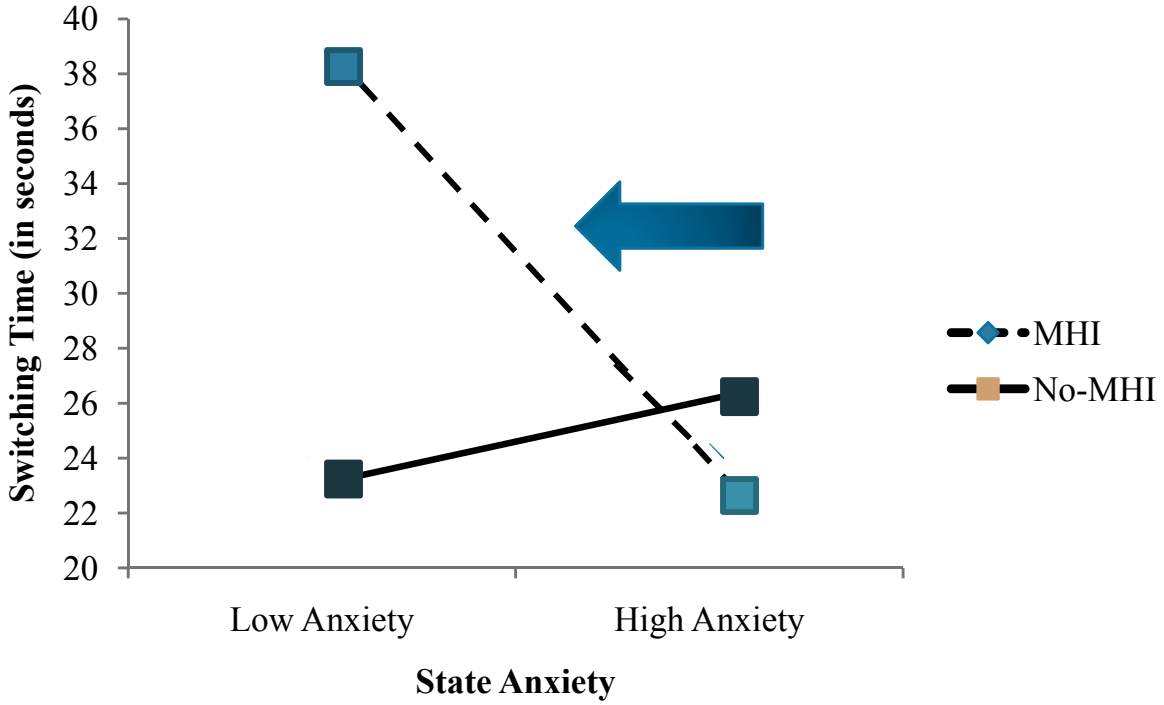
St. Cyr & Good (2006; 2007)

Arousal



Jung & Good (2006)

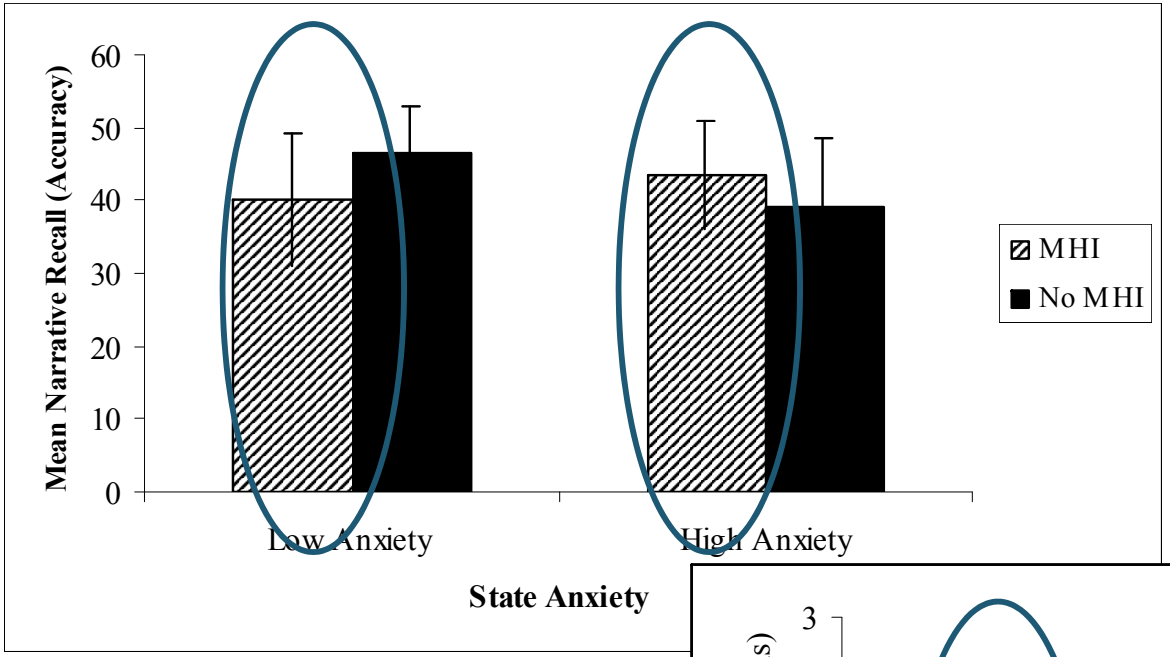
Cognition & Affect



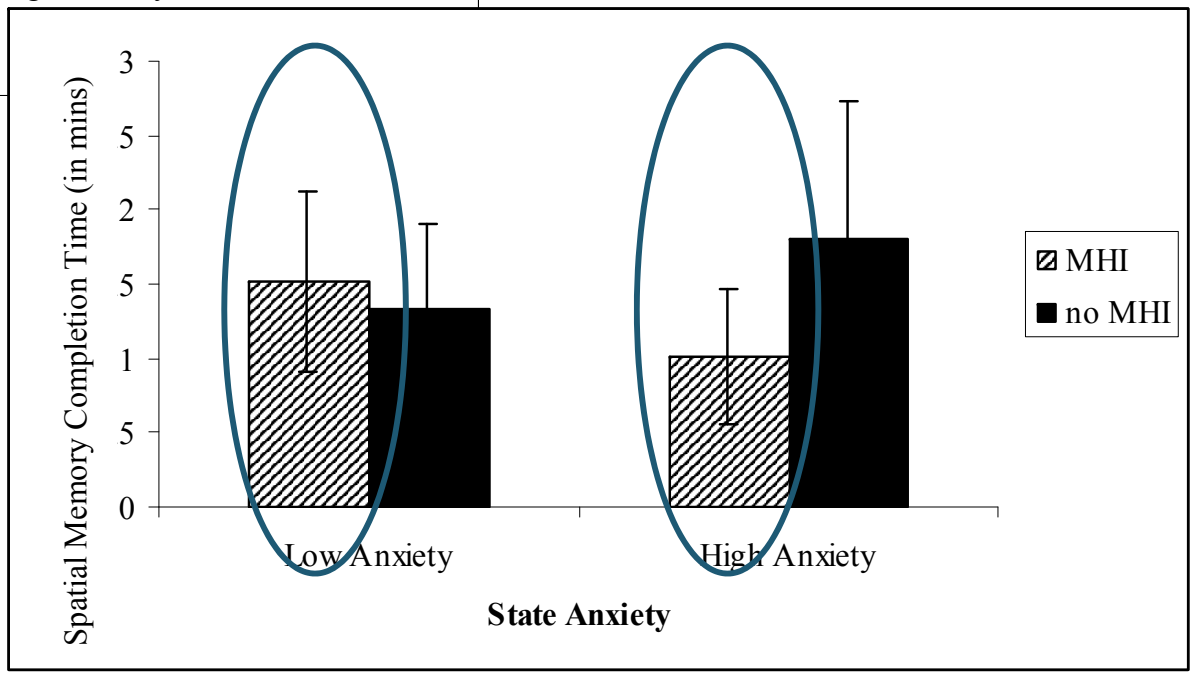
MHI group performed more slowly on a complex attentional task with lower reports of anxiety and otherwise perform comparably to their no-MHI cohorts when stressed

Jung & Good (2006)

COGNITION & AFFECT



Overall, persons with MHI were *faster* and *more accurate* for memory tasks *with higher reports of stress.*



St. Cyr & Good (2007; in press[1]). *Brain & Cognition*[1]

Purpose: To investigate the effect of Arousal Manipulation in persons with/without MHI

Stress

- Timed verbal mathematical subtraction task
- Told related to important aspects of intellectual functioning
- Male observer

(adapted from Shostak & Peterson, 1990; Wymer, 1996)

Relaxation

- Listened to and followed instructions on a cognitive relaxation C.D.
- Tranquil atmosphere (dimmed lighting, restful sounds)
- Aromatherapy (lavender)

Social Sciences and Humanities Research Council of Canada
Conseil de recherches en sciences humaines du Canada
Canada

Baker & Good (2009). *Journal of Head Trauma Rehabilitation, 24* (5)

MHI Indicator

Questionnaire:

- Demographics

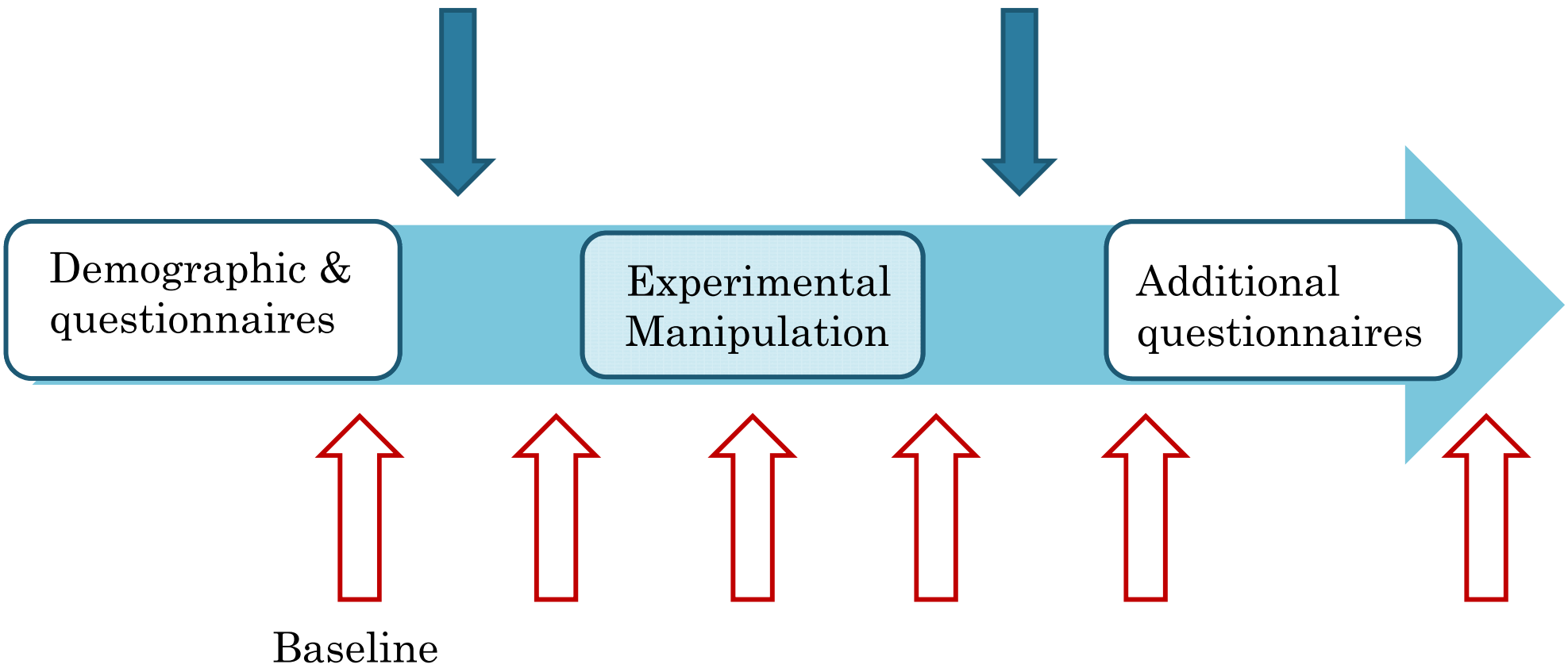
Have you ever had a head injury resulting in an altered state of consciousness (including: vomiting, dizziness, seeing stars, confusion)?

MEASURES

- Questionnaires
  - Demographic information re: MHI History (Kay et al., 1993)
  - PCSC (Gouvier et al., 1992)
- Cognitive Measures
  - Memory
  - Planning/abstract reasoning
  - Attention
  - Subtests from: WMS-III, WAIS-III, DKEFS and NEPSY-II
- Arousal State Measures
  - Electrophysiological Measures
    - EDA, HR, respiration (sympathetic activation)

  - Verbal self-report of arousal state
  - Everyday life Stress (adapted from Holmes & Rahe, 1967)
  - State-Trait Anxiety Inventory (Speilberger, 1983)

Procedure



= Cognitive Testing

= Physiological Recordings

Demographics

- $N = 91$
- Mean age 21 years ($SD = 3.20$)
- Males $n = 28$; females $n = 63$

Arousal Manipulation Condition	MHI	No-MHI	Total
Stress	27	18	45
Relaxation	24	22	46
Total	51	40	

DEMOGRAPHICS

56% (*n* = 51) of students reported a MHI occurring around 16 years of age; ~ 5 years post-injury (mode = 2 years)

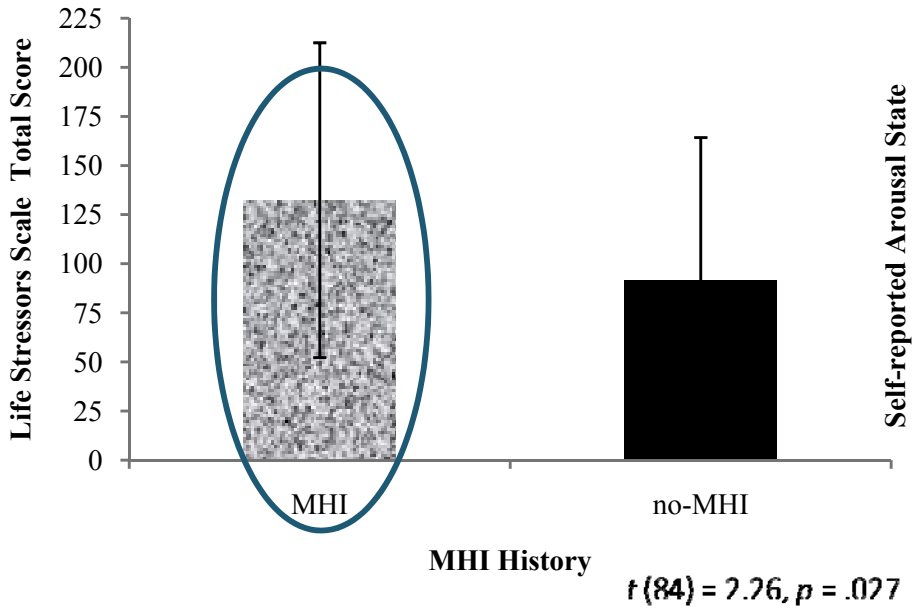
Indicators of Severity for Self-reported MHI

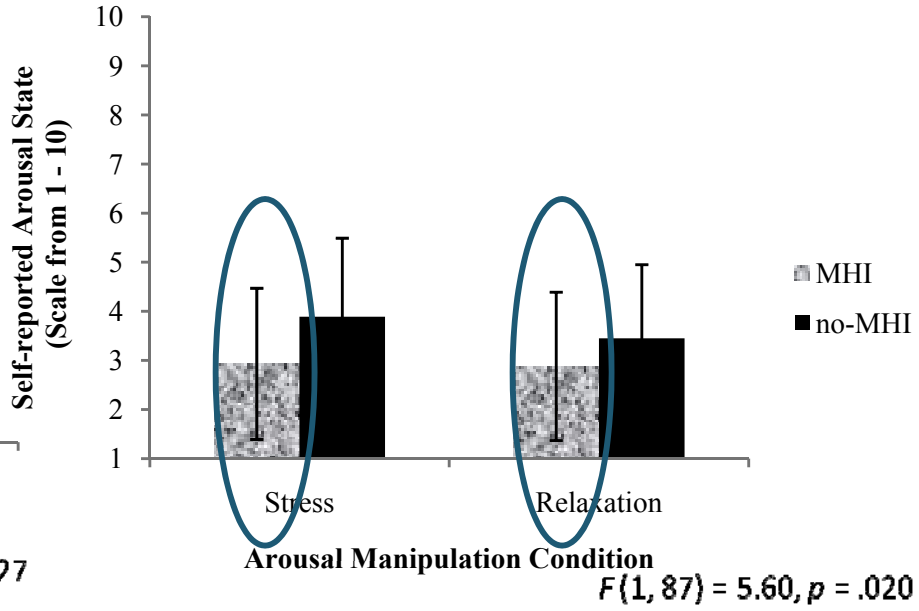
N = 51	*n*	Percentage
Loss of consciousness (LOC)	15	29.40
Less than 5 mins	14	**93.33**
More than 5 mins but less than 30 mins	1	6.67
Altered State of Consciousness (no LOC)	36	**70.59**
Concussion	24	47.10
Received medical treatment	20	39.20

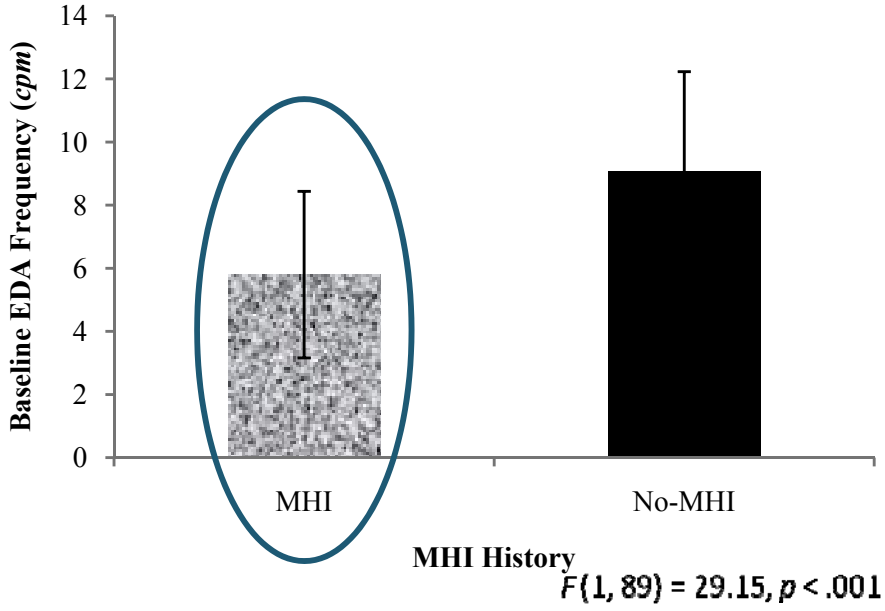
Etiology—sports-related injury: 54.90% (*n* = 28)
falling: 25.50% (*n* = 13)
other (e.g., fights): 19.60% (*n* = 10)

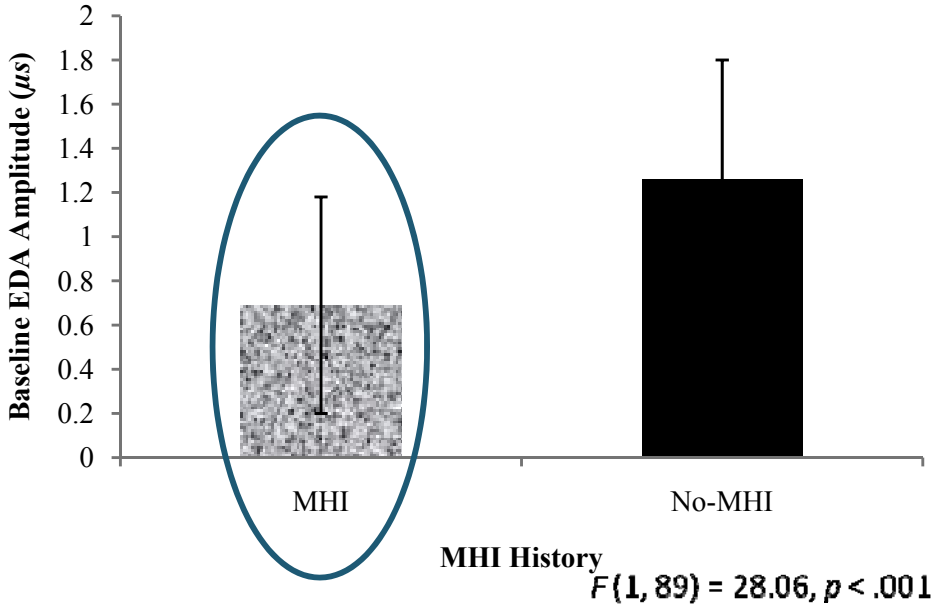
UNDERAROUSAL

Brock University

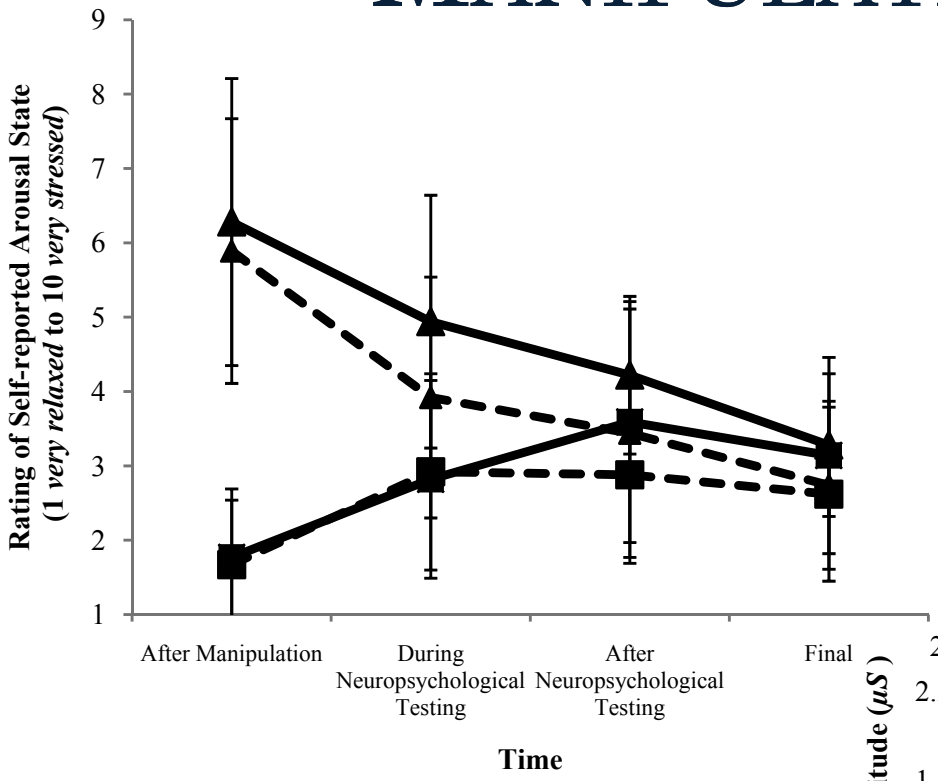


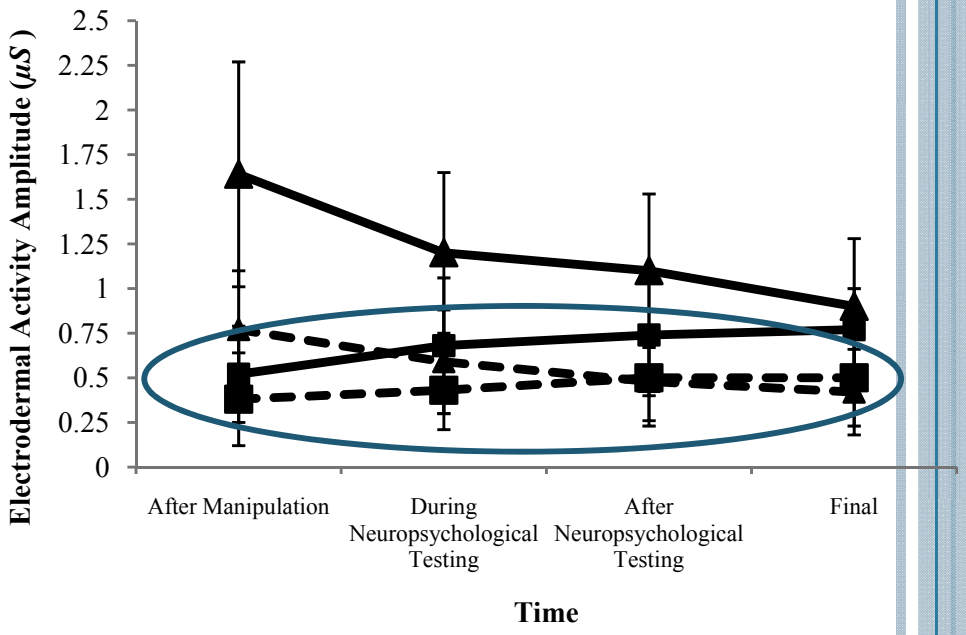






Responsivity to Arousal Manipulation





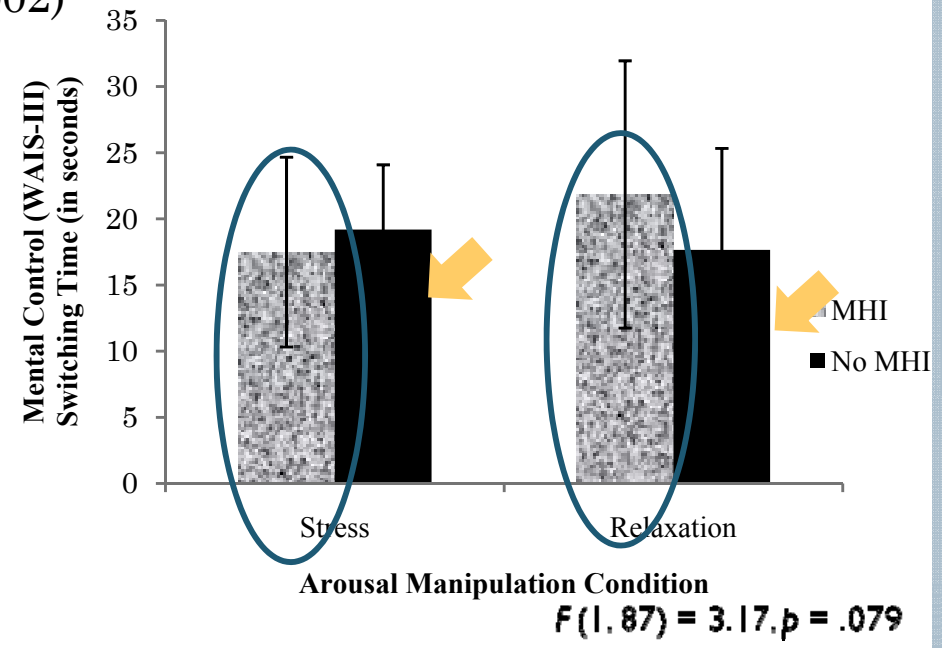
- Students with MHI had a diminished EDA response overall
- No-MHI had more extreme and larger range of responses to the manipulations than MHI

COGNITIVE PERFORMANCE

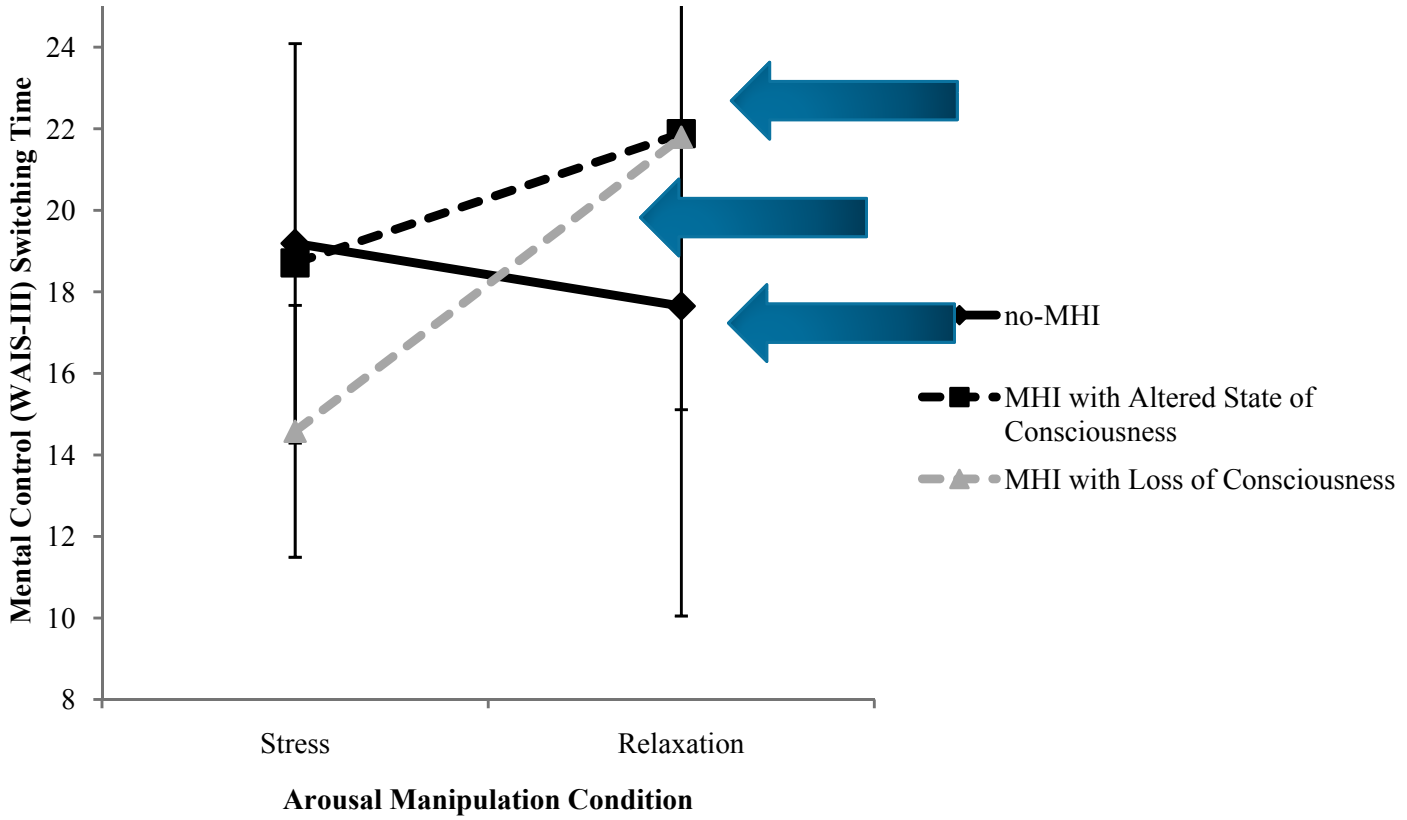
- As expected, prior to arousal manipulation (baseline) students with MHI *tended* (p = .06 to .09) to perform more poorly on:
  - working memory (WAIS-III, 1997; DKEFS, 2002)
  - attentional tasks (DKEFS, 2002)

Trend-Cognitive Flexibility Task

Performance for students with MHI *tended* to be:
→ Better in stress than relaxation
Whereas, for no-MHI:
→ Better in relaxation than stress



Cognition as a function of Severity of Injury



Summary & Conclusions

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- **Even individuals with mild head trauma present with a profile similar to that of persons with moderate-to-severe TBI**
  - underaroused (emotionally & physiologically)
  - increased reports of life stressors
  - less responsive to stressors in their environment
  - advantaged by increasing their arousal

- **Suggestive of long-lasting effects of neural disruption**
  - May indicate subtle disruption to OFC/VMPFC as this region has been implicated in the modulation of autonomic responses (e.g., Tranel & Damasio, 1994)

Brock University

THANK YOU!

And Thanks to all of the students in the NCR lab!

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http://www.psyc.brocku.ca/research/neurocognitive/index.html