NEURO INSTITUTE

Continuing Education for Rehabilitation Professionals

Environmental Enrichment to Promote Neuroplasticity and Prevent Cognitive Decline After Acquired Brain Injury

Nicole McCants, PT, DPT
Board Certification in Neurologic Physical Therapy

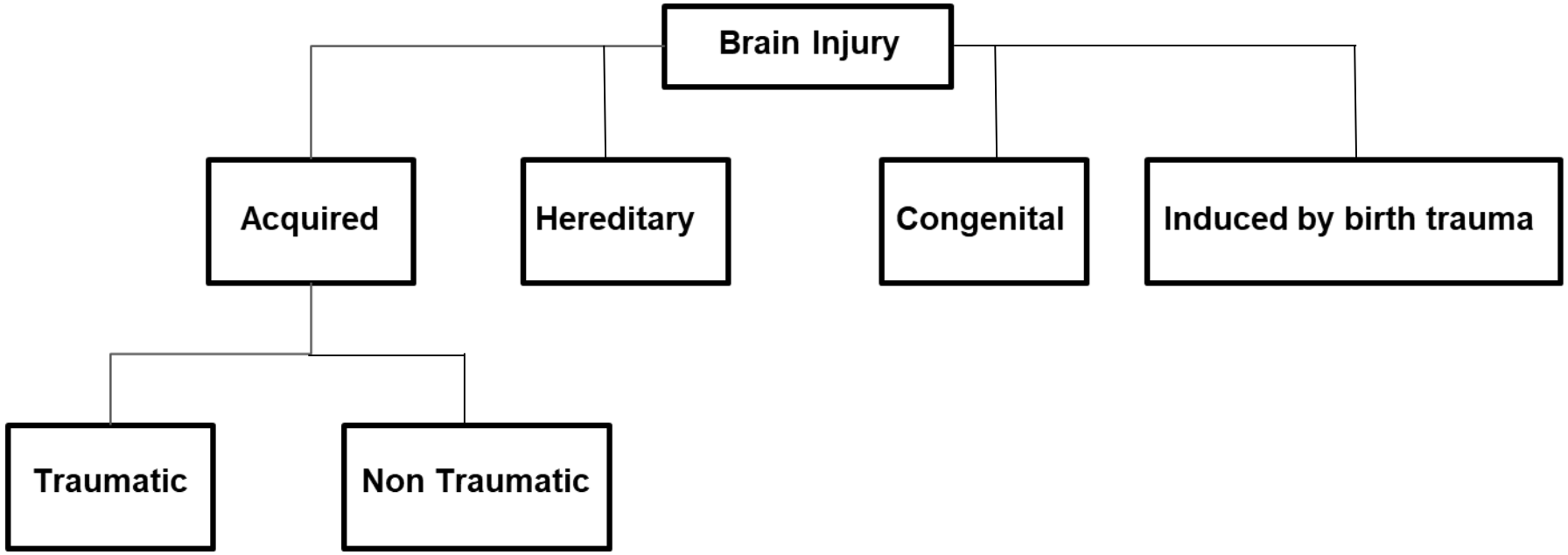
NeuroRestorative's COVID-19 Response

- We are committed to protecting the health and safety of the individuals we serve, our staff, and the community. Our services are considered essential, and we are taking precautions to minimize disruption to services and keep those in our care and our team members safe. In some programs, that has meant innovating our service delivery model through Interactive Telehealth Services. We provide Interactive Telehealth Services throughout the country as an alternative to in-person services. Through Interactive Telehealth Services, we deliver the same high-quality supports as we would in-person, but in an interactive, virtual format that is HIPAA compliant and recognized by most healthcare plans and carriers.

- You can learn more about our COVID-19 prevention and response plan at our Update Center by visiting **neurorestorative.com**.

What is a Brain Injury?

Neuro Restorative™
Rebuilding Lives. Restoring Hope.



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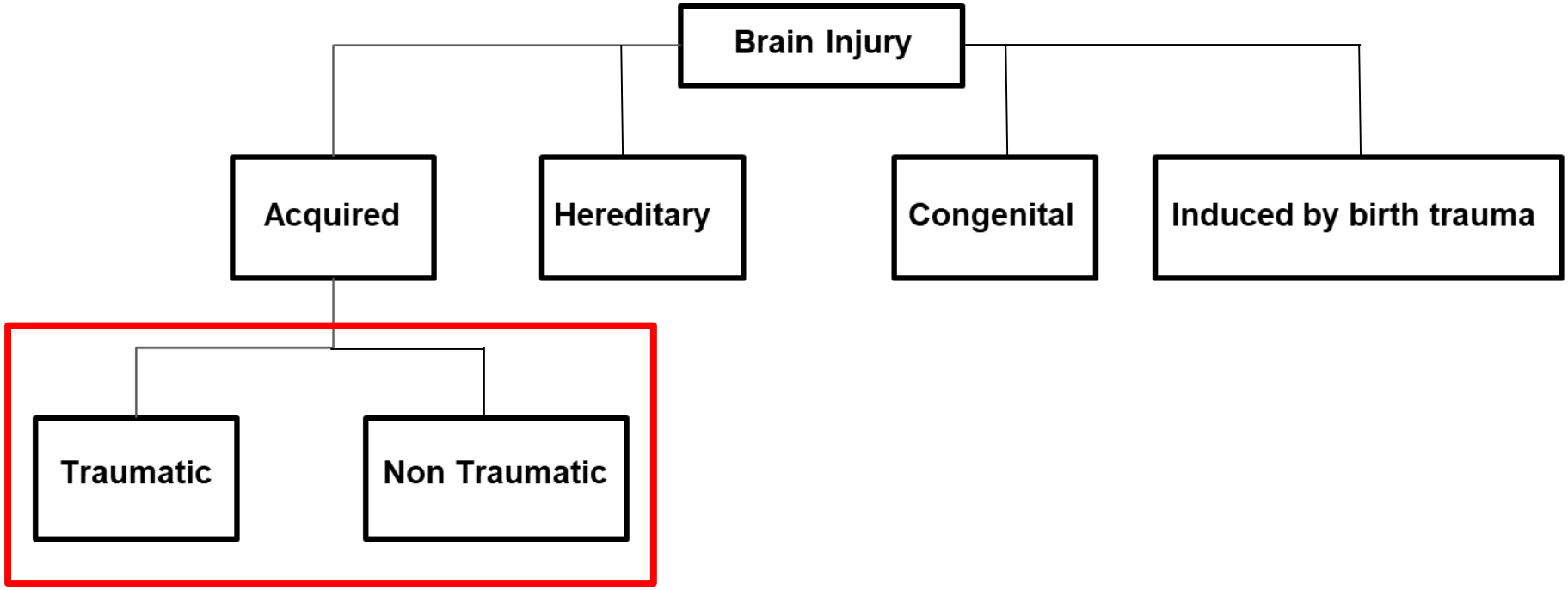

Acquired Brain Injury

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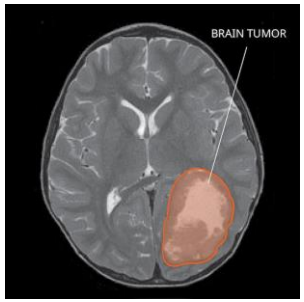
Traumatic (mild, moderate, severe)

- Falls
- Assaults
- Car accident
- Sports injuries
- Blast injuries

Non-Traumatic

- CVA
- Brain Tumor
- Hypoxic Ischemic Brain Injury
  - -Near drowning
  - -Cardiac arrest
- Aneurysm
- Infectious Disease
  - -Meningitis
  - -West Nile Virus
  - Toxic/metabolic



Brain Injury By the Numbers: Traumatic Brain Injury-TBI

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Centers for Disease Control and Prevention (CDC)

Traumatic Brain Injury

- 176 Americans died from a TBI-related injury each day in 2020
- Approximately 223,135 TBI-related hospitalizations in 2018 and 64,362 TBI related deaths in 2020
- Persons age 75 years and older have the highest incidence of TBI hospitalizations and deaths
- Males were 2 times more likely to be hospitalized and 3 times more likely to die of a TBI than females
- Children 0-17 years old had 16,070 TBI-related hospitalizations in 2018 and 2,774 TBI-related deaths in 2020

Brain Injury By the Numbers: Non Traumatic Brain Injury

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CVA (CDC, 2022)

- Every year in the U.S. more than 795,000 people experience a stroke
- Stroke is the leading cause of long-term-disability
- Reduces the mobility of more than half of stroke survivors ages 65 and older

Brain Tumor (National Brain Tumor Society, 2022)

- Approximately 700,000 people in the U.S. are living with a brain tumor
- More than any other cancer, brain tumors have a lasting and life-altering impact on physical, cognitive and psychological life

Encephalitis (Vora et al., 2014)(Lindberg, 2021)

- Between 1998 and 2010 an average of 20,258 encephalitis-related hospitalizations per year
- Survivors of severe cases are often left with permanent problems such as fatigue, irritability, impaired concentration, seizures, cognitive impairments, motor impairments

(Ng and Lee, 2019)

Pathophysiology of Brain Injuries: TBI

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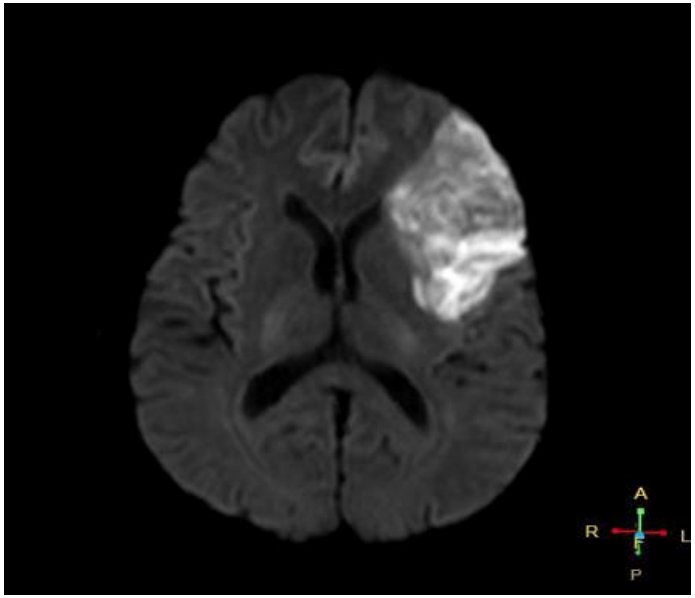
- Primary Vs. Secondary Injuries
  - Common in moderate and severe TBI
- Focal injuries (primary)
  - Causes necrotic area of neuronal and glial cells concentrated at the site of injury
  - Compromised blood supply can cause hematoma, epidural, subdural, intradural hemorrhage
  - Secondary impact at contre-coup site
- Diffuse injuries (primary)
  - Extensive neuronal and vascular damage most commonly in the subcortical white matter
    - Brainstem and corpus callosum
  - Ischemia and brain edema result
- Secondary Injuries
  - Excitotoxicity, oxidative stress, mitochondrial dysfunction, axonal degeneration, neuroinflammation, scarring, ongoing cell death

(Ng and Lee, 2019)

Pathophysiology of Brain Injuries: Nontraumatic

- Focal vs Diffuse

- Multiple mechanisms of injury
  - Ischemic
  - Hemorrhagic
  - Metabolic
  - Infectious
  - Autoimmune



radiopaedia.org

(Scottish Acquired Brain Injury Network (SABIN), 2017)

Brain Injury is a Progressive Condition

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"Head trauma is the beginning of an ongoing, perhaps lifelong, process that impacts multiple organ systems and may be disease causative and accelerative" (2)

- Moderate to severe TBI is increasingly being understood as a progressive disorder
- Reduced brain volume and white matter integrity, and lesion expansion in chronic phase of injury
- Scarring and edema reduction do not account for the amount of atrophy seen on imaging

- **Subacute deterioration attributed to functional and behavioral outcomes**
- **Increased incidence of neurodegenerative conditions**
  - **Parkinson's Disease**
  - **Alzheimer's**

Consequences of Acquired Brain Injury

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- Altered level of consciousness
- Changes in cognition and memory
- Loss of higher executive function
- Alterations in mood and behaviors
- Motor impairments
- Sleep dysregulation
- Swallowing and breathing issues
- Communication impairments: receptive and expressive
- Vision and hearing loss
- Dizziness
- Seizures
- Fatigue
- Sexual dysfunction
- Pain
- Reduced mobility
- Muscle spasticity and contracture
- Loss of independence
- Changes in sensation
- Loss of coordination
- Incontinence
- Confusion
- Endocrine disorders
- Sequelae associated with reduced mobility or immobility
- Skin breakdown
- Autonomic nervous system dysregulation
- Reduced participation in leisure, household, community and work activities
- Neurodegenerative conditions

How Does a Brain Injury Affect Each Individual?

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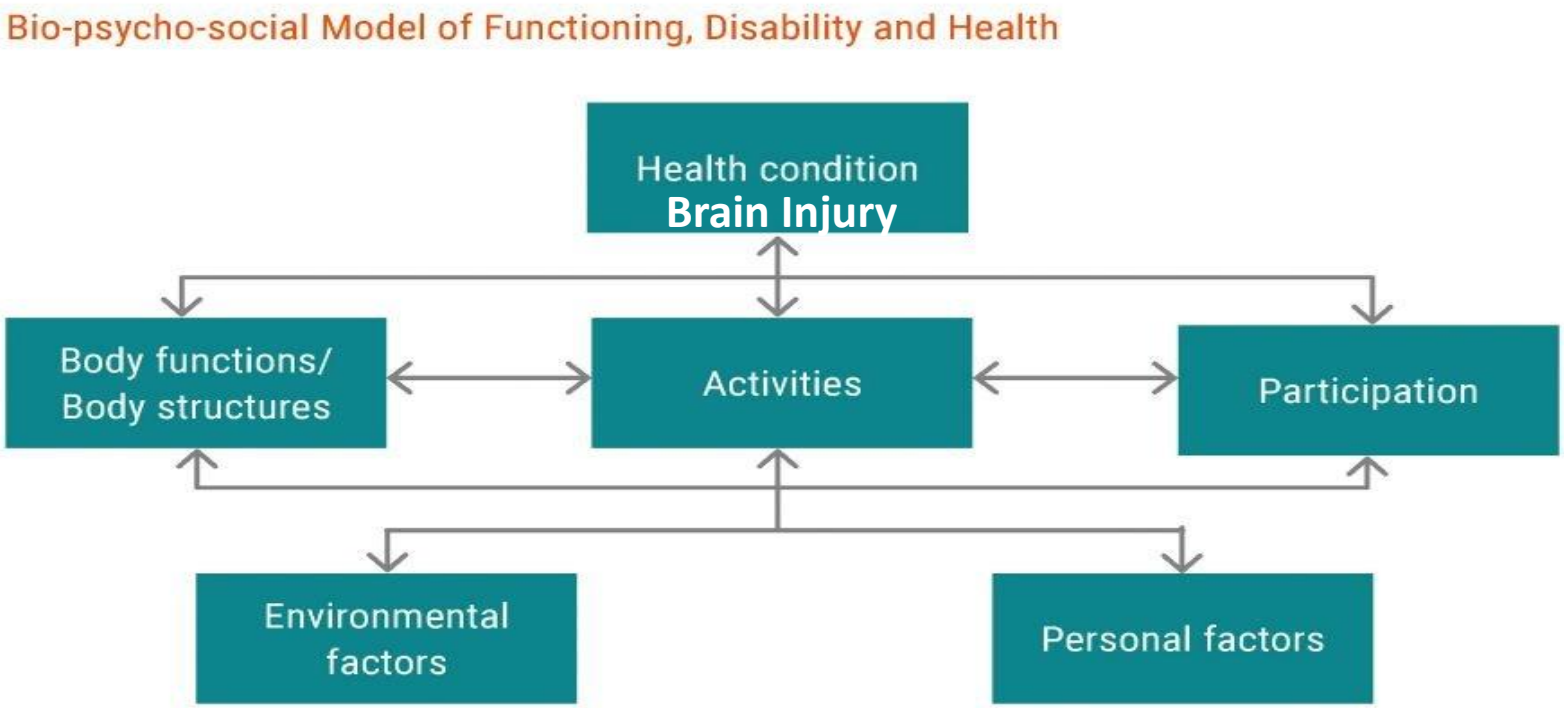

Figure 1: Bio-psycho-social model of the International Classification of Functioning, Disability and Health (ICF)

(World Health Organization, n.d.)

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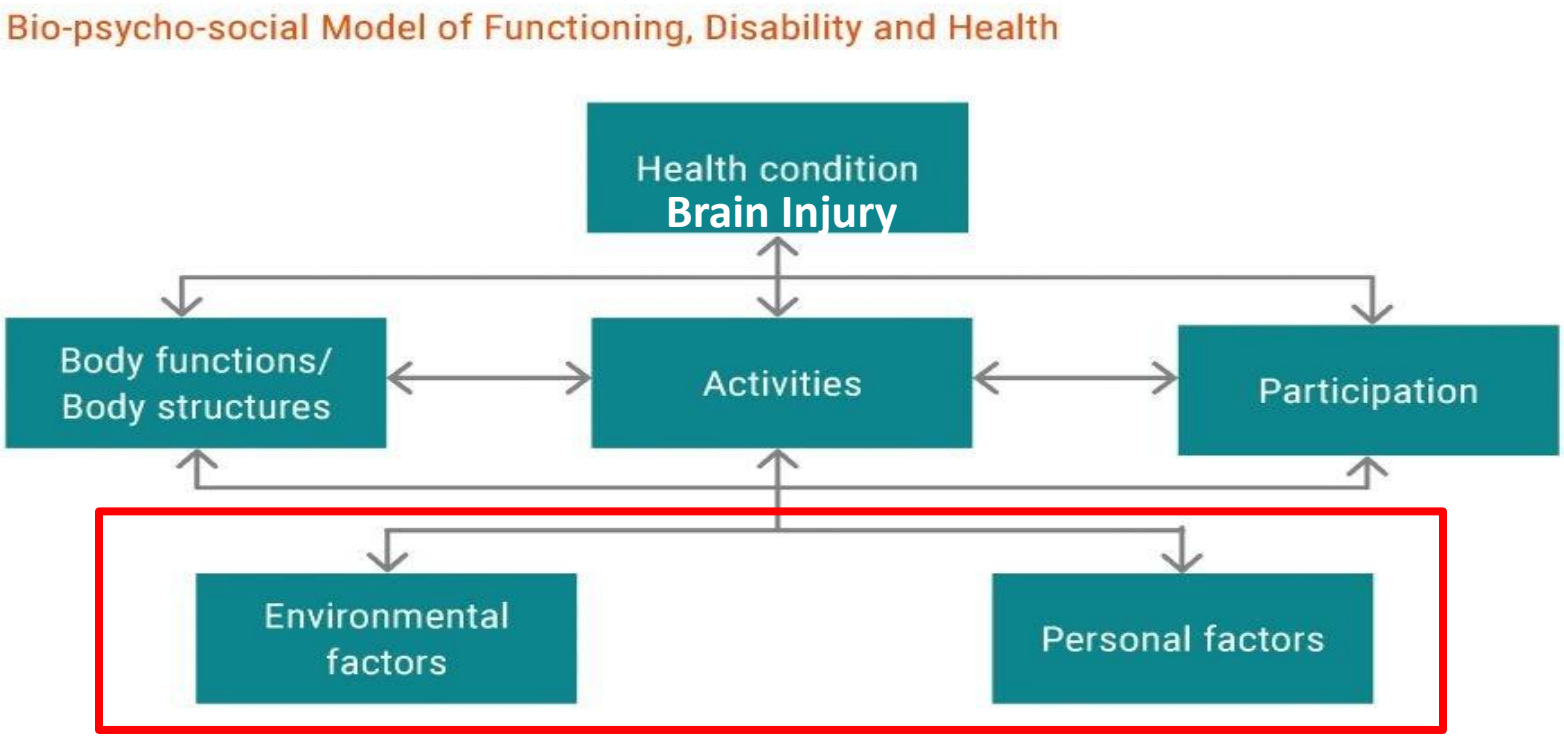

Figure 1: Bio-psycho-social model of the International Classification of Functioning, Disability and Health (ICF)

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Personal & Environmental Factors

Personal Factors

- Race, gender, educational status, coping style, religion, sexual orientation, profession, past life events, overall behavior pattern, upbringing, psychological assets

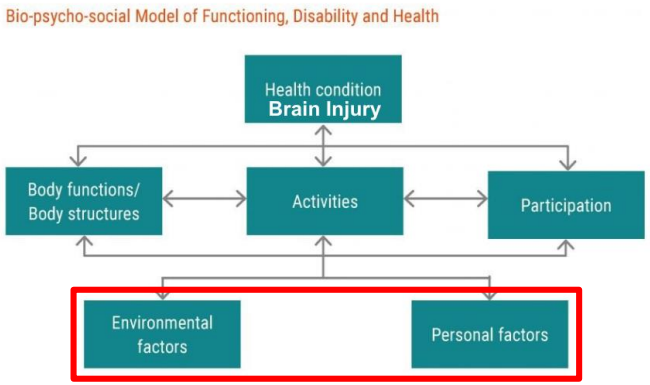

Figure 1: Bio-psycho-social model of the International Classification of Functioning, Disability and Health (ICF)

Environmental Factors

- Products and technology
- Natural environment
- Human made changes to environment
- Support and Relationships
- Attitudes
- Services, systems, policies

How Does This Relate to Our Care?

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- Negative neuroplastic changes secondary to disuse may → chronic cognitive and neural decline

  (Evans et al., 2008), (Green et al., 2014), (Tomaszczyk et al., 2014)

- Hippocampal atrophy is correlated to self-reported hours of environmental enrichment in the first year-post injury (Miller et al., 2013)

- “Use it or Lose it” principle (Shors et al., 2012)

- Engagement in simple routines may not be challenging enough to prevent volume loss in the hippocampus (Tomaszczyk et al., 2014)

What Factors are Modifiable?

- Schedules of Activity

- Environmental modifications

- Deficits in sensual-perceptual learning
  - Hearing and vision impairments
  - Light and sound sensitivity
  - Double vision
  - Visual field deficits

Activity Calendar

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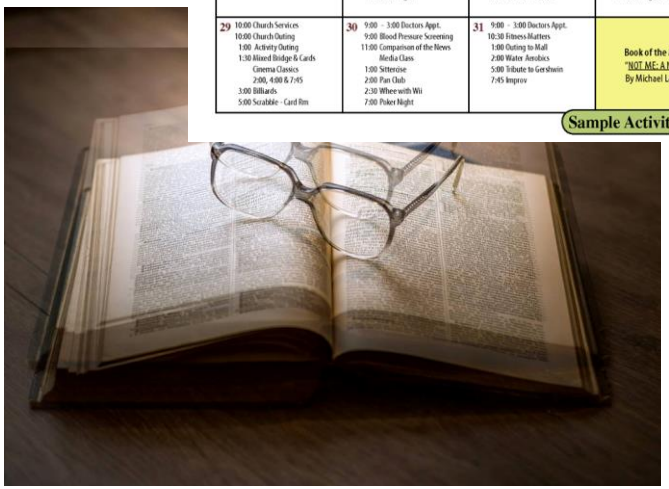
Sample Activity Calendar

https://dementiajourney.org/4563/nursing-home-activity-calendar-template_124661/



https://icrcat.com/en/eye-conditions/double-vision-diplopia/

(Tomaszczyk et al., 2014)

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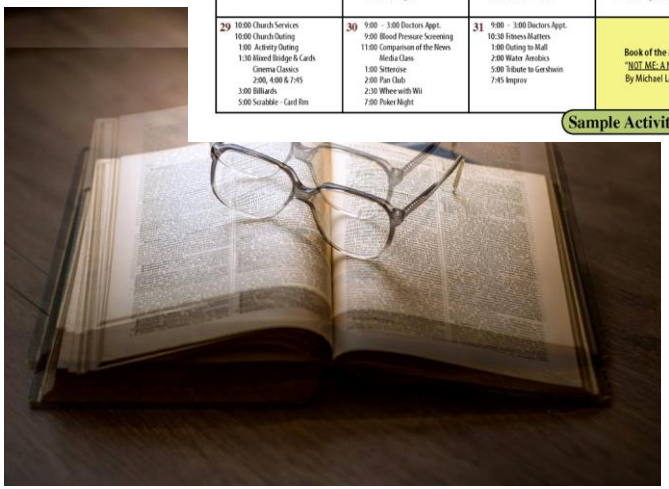

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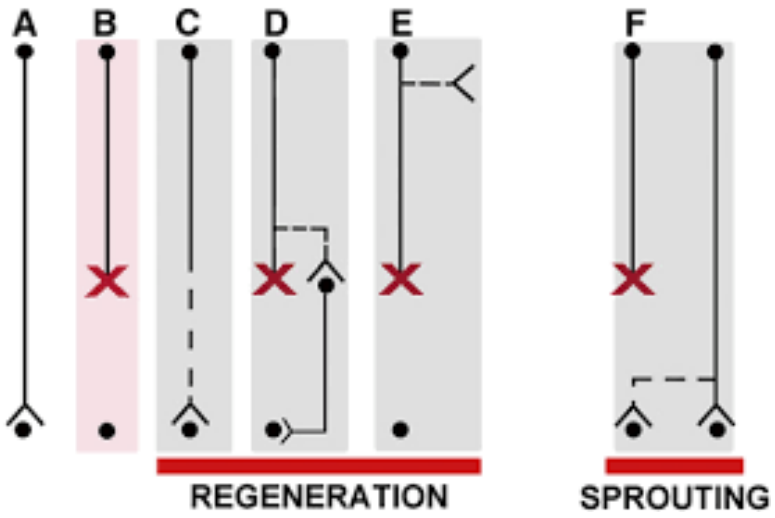
(Tomaszczyk et al., 2014)

Environmental Enrichment

A multifaceted form of housing that provides enhanced motor, cognitive, sensory and social stimulation

Brains in richer, more stimulating environments have higher rates of synaptogenesis



https://www.cell.com/neuron/pdf/S0896-6273(12)00433-3.pdf

What Does the Research Say?

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Research Articles

Temporal Effects of Environmental Enrichment–Mediated Functional Improvement After Experimental Traumatic Brain Injury in Rats

Neurorehabilitation and Neural Repair
25(6) 558–564

DOI: 10.1177/1545968310397206
http://nnr.sagepub.com
SAGE

Ashley M. Matter[1,2], Kaitlin A. Folweiler[1,2], Lauren M. Curatolo[1,2], and Anthony E. Kline, PhD[1-5]

Objective: To further assess the effects of time of initiation and duration of EE on neurobehavioral recovery after TBI

Method: TBI rats randomly assignment to group: 21 days of continuous EE, 7 or 14 days of early EE, early and late EE with none in the middle. Compared to injured rats in standard housing

Results: Motor ability was enhanced in TBI rats who received early EE compared to standard housing. Spatial recognition better in the group that received delayed EE

What Does the Research Say?

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Animal Studies cont.

- 4 weeks in an environmentally enriched cage modulated the persistent neuroinflammatory process and disturbances in brain energy homeostasis after mild TBI, mitigating cognitive impairment (Briones et al., 2013)

- Review article in 2014 found that EE “benefits behavioral and histological outcome after brain injury produced by various models…these cumulative findings provide strong support for EE as a generalized and robust preclinical model of neurorehabilitation (Bondi et al., 2014)

What Does the Research Say?

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Objective: assess the feasibility, safety, and functional recovery of an Environmental Enrichment (EE) inspired paradigm for enhancing daily activities in people with traumatic brain injury.

Feasibility of a home-based environmental enrichment paradigm to enhance purposeful activities in adults with traumatic brain injury: a case series

Devina S. Kumar & James C. Galloway

To cite this article: Devina S. Kumar & James C. Galloway (2021): Feasibility of a home-based environmental enrichment paradigm to enhance purposeful activities in adults with traumatic brain injury: a case series, Disability and Rehabilitation, DOI: 10.1080/09638288.2020.1868583

To link to this article: https://doi.org/10.1080/09638288.2020.1868583

Method: 2 adults with severe TBI and their primary caregivers took part. An overhead harness track was installed in one room in the house. Participants engaged in in-harness (IH) and out-of-harness (OH) activities.

Throughout the study, participation in social activities, home-based-hobbies, household chores, and leisure activities with friends was encouraged

Baseline functional measurements were taken and the study measured their activity over 6 months

What Does the Research Say?

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Figure 2. Environmental Enrichment for S1-C1 (A) S1 preparing an afternoon meal (B) house harness in the kitchen, and (C) C1 standing by while S1 carries milk to the breakfast table.

Figure 3. Environmental Enrichment for S2-C2 (A) S2 standing and playing video games with a console, (B) house harness in the living room, and (C) C2 helping S2 practice gait and balance training.

What Does the Research Say?

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Feasibility of a home-based environmental enrichment paradigm to enhance purposeful activities in adults with traumatic brain injury: a case series

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To cite this article: Devina S. Kumar & James C. Galloway (2021): Feasibility of a home-based environmental enrichment paradigm to enhance purposeful activities in adults with traumatic brain injury: a case series, Disability and Rehabilitation, DOI: 10.1080/09638288.2020.1868583

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Results: participants used the overhead harness on average, 4 days/week, no adverse events occurred

Specific indoor tasks were used to help meet functional goals for example, increased participation in community-level social activities

Statistically significant improvements were seen:

Subject 1: 10MWT, TUG and 6MWT

Subject 2: 6MWT and 10MWT

Long term family and community engagement in different EE settings can enhance the activity lifestyle after brain injury.

What Does the Research Say?

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frontiers in
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE
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Environmental enrichment may protect against hippocampal atrophy in the chronic stages of traumatic brain injury

*Lesley S. Miller[1], Brenda Colella[2], David Mikulis[3,4], Jerome Maller[5] and Robin E. A. Green[2,6]**

Objective: examine the relationship between post-injury EE, and hippocampal atrophy in the chronic stages of injury.

Method: 25 participants with moderate to severe TBI in IP rehab, who were able to follow simple commands, filled out the Lifestyle Activities Questionnaire to report participation in EE activities–cognitive, physical and social activities

MRI results 5-28 mos post-injury were used to measure hippocampal volume loss

Results: significant negative correlation was observed ($r = -0.42$, $p < 0.05$, $df = 21$) whereby greater general activity level at 5 months post-injury was associated with less bilateral hippocampal atrophy from 5 to 28 months post-injury. Cognitive and social activities seemed to have the greatest effect (vs physical)

Limitations to the research

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- Difficulty standardizing EE across research sites
- The exact mechanisms are correlative so far
- Which aspects of EE are critical for enhancing brain plasticity?
- What is the optimal dosing?
- We need more human studies and studies on non-traumatic TBI (other than CVA)

(McDonald et al., 2018)

Limitations to the research

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Cochrane Library
Cochrane Database of Systematic Reviews

Environmental enrichment for stroke and other non-progressive brain injury (Review)

Qin H, Reid I, Gorelik A, Ng L

- planned to include trials that compared environmental enrichment with standard services.
- Studies included any intervention that facilitates physical, cognitive, and social activity by the provision of equipment and organisation of a stimulating environment whereby the intervention is not therapist- (or other health-professional) dependent (or prescribed) and exposure alone to such environments encourages patients to perform activities.
- 1 small RCT at high risk of bias (Khan 2016) met the criteria
- data are insufficient to provide any reliable indication of benefit or risk of environmental enrichment in an inpatient rehabilitation setting for improving mood, cognition, motor function, coping or quality of life.

Who is Responsible for Enriching the Environment?

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Who is Responsible for Enriching the Environment?

Occupational therapist

Recreational therapist

Life Skills Trainers

Family members

Nurses

Physical therapists

Music therapists

Example: School-Based EE

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EE STRATEGIES IN CHILDREN WITH TBI

Implementing environmental enrichment strategies to help children who have sustained a moderate or severe traumatic brain injury

PAUL B. JANTZ

- EE interventions that contained novelty, intensity and prolonged periods of engagement resulted in significant increases in recovery outcomes, including functional gains.
- Skill and task-specific interventions prescribed by a therapist tend to result in improvements in that specific skill but are not overly generalizable to other environments
- We can use EE to provide opportunities to use these skills outside of therapies in varied environments in novel and new ways that pertain to the individual's interests and needs

(Jantz, 2020)

Special Considerations for Persons with Brain Injury

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-Fatigue

-Overstimulation

-Understimulation

-Behavioral

-Cognitive and Motor impairments

-Vision impairments

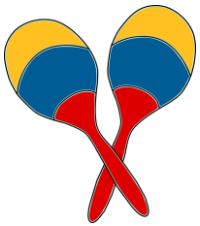
-Hearing Impairments

How can we apply these concepts?

- Work as a team to determine what types of activities and level of difficulty is most appropriate to help generalize skills

- Find out what is important and salient to the individual
- Prepare the space to have activities and equipment readily available
- Set aside time daily to allow the individual to interact with these things
- Staff members may be necessary to assist the individual

How can we apply these concepts?



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- Observe for signs of overt frustration, unwanted behaviors, or fatigue that might signal it is time to stop or change the activity
- Consider the need for adaptive equipment or modifications to improve participation
- Look around you…do you feel inspired to engage with the environment?
- Realize that every day may be different
- Keep the activities novel–consider a rotation of equipment and activities

Potential Barriers to Implementation

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- Staffing
- Budgeting
- Space limitations
- Meeting the needs of many individuals
- Physical and cognitive barriers of participation
- Lack of awareness or training of staff
- Access to transportation and equipment
- Lack of specifics around dosing and which EE strategies are best
- Family support

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Thank You!

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