

## Evidence-Based Strategies for Promoting Neuroplasticity

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The literature in Neuroscience and in Occupational Therapy on neuroplasticity suggests five Rehabilitative strategies that elicit the best evidence for improving cognitive function with people with neurological challenges.

1. **Task-Oriented Training**- Chan,2014; Cumming , Marshall, Lazar, 1994; Foster, Bedekar , Tickle-Degnen, 2014, Hoffmann, Bennett, Koh, McKenna 2011, Kim &Kim, 2014; Kleim, J.A. & Jones,2008, Lambert, Hyer, Bardi, Rzucidlo, Scott, Terhune-Cotter, Hazelgrove, Silva, & Kinsley,2016; Lambert,2006, Langhorne Bernhardt, Kwakkel,2011; McGrath, O'Callaghan,2014; Matilla-Mora, Martínez-Piédrola, Fernández Huete, 2016; Park HY, Maitra K, Martinez,2015; Wittich, Barstow, Jarry, Thomas,2015.
2. **Enriched Environments**- Humphreys and Sui,2014; Lambert, Hyer, Bardi, Rzucidlo, Scott, Terhune-Cotter, Hazelgrove,, Silva, & Kinsley, 2016; Lambert, & Kinsley,2011.
3. **Physical Exercise** – Bherer,2015; Carvalho, Rea, Parimon, Cusack,2014; Karr, Areshenkoff, Rast , Garcia-Barrera,2014; Langhorne, Bernhardt J, Kwakkel,2011
4. **Formal Motor Training**- Cumming, Marshall, Lazar,2013; Jacoby, Ahissar,2014; Karr, Areshenkoff, Rast, Garcia-Barrera,2014; Krasny-Pacini, Chevignard, Evans,2014; McGrath, O'Callaghan,2014; Merzenich, & Van Vleet,2014; Takeuchi, Kawashima,2012; Yuan & Raz,2014.
5. **Cognitive Reserve**- Herholz & Herholz, 2013; Lambert, & Kinsley,2011; Lane & Schaaf,2011; Langhorne, Bernhardt, Kwakkel,2011; Vance, Roberson, McGuinness, Fazeli,2010

### Rationale:

- The literature has demonstrated that real Task-Oriented training or Purposeful Activity is superior to non-purposeful activities such as stacking cones. **Task oriented training and handcrafts** that provide rhythm, synchrony and coherence strengthens synaptic connections between neurons. In other word, “neurons the fire together, wire together (Hebb, 1949).
- Enriched environments develop thicker cerebral cortices especially in the occipital cortex.
- Physical exercise increases the thickness of the motor cortex, angiogenesis in the cerebellum, and neurogenesis in the hippocampus.
- Formal motor training increases thickness in the motor cortex, and synaptogenesis in the hippocampus (Memory and Learning).
- Cognitive reserve is equated with higher levels of intelligence and education which seems to build more complex interconnects among neurons and acts as a buffer against loss of function and better capacity to recover from neurologic brain insults.

Note: The occupational therapist can use creative ways to build upon the principles listed above into a treatment plan that is evidence-based in respect to neuroplastic rehabilitative strategies and at the same time stay within the OT Framework scope of practice.

Questions for Discussion:

1. What have you learned from this session that you did not know before attending?
2. How will you use this information in your OT Practice?
3. How has the Neuroscience behind Handcrafts enhanced your appreciation for therapeutic media?
4. How would you describe Effort Driven Reward Training?

## Neuroplasticity References and Abstracts

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Bherer L Cognitive plasticity in older adults: effects of cognitive training and physical exercise. *Ann N Y Acad Sci.* 2015 Mar;1337:1-6. doi: 10.1111/nyas.12682. Abstract: Overall, results reviewed here support the notion that cognitive plasticity for attentional control, as induced by cognitive training or physical activity and exercise, is preserved in late adulthood. Moreover, results of studies with patients at risk of cognitive decline also suggest that cognitive training and exercise interventions are promising nonpharmaceutical tools to help improve cognition in older at-risk individuals.

Carvalho A, Rea IM, Parimon T, Cusack BJ. Physical activity and cognitive function in individuals over 60 years of age: a systematic review. *Clin Interv Aging.* 2014 Apr 12;9:661-82. doi: 10.2147/CIA.S55520. eCollection 2014 **Abstract:** The preponderance of evidence suggests that physical activity is beneficial for cognitive function in the elderly. However, the majority of the evidence is of medium quality with a moderate risk of bias. Larger randomized controlled trials are needed to clarify the association between exercise and cognitive function and to determine which types of exercise have the greatest benefit on specific cognitive domains. Despite these caveats, the current evidence suggests that physical activity may help to improve cognitive function and, consequently, delay the progression of cognitive impairment in the elderly.

Chan, Y. Reorganization and plastic changes of the brain associated with skill training and expertise. *Frontiers in Human Science*, (2014). 8:35 doi:3389/fnhum201.00035

Cumming TB1, Marshall RS, Lazar RM. Stroke, cognitive deficits, and rehabilitation: still an incomplete picture. *Int J Stroke.* 2013 Jan;8(1):38-45. doi: 10.1111/j.1747-4949.2012.00972.x **Abstract:** Effective cognitive rehabilitation approaches have been reported for focal cortical deficits such as neglect and aphasia, but treatments for more diffusely represented cognitive impairment remain elusive. In the future, the hope is that different techniques that have been shown to promote neural plasticity (e.g., exercise, brain stimulation, and pharmacological agents) can be applied to improve the cognitive function of stroke survivors.

Degen C, Schröder J. Training-induced cerebral changes in the elderly. *Restor Neurol Neurosci.* 2014;32(1):213-21. doi: 10.3233/RNN-139009 Abstract: The human brain retains a high degree of plasticity in old age. Moreover, it seems that practice leads to more efficient processing, requiring less neural engagement to perform the same task. While the concept of economization finds widespread support in healthy populations, in patient groups this effect has proven to be absent or reversed. The concept of cognitive reserve and potentially compensatory mechanisms are discussed in this context.

Englehart C, Eisenstein N, Meininger J. Psychometric properties of the Neurobehavioral Cognitive Status Exam. *Clinical Neuropsychologist*. 1994;8(4):405-415.

Fisher M, Holland C, Subramaniam K, Vinogradov S. Neuroplasticity-based cognitive training in schizophrenia: an interim report on the effects 6 months later. *Schizophr Bull*. 2010 Jul;36(4):869-79. doi: 10.1093/schbul/sbn170. Epub 2009 Mar 5 **Abstract:** A total of 50 hours of neuroplasticity-based computerized cognitive training appears sufficient to drive improvements in verbal learning/memory and cognitive control that endure 6 months beyond the intervention, but a higher "dose" and more "broad-spectrum" training may be necessary to drive enduring gains in processing speed and global cognition.

Foster ER, Bedekar M, Tickle-Degnen L. Systematic review of the effectiveness of occupational therapy-related interventions for people with Parkinson's disease. *Am J Occup Ther*. 2014 Jan-Feb;68(1):39-49. doi: 10.5014/ajot.2014.008706 **Abstract:** We describe the results of a systematic review of the literature on occupational therapy-related interventions for people with Parkinson's disease (PD). Three broad categories of intervention emerged: (1) exercise or physical activity; (2) environmental cues, stimuli, and objects; and (3) self-management and cognitive-behavioral strategies. Moderate to strong evidence exists for task-specific benefits of targeted physical activity training on motor performance, postural stability, and balance. Low to moderate evidence indicates that more complex, multimodal activity training supports improvement in functional movement activities. The evidence is moderate that the use of external supports during functional mobility or other movement activities has positive effects on motor control. In addition, moderate evidence is available that individualized interventions focused on promoting participant wellness initiatives and personal control by means of cognitive-behavioral strategies can improve targeted areas of quality of life. The implications for practice, education, and research are discussed.

Herholz SC, Herholz RS, Herholz K. Non-pharmacological interventions and neuroplasticity in early stage Alzheimer's disease. *Expert Rev Neurother*. 2013 Nov; 13(11):1235-45. doi: 10.1586/14737175.2013.845086. Epub 2013 Oct 17. **Abstract:** We discuss cognitive reserve and possible mechanisms that drive neuroplasticity and new learning. Finally, we identify promising avenues for future intervention strategies and research, such as combinations of cognitive and pharmaceutical interventions, and individual strategies adapted to the disease stage and tailored to the needs, predispositions and preferences of patients.

Hoffmann T, Bennett S, Koh C, McKenna K. The Cochrane review of occupational therapy for cognitive impairment in stroke patients. *Eur J Phys Rehabil Med*. 2011 Sep;47(3):513-9. Epub 2011 Apr 14. **Abstract:** The effectiveness of occupational therapy for cognitive impairment post-stroke remains unclear. The potential benefits of cognitive retraining delivered as part of occupational therapy on improving basic daily activity function or specific cognitive abilities, or both, of people who have had a

stroke cannot be supported or refuted by the evidence included in this review. More research is required.

Humphreys, G. W., and Sui, J Attentional control and the self: the Self-Attention Network (SAN). *Cogn. Neurosci.* . (2015).doi: 10.1080/17588928.2015.1044427.

Jacoby N, Ahissar M. What does it take to show that a cognitive training procedure is useful? A critical evaluation. *Prog Brain Res.* 2013;207:121-40. doi: 10.1016/B978-0-444-63327-9.00004-7. Abstract: Individuals substantially improve with training, indicating that a large degree of plasticity is retained across ages. In the past 20 years, many studies explored the ability to boost cognitive skills (reasoning, linguistic abilities, working memory, and attention) by training with other tasks that exploit limited cognitive resources. Indeed, individuals with long-term training on challenging skills (musicians and action video gamers) show impressive behavior on related tasks (linguistic and visual attention, respectively). However, a critical evaluation of training studies that last weeks to months shows typically mild effects, mainly with respect to control groups that either did not practice or practiced with less challenging, rewarding, or exciting conditions. These findings suggest that future training studies should evaluate these factors carefully and assess whether they mainly impact the testing sessions or actual longer-term skills, and whether their impact can be further strengthened. The lack of a comprehensive theory of learning that integrates cognitive, motivational, and alertness aspects poses a bottleneck to improving current training procedures.

Kalat, J. W.. *Biological Psychology* (11th ed.) Cengage Learning. 2013

Karr JE, Areshenkoff CN, Rast P1, Garcia-Barrera MA. An empirical comparison of the therapeutic benefits of physical exercise and cognitive training on the executive functions of older adults: a meta-analysis of controlled trials. *Neuropsychology.* 2014 Nov;28(6):829-45. doi: 10.1037/neu0000101.

**Abstract:** A robust body of aging-related research has established benefits of both physical exercise (PE) and cognitive training (CT) on executive functions related to the activities of daily living of older adults; however, no meta-analysis has compared these treatments.

Kiernan, R.J., Mueller J., Langston J.W., Van Dyke C. The Neurobehavioral Cognitive Status Examination, A Brief but Differentiated Approach to Cognitive Assessment. *Annals of Internal Medicine.* 1987; 107:481–485

Kim EY, Kim KW. A theoretical framework for cognitive and non-cognitive interventions for older adults: stimulation versus compensation. *Aging Ment Health.*2014;18(3):304-15. doi:

10.1080/13607863.2013.868404. **Abstract:** Current interventions for age-related cognitive decline are reviewed in terms of stimulation- and compensation-focused interventions. Stimulation-focused, cognitive and non-cognitive training, with or without specific targets, tend to result in general improvement in attention and sensory or other cognitive functions. Meanwhile, compensation-focused

training is likely to be the most effective when the intervention specifically supports the frontally mediating activity in accordance with the direction of indigenous adjustments in the aging brain.

Kleim, J.A. & Jones, T.A.. Principles of experience dependent neuroplasticity: Implications for children and adolescents. *Speech, Language and Hearing Research*, (2008) 51, C225-S239.

Krasny-Pacini A, Chevignard M, Evans J. Goal Management Training for rehabilitation of executive functions: a systematic review of effectiveness in patients with acquired brain injury. *Disabil Rehabil*. 2014;36(2):105-16. doi: 10.3109/09638288.2013.777807. Epub 2013 Apr 18. **Abstract:** GMT with: Problem Solving Therapy; personal goal setting; external cueing or prompting apply GMT to the current task; personal homework to increase patients' commitment and training intensity; ecological and daily life training activities rather than paper-and-pencil, office-type tasks. Level of support for GMT was higher for studies measuring outcome in terms of increases in participation in everyday activities rather than on measures of executive impairment.

Lambert, K., Hyer, M., Bardi, M., Rzucidlo, A., Scott, S., Terhune-Cotter, b., Hazelgrove, A., Silva, I., & Kinsley, C. (2016). Natural-enriched environments lead to enhanced environmental engagement and altered neurobiological resilience. *Neuroscience*, 330, 386-394.

Lambert KG. Rising rates of depression in today's society: consideration of the roles of effort-based rewards and enhanced resilience in day-to-day functioning. *Neurosci Biobehav Rev*. 2006;30(4):497-510. Epub 2005 Oct 25. **Abstract:** Despite the existence of a vastly improved health care system and a multi-billion dollar antidepressant industry, the rates of depression in the US remain alarmingly high. An exploration of lifestyle changes over the past century suggests that the level of physical activity necessary to provide life's basic resources, referred to as effort-based rewards, has diminished in our industrialized, technologically advanced, service-oriented society. The evolution of the accumbens-striatal-cortical circuitry and its modulating neurochemicals in our ancestors played a significant role in sustaining the continued effort critical for the acquisition of resources such as food, water and shelter; consequently, vast reductions in the degree of physical activity required to obtain necessary resources in today's society likely lead to reduced activation of brain areas essential for reward/pleasure, motivation, problem-solving, and effective coping strategies (i.e. depressive symptomology). Comparative cultural and gender analyses reinforce the significant role of effort-based rewards in mood regulation, suggesting that minimal engagement in such endeavors leads to compromised resilience upon exposure to life's stressful challenges. If physical activity is indeed important in the maintenance of mental health, increased emphasis on behavioral and behavioral/cognitive preventative life strategies, as opposed to an emphasis on psychopharmacological strategies directed at very specific neurochemicals after the onset of depression, should be adopted as protective measures against the onset of depressive symptomology. Thus, strategies that include more global neurobiological activation in the relevant context of directed efforts provide a fresh perspective for depression research.

Lambert, K *Lifting Depression: A neuroscientist's hands-on approach to activating your brain's healing power*. New York: Basic Books. 2008.

Lanbert, K.G. & Kinsley, C. *Clinical Neuroscience: Psychopathology and the Brain* (2<sup>nd</sup> edition) New York: Oxford University Press; 2011.

Lane, S. & Schaaf, R.C. Examining the neuroscience for sensory driven neuroplasticity. *AJOT*, (2010). 643,375-390.

Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. *Lancet*. 2011 May 14; 377(9778):1693-702. doi: 10.1016/S0140-6736(11)60325-5. **Abstract:** Potentially beneficial treatment options for motor recovery of the arm include constraint-induced movement therapy and robotics. Promising interventions that could be beneficial to improve aspects of gait include fitness training, high-intensity therapy, and repetitive-task training. Repetitive-task training might also improve transfer functions. Occupational therapy can improve activities of daily living; however, information about the clinical effect of various strategies of cognitive rehabilitation and strategies for aphasia and dysarthria is scarce. Several large trials of rehabilitation practice and of novel therapies (eg, stem-cell therapy, repetitive transcranial magnetic stimulation, virtual reality, robotic therapies, and drug augmentation) are underway to inform future practice.

McGrath M, O'Callaghan C. Occupational therapy and dementia care: a survey of practice in the Republic of Ireland. *Aust Occup Ther J*. 2014 Apr;61(2):92-101. doi: 10.1111/1440-1630.12081. Epub 2013 Sep 12 **Abstract:** There is a growing body of research to support the role of occupational therapy in dementia care. However, little is known about the extent to which this research is translated into occupational therapy practice. This study addresses this gap by considering current occupational therapy practice in the field of dementia care in Ireland. Forty-seven therapists responded to the survey. The majority of respondents worked in primary care and provided services for people with early stage or mild dementia. Assessment practices were primarily focused on cognitive screening and functional performance. Limited attention was paid to occupational participation. Interventions typically addressed environmental modification, assistive devices and compensatory strategies. The ability of therapists to apply research evidence to practice appears to be strongly constrained by practice and organizational demands.

Merzenich, M & Van Vleet, M. Brain plasticity-based therapeutics. *Frontiers in Human Neuroscience*, (2016) 27 June 2014 [hps://doi.org//10.3389/ Fnhum2014.00385](https://doi.org/10.3389/Fnhum2014.00385)

Matilla-Mora R, Martínez-Piédrola RM, Fernández Huete J. Effectiveness of occupational therapy and other non-pharmacological therapies in cognitive impairment and Alzheimer's disease]. *Rev Esp Geriatr Gerontol*. 2016 Nov - Dec;51(6):349-356. doi: 10.1016/j.regg.2015.10.006. **Abstract:** The evidence obtained showed the efficiency and effectiveness of OT in delaying the progression of various disorders, especially when structured home OT programs are used.

Pattyn, N.; Neyt, X.; Henderickx, D.; Soetens, E. "Psychophysiological Investigation of Vigilance Decrement: Boredom or Cognitive Fatigue?". *Physiology & Behavior*. (2008). 93 (1–2): 369–378. doi:10.1016/j.physbeh.2007.09.016.

Park HY, Maitra K, Martinez KM. The Effect of Occupation-based Cognitive Rehabilitation for Traumatic Brain Injury: A Meta-analysis of Randomized Controlled Trials. *Occup Ther Int*. 2015 Jun;22 (2):104-16. doi: 10.1002/oti.1389. Epub 2015 Mar 24. **Abstract:** The purpose of this study was to investigate the overall effect of occupation-based cognitive rehabilitation on patients' improvement in cognitive performance components, activity of daily living (ADL) performance, and values, beliefs and spirituality functions of patients with TBI. The papers used in this study were retrieved from the Cochrane Database, EBSCO (CINAHL), PsycINFO, PubMed and Web of Science published between 1997 and 2014. Evidence from the present meta-analytic study suggests that occupation-based cognitive rehabilitation would be beneficial for individuals with TBI for improving daily functioning and positively be able to affect their psychosocial functions. Collecting many outcome measures in studies with relatively few participants and the final data are less reliable than the whole instrument itself. Future research should evaluate the effectiveness of specific occupation-based cognitive rehabilitations programs in order to improve consistency among rehabilitation providers.

Phillips, LH; et al."Mental planning and the Tower of London task". *Quarterly Journal of Experimental Psychology - Section A-Human Experimental Psychology*. (2001)54 (2): 579–597. doi:10.1080/713755977.

Schwamm L.H., Van Dyke C., Kiernan R.J., Merrin E., Mueller J. The Neurobehavioral Cognitive Status Examination, Comparison of the NCSE and MMSE in a Neurosurgical Population. *Annals of Internal Medicine*. 1987; 107:486-491

Silveri, M. C.; Ciccarelli, N; Cappa, A "Unilateral spatial neglect in degenerative brain pathology". *Neuropsychology*. (2011). 25 (5): 554–66. doi:10.1037/a0023957. PMID 21639641.

Skarratt, P. A., Cole, G. G., and Kuhn, G. Visual cognition during real social interaction. *Front. Hum. Neurosci*. (2012). 6:196. doi: 10.3389/fnhum.2012.00196

Takeuchi H1, Kawashima R. Effects of processing speed training on cognitive functions and neural systems. *Rev Neurosci*.2012 May 23;23 (3):289-301. doi: 10.1515/revneuro-2012-0035.**Abstract:** Processing speed (PS) is an individual cognitive ability that measures the speed with which individuals execute cognitive tasks, particularly elementary cognitive tasks. PS has been proposed to be a key cognitive component, along with working memory, and is psychologically and clinically important.

Yuan P, Raz N. Prefrontal cortex and executive functions in healthy adults: a meta-analysis of structural neuroimaging studies. *Neurosci Biobehav Rev*. 2014 May;42: 180-92. doi: 10.1016/j.neubiorev.2014.02.005. Epub 2014 Feb 23 **Abstract:** Lesion studies link the prefrontal cortex (PFC) to executive functions. However, the evidence from in vivo investigations in healthy people is mixed, and there are no quantitative estimates of the association strength. To examine the relationship

between PFC volume and cortical thickness with executive cognition in healthy adults, we conducted a meta-analysis of studies that assessed executive functions and PFC volume (31 samples,) and PFC thickness (10 samples) in vivo, N=3272 participants. We found that larger PFC volume and greater PFC thickness were associated with better executive performance. Stronger associations between executive functions and PFC volume were linked to greater variance in the sample age but was unrelated to the mean age of a sample. Strength of association between cognitive and neuroanatomical indices depended on the executive task used in the study. PFC volume correlated stronger with Wisconsin Card Sorting Test than with digit backwards span, Trail Making Test and verbal fluency. Significant effect size was observed in lateral and medial but not orbital PFC. The results support the "bigger is better" hypothesis of brain-behavior relation in healthy adults and suggest different neural correlates across the neuropsychological tests used to assess executive functions.

Vance DE, Roberson AJ, McGuinness TM, Fazeli PL. How neuroplasticity and cognitive reserve protect cognitive functioning. *J Psychosoc Nurs Ment Health Serv.* 2010 Apr;48(4):23-30. doi: 10.3928/02793695-20100302-01 **Abstract:** Overall cognitive status can vary across an individual's life span in response to factors that promote either positive or negative neuroplasticity. Positive neuroplasticity refers to the physiological ability of the brain to form and strengthen dendritic connections, produce beneficial morphological changes, and increase cognitive reserve. Negative neuroplasticity refers to the same physiological ability of the brain to atrophy and weaken dendritic connections, produce detrimental morphological changes, and decrease cognitive reserve. Factors that promote positive neuroplasticity include physical activity, education, social interaction, intellectual pursuits, and cognitive remediation. Factors that promote negative neuroplasticity include poor health, poor sleep hygiene, poor nutrition, substance abuse, and depression and anxiety. Implications for promoting positive neuroplasticity and avoiding negative neuroplasticity across the life span are emphasized to facilitate optimal cognitive health and ensure successful cognitive aging.

Wittich W, Barstow EA, Jarry J, Thomas A. Screening for sensory impairment in older adults: Training and practice of occupational therapists in Quebec. *Can J Occup Ther.* 2015 Dec; 82(5):283-93. doi: 10.1177/0008417415573076. Epub 2015 Feb 19 **Abstract:** Occupational therapy considers numerous aspects of physical, cognitive, and emotional well-being. The question remains as to what extent vision and hearing health should take their place among these priorities.