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Focusing on cognitive development and rehabilitation and the promotion and maintenance of personal well-being through the principles of Applied Social Neuroscience (ASN)

Special Issue

The CNE Booklet: Cognitive Neuroeducation (CNE) _Origins and Features (Revised)

CNE Cognitive Neuroeducation

A rigorously researched cutting-edge neuroscience-informed, human-values-oriented modality for prevention of and recovery from cognitive and behavioral disorder

Cognitive Neuroeducation (CNE) is an innovative activities-based setting applying fundamental principles of brain-mind-behavior interaction in broadly stimulating and exercising the brain.

Through an enveloping enriched environment and interaction within a cohesive group dynamic, CNE builds both a neuroprotective shield and core cognitive resources.

- **Neuroprotection**: The CNE group experience in highly engaged social and learning activities and interpersonal bonding forms a high brain and cognitive reserve in the prevention of cognitive decline and maladaptive behavior associated with past negative life conditions or neurophysiological disturbance from the effects of disease.

- **Strengthening Core Cognitive Resources**: Through the CNE enriched environment of learning and activities that combine high cognitive functionality with emotionally compelling social engagement, core cognitive resources are strengthened and expanded to enable the realization of deep, enduring learning outcomes and rediscovery of self in recovering from cognitive and behavioral disorder.

The continual development of cognitive resources through the CNE enriched environment stimulates the renewal of self-defined, positive, responsible behavior leading to fluid social integration and a positively embraced, meaningful life, full of the joys of companionship, learning, sharing and anticipation of the discoveries of the wonders of life tommorow may bring.

The Origins of CNE

CNE is a second-generation social-interaction-focused cognitive development and regeneration modality built on the framework of Cognitive Enhancement Therapy (CET). CET was the first cognitive rehabilitation program to emphasize social orientation in recruiting positive neuroplasticity to improve social engagement and broad-based cognitive functioning in cognitively impaired individuals. [Neuroplasticity is defined herein as the neurophysiological reaction of the human brain to environmental conditions (including states of mind and physical illness) by cellular structural and functional changes throughout an individual's life – such changes being critical in inducing either productive or nonproductive (nonproductive = stagnant or deleterious) cognitive reactiveness.]

Though CET was developed specifically for remediating deficits in the cognitive functioning of individuals with schizophrenia and schizoaffective disorder, its great success in improving overall cognitive functioning and reestablishing the behavioral fundamentals of social interaction over a widely varying population of adults with schizophrenia or schizoaffective disorder led to expanding CET treatment to include young adults defined as high-functioning on the scale of autism spectrum disorders (ASD) that however remained constrained in life choices by deficient social engagement.

CET, through its emphases on both social interaction and the recruitment of the inherent mechanisms of positive neuroplasticity in the human brain to effect positive changes in cognitive functioning, constituted a critical breakthrough in both the understanding of and intervention in cognitive and behavioral disorder. The remarkable results and duration of effect in cognitive recovery and renewed social integration achieved by CET in schizophrenia and schizoaffective disorder (and more recently ASD) formerly resistent to significant cognitive rehabilitation is well documented through 15+ years of clinical trial studies and reports of program outcomes from different mental health facilities running CET clinics (see pages 14-17 for a listing of CET background research reports and clinical trial results).

Intrigued by the great success of CET, but frustrated by the lack of theoretical grounding in the CET literature and its ill-defined perspective on neuroplasticity and the mechanisms which drive it, the Center for Applied Social Neuroscience (*CASN*), in correlation with *CASN*'s ongoing synthesis incorporating established principles and new findings in neuroscience, psychology, human evolution and the social sciences, began to study the CET curriculum to understand the mechanisms at work in CET, from which the seeds of Cognitive Neuroeducation (CNE) were planted.

From CET to CNE

In a comprehensive study of the CET curriculum in coordination with *CASN*'s intensively broad-based synthesis of established principles and new findings in neuroscience, psychology, human evolution, social sciences and adjacent fields, *CASN* developed an entirely new paradigm in the understanding of the antecedents of human behavior and the fundamental neurophysiological mechanisms driving behavioral outcomes, culminating in a theoretical foundation and basic operating principles in the formation of a working model (i.e., a neurophysiological/cognitive representational framework) of the human mind (i.e., a model of human brain-mind-behavior interaction).

In applying this model to the CET curriculum to better understand what CET was doing neurophysiologically, and to define the distinct behavioral channels through which CET-induced cognitive changes occurred, *CASN* began to experiment with the individual parameters of the CET curriculum in identifying the mechanisms responsible for positive behavioral outcomes and thereby defining the conditions by which those mechanisms are disturbed to induce adverse or negative behavioral outcomes that may present as a cognitive and behavioral disorder. As a result, in acquiring a broadly scientifically informed understanding of these mechanisms, and from ongoing alterations in fine-tuning CET to optimize the promotion of positive behavioral outcomes and more effectively prevent and remediate negative behavioral outcomes across the widest conditions of cognitive and behavioral disorder, CET evolved into CNE.

In the evolution from CET to CNE, CNE retained key principles of CET while adding emerging principles, all tightly conjoined within an encompassing theoretical grounding; and, wholly reconstructing the CET curriculum, CNE transitioned into a second-generation modality in social-interaction-focused cognitive rehabilitation, unfolding as the only comprehensively neuroscience-informed, noninvasive, nonpharmacological intervention addressing the full spectrum of cognitive and behavioral disorder.

Even though CNE evolved from CET, the differences between them are substantial, briefly enumerated as follows: 1) CET was developed in the absence of any fully formed theoretical base; whereas CNE resulted from the application of principles derived from a comprehensive, tightly integrated, intensively researched, scientifically established theoretical foundation; 2) CNE has replaced the CET computer-aided excercises with a natural, human-centered, cognitively engrossing, socially bonding, enriched environment; and 3) CNE has eliminatated all references to the stigma and negative connotations of pathology, disability, mental abnormality or diagnostic label, replacing CET's psychoeducation sessions with fun, engaging activities in an enriched learning environment of camaraderie and sharing in optimizing cognitive receptivity.

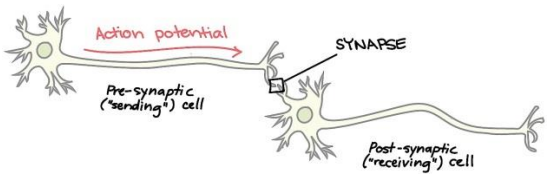
The Technical Dimensions of CNE

Though sharing a focus on social integration with CET, CNE's understanding of the mechanisms of social integration is an inherent product of the CNE model of the mind centering on the evolutionary basis of the *uniquely* human social brain. In tracing the evolutionary forces that shaped the human social brain, both the behavioral dispositions engendered therefrom and the macrostructural neurophysiological mechanisms driving behavioral patterns emerged. From this foundation, the linkage between a) the fundamental macrostructural neurophysiology of the social brain; b) behavioral traits and outcomes; and c) the relationship between brain, mind and behavior and between productive behavioral outcomes and nonproductive (i.e., stagnant or deleterious) behavioral outcomes, provided the means to most broadly and effectively address both the prevention of and intervention in cognitive and behavioral disorder.

The uniquely human social brain is a well-established concept of neuroscience emerging in the 1970s (Cozolino 2006, p. 11), and is the very foundation of the field of social neuroscience (Cacioppo and Decety 2011; Cacioppo and Amarel et al. 2007) as well as its offspring, the field of Applied Social Neuroscience (ASN) [Robinson 2015], which not only recognize but center on the critical issue of the unique orientation of the human brain in the navigation of intricate social interaction and in cooperation between individuals in the formation of and reliance on complex social structures constituting the core of human behavior [Saxe 2006; Blakemore 2008 and 2010; Insel and Fernald 2004; Adolphs 2009; Robinson 2021 (pp. 14-47, p. 123, pp. 128-134) and 2018 (pp. 4-6, s.v. "Insights on Being Human"); Kennedy and Adolphs 2012; Frith and Frith 2010; Leiberman 2013; Cozolino 2006 and 2013; Grossman and Johnson 2007; etc. – see pages 18-19 for publication details on the above citations and a more extensive list of studies regarding the uniquely human social brain].

In the CNE model, the central operating principle of the social brain is apperception – which refers to how individuals register information, whereby any new experience is assimilated into and transformed by the residuum of past experience of the individual to form a new whole. Apperception consists of the counteractions between the process of socialization and ingrained pseudo-fixed action patterns constituting an autonomic cognitive processing engine, the neurophysiological machinery of which is embedded within the mechanics of neuroplasticity driven by the modulation of neuron interconnection strength predominantly through the interplay of synaptic long-term potentiation (LTP) and long-term depression (LTD).

A **neuron is a nerve cell**, an electrically excitable cell that receives, processes, and transmits information through electrical and chemical signals. These signals between neurons occur via specialized connections called synapses. Neurons in the brain connect to one another to form neurocircuits in varying patterns of interconnectivity in response to life's experiences.



The Mechanism of Learning

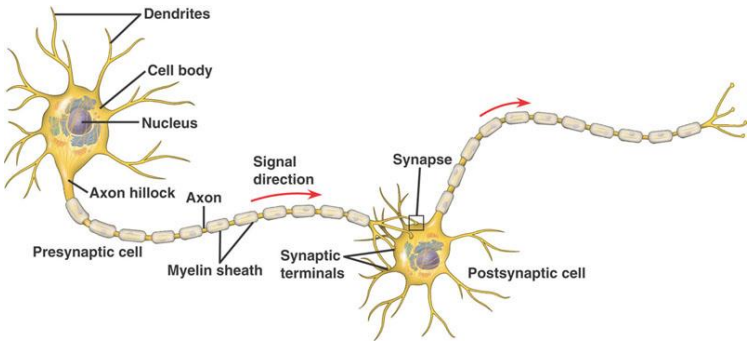
- Both sense-given impressions of external stimuli and self-generated stimuli from the internal reconfiguration of impressions form distinctive patterns of neuronal interconnectivity in the brain representing basic subliminal conceptualizations by which thought frameworks are molded and experiences are cognitively codified.
- This process entails the systematization of the collection of internalizations of reactions to all the distinct stimuli that constitute an individual's total experience in the formation of a fundamental conceptual schema at the subliminal level of understanding.
- From the internalized collection and systematization of the aggregate of the immediate reactions to distinct stimuli, patterns of relationships are constructed (i.e., cognitive conceptualizations of experience are formed). This process is known as "apperception."
- Apperception refers to the mechanism by which new experience is assimilated into, and transformed by, the residuum of past experience of the individual to form a new whole.
- In apperception new experience is understood or interpreted through the lens of previous experience and the perspective formed from that previous experience, but also the new experience, however transformed, becomes part of the aggregate of experience of the individual and adds new information to the aggregate, thereby altering perspective, by which the new experience transforms the residuum of the individual's life experience; the new experience being both transformed and transforming.

The Foundations of the CNE Model

Apperception. Like the concept of the uniquely human social brain, apperception is a well-established principle, first introduced by Johann Friedrich Herbart in his seminal work of 1824 and 1825 (albeit in primative form), and adopted as a first principle by his fellow founding fathers of psychology from the early to late 19th century in the pioneering works of Alfred Adler (see Ansbacher and Ansbacher 1964 and Griffith and Powers 2007), Wilhelm Maximilian Wundt (1893 and 1919, and see Kim 2016), and William James (1899). Although defined with a more modern understanding from the 1940s (Wood 1942), the full implications of the principle of apperception have failed to be appreciated in later psychological discourses in the understanding of human behavior, and, especially, in the understanding of disordered behavior. (See pages 19-20 for the publication details of the above citations.)

Socialization. Socialization, the process of which in conjunction with pseudo-fixed action patterns mediates apperception, arose as a conceptual formulation from the advent of the field of sociology, referring to the process by which individuals internalize the norms and ideologies of the society in which they live. Based on the early work of Jean-Jacques Rousseau and later John B. Watson and the identification of the stages of the socialization process throughout the life course of the individual (the stages of moral development as defined by Lawrence Kohlberg and the stages of psychosocial development as defined by Erik H. Erikson), socialization became an integral component of the field of developmental psychology and behaviorism, the latter developed from the social behaviorism of George Herbert Mead and the school of behaviorism in psychology founded by John B. Watson. Socialization also became the conerstone of social psychology and a major principle of cultural (social) anthropology.

Socialization is basically understood as the whole process of learning throughout an individual's life course, and, as such, socialization and learning are inextricably intertwined – socialization is learning and learning is socialization. This dual identification of socialization and learning, as well as the concept of the uniquely human social brain became a central core of the psychology of Lev Vygotsky as interpreted and expanded by his followers – the Vygotsky school a major influence today in the principles of education and pedagogy.



Evolutionary Path of Human Social Brain:

From Fixed Action Patterns to Pseudo-Fixed Action Patterns and Learned Response

- Anatomically modern humans (AMH), distinct from all other extant animal taxa (taxon = a specific type of organism), are not biologically preprogrammed for specialized physiological and behavioral adaptation to a discrete habitat.
- Other taxa vs. AMH: Fixed action patterns (also known as modal action patterns that operate through innate releasing mechanisms, and commonly referred to as "instincts") vs. AMH pseudo-fixed action patterns and learned responses through socialization.

Pseudo-Fixed Action Patterns

- Acute stress response (fight-or-flight response), attachment/bonding response, mating response, tend-and-befriend response, etc.
- Central mechanism of basic behavioral propensities = affective (emotive) properties embedded within pseudo-fixed action patterns; e.g., fear, anger, rage, hate and violence in the acute stress response; love, compassion, empathy, concern, and selfless, protective loyalty in the attachment/bonding response and the tend-and befriend response, etc.

Learned vs. Preprogrammed Behavior

- Unlike rigid automated mechanisms of fixed action patterns, human pseudo-fixed action patterns may be overridden by learning/experience and are mediated by individual genotype and phenotype and affective (emotive) profile.
- While the predisposition of affect is an innate biological determinant of human behavior, the individual capacity for, and/or particular nature of, affective reaction is mediated by genotype and phenotype to the extent that each individual possesses a unique basic affective profile.
- The pseudo-fixed action pattern of curiosity, or inquisitiveness, is the driving force of exploration, imagination, discovery and invention necessary for adaptation to different habitats by obtaining knowledge about and making innovative use of natural resources in the manipulation of the environment to meet basic human needs.
- Because we are not physically fine-tuned to any particular habitat, we have to manipulate our environment to maintain our lives. By creatively transforming natural resources into shelter, clothing and tools for hunting, fishing, food gathering and food preparation and for defense against predators and foes, we were able to sustain ourselves in any livable habitat.

The Foundations of the CNE Model (continued)

Pseudo-Fixed Action Patterns. "Fixed action patterns" is a term used in ethology to refer to the phenomenon first identified by Konrad Lorenz (1970, pp. 316-350) as the automated responses of nonhuman animals to particular stimuli (i.e., environmental "triggers" – referred to as "sign stimuli" or "releasers") within a discrete habitat. In defining a range of human traits in distinction from fixed action patterns, the CNE model has adopted the term "pseudo-fixed action patterns" to refer to strong behavioral dispositions that characterize quintessential human nature that, rather than hardwired, are subject to mediation by genotype and phenotype, and may even be entirely overridden by experience, stressing the flexibility of human nature, its dependency on learned response (i.e., socialization) and, consequently, its susceptibility to environmental influence.

In fixed action patterns environmental changes may eliminate some triggers required to elicit essential behavior or may trigger ineffective or detrimental behavior with respect to the new adaptation strategies required by the changed conditions, leading over time to the demise of specific groups of animals (i.e., taxa). In human pseudo-fixed action patterns behavioral flexibility and inventiveness can respond as group action to meet changing environmental demands, however, social pressures (in the form of social indoctrination) on individuals in the group can mold individual characteristics to such extent that basic dispositions are altered or overridden, skewing the very nature of the individual, of groups, and even of entire societies, leading to cognitive and behavioral disorder in individuals and/or dysfunctional (i.e., non-sustainable) societies.

Of course it must be understood that whatever characteristics that are herein presented as distinctly human are uniquely human only in context and with regard to extent or degree. While many kinds of animals (i.e., taxa) are behaviorally oriented toward a community or social structure, with biologically *hardwired*, *preprogrammed* role-specific differentiation such as in ant and bee colonies, or by a general rudimentary cognitive tendency toward forming simple social groups, such as by chimpanzees or gorillas – some animals eliciting such behaviors that appear as love, devotion, sympathy and even altruism – only humankind can be definitively understood as having evolved a unique social brain inherently biologically encoded in the self-construction of the *cognitive* configuration and interpretation of self and individual experience within the framework of intricately defined social roles and the construction of complex, intertwined layers of social organization.

- Curiosity, or inquisitiveness, as a vehicle of adaptation, is consequently the major vehicle of learning. Curiosity, or inquisitiveness, an innate, essential and powerful motivator of human behavior, may be seen as a major driving force in all normative human behavior.
- Through curiosity and imagination, this innate behavioral orientation toward discovery and adaptation has enabled humans to survive in a variety of habitats without being restricted to any single narrowly defined habitat or ecosystem, and, with the capacity to learn an endless variety of adaptive strategies, has enabled humans – by exploitation of all available resources and the flexibility to adjust to environmental changes – to successfully compete with animals that though much more biologically attuned to any specific habitat, are nevertheless restricted to rigidly fixed adaptations and thereby are highly vulnerable to environmental change.
- Insufficiently equipped to compete with other animal taxa for survival on an individual basis, humans evolved to rely on the competitive edge of cooperative behavior in groups.

Cooperation: The Key to Human Survival

- By cooperative behavior facilitated by language, which led to both higher-order reasoning and tool-making flexibility to manipulate their environment, humans were able to out-strategize, out-plan, out-maneuver, and simply out-think their taxonomic rivals for survival.
- Human groups also competed with each other for survival in a particular habitat or region, so that social cohesiveness, role and skill diversification and skill expertise within a group leading to more specialized supportive social structures became the keys to group survival that pushed evolutionary determinants toward the human tendency for more sophisticated, intricate and complex social organization.
- So-called "morality" evolved as a condition of group survivability.

Neuroplasticity and LTP/LTD

Although pseudo-fixed action patterns in general have been conventionally considered responses to stress or threat, and the acute stress response (fight-or-flight response) is certainly designed to trigger a reaction to threat; however, the mating response is not only essential for propagation and the perpetuation of the species, triggered most readily in conditions of security and stability, but, like other pseudo-fixed action patterns, such as the tend-and-befriend response and the attachment/bonding response, is also designed to elicit bonding with and concern and responsibility for other individuals in establishing ties with others through identifying oneself with others in groupings, from pair, to family, circle, community, etc., strenghtening group connection and group cooperation as a principle strategy for survival, not simply in response to stress or threat, but as an ingrained disposition fostering a productive, self-sufficient community and the enrichment of a higher-order of life through companionship, sharing, and mutual understanding, making life itself more meaningful and precious, imbuing the individual and the community with stronger motivation and determination in protecting not only life but the quality of life provided by the community and its interrelationships.

Pseudo-fixed action patterns – defining the core nature of humankind – and **socialization** – constituting the experiences and learning that mediate an individual's core nature (as defined by an individual's unique profile of innate pseudo-fixed action patterns), reinforcing, suppressing or perverting basic tendencies – together interact in the process of apperception to mold the behavior of an individual through an autonomic cognitive processing engine and the neurophysiological mechnisms of neuroplasticity driven by synaptic strength modulation as a function of long-term potentiation (LTP) and long-term depression (LTD) in conjunction with synaptogenesis and synaptic pruning.

Neuroplasticity is the principal neurophysiological mechanism of the human brain through which apperception occurs. In the context of learning as the mechanism that drives human cognitive construction, neuroplasticity is defined as the biologically inherent and ongoing process of macrostructural changes in the human brain that occur throughout life as a result of 1) normal brain maturation and 2) the subsequent effect of everyday sensory and extrasensory stimuli as shaped by apperception.

Neuroplasticity may be fundamentally understood as constantly changing patterns of neuronal interconnectivity through synaptic strength modulation involving the mechanisms of long-term potentiation (LTP) and long-term depression (LTD) in conjunction with synaptogenesis (the generation of new synapses) and synaptic pruning (synapse removal).

- Such so-called human "virtues" as courage, love, compassion, forgiveness, charity, mercy, consideration, honesty, honor, selflessness, steadfastness, loyalty, self-sacrifice, etc., are not simply moral codes of religious convictions or social ideals, but, like reason and rationality, are *natural* tendencies embedded within the pseudo-fixed action patterns and cognitive constructions of the human social brain that are designed to solidify group cohesiveness and effectiveness in maximization of the competiveness of a group – the greater these qualities among its members the stronger the group; conversely, the degree to which they are lacking among the members of a group (be it a mating pair, a family, a band, etc.), the less a group is able to work together effectively and benefit from the interrelationships of its members.
- For basic survival,

1) learning became the central operating principle of the human social brain;
2) curiosity or inquisitiveness in response to novelty became the driving force of learning;
3) logic and reason became the principal method of understanding;
4) and affective state (emotive response) became the mechanism arbitrating the balance between understanding and action.

Long-Term Potentiation and Long-Term Depression

- Long-term potentiation (LTP) is defined as the development of a long-lasting synaptic strength or vitality between a pair of presynaptic and postsynaptic neurons as a product of the interactivity of the pair. The opposite of LTP is long-term depression (LTD), which produces a long-lasting depression of synaptic action between a pair of neurons. LTP and LTD are processes by which neurons are able to change their connective strength between one another, constituting a principal cellular mechanism of learning, as memories (i.e., experiences) are encoded by the modification of the strength of neuronal connections that form changing patterns of neurocircuit interconnections.

- At the macrostructural level of the human brain, neuroplasticity is predominantly a function of the modulation of neuronal connection strength through synaptic strengthening and weakening in conjunction with synaptogenesis (the generation of new synapses) and pruning (synapse removal) by the interaction of LTP and LTD. Through neurocircuit activity, particular synapses are strengthened or weakened. A persistently weak synapse triggers LTD, which in turn triggers synaptic pruning, eliminating the unused synapse. Synapse elimination (pruning) allows the formation of new synapses without superfluous synapses, maintaining homeostasis (a relatively stable synaptic count) and finely tuned neurocircuit integrity.

Social Integration, Learning and the Enriched Environment

All voluntary human behavior, including social integration, is learned. All learning takes place in a social context and all positive, lasting learning takes place in a normative stimulating environment (or, in negative learning, in an impoverished environment – "impoverished" referring to a lack of sufficient positive stimuli or experiences, including lack of social interaction and lack of, or inappropriate, social or interpersonal bonding). Recovery from cognitive and behavioral disorder requires more intensive stimulation than a positive normatively stimulating environment to trigger sufficient LTP and LTD action to rebuild neurocircuits, reverse cognitive deficiency and override and transform the set negative cognitive constructs and behavioral patterns of the previous negative experience. The design, content and application of such a more intensive positive stimulation is referred to as the "enriched environment."

The CNE enriched environment is one that has constancy, maintains a bonding group dynamic, provides fun, engaging and challenging but not overambitious eclectic learning experiences and is positive, reinforcing, stimulating, rewarding, encouraging, supportive, and full of possibilities. As new thought patterns and cognitive constructs emerge from engaged, affirmative, self-fulfilling learning experiences within the enriched environment, both the depth and breadth of the individual's cognitive core is exercised, strengthened and continually expanded through the introduction of new ideas, ways of thinking, frameworks of knowledge and understanding that open up ever-multiplying doors of possibilities. The richness of experience of bonding with and developing respect for and appreciation of others and the joy of belonging and acceptance in group identity and sharing discovery and feelings opens up the individual's self-conceptualization and the possibilities of being. Learning becomes easier, and the challenges of learning fun, eagerly awaited, new adventures in the absorbing mystery of life and the universe.

The constancy of the socially infused, deeply engaged learning experiences within the enriched environment and the numerous reexamination of concepts and facts through the exercise of the consideration of many different points of view within widely ranging eclectic subject matter and topics within a subject and highly imaginative "what if" scenarios within each topic, the presynaptic and postsynaptic connection between neuron pairs comprising the pattern of neuronal interconnections representing a concept or facts and its associations are repeatedly and persistently activated triggering LTP for durable and efficacious neuronal interconnectivity and long-lived internalization of concepts and facts and the development of powerful, highly comprehensive and penetrating cognitive formulations composed of wide and deep associations.

- A strengthened synapse provides a long-lasting, efficient connection between a pair of presynaptic and postsynaptic neurons for tightly-coupled neurocircuit integration necessary for deep internalization of an experience and the formation of well-defined cognitive constructs enabling comprehensive understanding and long-lasting learning.
- By changing relative neuron connective strength through the selective strengthening and depression of synaptic action, which produces different neurocircuit interactions, and by the elimination of weak, ineffective synapses through the triggering of synaptic pruning, enabling synaptogenesis (the generation of new synapses) and the variability of the number of synapses innervating a specific neuronal connection as well as the formation of new neuronal connections, the interaction of LTP and LTD is the principal mechanism for changing the patterns of neuronal interconnections in the human brain.
- This ceaseless changing of patterns of neuronal interconnections in the human brain is defined as neuroplasticity and represents the constant reaction, impression and internalization of discrete experiences of an individual throughout every moment of the individual's life. Neuroplasticity through the interaction of LTP and LTD is the mechanism of knowing about and understanding the world around us and by which all learning occurs.
- LTP and LTD basically operate on the principle of "neurons that fire together wire together;" that is, the "use it or lose it" principle, which means that persistent reverberatory action in the repeated firing of a presynaptic neuron in the firing of a postsynaptic neuron bonds the pre- and postsynaptic neurons together in a tightly-coupled, strong communication channel; whereas infrequency or lack of reverberatory action between a pre- and postsynaptic neuron weakens the bond between them, reducing the efficiency for communication across that neuron pair, with continuing weakening leading to the elimination of the synaptic connection between them.
- In achieving positive-directed learning and positive behavioral outcomes, this "use it or lose it" phenomena can be stimulated in individuals to simultaneously induce coherent, affirmative learning and behavior and eliminate negative or faulty learning and ineffectual or self-detrimental behavior, and, through positive-directed learning with intact neuroplasticity, restore cognitive potency across a broad range of conditions of cognitive impairment. The key to effecting positive-directed learning, self-actualizing behavior and effective cognitive functioning is the **enriched environment** which stimulates LTP in positive learning experiences, simultaneously stimulating LTD in depressing synaptic responsiveness in less-active neuronal connections, thereby triggering the elimination of the patterns of neuronal interconnections constituting negative cognitive constructs of detrimental behavior.

Social Integration, the Group Dynamic and CNE

Humankind has been evolutionarily directed to live in a social environment, with a principal tendency toward sophisticated social structures consisting of societies composed of a hierarchy of overlapping nested groups, each constituting specific cultural and social norms under the umbrella of the general cultural and social norms of the encapsulating society. The well-being and quality of life of the individual depends on the cognitive skills to effectively negotiate social interaction in meeting the demands of the individual's social environment. Beyond pure social adaptation, the human being is a psychologically complex being that neurotypically requires different levels of interaction with other human beings to meet basic psychological needs.

The regulation of affect is pivotal to the formation and maintenance of social relationships. Affect not only informs and directs reasoning, but may also block it. With this understanding, "emotional intelligence" has now been recognized as an integral component of social integration. The rules, expected conduct and affective reaction in social relations are differentially defined through a hierarchy of social groupings, from family, dyad, workplace, ethnic and religious circles, and professional, educational, recreational and special-interest clubs, associations, organizations and institutions; to community, city, district, nation, society, culture and civilization.

Although normatively conforming to the general rules and behavioral expectations of the larger umbrellas of civilization, culture, society, nation, district, city and community, social relations are actually experienced more directly, intensely, consistently and personally in small group settings, as outside of small groups person-to-person encounters are more random, fleeting, and superficial, particularly so in the massed automated anonymity of modern urbanized daily life; hence, social rules and relations are more directly defined and reinforced in interpersonal interactions within the group dynamic in small group settings.

Since social relations are defined by groups, social integration is developed through the individual's interaction within each distinct group to which the individual belongs, particularly through the formation of a shared understanding regarding common themes. It is the group dynamic in the participation of social/learning activities in small groups that forms the vehicle by which both social integration and learning is enhanced in CNE with its emphasis on perspective taking.

- The enriched environment contains strong, affirmative, stimulating, deep, constantly reinforced learning experiences that trigger persistent reverberatory action in neuronal connections, and through such continually reinforced action effecting a change of thought patterns, weakens the reverberatory action of neuronal interconnections representing previous faulty learning and the attendant ineffectual or detrimental cognitive constructs through lack of excitatory action as excitatory action is dominated by the affirmative learning and newly configured thought patterns constantly reinforced by the positive-directed learning.
- The cognitive constructs formed from the new learning within the enriched environment are continually strengthened by LTP and become dominant cognitive constructs undermining the relevance of old, detrimental or negative cognitive constructs, whereby the presynaptic and postsynaptic connection between neuron pairs comprising the pattern of neuronal interconnections representing a negative cognitive construct are less activated as the negative cognitive construct more and more fades from ongoing thought patterns with the associated synaptic connections continually weakened to a threshold point, triggering LTD that, in turn, triggers the elimination of the synaptic connection between the neuron pairs comprising the pattern of neuronal interconnections representing the negative cognitive construct, entirely purging the negative cognitive construct.

Perspective taking consists of the ability and custom to go beyond spontaneous, initial surface impressions and apply a thoughtful appraisal and a honed proficiency in recognizing and interpreting social cues that explain another person's thinking, feeling and behavior from that person's perception of her or his own situation in a particular social encounter.

- Perspective taking involves the development of respect for, understanding of, and empathy with, other individuals by putting oneself in the other person's place and reflecting how one themself would act and feel in that place.
- An important component of perspective taking is social context appraisal – the balanced assessment of social contexts and circumstances which account for an individual's behavior in a particular social encounter.
- While the context of the individual is always essential for understanding individual behavior, in the group dynamic social context appraisal transcends individual behavior, extending to the culturally transmitted "norms" of the group.
- In the group dynamic, perspective taking must take into account both the personal context and the social context defined by the group "norms" and the individual's role or position within the group.

CNE Learning Activities and the Enriched Environment

CNE is essentially a learning program whereby learning is self-defined from within each participant through the experience of group interaction and self-reflection that effectively energizes or restarts the inherent cognitive developmental process of social integration needed to acquire the cognitive competencies that support a personally meaningful and rewarding life.

In CNE the participant learns to THINK AND FEEL, as opposed to simple rote memorization, the accumulation of loosely connected facts, or learning pure MECHANICAL BEHAVIOR. CNE is designed for flexibility in implementation within a wide variety of settings. This flexibility is achieved by a wide scope of learning material and activities targeting different age, educational and functional levels and capabilities.

To maintain the greatest flexibility in program efficacy across the widest range of settings, CNE implementation is facilitator based. The CNE facilitator determines the appropriate materials and activities to incorporate within the CNE group dynamic, being careful to ensure a fluid synergy between activities, materials and the group dynamic. In the CNE learning experiences affective involvement, social skills, and positive behavioral orientation are heightened and broadened through progressive interaction with the group dialog and the activities and associated materials that comprise each experience, building on the social adaptation and cognitive gains from each preceding experience.

In the CNE enriched environment, affective involvement, social skills and positive behavioral orientation naturally evolve as an inextricable, seamless, indivisible part of the give and take of attentive, concerned and connected listening and empathetic, constructive criticism and supportive feedback in the CNE group dynamic and in the attendant identification with, and absorption in, the characters and their personal situations in role playing in such CNE activities as reading and discussing stories from the various characters' points of view; in performing skits or plays; and from the emergent absorption in the transcendent evocations of expression in music, dance and art.

- Another essential component of perspective taking is affective engagement. It is precisely one's own emotional state that influences the perception of another's emotional state and determines the selection and processing of individually relevant social information; either effectively picking out the essential information and its implications within the particular social encounter, or completely missing or distorting that information to one's own detriment.
- An individual's feelings are a principal determinant of behavior in any social situation, and it is imperative to understand another's feelings in order to understand that person's behavior and likely response in any social interaction as a clue to one's own behavior in a particular social encounter.
- However, it is impossible to understand the affective state of another unless one's own affective response is appropriately well harmonized with one's personal situation relative to the context of any particular experience. In order to correctly understand another's feelings, one has to consistently experience one's own appropriate emotional reactions. A lack of affect can be no less self-destructive and socially disruptive as uncontrolled, inappropriate emotional outbursts.
- A major part of perspective taking then, is the realization of the individual's own emotional capacity by learning to engage experiences deeply through commitment and the full giving of oneself to the experience with introspection, reflection, sharing and attachment.
- By putting oneself totally into the experience as an integral part of the experience, the individual learns involvement and concern; and learns to fully relate to the experience and to others – to feel, to empathize and to bond.

The Cultivation of Curiosity, Imagination, Motivation and Eager Anticipation Full of Possibilities

We are normally born with a pseudo-fixed action pattern of curiosity about our environment and the world we live in. Through this curiosity we learn about our environment and experience the great wonder and delight of discovery. Curiosity is manifest from infancy and becomes the dominant preoccupation of early childhood. If this natural curiosity is nurtured it may be maintained throughout life, fostering creativity, an open, receptive mind, critical thinking, and a lifelong love of learning. Learning is inherently fun, inspirational, and essential for self-development, independence and fulfillment.

The accumulation of learning, that is, knowledge itself, is composed of relative truths, as all things may be understood from many different positions, starting points, frames of reference and personal perspectives. Being relative does not make these "truths" any less real to the frames of reference in which they reside. The full recognition of this relativity leads to the undeniable, stirring realization that there are so many more, endless things to discover, so many more, endless ways by which to view all phenomena, so many more, endless ways to think about life and all its mysteries and so many more, endless contributions to knowledge waiting for eager, imaginative, curious, probing, questioning minds to reveal.

Learning is the processing of new information involving thinking, reflection, imagination and inspiration, not static memorization. The formulation of ideas evolves through discussion, sharing ideas and considering the ideas of others in a dialog in which one's ideas may be confirmed, reinforced, expanded, modified to greater or lesser extent or entirely reformulated by the exchange of different perspectives. We are what we know and we only know what we read, are told and directly experience, all extensively enriched and broadened in reconsideration and reflection through interactive dialog.

The CNE activities, related materials and group dialog explore the different realms of understanding and knowledge from the widest possible perspectives, stimulating each of the group members with the awe of the vast potentials of discovery, of endless paths on the journey through life, and the eager anticipation of the possibilities waiting beyond the next turn in the road on the great adventure of being. We live within our mind, and the journey of life continues on in elderhood and even in infirmity of body through a healthy, active mind and an environment encouraging our innate curiosity and deep human need to share and involve ourself with others.

Perspective taking, including social context appraisal, appreciation of one's own and another's affect, reflection on past interpersonal experiences, and the development of a shared understanding, are the foundation stones of the learning environment implemented within the CNE program.

It is the pure excitement of discovery that is the single most important impression that can be imparted by a teacher to a learner. It is the joy of learning, the awe of the endless mysteries of life and the universe, the thrill of new understanding through the awakening of the individuals' natural curiosity that is the prime objective of the CNE enriched environment.

CNE focuses on both the expression of and exposure to the different ideas of each member of the group through dialog in a group dynamic by which ideas are exchanged and thought and critique are stimulated and the voice of each participant becomes part of the discussion, both a unique and integral piece of the group's voyage of discovery and self-enrichment.

While the CNE facilitator oversees basic curriculum; introduces, guides, monitors, suggests, advises, clarifies; and addresses inquiries; it is the participant's voice that must be clearly heard, encouraged and equally respected in all discussion and activities. Real learning takes place inside the head of the learner, not through the mouth of a teacher.

In the CNE program, ***all*** learning and activities are integral to the group dynamic and develop as a group process, with the experiences of the program ***uniquely*** internalized by each individual participant, being both simultaneously shared and highly personal, as each individual participant develops her/his own viewpoint of life and understanding of her/himself.

The Basics of CNE

CNE is a carefully constructed framework that maintains an enriched environment for exercising the social brain in effecting optimum levels of cognition and learning realization in reaching positive, balanced, self-actualizing behavioral outcomes.

Long-Term Elder Care, Dementia, and CNE

There is a great culture change movement that is gaining ever more traction within the community of caregivers for elders and those with dementia in long-term care facilities. This movement and the initiatives it has inspired are referred to by a variety of similar terms, such as: person-centered care, patient-centered care, person-and-family-centered care, resident-centered care, client-centered care, etc., and, though each of the different initiatives propose their own specific guidelines, they all embrace a philosophy that focuses on the humanity of care, recognizing that every individual is a unique personality, every long-term care resident an individual with a unique set of needs, and that life in a residential care facility need not, and most definitely *must not* deny the resident the fundamental right to maintain her/his individuality with dignity and respect.

In this philosophy, the long-term care facility, rather than a place that simply provides for the bare rudimentary physical needs of a dead-end existence, as in the conventional conception of the "nursing home," becomes instead the hub of a nourishing environment that facilitates the engagement of life, providing challenge and growth to the fullest of each individual's capacity, focusing on the resident's strengths and activities that excite the individual's interests and promotes: a) a sense of accomplishment, b) bonding with others; c) joy of the moment; and d) a keen anticipation of the discoveries, camaraderie and achievements tomorrow may bring. These qualities are infused throughout the elements comprising the CNE program, such as the enriched environment, the group dynamic, perspective taking, empathetic engagement, individual initiative, facilitation of the voice of the individual, and the confirmation of self.

Cognition is an essential component of well-being – a healthy, active mind promotes a more fulfilling life. CNE can prevent dementia and general cognitive decline by activation of neuroprotective agents in the brain, can retard cognitive decline in neurodegenerative disease by building up cognitive and brain reserve and enhancing cognitive proficiency, and, in many cases of preexisting conditions of cognitive erosion, can effect recovery of fundamental cognitive reaction. In cases where tissue damage is not excessive, CNE can effect full recovery of an individual's cognitive resources.

As social beings, we learn to understand the world around us through social reinforcement, therefore we need to look into the experiences of others to validate our own because we can never be sure that the experiences of our own experience are not just ever-tightening circles of self-reinforcing distortion entrapped within the walls of our self-confined, limited cognitive constructions.

Perspective taking involves the development of respect for, understanding of, and empathy with, other individuals by putting oneself in the other person's place and reflecting how one themself would act and feel in that place.

The CNE group structure, establishing and reinforcing group values and rules of interaction, equally encourages individual contribution of new and different viewpoints and considerations, such that, rather than enforcing any conformity of personality, actually provides a powerful vehicle of self-discovery and development of individuality.

By observing the differences in each individual member of the group and interacting with them; sharing thoughts and experiences and developing a deeper understanding of each member and their unique styles of expression; one begins to recognize not only the differences between each member of the group, but also between each member and oneself.

Such realization informing a clearer recognition of one's own individuality, of who one is, and, in learning to appreciate the different personalities of the group, each's individual perspectives and ways of thinking and each's humor, warmth, and unique contributions to the group, one begins to better understand and appreciate one's own unique contributions and individuality with a growing sense of self and self-confidence.

Since we are social beings with social brains, our personalities are formed from the way each of us uniquely interacts with other people within the commonly agreed rules of social conduct.

Long-Term Elder Care, Dementia, and CNE (continued)

Although developed from a completely different trajectory than the person-centered care movement, CNE, from its inception and fully implemented within its framework, embodies the basic principles and philosophical orientation of the person-centered care movement – both incorporating an enriched environment – that of CNE directed at the prevention of and intervention in dementia and cognitive decline in later life, and that of the person-centered initiatives directed at the process and manner of the daily personal care of the elder and those with dementia in a long-term care facility. Individually CNE and the person-centered care approach each provide half of the recipe for well-being in a long-term care setting, but together constitute a total, seamless intervention-care program.

The clinical approach to cognitive and behavioral disorder of "treatment" and "session" is invalid since it is the day-to-day orientation that is the critical factor in cognitive and behavioral dysfunction and it is this orientation that must be modulated; however, in a conventional long-term care setting, the institutional milieu and stagnant, rote routine suppress natural inclinations, opportunities of engagement and individual initiative, eroding one's sense of self, fostering social withdrawal leading to cognitive decline, unmet psychological needs and responsive behaviors.

CNE, integrated within a person-centered care program, transforming the setting from an institutional one to that of a community of care, intervention and engagement, together create the sustained, seamless environment for long-term intervention-care in the restoration and maintenance of cognitive acuity, behavioral balance and a realistic avenue for growth and self-fulfillment in optimizing the well-being of the individual residing in a long-term care facility.

In the continuing improvement of cognitive reaction in engagement in examining responses to situations, beliefs, modes of social interaction and interpersonal relationships, emotive contours, flights of imagination, aesthetic visions, creative artistry and nuance, duty, purpose, loyalty, love, spirituality, sense of destiny and myriad other products of the mind in a variety of contexts through a range of media and activities, insights on the essence of being human unfold and long submerged memories of one's life resurface and are transformed by new recognitions, regaining or crystalizing one's sense of self by connecting one's own unique past with new understanding and possibilities learned and imagined from ongoing new adventures in the enriched environment.

In profound cognitive disorder, deeply subjective associations of sights, sounds and other sensations stimulated within the enriched environment connect within the individual and trigger a reawakening from the dark void of cognitive disintegration, opening up the road forward, step-by-step, into the light of renewed cognitive facility and a reclaimed selfhood.

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"We are an intensely social species.
Everyone knows that."
—Robert B. Cialdini

"The notion of the [human] brain as a social organ emerged in neuroscience in the 1970s" [Cozolino 2006, p. 11] (insertion in brackets added).

- "The human brain is a social organ criss-crossed with neural networks dedicated to receiving, processing and communicating messages across the social synapse . . . . From primitive brainstem reflexes that orient us toward our mother's voice to the participation of the broad circuitry required for acts of altruism, the entire [human] brain participates in social behavior" [Cozolino 2006, p. 50] (insertion in brackets added).

Matthew D. Lieberman (2013), defining the uniquely human social brain, describes how the human need to reach out and connect with others is a primary driving mechanism of human behavior. The human brain has been primed by evolution to view the world in social terms, evolving sophisticated survival mechanisms for securing the perpetuation of humankind through the construction of and reliance on social relationships and community.

- The deep social wiring of the human brain bestowed a unique ability to read the perspectives of other individuals to discern their hopes, fears and motivations enabling shared frames of reference, highly engaged interaction and interdependency to cooperate in harmony as a group, the members of which coordinating their lives with one another dedicated to group survival.

- Self-identity became intimately linked to both the important people in an individual's life and the group in which each individual was a part. This deep social wiring instilled restraint of selfish impulses for the greater good necessary for the success of the group, and, ultimately, the species. Over the course of evolution the human mind developed intricate cognitive processes of response to group challenges such that norms of altruism and cohesion became ingrained in human cognitive neurophysiology.

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[1]WIREs = Wiley Interdisciplinary Reviews

- Since the uniquely human social brain is wired, first and foremost, to harmonize and connect with others, social interaction mediates cognitive and behavioral balance. In problematic social interaction (excluding an initial organic etiology), negative or cognitively impoverished environments induce social apathy/disengagement or socially resistant responses altering the neurophysiological processes maintaining behavioral orientation, such alteration the source of cognitive and behavioral disorder.

In defining the human brain as a social organ, Louis Cozolino (2013) states that: "our brains require stimulation and connection to survive and think. A brain without connection to other brains [i.e., without the input and companionship of other people] and without sufficient challenge [i.e., without a sufficiently positive, stimulating environment] will shrink and eventually die – moreover, the modern human brain's primary environment is our matrix of social relationships. As a result, close, supportive relationships stimulate positive emotions, neuroplasticity, and learning" (insertions in brackets added).

- Cozolino explains how our brains evolved to learn "through trial-and-error exploration. This is true of learning and adapting to both our social and physical environments. Therefore, using what we learn to attempt to solve real-world problems and adjusting our behaviors or ideas based on the results augments the retention of skills and information. We were born to explore" [Cozolino 2013].

"Psychiatric and neurological disorders have historically provided key insights into the structure-function relationships that subserve human social cognition and behavior, informing the concept of the 'social brain.' . . . We suggest that the social brain, and its dysfunction and recovery, must be understood not in terms of specific structures, but rather in terms of their interaction in large-scale networks" [Kennedy & Adophs 2012, p. 1].

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"The use of deliberate social signals can serve to increase reputation and trust and facilitates teaching. This is likely to be a critical factor in the steep cultural ascent of mankind" [Frith & Frith 2010, p. 165].

"Social cognition in humans is distinguished by psychological processes that allow us to make inferences about what is going on inside other people – their intentions, feelings, and thoughts. Some of these processes likely account for aspects of human social behavior that are unique, such as our culture and civilization" [Adolphs 2009, p. 693].

"Because information about gender, kin, and social status are essential for [human] reproduction and survival, it seems likely that specialized neural mechanisms [in the human brain] have evolved to process social information" [Insel & Fernald 2004, p. 697] (insertions in brackets added).

In Sarah-Jayne Blakemore's 2010 paper on human social brain development, she argues that "humans are an exquisitely social species" and, as a consequence, "social cognition is uniquely important" to human behavior. In the paper she proceeds to describe "evidence that social interaction plays a critical role in early [human] brain development" [Blakemore 2010, p. 744] (insertion in brackets added).

In Rebecca Saxe's 2006 paper on uniquely human social cognition, she argues that specific components of the human brain support "the uniquely human ability to reason about the content of mental states," with the human brain organized in the formulation of two "uniquely human components of social cognition," the first, she refers to as a 'representational Theory of Mind' and the second, she refers to as a representation of triadic relations [i.e., the ability to create coreferents with another individual or individuals]: "You, and Me, collaboratively looking at, working on or talking about This" ['This' = a jointly shared identical subject of reference] [Saxe 2006, p. 235] (insertions in brackets added).

Tobias Grossmann and Mark Johnson, in their 2007 paper reviewing research findings exploring the developmental stages of the human social brain, note that, while "much research has focused on how the adult human brain processes the social world, yet until recently, little was known about the early development of these abilities. Developmental studies inform debates about the specificity of social functions in the adult cortex." In reviewing these studies they conclude that "the findings illustrate that the human brain is fundamentally adapted to develop within a social context, and that this context contributes to many of the specializations seen in the adult cortex" [Grossmann & Johnson 2007, p. 909].

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Sarah-Jayne Blakemore, in defining the human social brain in a 2008 paper, states "Humans are inherently social. A large proportion of the human brain is involved in social interaction and understanding other people. The brain regions that are involved in social cognition are collectively referred to as the 'social brain'. . . . The social brain is defined as the complex network of areas that enable us to recognize others and evaluate their mental states (intentions, desires, and beliefs), feelings, enduring dispositions and actions" [Blakemore 2008, p. 267].

John T. Cacioppo and Jean Decety, in their 2011 paper addressing both the challenges and the opportunities in the field of social neuroscience since its recent inception and anticipated in the further exploration of the field, define the particular interest in humans and the uniquely human social brain – "Humans are a unique social species in that our social institutions, civilizations, and cultures are highly developed, our territorial reach knows few boundaries, and our selection of and impact on the environment in which we live – and the impact of this environment on our genes – is unmatched by any other species . . . . Our biology has helped shape the social environments that we have created, and our social environment has helped shape our genes, gene expressions, brains, and bodies" [Cacioppo & Decety 2011, pp. 163-4].

- "There is strong evidence, for instance, for regarding empathy as having deep evolutionary, neurological, and biochemical underpinnings. Even the most advanced forms of empathy in humans are built on more basic forms and remain connected to core mechanisms associated with affective communication, social attachment, parental care, and motivation to help" [Cacioppo & Decety 2011, p. 164].

In their 2007 paper on the progress and implications for mental health of the field of social neuroscience, John T. Cacioppo and David G. Amaral et al. conclude that, "Understanding the human brain and mind, when healthy and in plight, requires the merging of multiple, distinct disciplines with translation across scientific perspectives and levels of analysis. . . . As understanding of the social brain advances, this knowledge can support understanding of the mechanisms by which social factors and social deficits operate as causes and consequences of psychopathology. This perspective assumes mutual influences among biological and social factors in determining behavior" [Cacioppo & Amaral et al. 2007, p. 113].

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In their 2014 review of environmental enrichment published in the journal *Frontiers in Systems Neuroscience*, Dasuni S. Alwis and Ramesh Rajan relate how "The brain's life-long capacity for experience-dependent plasticity allows adaptation to new environments or to changes in the environment, and to changes in internal brain states such as occurs in brain damage. Since the initial discovery by Hebb (1947) that environmental enrichment (EE) was able to confer improvements in cognitive behavior, EE has been investigated as a powerful form of experience-dependent plasticity."

- In their paper they illustrate "the demonstrated sensorimotor and cognitive benefits associated with exposure to EE, and their possible mechanisms" and explore "the use of EE-based rehabilitation in the treatment of human TBI [traumatic brain injury] patients" [Alwis and Rajan 2014, p. 1] (insertion in brackets added).

- Alwis and Rajan begin their review by explaining that: "Experience-dependent plasticity encompasses a vast number of paradigms that range from deprivation to alterations and enrichments in the environment, and has been investigated in great detail across development through to adulthood."

- Further stating that: "For the purposes of the present review, we chose to focus on plasticity conferred by global changes to the environment, termed environmental enrichment (EE). We will focus only on the changes evoked by this manipulation when applied in adulthood as our final aim is to demonstrate that it represents an exciting potential therapy in adult traumatic brain injury (TBI). As we shall review, EE alters neuronal function through a range of morphological and molecular interactions, which lead to alterations in sensorimotor and cognitive behavior. These changes make EE an ideal candidate in the treatment of TBI" [Alwis and Rajan 2014, p. 1].

Anthony J. Hannan, in his 2014 paper on the therapeutic effects of the enriched environment published in the journal *Neuropathology and Applied Neurobiology*, argues that "Environmental enrichment (EE) increases levels of novelty and complexity, inducing enhanced sensory, cognitive and motor stimulation."

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- "Whilst environmental enrichment is of course a relative term, dependent on the nature of control environmental conditions, epidemiological studies suggest that EE has direct clinical relevance to a range of neurological and psychiatric disorders."

- "EE has also been found to ameliorate behavioural, cellular and molecular deficits in animal models of various neurological and psychiatric disorders, including Parkinson's disease, stroke, traumatic brain injury, epilepsy, multiple sclerosis, depression, schizophrenia and autism spectrum disorders" [Hannan 2014, p. 13].

In their 2008 paper defining the principles of experience-dependent neural plasticity and their implications for rehabilitation after brain damage, Jeffrey A. Kleim and Theresa A. Jones note that "Over the last several decades, neuroscience research has begun to characterize the adaptive capacity of the central nervous system (*plasticity*)."

- "The existing data strongly suggest that neurons, among other brain cells, possess the remarkable ability to alter their structure and function in response to a variety of internal and external pressures, including behavioral training. We will go so far as to say that neural plasticity is the mechanism by which the brain encodes experience and learns new behaviors. It is also the mechanism by which the damaged brain relearns lost behavior in response to rehabilitation" [Kleim and Jones 2008, p. S225].

In his 2011 paper published in the *Journal of Communication Disorders* Jeffrey A. Kleim discusses the central role of learning and the critical relationship between learning and neuroplasticity in reacquiring lost cognitive and behavioral function after brain injury or disease, as follows: "Following brain injury or disease there are widespread biochemical, anatomical and physiological changes that result in what might be considered a new, very different brain."

- "This adapted brain is forced to reacquire behaviors lost as a result of the injury or disease and relies on neural plasticity within the residual neural circuits. The same fundamental neural and behavioral signals driving plasticity during learning in the intact brain are engaged during relearning in the damaged/diseased brain."

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- "The field of neurorehabilitation is now beginning to capitalize on this body of work to develop neurobiologically informed therapies focused on key behavioral and neural signals driving neural plasticity. Further, how neural plasticity may act to drive different neural strategies underlying functional improvement after brain injury is being revealed."

- "The understanding of the relationship between these different neural strategies, mechanisms of neural plasticity, and changes in behavior may facilitate the development of novel, more effective rehabilitation interventions for treating brain injury and disease" [Kleim 2011, p. 521].

- In presenting the intended learning outcomes from this paper, Kleim purports that "Readers will be able to: (a) define neural plasticity, (b) understand how learning in the intact and damaged brain can drive neural plasticity, (c) identify the three basic neural strategies mediating functional improvement, and (d) understand how adjuvant therapies have the potential to upregulate plasticity and enhance functional recovery" [Kleim 2011, p. 521].

- "Restoring function after brain injury or disease is not trivial and although neuroscience has made major advances, we are far from understanding brain circuitry at the level needed to place new neurons and synapses in just the right places to restore lost function after damage."

- "One way to approach the problem is by recognizing that functional improvement after injury is a relearning process. . . As such, the brain will rely on the same fundamental neurobiological processes it used to acquire those [lost] behaviors initially. The basic rules governing how neural circuits adapt to encode new behaviors do not change after injury."

- "Studying learning-dependent neural plasticity in the intact brain therefore provides some insight into how the injured brain may adapt during rehabilitation" [Kleim 2011, p. 522] (insertion in brackets added).
- "Evidence for learning-dependent neural plasticity can be found in every animal species across every behavioral modality" [Kleim 2011, p. 522].

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- "Although this paper presents neurorehabilitation as a relearning process there is one clear difference between learning in the intact brain and relearning in the damaged brain. Specifically, unlike in normal learning conditions, rehabilitation can take advantage of previously learned behaviors that may still exist within the residual neural circuits of the damaged brain" [Kleim 2011, p. 523].

- "These behaviors may have been masked due to some neurobiological phenomenon such as inflammation, edema, or increased neural inhibition. This is not the case during normal learning conditions where behaviors are acquired de novo."

- As Kleim emphasizes in his 2011 paper, while it is clear that learning is the key process in rehabilitation in neurocognitive and behavioral disorder, in normal incidental learning vs. relearning after brain injury or disease, the cognitive processes and neurophysiological mechanisms don't change but the conditions of change do, often dramatically, because of the differences in both brain reserve and cognitive reserve prior to and after brain injury, disease or psychological imbalance.

"The *cognitive reserve* concept [i.e., brain and cognitive reserve (BCR)] has been proposed to account for the frequent discrepancy between brain pathology and the cognitive performance of an individual" [i.e., clearly observed pathological conditions in the brain in the absence of the presentation of any cognitive and behavioral dysfunction]. [Sampedro-Piquero and Begega 2017, p. 459].

- "The reserve concept [BCR] can be divided [into distinctions of] *cognitive reserve* and *brain reserve* being both not exclusive [i.e., are simultaneously operational in] taking part in the protection against neurodegenerative diseases."

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- "The main difference between them is their active [learning-based] or passive [structural-based] role. *Brain reserve* is an example of passive [structural-based] reserve in which individual differences in brain size, number of neurons, synapses or dendritic branches [etc.] allow us to cope better with brain damage."

- "In contrast, *cognitive reserve* has an active [learning-based] role, [involving cognitive/behavioral] functioning rather than [simply] the structure of the brain being more important; hence [in cognitive reserve] our brain copes with injury [by] activating compensatory mechanisms and using more efficient ways of processing."

- "However, current studies suggest a close relationship between [brain and cognitive] *reserves* [with a] higher *cognitive reserve* promoted by an active lifestyle, [which] would develop a higher *brain reserve* which in turn would help us to tolerate brain damage" [Sampedro-Piquero and Begega 2017, pp. 459-460] (insertions in brackets added).

"'Brain and cognitive reserve' (BCR) refers here to the accumulated neuroprotective reserve and capacity for functional compensation induced by the chronic enhancement of mental and physical activity. BCR is thought to protect against, and compensate for, a range of different neurodegenerative diseases, as well as other neurological and psychiatric disorders" [Nithianantharajah and Hannan 2011, p. 331].

"The concept of 'cognitive reserve', and a broader theory of 'brain reserve,' were originally proposed to help explain epidemiological data indicating that individuals who engaged in higher levels of mental and physical activity via education, occupation and recreation, were at lower risk of developing Alzheimer's disease and other forms of dementia"[Nithianantharajah and Hannan 2009, p. 369].

- "Subsequently, behavioral, cellular and molecular studies in animals (predominantly mice and rats) have revealed dramatic effects of environmental enrichment, which involves enhanced levels of sensory, cognitive and motor stimulation via housing in novel, complex environments."

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- "Here we review animal studies that have investigated the effects of modifying mental and physical activity via experimental manipulations, and discuss their relevance to brain and cognitive reserve (BCR). Recent evidence suggests that the concept of BCR is not only relevant to brain aging, neurodegenerative diseases and dementia, but also to other neurological and psychiatric disorders" [Nithianantharajah and Hannan 2009, p. 369].

"In recent decades, the interest in behavioral interventions has been growing due to the higher prevalence of age-related cognitive impairments. Hence, behavioral interventions, such as cognitive stimulation and physical activity, and along with these, our lifestyle (education level, work position, frequency of cognitive and social activities) have shown important benefits during cognitive impairment, dementia and even recovery after brain injury" [Sampedro-Piquero and Begega 2017, p. 459].

- "This is due to the fact that these types of intervention and activities promote the formation of a cognitive and brain reserve that allows tolerating brain damage during a long period of time without the appearance of cognitive symptoms" [Sampedro-Piquero and Begega 2017, p. 459].

- "... all these [reviewed] studies show the importance of our lifestyle in the promotion of successful aging, but a drawback of the *cognitive reserve* hypothesis is the lack of knowledge about its neural substrate, so animal research and the Environmental Enrichment (EE) paradigm [EE defined as 'a laboratory condition in which some aspects of an active life are reproduced' (p. 459)] provide us with information about the effect of different types of stimulation on brain structure and function."

- "Besides, research with animal models allows us a better control of the different variables and also of longitudinal studies owing to their [i.e., the animals relatively] short lifespan" [Sampedro-Piquero and Begega 2017, p. 461] (insertions in brackets added).

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"Neuronal plasticity is a central theme of modern neurobiology, from cellular and molecular mechanisms of synapse formation in Drosophila to behavioural recovery from strokes in elderly humans. Although the methods used to measure plastic responses differ, the stimuli required to elicit plasticity are thought to be activity-dependent" [van Praag, Kempermann and Gage 2000, p. 191].

- "Over the past two centuries, there have been several accounts of, and claims for, the positive effects of environmental stimulation and enrichment on the brain and brain function. A modern conceptual framework for neuronal plasticity in the adult brain was formulated by Hebb, who postulated in 1949 that, when one cell excites another repeatedly, a change takes place in one or both cells such that one cell becomes more efficient in firing the other."

- "Hebb's view has since been extended to include the plasticity of many definable anatomical substrates, such as synapses, neurites or entire neurons. Obviously changes on these levels are, in turn, based on changes at the biochemical and molecular levels."
- "In the late 1940s, Hebb was also the first to propose the 'enriched environment' as an experimental concept."

- van Praag et al. in tracing the evolution of the concept of the enriched environment as a principal instrument in the remediation of cognitive and behavioral disorder note the experimental approaches initiated in the 1960s to investigate the effects of experience on the brain, and the studies by Rosenzweig and colleagues that "introduced enriched environments as a testable scientific concept (Rosenzweig 1966; Rosenzweig, Krech, Bennett and Diamond 1962; Rosenzweig and Bennett 1996)."

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- "In the initial studies, the effects of environmental stimuli on parameters such as 'total brain weight,' 'total DNA or RNA content' or 'total brain protein' were measured. Subsequently, many studies have shown that environmental stimulation elicits various plastic responses in the adult brain, ranging from biochemical parameters to dendritic arborization, gliogenesis, neurogenesis and improved learning" [van Praag, Kempermann and Gage 2000, p. 191].

". . . intellectually, physically and socially active lifestyles (that are akin to EE [environmental enrichment]) have been linked to improved cognitive function and lower incidences of cognitive impairment, particularly in older, uninjured adults (Seeman, Lusignolo, Albert and Berkman 2001; Scarmeas and Stern 2003; Wilson, Barnes and Bennett 2003; Newson and Kemps 2005; Fujiwara et al. 2009; Voss, Nagamatsu, Liu-Ambrose and Kramer 2011)" [Alwis and Rajan 2014, p. 11] (insertion in brackets added).

- "Similarly, cognitive enrichment early in life has also been linked to improved cognitive abilities in later life (Milgram, Siwak-Tapp, Araujo and Head 2006), while Kramer and Bherer et al. (2004) have suggested that enhanced cognitive enrichment results in improved crystallized intelligence."

- "In a clinical setting, EE [environmental enrichment] can be broadly classified as a paradigm that specifically enhances and promotes engagement with cognitive, social and physical stimulation."

- "An important caveat to the discussion about the role of EE in the treatment of TBI [traumatic brain injury] is that post-TBI rehabilitation programs are *widely considered to be comparable to enriched environments, in that these programs often comprise of multiple components that are considered hallmarks of EE* [environmental enrichment], which include physical and cognitive therapy, multimodal stimulation, novelty, duration, functional relevance, and social integration."

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- "It has to be noted, however, that *specific skill rehabilitation paradigms often do not result in improved general performance in the post-discharge environment, and instead act to improve task-specific performance* (Sohlberg and McLaughlin et al. 2000; Park and Ingles 2001)" [emphases added].
- "It has instead been suggested that *a more generalized treatment would be beneficial in improving overall function* (Toglia 1991; Toglia, Johnston, Goverover and Dain 2010)" [emphasis added].
- "Rehabilitation paradigms treating brain injury are often implemented in the acute stages post-injury, in an in-patient hospital setting."

- *"Rehabilitation based on EE principles in TBI patients results in better general functional outcomes, such as improved cognitive and motor skills* (Willer, Button and Rempel 1999; Powell, Heslin and Greenwood 2002; Cifu and Kreutzer et al. 2003; Boman, Lindstedt, Hemmingsson and Bartfai 2004; Hayden and Plenger et al. 2013), *and better community integration* (Zhu, Poon, and CCH and SSH Chan 2001; Cicerone, Mott, Azulay and Friel 2004)" [emphases added].

- *"A number of studies have also shown that increasing the duration and intensity of exposure to rehabilitative therapy results in improved recovery times* (Blackerby 1990; Spivak, Spettell, Ellis and Ross 1992; Shiel and Burn et al. 2001; Zhu, Poon, and CCH and SSH Chan 2001 and 2007; Slade, Tennant and Chamberlain 2002; Cifu and Kreutzer et al. 2003; Cicerone, Mott, Azulay and Friel 2004)" [Alwis and Rajan 2014, p. 11] (emphasis and insertions in brackets added).

- "It has also been suggested that a lack or an absence of EE [environmental enrichment] is linked to cognitive decline post-injury (Till, Colella, Verwegen & Green 2008; Frasca, Tomaszczyk, McFadyen and Green 2013), demonstrating the importance of continued exposure to EE in the post-discharge stages after brain injury."

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- "In that sense, a number of factors could contribute to the provision of an appropriate level of enrichment once a patient has left an intensive rehabilitative environment. These factors include ease of access to activities and resources that are cognitively, physically and socially stimulating, as well as support that encourages participation and integration with these environments (Frasca, Tomaszczyk, McFadyen and Green 2013)."

- "Frasca et al. (2013) have also suggested that although patients eventually return to an environment that could be considered enriched post-TBI, interactions with these environments may be restricted due to limitations in cognitive and/or physical deficits. This is especially relevant during the transition from the in-patient rehabilitation environment, to post-discharge home environments, where complexity of, and engagement with environments may reduce."

- "A reduction in enrichment in the post-acute period could be detrimental to recovery as studies have shown that functions gained during stimulation of neural pathways (such as during rehabilitation) can be lost through under-use (Rubinov, McIntosh, Valenzuela and Breakspear 2009; Warraich and Kleim 2010; Frasca, Tomaszczyk, McFadyen and Green 2013)" [Alwis and Rajan 2014, pp. 11-12] (insertions in brackets added).

- "Given the complexity and ethics of manipulations of the environment in humans recovering from TBI, in addition to the difficulties in accurately comparing the effectiveness of various rehabilitation paradigms, questions of the correlation between these effects and EE-induced functional changes remain. Injury heterogeneity also raises challenges in defining exactly what level of enrichment is optimal and beneficial."

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- "However, *the findings* presented in this section *strongly suggest* that *EE* [environmental enrichment] *or EE-based therapy* tailored to the patient's needs could *significantly improve outcomes* when applied in both the in-patient, acute and post-discharge, chronic settings" [Alwis and Rajan 2014, p. 12] (insertion in brackets and emphases added).

"This article reports recent insights in human brain plasticity with particular emphasis on (dynamic) learning-related structural gray and white matter changes and its behavioral correlates" [Taubert, Villringer and Ragert 2012, p. 320].

- "Neuroscientists have long speculated about the underlying functional and structural mechanisms of skill learning in the central nervous system. More than 60 years ago, Donald O. Hebb proposed that learning and brain plasticity are closely related, providing a conceptual framework that has become extremely influential (Bliss and Collingridge 1993; Bliss and Lomo 1973; Hebb 1949; Rioult-Pedotti, Friedman and Donoghue 2000)."

- "Specifically, Hebb postulated that connections between neurons are strengthened and remodeled by experience (Hebb 1949). Experimental evidence from the last two decades has clearly shown that learning causes distinct physiological, molecular, and structural changes in the brain (Kandel 2001; Markham and Greenough 2004; McGaugh 2000)" [Taubert, Villringer and Ragert 2012, p. 320].

- Taubert, Villringer and Ragert identify a number of studies pointing to "a functional relevance of learning-induced structural brain plasticity" citing Driemeyer and Boyke et al. 2008; Filippi and Ceccarelli et al. 2010; Ilg and Wohlschläger et al. 2008; Taubert and Draganski et al. 2010; Draganski and Gaser et al. 2004; Taubert and Lohmann et al. 2011; Fox and Raichle 2007 [Taubert, Villringer and Ragert 2012, p. 321].

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Driemeyer J, Boyke J, Gaser C, Büchel C & May A (2008). Changes in gray matter induced by learning – revisited. *PLoS ONE* 3(7): e2669. doi: 10.1371/journal.pone.0002669.

- They further report that "Although macroscopic MRI [magnetic resonance imaging] findings clearly indicate that some structural changes are occurring, they are unspecific regarding the underlying cellular events. Based on recent animal studies (Lerch and Yiu et al. 2011) it is reasonable to assume that structural brain alterations are consequences of a complex array of morphological alterations that may include the formation of *new [neuronal] connections by dendritic spine growth (synaptogenesis)*, proliferation of glial cells, and perhaps changes in the size and number of neurons (neurogenesis, proven, however, only in a very few brain regions)" [Taubert, Villringer and Ragert 2012, p. 321] (emphasis and insertions in brackets added).

"Contrary to assumptions that changes in brain networks are possible only during critical periods of development, modern neuroscience adopts the idea of a permanently plastic brain (Johansson 2004; Pascual-Leone, Amedi, Fregni and Merabet 2005). We use the term *plasticity* referring to either functional or structural changes that occur in the adult brain in order to adjust to perturbations in the external environment or internal milieu. We also consider that the extent of plastic reorganisation is conditional on the relevance of the alterations for the individual and can result in beneficial or maladaptive behavioural consequences (Pascual-Leone, Amedi, Fregni and Merabet 2005)" [Draganski and May 2008, p. 137].

- "Novel experience and new skill learning became widely used as paradigms for studying different aspects of plasticity at the level of brain systems. At the cellular level different neurotransmitters released by neuromodulatory systems were found to modify the mechanisms of long-term potentiation (LTP) and long-term depression (LTD) considered as crucial for information storage in the mammalian cell (Feldman, Nicoll and Malenka 1999; Lüscher, Nicoll, Malenka and Muller 2000)."

- "Regarding the temporal characteristics of experience/lesion-induced plasticity changes, it was assumed that recovery from central or peripheral nervous system damage was only possible in the neonatal, and to a certain extent, pre-adolescent brain. MR-based morphometry added a completely new facet to our understanding of brain plasticity, in that it provided *in vivo* evidence of the capacity of the human brain not only to achieve *functional* reorganization (Flor and Elbert et al. 1995), but also adapt *structurally* with an unexpected amount of plasticity" [Draganski and May 2008, p. 139].

Eack SM (2012). Cognitive remediation: A new generation of psychosocial interventions for people with schizophrenia. *Social Work* 57(3): 235-46. doi:10.1093/sw/sws008.

Eack SM, Bahorik AL, Hogarty SS, Greenwald DP, Litschge MY, Mazefsky CA & Minshew N.J (2013). Brief report: Is cognitive rehabilitation needed in verbal adults with autism? Insights from initial enrollment in a trial of cognitive enhancement therapy. *Journal of Autism and Developmental Disorders* 43(9): 2233-7. doi:10.1007/s10803-013-1774-2.

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Eack SM, Hogarty SS, Greenwald DP, Litschge MY, McKnight SA, Bangalore SS, Pogue-Geile MF, Keshavan MS & Cornelius JR (2015). Cognitive enhancement therapy in substance misusing schizophrenia: Results of an 18-month feasibility trial. *Schizophrenia Research* 161(2-3): 478-83. doi: 10.1016/j.schres.2014.11.017.

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- "A vast amount of cross-sectional morphometric studies have demonstrated neuroanatomic correlates of learning and experience in different cognitive domains. For example, navigational experience has been reported to be correlated with posterior hippocampus size (Maguire and Gadian et al. 2000) and musical proficiency to be associated with volume enlargement of motor and auditory areas and their anatomical connections (Bengtsson and Nagy et al. 2005; Gaser and Schlaug 2003a; Gaser and Schlaug 2003b; Sluming and Barrick et al. 2002)."

- "Visual memory performance and visuo-spatial attention is reported to be correlated with fractional anisotropy – a measure of axonal integrity and coherence – (Begré and Frommer et al. 2007; Tuch and Salat et al. 2005). Parietal gray matter volume and underlying white matter fibers were highlighted for their pivotal role in acquisition of novel sounds and knowledge of vocabulary (Golestani and Pallier 2007; Golestani, Paus and Zatorre 2002; Golestani and Zatorre 2004; Lee and Devlin et al, 2007; Mechelli and Crinion et al. 2004)."

- "While structural MRI images provide adequate resolution to describe *in vivo* macroscopic changes in brain structure due to exercise and learning, the nature of the underlying cellular events is almost unknown. Animal studies suggest that the increase in cortical grey matter is the result of a complex array of morphological changes including local synaptic events such as the formation of new connections by dendritic spine growth and change in strength of existing connections [i.e., 'neuronal connection strength modulation'] (Chklovskii 2004; Chklovskii, Mel and Svoboda 2004, Holmaat and Willbrecht et al. 2006; Sur and Rubenstein 2005; Trachtenberg and Chen et al. 2002)" [Draganski and May 2008, pp. 139-40] (insertion in brackets added).

- Draganski and May note that among the many processes that constitute neuroplasticity "Larger scale cortical reorganization involving processes such as axonal remodelling may also occur, possibly in response to fundamental shifts in the environment. Considering the importance of intracranial pressure and volume homeostasis it is also to be tested whether the signal changes detected with morphometric techniques represent structural rearrangements on the cellular level rather than true volumetric expansion" [Draganski and May 2008, p. 140].

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- "However, a host of other changes, including increase in the size of the soma and nucleus of neurons, glia and capillary dimensions have also been demonstrated to influence cortical morphology in animals exposed to enriched environments (for review, see Muotri and Gage 2006)" [Draganski and May 2008, p. 140].

- "There is some direct *post mortem* evidence that similar processes occur in humans. For example, adults with university level rather than high school level education are likely to have a higher IQ. Further, high IQ subjects demonstrated a greater number of dendrites on neurons in cortical regions important for language processing (Jacobs and Batal et al. 1993) whereas individuals with very low IQs seem to have less dendritic branching (Huttenlocher 1991)."

- "Potential correlates of the observed morphometric changes include a simple change in cell size, growth or atrophy of neurons or glia (Gage 2002), as well as changes in the intracortical axonal architecture (i.e., synaptogenesis) (Aimone, Wiles and Gage 2006; Leuner, Gould and Shors 2006)."

- "Changes in the synaptic contacts known to be the morphological substrate LTP and LTD or the cellular properties by themselves could add to the increasingly sophisticated explanations of brain plasticity."

- "Further mechanisms reported to be linked to behavioural training related plasticity are changes in gene expression (Kleim and Lussnig et al. 1996), protein synthesis (Hydén and Lange 1983; Jin and Wang et al. 2005; McAllister, Lo and Katz 1995) and dendritic density (Comery, Shah and Greenough 1995; Kolb, Buhrmann, McDonald and Sutherland 1994). Recent reports claim to have observed learning related astrocytic proliferation, supporting the idea of glial involvement in learning-induced plasticity (Kleim, Kleim and Cramer 2007; Markham and Greenough 2004)" [Draganski and May 2008, p. 140].

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"Several studies have built on and extended the findings in procedural learning (Klöppel and Mangin et al. 2010; Taubert and Draganski et al. 2010; Herdener and Esposito et al. 2010; Granert and Peller et al. 2011; Hyde and Lerch et al. 2009) by studying longitudinally morphometric changes related to memory and learning." [May 2011 p. 478].

- "The first study of this type investigated a 'real-life' situation: the German basic medical exam, called 'Physikum' (Draganski and Gaser et al. 2006), which includes both oral and written tests in biology, chemistry, biochemistry, physics, social sciences, psychology, human anatomy and physiology demanding a high level of encoding, retrieval and content recall. This study observed differential effects of learning regarding dynamic temporal characteristics on cortical structures such as the hippocampal and parahippocampal gray matter and the posterior parietal cortex (PPC)."

- May also cites particular studies suggesting that "at least in principle, the human brain even in older age maintains its capacity to change its structure according to learning and physical or cognitive exercise demands (Boyke and Driemeyer et al. 2008; Engvig and Fjell et al. 2010)" [May 2011 p. 478].

Although many of the details of the molecular mechanisms involved in the macrostructural processes of neuron connection strength modulation including synaptogenesis, synaptic pruning and other macrostructural processes that contribute to neuroplasticity in the human brain remain unclear, as do the details of the ways in which those processes interact with each other, and whether or not the incredible complexity of the human brain will remain forever impenetrable, one thing is clear; that the principal macrostructural mechanisms involved in the neuroplasticity of the human brain directly affected by learning and experience are sufficiently understood to 1) shape positive, self-actualizing behavior, 2) intervene in and enable recovery from cognitive and behavioral disorder, and 3) effectuate positive learning realization (Robinson 2015, p. 82).

One particular study using cortical thickness measurements across the cortical mantle (Engvig and Fjell et al. 2010) demonstrated that "memory training in the elderly improved source memory performance as well as regional increases in cortical thickness in the right fusiform and lateral orbitofrontal cortex, which correlated positively with improvement in source memory performance" [May 2011 p. 478].

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- "An intrinsic property of the human central nervous system is the lifelong ability for structural and functional brain reorganization (Pascaual-Leone, Amedi, Fregni and Merabet 2005)."
- "The term 'plasticity' refers to functional or structural changes (which may trigger each other) that occur in the adult brain to adjust to changes in the external environment or internal milieu (Zilles 1992; Kempermann 2006)."
- The extent of plastic reorganization is conditional on the relevance of the alterations for the individual and can have either beneficial or maladaptive consequences (Pascual-Leone, Amedi, Fregni and Merabet 2005)."
- "... nearly all studies investigating brain morphology on an individual basis over time, that is not comparing cohorts, have found a strong direct correlation between learning and brain changes (Draganski and Gaser et al. 2004; Draganski and Gaser et al. 2006; Draganski and May 2008; Gaser and Schlaug 2003a; Jäncke and Koeneke et al. 2009; Boyke and Driemeyer et al. 2008; Driemeyer and Boyke et al. 2008)" [May 2011 p. 475].
- "Learning-induced structural changes can also affect the anatomical connectivity in the adult brain. Recent work has identified axonal remodelling, growth of new dendritic spines and synapse turnover as important structural mechanisms for experience-dependent plasticity in mature cortex (Barnes and Finnerty 2010)" [May 2011 p. 476].
- "It is by all means reasonable to assume that plasticity is a characteristic of the nervous system that evolved for coping with changes in the environment (Draganski and May 2008). Because some elegant studies could demonstrate a reorganization of cortical representation fields due to changes in environmental demands (Jenkins and Merzenich 1987; Pons and Garraghty et al. 1991; Jain, Florence, Qi and Kaas 2000; Henderson and Gustin et al. 2011) the term brain plasticity very often refers to functional changes of brain activity."

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- "The concept of an enriched environment, described anecdotally already by Hebb (1947), is one of the most widely used experimental paradigms for studying learning-induced plasticity. . . At the behavioral level enrichment is associated with increased learning and memory and reduction in age-related decline (Rampon and Jiang et al. 2000; van Praag, Kempermann and Gage 2000)" [May 2011 p. 476].

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[1]APA/CAPP = American Psychological Association Committee for the Advancement of Professional Practice

[2]WIREs = Wiley Interdisciplinary Reviews

Postlude

In the CNE program we explore together conceptualizations, beliefs, modes of social interaction and interpersonal relationships, reactions to situations, emotive contours, flights of imagination, aesthetic visions, creative artistry and nuance, duty, purpose, loyalty, love, spirituality, sense of destiny and myriad other products of the mind in a variety of contexts through a range of media by which we gain insights on the essence of being human.

We explore behavior through a variety of activities and media, learning how to interpret frames of meaning in understanding others and discovering or rediscovering ourselves in outings, games, stories and through music, drama, motion picture films, dance, etc.

In answering the criticism that a large portion of such material is creative, often fanciful, and does not reflect real life; such components are however indisputably products of the mind – the depository of all that we experience and think about – and therefore representative of our hopes, dreams, fears, longings, visions, imaginings, in short, the true essence of being human, and in such dialogue and group experience, we learn what it is to be human and how to connect with others and through that connection with others, discover our very own personal, unique core of being, reforming our cognitive constructs in redefining a more positive, personal, harmonious lifestyle supporting balanced, self-actualizing behavior, fluid, engaged social interaction and a real, unequivocal bonding and reengagement with oneself, with others and with life itself.

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