Exploring the Art of Neuropharmacology

Envisioning new ways of using the Arts to inspire and advance molecular & behavioral neuropharmacology

Introduction

All art and aesthetic experiences embody brain actions that encompass molecular and behavioral neuropharmacology. The whole process of making art, experiencing and appreciating art—as well as applying art in all-purpose ways to enrich our lives—entails neurochemical interactions that involve our central and peripheral nervous systems. We sense this first-hand the instant we're attracted to or repelled by an artwork we like, or dislike; it's evidenced by spikes in sensory evoked potentials or rapid rises in neurotransmitters norepinephrine and dopamine with sharp fluctuations in our heart rate and blood pressure. We know this when we self-discover how an artwork resonates with our work and lives; a visceral connection is made that is as visible as a surge of serotonin in the brain reward system. Our responses reveal that we feel either inspired with wonder or agitated and dismayed because we were expecting more tangible things to takeaway other than ephemeral memories.

The challenge remains understanding why and how art is much more than these brain mechanisms: amino acid neurotransmitters (glutamate, aspartate, D-serine, γ-aminobutyric acid [GABA], glycine), monoamines and biogenic amine neurotransmitters (dopamine, noradrenaline, epinephrine, histamine, serotonin), neuropeptides, neurohormones, enzymes, receptor proteins, ligand-gated ion channels (LGIC) receptors, and other neural mechanisms that enable and influence our creative acts of thinking, feeling, discovering, innovating, and communicating. It is an amalgamation of these neural processes and products, which we freely interpret and use endlessly with imagination.

Neuropharmacology can play a central role in advancing our understanding of the myriad ways art positively affects our nervous systems; especially, the brain's pleasure and reward system that's intimately involved in learning, memory, motivation, and actions. It can also provide fresh insights into the creative process of art, which naturally connects all forms of symbolic languages, representations and expressions of ideas, knowledge, experiences, and sensory impressions. The author posits that virtually all of our creations can be experienced as "works of art"; including works of science, technology, engineering, and mathematics, among other manifestations of human knowledge. In sum: Art encompasses All representations of thought, utilizing all ways and means of creation. Arts-based methods and tools, which have evolved over millennia, are essential for exploring the complexities and mysteries of human nervous systems.

Materials and Methods

The metaphorical art presented here represents a small selection of works created by the author over the past 45 years as a professional visual artist who applies basic observational science in studying human nervous systems. The artworks make and interpret various connections between the brain and its creations all of which manifest neural processes. The art may be useful for demonstrating how neuropharmacology can enhance our understanding and experiences of art. More empirical studies need to be conducted that compare the brain profiles of individuals making and viewing art who are under the influence of such common and natural "highs" as inspiration and self-motivation, in contrast to individuals who are under the physiological influence of drugs (e.g., cocaine, cannabis, barbituates), abuse substances (e.g., Phencyclidine [PCP] or "angel dust" and other dissociative anesthetic agents), neurological or psychological disorders.

The point is neuropharmacologists stand to gain innumerable insights into healthy and impaired brain dynamics, behaviors and human interactions through this comparative study. This study will likely enable researchers to develop drugs that enhance cognitive and affective processes for medicinal purposes, stimulating a sense of open-mindedness (countering willful closed-mindedness and blindness), empathy, compassion, and rationality. Moreover, it may lead to better treatments of different neurological disorders, including pain, neurodegenerative diseases (e.g., Parkinson's, Alzheimer's and Huntington's diseases), psychological disorders (e.g., somatization), addictions, and other dysfunctions that impact the quality of life.

Figure 1. "Silence" (1970) graphite on paper, 12" x 9"

Figure 2. "Man Without Words" (1975) Ink on Arches paper, 35" x 26"

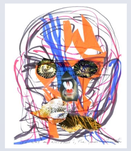


Figure 3. "Human Beings: The Most Endangered Species. Reflections on Breaching the Species Barrier" (1991) mixed media on paper, 8.5" x 11"

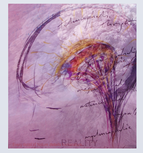


Figure 4. "Reality: Every Detail of Nature *Details* Humanature." (2010-11). Monotype print on Hahnemuhle paper,18" x 24"

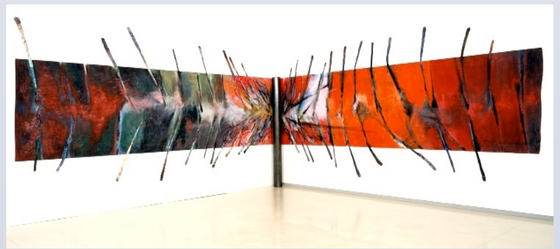


Figure 5. "Breaking the Mind Barrier: The Symmetries of Nature," 1986. Mixed media collage on synthetic canvas, steel cylinder with photostrobe and audiotape, 9ft. X 39ft. X 3ft. Installation view: Saidye Bronfman Centre, Montreal, Quebec.

Figures 4 &5 point to four interconnected regions of the brain (rhomencephalon-mesencephalon-diencephalon-telencephalon) that may be activated for milliseconds in a personally memorable moment of idea-generation that stick in our long-term memories and imagination (Siler, 1986). These exploratory artworks envision many ways human emotions are naturally as unpredictable and uncontrollable even with forewarning, not unlike the sudden explosion of Mount St. Helens in Washington States on May 18, 1980. Literally speaking, this volcanic event was preceded by several earthquakes and steam-venting events that were as plainly obvious and self-evident as the nose on one's face. Metaphorically, the cataclysmic actions of this physical system bear striking resemblances to certain process of our neuropsychological systems, such as the rush of sometimes rageful emotions induced by illicit crystal meth hydrochloride; these reactions contrast the controlled, low-dosage use of *Desoxyn*, a USFDA-approved pharmaceutical methamphetamine hydrochloride prescribed for adults and children suffering from attention deficit hyperactivity disorder (ADHD) and obesity (https://en.wikipedia.org/wiki/Methamphetamine). Note that the creator of these artworks does not suffer from either of these two disorders. Common stress with spells of melancholy? Yes, like billions of other people coping with our chaotic world.

In the February 24, 2003 Issue of *Newsweek*, the feature article, "Anxiety And Your Brain: How Living With Fear Affects the Mind and Body," describes the neural pathways that are active when processing the angst associated with the international war on terrorism. It generally diagrams the pattern of responses the brain gives to familiar and unfamiliar stimuli. Unfortunately today, the public's heightened fear are at the same alarming level as the 9/11 terrorism. Contributing to this raised alert, the market-driven News Corporation and Internet keep us in a suspended state of suspense, like the most state-of-the-art Entertainment and Licensed Gaming Industries.

How can neuropharmacology help us better understand and manage these common patterns of actions and behaviors, or habits, that can be highly destructive when left unchecked or untreated? These patterns are rapidly becoming so commonplace that we swiftly dismiss them as the "new normal," because we've become habituated to them; consequently, we rationalize them when our intuitions tell us otherwise. "The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and forgotten the gift," Albert Einstein wisely observed.

Discussion

Art manifests the symbolic expressions of human nervous systems (Siler, 1986, 1993), embodied aesthetics (Ticini et al., 2015) and creativity (Zeki, 2001). This wide array of artworks and aesthetics serves to illuminate the neuropsychological processes underlying emotions that influence every aspect of learning, decision-making and related cognitive and affective processes, and consciousness.

Figure 6. "Prescience, Foresight" (1986-88). Mixed mediums on synthetic canvas with collage elements, 5ft. x 9ft.
(Courtesy of The Metropolitan Museum of Art, 20th Century Collection, New York City.)

This neuro-impressionist painting, "Prescience, Foresight," pictures the neurobiological roots of anxious feelings about our collective future. It explores the common, chronic angst a world of concerned global citizens sense when we consider some critical things that will most likely change—or remain the same—over the next one hundred years. Although the art depicts such natural phenomena as fear, uncertainty, and chaos, its creator has not suffered the same severe panic attacks and other anxiety-disorders candidly rendered in Scott Stossel's insightful book, *My Age of Anxiety* (2013). This artwork reflects on milliseconds of my imagination, when I'm dwelling on the future of human development—groping to grasp how we can best work together to create a sustainable future while everything's in constant transition.

The art installations "Radical Futures" (1993) and "Changing Minds" (1997) are especially relevant to highlight here. Both are chocktull of shocking feelings that typically accompany intense instances of great ambiguity and uncertainty, such has worrying about near and distant future states of the world (Bern, 2011).This art examines states of mind that still stonewall the scientific method regarding the nature of mind, creativity, and our uniquely personal ways of making sense of physical reality. These installations probe the inner workings of minds as seen in an evolutionary context. In "Changing Minds," over one hundred cross-sectional coronal views of the human brain (through the Thalamus and Limbic system) are randomly assembled in this multi-part artwork that consists of drawings, paintings, sculptural sketches, constructions, and visual notations. These symbolic Brain/Mind Icons resonate with an original, musical composition, "Homage To Art," and performance by the pioneer freeform jazz musician and composer, Ornette Coleman, and his group, Harmolodics.

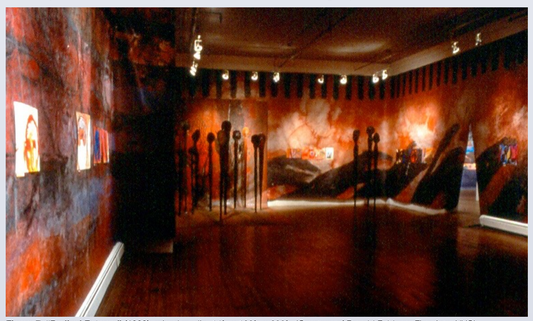


Figure 7. "Radical Futures" (1993). mixed media, 14ft. x 100ft. x 200ft. (Courtesy of Ronald Feldman Fine Arts, NYC)

Figure 8. "Changing Minds" (1997) mixed media, 14ft. x 100ft. x 200ft. (Courtesy of Ronald Feldman Fine Arts.)

The contents of these Mind Icons consider how, for some people, 'there's nothing new under the sun,' and for others, everything can be seen anew with novel interpretations and implications. Overall, they metaphorically mirror our billions of minds *in the process of changing*. They do so without moralizing this change or predicting its direction: either for the better or the worse. After all, nature doesn't care one way or another whether or not we become 'a society of insects and grass' (Schell, 1980). Similarly, these works of art neither attempt to sway, convince, guide, plead, proselytize, nor explain the unpredictable actions of our minds *en masse*. Essentially, the art adventures this premise: The universe exists to evolve by changing, as humans exist to change by learning. Clearly, learning to change and adapt is often catalyzed by human and natural catastrophes. However, it's nature's way of implementing its evolutionary process.

When you enter that beaver's lodge in the center of the gallery space, titled "Simplexity: Seeing the Simple in the Complex," and sit inside that chaotic pile of 4,000 lbs. of raw lumber 14ft x 20ft. x 24ft., a peculiar calmness and peacefulness sweep over you. The sensation is not unlike standing in the eye of a hurricane and feeling that strange stillness before the torrential winds pick up again. Sitting quietly, enveloped by the scent of forest wood, all your senses start to absorb the nuances of our notions of "beauty" and "truth." Indeed: there's beauty *and* truth. And there's beauty *in* truth. But the truth is not always beautiful. And the beautiful is not always truthful. In that tranquil moment of higher awareness, you begin to connect *beauty & truth*, *art & science, mind & nature*, and other binary concepts that link the mosaic of Mind Icons mounted on the walls.

Results

The results in this report are obviously not presented rigorously like the Cochrane Review, which systematically evaluates primary, evidence-based research in human health care. Rather, it's personal and largely self-referential. It draws on introspections that can change with each new viewing of the art in unique contexts and environments.

Figure 9. "BrainMind Icon: Beauty / Truth" (1995). Nambe metal, 25" x 30" x 20"

What you see in this symbolic sculpture is limited only by what you see in yourself. You mirror it. It mirrors you. This biomirror of reality (Siler, 1980, 1983) reflects your inner world. Even when the art is removed from your sight, it remains etched in the neuronal folds and folders of your memories; that is, if you connect your experiences of it with things you know already and that interest you, thus making this art memorable through elaborative encoding (Schacter, 1996). In many respects, it invokes the actions of our "mirror neurons" (Ramachandran, 2000, 2011), a controversial theory that describes how certain brain cells enable us to 'imitate movement and gesture' and to 'empathize' as we engage in the process of learning and understanding. This possibility prompts the question: If we all have mirror neurons and neuroscientists know their functional architecture in the Somatosensory Cortex and other areas, can we figure out how to *mirror our very best creative habits of mind and lifelong learning*, rather than imitate our worst ones that reinforce our destructivity? What key role can neuropharmacology play influencing other deeper areas of the brain that directly connect with the Somatosensory Cortex, such as the Limbic system and brain reward system located in "the heart of the brain" (Siler, 2015). These areas process the visceral and emotional contents of our creative thoughts, as we consciously/unconsciously build on our conceptual connections and perceptions stimulated by sensory impressions (Kandel, 2012). Maybe this knowledge can change our most destructive habits or help balance them by stimulating a sense of humanity and civility. Or maybe our unconscious mind will always influence our mirror neurons, causing effects that either enrich our lives or accelerate our demise.

Figure 10a. "The Encoded Monolith" (1979-1991) Stainless steel with engraved numbers from a Radian protractor in 42 drawers; 800 drawings, paintings, visual notations are encased in these symbolic drawers, applying the ArtScience process; 10ft. x 10ft. x 10ft.
(Courtesy of Ronald Feldman Fine Arts, NYC)

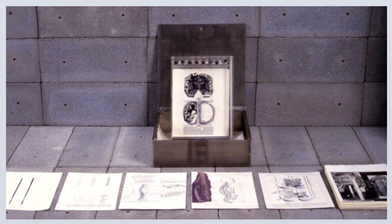


Figure 10b. "The Encoded Monolith" (1979-1991) (Detail) A selection of drawings and visual notations that conceptually connect neuroscience and nuclear physics. (Courtesy of Ronald Feldman Fine Arts, NYC)

Given the current high level of chronic stress and emotional chaos in contemporary life, one wonders how our nervous systems will learn and adapt fast enough in order to productively manage these daily, relentless stress. Could all these accumulative stresses be contributing to a global, mass sociogenic illness of sorts that resembles common symptoms of ADHD, schizophrenia, bipolar behaviors, and other neurological problems? Studies of the dopamine D2 receptors indicate that the dopamine system, whose primary functions serve as the brain reward system, is associated with divergent thinking, movement, and anticipated rewards (Manzano et al., 2010) that include a wide range of expressions of creative cognition (Freedberg and Gallese, 2014). Fredrik Ullén from Karolinska Institutet's Department of Women's and Children's Health, has noted that the dopamine system, which consists of clusters of neurons in the mesencephalon that are connected to the basal ganglia and Limbic system 'in healthy, highly creative people is similar to that found in people with schizophrenia.' The psychometric tools used to measure divergent thinking in problem solving tasks helped reveal 'that highly creative people who did well on the divergent tests had a lower density of D2 receptors in the thalamus than less creative 'people' (Manzano et al., 2010). The thalamus, which manages our affective functions, filters information in advance of relaying it to various areas of the cerebral cortex. In this regard, it seems our feelings for certain types of information directly influence how we think about and respond to information that interests or intrigues us. As Dr. Ullén noted: "Fewer D2 receptors in the thalamus probably means a lower degree of signal filtering, and thus a higher flow of information from the thalamus." Implying, this increased flow enables creative people to fluidly and freely make all sorts of novel connections when engaged in challenging problem-solving tasks. His conclusion: "Thinking outside the box might be facilitated by having a somewhat less intact box." This intimates why and how creative collaborations across disciplines thrive utilizing transdisciplinary thinking (Root-Bernstein et al., 2011) that blurs the boundaries between our compartmentalized data, knowledge, ideas, concepts, theories, life experiences, etc. In effect, there's a 'less intact box' of compartmentalized knowledge to have to navigate around artificial obstacles. More to the point: these findings suggest that we need to more broadly and deeply consider how creativity may be *any* unconditioned response to *any* familiar or unfamiliar stimuli.

Conclusions

These metaphorical artworks (Figures 1-12) seek-and-inspire insights into nature, using the art of science and science in art; meaning, the ArtScience process of creative inquiry. This brain-based art reflects on some of the most basic questions about the nature of human creativity and its connections with nature (Siler, 2015).

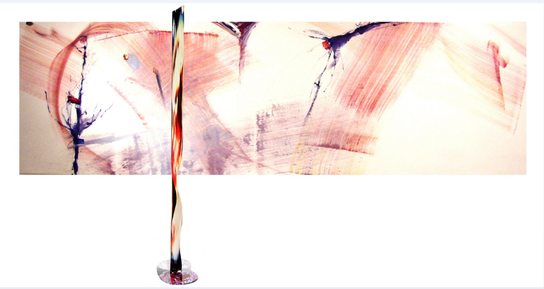


Figure 11. "Neural Fragments" (2000-2010). Mixed-media on synthetic canvas (6ft. x 15ft.) with *Photosculpture*: "Human Mind In 11-D," metaphorms fused to cut and welded aluminum plate, 90" x 24" x 18"

Nature embodies art, just as the human brain embodies art in all representations of thought; all interpretations of reality that we use to describe the laws and forces of nature. Through the ArtScience process (Siler, 2011), we can learn about virtually everything nature is or may be, without making and mistaking our definitions of nature's truth and beauty anything other than what they are: concepts and theories of phenomena that exist because we experience them to be true or not, real or not, knowable or not as verified by the scientific method.

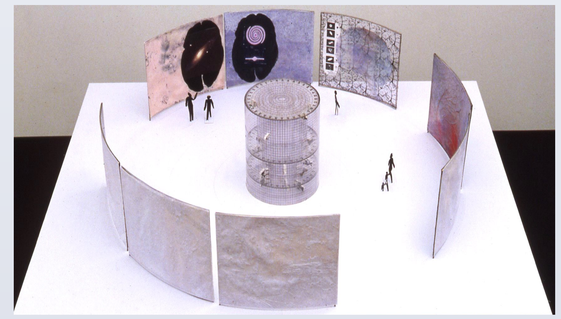
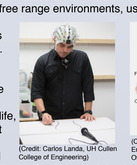


Figure 12. "Cerebrarium: Model & Apparatus for Describing the Nature of Creativity" (1981) Mixed media on paper, 4ft. x 4ft. x 1ft.
(Courtesy of the Denver Art Museum.)

This dynamic sculpture, "Cerebrarium," was designed to connect and transform information about the creative process across all domains of human knowledge and life experiences. Viewers are afforded the opportunity to experience how they are connected to everything in the built and natural environment. The changing symbolic images projected on the moveable screens in this metaphorical brain theater point to how we intuitively connect information, make discoveries and innovate, as we learn to see *what nature makes and what we make of nature*. It invites viewers to question and rethink what we see and believe about human/nature's creative potential.

Neuroscience is fast-approaching the time when researchers are no longer limited methodologically to observing a person being naturally and spontaneously creative in real-life, real-time and at any time, space, or place. That limitation has narrowed neuroscience of creativity, art, neuroaesthetics (Zeki, 2001) underlying insight, intuition, divergent and convergent thinking (Jung & Haier, 2007; Jung et al., 2013) Currently, researchers are combining the methodological and technological developments in Biomedical Engineering with the neuroimaging tools used in studying the neuroscience of creativity and art. Researchers Saurabh Prasad, Badrinath Roysam and Jose Contreras-Vidal at the University of Houston's Integrative Strategies for Understanding Neural and Cognitive Systems are observing the brain activity of diverse groups of people freely behaving as they walk about art museums, experience various games, try their hands at painting, drawing and engage in dancing as well as watch others perform these creative activities (Arrien, 2015). These researchers are gathering EEG data on individuals in various free range environments, using wireless EEG skullcaps they've engineered that enable them to record neural activity in natural settings rather than artificial ones. At a distance, they're getting up-close-and-personal with the creative process and functional connectivity in everyday life, that's generalizable to art and science alike. This data can be incorporated and further interpreted with relational data-mining tools used in Neuroinformatics (Koslow and Subramaniam, 2005), to make more comprehensive and predictive functional connectivity maps. The same course of adventurous research in neuropharmacology may yield similar results.



(Credit: Carlos Landa, UH Cullen College of Engineering)

(Credit: UH Cullen College of Engineering and Communications Office)

References

Arrien,J. (2015) http://www.nsf.gov/mobile/discoveries/disc_images.jsp?cntn_id=136954&org=NSF
Bem, J. B. (2011). Feeling the Future: Experimental Evidence for Anomalous Retroactive Influences on Cognition and Affect. *Journal of Personality and Social Psychology, 100*, 407-425. http://dx.doi.org/10.1037/a0021524
Contreras-Vidal, J. et al. (2015). NCS-FO: Assaying neural individuality and variation in freely behaving people based on qEEG. NSF-Award Abstract #1533691
Freedberg, D. and Gallese, V. (2014). 'Motion, emotion and empathy in esthetic experience,' TRENDS in *Cognitive Sciences*, Vol.11 No.5; pp. 197-203.
Heilbom, E. (2014). Intuition, a Part of Bipolar Disorder? The Emotional Brain-Survival and Time. *Open Journal of Depression, 3*, 41-44. http://dx.doi.org/10.4236/ojd.2014.32009
Jung, R. E., & Haier, R. J. (2007). The Parieto-Frontal Integration Theory (P-FIT) of intelligence: Converging neuroimaging evidence. *Behavioral and Brain Sciences, 30*,135–154.
Kandel, E. R. (2012). *The Age of Insight: The Quest to Understand the Unconscious in Art, Mind and Brain, from Vienna 1900 to the Present.* New York: Random House.
Koslow, S. H., and Subramaniam, S. (2005). *Databasing the Brain: From Data to Knowledge Neuroinformatics.* Hoboken, NJ: John Wiley and Sons.
LeDoux, E. J. (2012). Evolution of Human Emotion: A View through Fear. *Progress in Brain Research, 195*, 431-442. http://dx.doi.org/10.1016 B978-0-444-53860-4.00021-0
Manzano, O., Cervenka, S., Karabanov, A., Farde, L.& Ullén, F. (2010). 'Thinking Outside a Less Intact Box: Thalamic Dopamine D2 Receptor Densities Are Negatively Related to Psychometric Creativity in Healthy Individuals', PLoS ONE, online 17 May 2010; Read the article: http://dx.plos.org/10.1371/journal.pone.0010670 Karolinska Institutet
Ramachandran, V. S. (2011). *The Tell-Tale Brain. A Neuroscientist's Quest for What Makes Us Human.* New York, NY: Norton.
Root-Bernstein, B., Siler, T., Brown, A., and Snelson, K. (2011). ArtScience: integrative collaboration to create a sustainable future. *Leonardo* 44:192. doi: 10.1162/leon_a_00161
Schacter, D. L. (1996). Searching for Memory: The Brain, the Mind and the Past. New York: Basic Books.
Schell, J. (1982) *The Fate of the Earth.* New York: Avon Books.
Siler, T. (2015). Neurocart: picturing the neuroscience of intentional actions in art and sciencehttp://journal.frontiersin.org/article/10.3389/fnhum.2015.00410/abstract
___ (2012). Neuro-Impressions: interpreting the nature of human creativity. October 2012 | Volume 6 | Article 282 | 1–5
___ (2011). The artscience program for realizing human potential. *Leonardo* 44, 417–424. doi: 10.1162/leon_a_00242
Sternberg, R. J., and Lubart, T. I. (1999). The concept of creativity: prospects and paradigms. *Handbook of Creativity*, ed. R. J. Sternberg (Cambridge: Cambridge University Press), 3–15.
Stossel, S. (2013). *My Age of Anxiety: Fear, Hope, Dread, and the Search for Peace of Mind.* New York: Alfred A. Knopf.
Ticini, L. F., Urgesi, C., and Calvo-Merino, B. (2015). Embodied aesthetics: insight from cognitive neuroscience of the performing arts. *Aesthet. Embodied Mind Beyond Art Theory Cartesian Mind-Body Dichotomy Contributions Phenomenology 73*, 103–115. doi: 10.1007/978-94-017-9379-7_7
Zeki, S. (2001). Artistic creativity and the brain. *Science 293*, 51–52. doi: 10. 1126/science.1062331

Todd Siler, Ph.D., ArtScience® Publications, P.O. Box 372117, Denver, Colorado 80237 USA
toddsiler@alum.mit.edu Website: www.ToddSilerArt.com