Creativity and the Brain

Kenneth M. Heilman M.D.

Department of Neurology, University of Florida College of Medicine

Creativity is defined as the ability to understand, develop, and express in a systematic fashion, novel orderly relationships. Although it is one of humans most important attributes little is known about the neuropsychology of creativity. Creativity can be divided into three major stages, preparation (intelligence and special talents), innovation (which includes incubation and illumination) and production. This talk will focus on some of the brain mechanism that allow special talents and the brain mechanism that are important in innovation including curiosity and risk taking, divergent thinking, as well as associative and convergent thinking (finding the thread that units). Finally, this lecture will also mention how some neurological disease may influence creativity and the means by which people can enhance their creativity.

Definitions of Creativity

Webster's Dictionary: productive, marked by originality.

Problem: Randomly hitting keys on a word processor for many days is very productive (output) and novel, but not creative.

Bronowski: Finding unity in what appears to be diversity.

Problem: No mention of originality or productivity.

Heilman: The ability to understand, develop, and express in a systematic fashion, novel orderly relationships.

Stages of Creativity

- Helmholtz's (1896) Four Stages:
  - 1. *Preparation*…Learning background knowledge and skills.
  - 2. *Incubation*…Subconscious thinking about a problem.
  - 3. *Illumination*…Become aware of the answers. "Eureka!"
  - 4. *Verification*…Performing studies or producing work of art.

Modified Stages of Creativity

Modifications:

Thinking does not have to be subconscious, and during the incubation stage there is often conscious searching. Illumination is the termination of the incubation period. Thus, both incubation and illumination are combined to give the stage of *Innovation*.

Three Stage Model:

Stage 1: Preparation

Stage 2: Creative Innovation

Stage 3: Production

Stage 1: Preparation

- Intelligence:
  - The ability to acquire knowledge.
    - Three major factors: 1) Number of neurons; 2) Connectivity; 3) Ability to alter synaptic strengths.
  - People with high IQ are often termed "genius." But after threshold [IQ of 110-120] is reached there is no relationship between IQ and creativity (e.g., "Terman's geniuses")

Special Talents and Skills

Gall and Broca- Modularity and size.

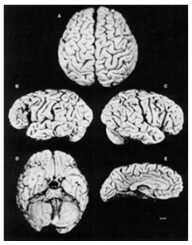
Geschwind and Levitski- Planum temporale

Einstein's Brain

The Exceptional Brain of Albert Einstein
Sandra F. Witelson

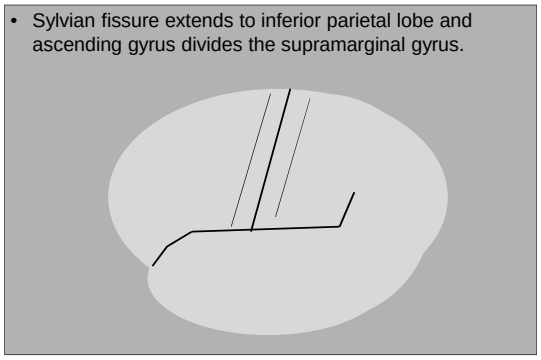
- The gross anatomy of Einstein's brain was within normal limits with the exception of his parietal lobes. In each hemisphere, morphology of the Sylvian fissure was unique, the posterior end of the Sylvian fissure has a relatively anterior position, associated with no parietal operculum. In addition, a subsequent analysis revealed in increase in the size of his right frontal lobe.

EINSTEIN'S BRAIN



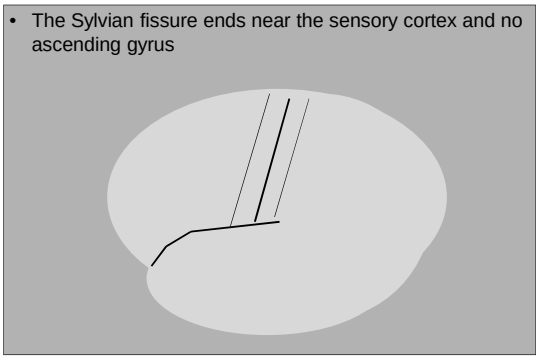
Normal Brain

- Sylvian fissure extends to inferior parietal lobe and ascending gyrus divides the supramarginal gyrus.



Einstein's Brain

- The Sylvian fissure ends near the sensory cortex and no ascending gyrus



Einstein

- 1) Age of 3 parents brought him to pediatrician…not speaking.
- 2) Dyslexia
- 3) Used spatial reasoning…Possible disinhibition of right hemisphere global-spatial reasoning
- 4) Bruce Miller- semantic dementia induced artistic creativity…
- 5) Large right frontal lobe, enhanced spatial divergent reasoning.

Stage 2 Innovation

- Disengagement and Divergent Thinking: 1
- 1) Denny-Brown: Frontal lobes mediate avoidance-parietal approach
  2) Berg's Wisconsin Card Sort; Brenda Miller and frontal lobes.
  3) Alternatives uses test.
- Curiosity, and Risk Taking:
  - ? Ventral striatum and ventral medial frontal lobes.
  - Patients treated with dopamine agonists increase risk taking and possibly creativity.
- Finding the thread that units:
  - William James (1890) "…unheard of combinations of elements and subtle associations…"

Innovation Continued

– Spearman (1931) "Creative ideas result from the combination of ideas that have been previously isolated."
(e.g., $E = MC^2$)

– Supporting Evidence
- 1) Lexical Priming - Creative people have flatter association curves.
- 2) EEG Coherence – When developing creative ideas people have greater gamma coherence.
- 3) Bogen – Corpus callosum permits hemispheric specialization. The suspension of interhemispheric inhibition permits creative illumination. Lewis showed using the ink blot test that interpretation of these stimuli was less creative after callosal section.

Innovation Continued

Major Hypothesis: Innovation is induced by the ability to engage large distributed networks and co-activate anatomically distributed networks, both inter and intra hemispherically.

But how are the size of networks and the co-activation of networks mediated?

Innovation Continued

- Observations:

1. Before and after sleep.

Kekule (1865)-benzene ring.

2. Relaxation:

- A) Examples: Newton – mother's farm-calculus; Darwin – Beagle – evolution; Einstein – late in patent office -relativity; Archimedes-bathtub – buoyancy.
- B) Raymond y Cajal – "If a solution fails to appear yet we feel success is around the corner…try resting for a while."

3. Depression:

– A) Aristotle asked, "Why are men who are outstanding in the arts and philosophy melancholic?
– B) Kraeplin (1921) and Post (1996) noted most creative authors, artists, composers and many scientists have depression or bipolar disorder.

Innovation Continued

- Hypothesis 1: Sleep – post sleep, relaxation and depression are all associated with decreased nor-epinephrine (NE). NE reduces the sizes of networks (focus) and orients attention outward. Therefore reduced NE can enhance creativity.
- Support
- 1) Kischka (1996): Increase of RT with indirect primes when subjects give levodopa (which is converted in part to NE).
- 2) Beversdorf- Increased ability to solve anagram with propanolol, but not with b-blockers that do not go to brain.
- 3) Ghasbeh- Vagal stimulation, which increases NE decreases performance on Torrance Test of Creativity.
- Hypothesis 2: Activation of the 'default network.' Mayselless et al., (2015) found increase default activation was associated with divergent thinking.
- Other investigator found that both elements of default network together with lateral prefrontal lobe are activate with divergent thinking.

Aging and Creativity

1. Simonton (1991) showed a relationship between creativity and aging.
A) Increase of productivity between ages of 20-30.
B) Peak at ages of 30-50.
C) The decline.

2. Possible neuropsychological reasons :
-A) Run out of ideas.
-B) Decrease in intelligence- Decrease in WAIS performance, but no change or increase of verbal IQ.
-C) Fluid intelligence more important for creativity that crystallized.
-D) Decreased disengagement and divergent thinking.
-E) Dementia

Creativity and Aging Continued

3. Changes in Aging Brain
-A) Little loss of neurons < 10% between age of 20 and 80. however, neurons are lost in frontal lobes.

-B) Most atrophy with aging related to white matter loss. The areas that are the latest to myelinate appear to be the first to go (e.g., frontal lobes).

-C) Frontal lobe function is heavily dependent on white matter connectivity (temporoparietal, dorsomedial thalamus and basal ganglia) and frontal lobe connection one of the last to myelinate.

-D) With aging also decrease of corpus callosum.

-E) Right hemisphere has more white matter than left. Right hemisphere important in global (versus) local attention (seeing the forest rather than the trees) important in seeing the thread that unites.

Dementia and Creativity

1) Semantic dementia: Miller reported that this dementia can be associated with increase visual creativity.
2) Non-fluent primary progressive aphasia: Finney and Heilman reported artist with this disorder who had decreased novelity.
3) Parkinson's disease (PD): Patients with PD with dopaminergic treatment may have enhanced creativity related to divergent thinking and risk taking.
4) Vascular dementia (VD): Patients with VD may have frontal executive dysfunction and with decrease divergent thinking, decrease associative thinking and decrease productivity (goal oriented behavior).
5) Alzheimer's disease (AD); Patients with AD should who have lexical and semantic disorder should have decrease verbal creativity (e.g., Iris Murdock). Their impairment in spatial abilities should also impair visual art and poor organization. Patients with AD also like patients with corticobasal degeneration may have apraxia that can interfere with visual creativity.

Possible Means of Enhancing Creativity

The development of creative products requires skill and most creative people practice, practice and practice.
Try new forms of creativity.
Rest, relaxation, and even sensory deprivation are all associated with creativity.
Immediately after awakening in the morning, many people develop creativity ideas.
Performing meditation may enhance creativity.
Anxiety is associated with increased brain NE and a reduction of anxiety might allow the activation of widely distributed networks and the ability to direct attention inward.
While not approved for treatment of creativity, propranolol may enhance creativity.
tDCS of frontal lobe may enhance creativity (Mayselles et al., 2015)
Creativity requires risk taking and while not tested some dopamine agonists increase risk taking.
Avoid injury (TBI) and treat diseases that can impair frontal lobe function (e.g., hypertension.
Keep exercising.

Summary

1) Creativity is defined as the ability to understand and express unity-order in what appeared to be diversity-disorder.

2) Cognitive intelligence, the ability to acquire and store knowledge, and development of skills are important in creativity, but after reaching an IQ threshold, cognitive intelligence and skills do not predict creative abilities.

3) Disengagement and divergent-associative thinking are important elements in creativity.

4) Dreaming, rest, relaxation, and depression are all associated with creativity. A reduction of NE might allow the activation of widely distributed networks and the ability to direct attention inward.

5) Since the frontal lobes are critical for divergent thinking and also control the activity of the locus ceruleus…they are the primary organ of creativity.