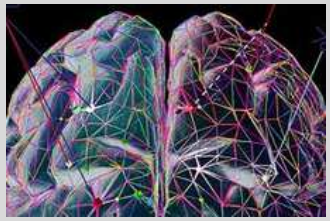
DIYneuroscience

Categories of Increasing Human Cognitive Ability



Brain Fitness
Brain Training (Lumosity)
Logic Games (Chess, Go)

Learning
Spaced-repetition learning
Dual n-back training (memory)

Topic-specific Training
Rationality instruction
Math or logic problems
Affect management (Ekman training)
Prolonged sensory deprivation
Operant conditioning

Physiology and Nutrition
General physical health
Specific types of exercise and yoga
Changing the oxygen content of breathe intake
Potassium and nutrients/micronutrients in general
Paleo and other popular diets
Nicotine, caffeine, creatine
GHB (Gamma-Hydroxybutyric acid)
Irradiation or administration of other toxins
Intermittent fasting

Sleep
Ability to relax
Healthy amount of sleep
Lucid dreaming

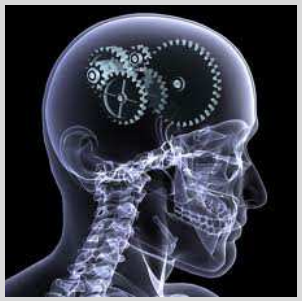
Practices
Meditation, yoga, exercise, visualization
Gratitude, journaling, happiness
Music, art, foreign language

Chemical
Caffeine
Modafinil
Adderall, Riatlin
Valproate
Steroids

Electrical Stimulation
tDCS (transcranial direct current stimulation)
rTMS (repetitive transcranial magnetic stimulation)
Transcranial Pulsed Ultrasound, Ultrasonic Neuromodulation
CES (cranial electrotherapy stimulation), Transcranial Electrotherapy, Sleectrosleep therapy, Neuroelectric therapy
Neurofeedback: EEG, etc.

Research Overview

- Mission: review, investigate, and conduct studies regarding the possibilities of increasing human cognitive ability
  - Definitions (cognition, cognitive ability), metrics, measurement, evidence, standards
  - Measures: standards (?) in existing studies, cognitive restoration techniques (stroke), cognitive pathology measures, utility evaluation, translation to everyday life
- Research Questions
  - What kinds of cognitive enhancement techniques are currently available, what is their impact, and what are their future prospects for success?
  - Which classes of techniques could be most/least successful?
  - What are the obvious roadblocks and factors that need to be resolved to move forward?
  - What are worldwide social and philosophical attitudes towards cognitive enhancement (both in cognitive enhancers and the general public)?
- Research Outcome
  - Identify and categorize evidence-based techniques for cognitive enhancement, evaluate future prospects of such efforts, and examine attitudes towards and use of such techniques in clinical and DIY communities



Research Program

- Review current types of cognitive enhancement techniques/studies
- Conduct new studies
  - Personalized genomics
    - Overall cognitive enhancement profile including attention, alertness, concentration; drug response; meditation, relaxation, sleep; pathology predisposition (Alzheimer's disease, Parkinson's disease)
    - Thinking Fast and Slow, Subjective Experience (in process), Quantified Creativity (in planning)
  - Consumer electrical stimulation (tDCS, TMS, neuro-feedback (EEG))
  - Cognitive enhancement attitudes survey (US, Japan cohorts; cognitive enhancers, general public cohorts); philosophy and psychology of cognitive enhancement
  - Consumer-available alternative to valproic acid targeting same mechanisms
  - mRNA transcriptome profile, meditation, flow state, group flow state
- Develop novel analysis methods (statistical, algorithmic, big data pattern analysis, data stream synthesis)

Short-term high-impact Studies Cognitive Performance Genomics

Connecting personal genomics to cognition enhancement

Eras of Application in Personal Genomics

- I. Ancestry, Pre-natal Screening, Forensics
- II. Medical Genomics, Pharmaceutical Response
- III. Social Intelligence, Athletic Performance
- IV. Cognitive Performance and Emotional Mastery
- V. Predictive Profiling: Wellness, Environment, Product Response

Cognitive Performance Genomics

Thinking Fast and Slow: cognitive bias in thinking (loss aversion and optimism bias)	
Creativity and Innovation: process and capacity	
General Cognitive Abilities: memory, attention, speed, flexibility, problem-solving	

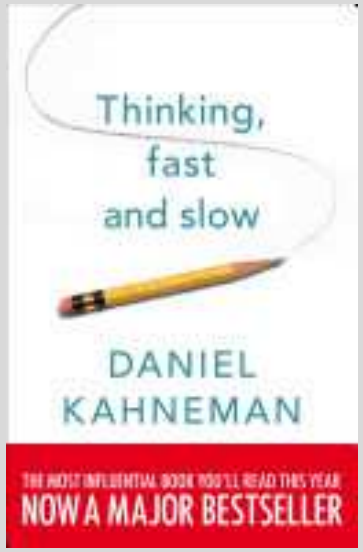
Genes Associated with Cognitive Performance

- Neurotransmitter activation and Neuroplasticity
  - **COMT** (catechol-O-methyltransferase) protein encoding to inactivate neurotransmitters and hormones
  - **BDNF** (brain-derived neurotrophic factor) stimulates nerve growth factor; neuroplasticity
  - **NRG** (neuregulin) related to neuronal development
- Dopamine and serotonin receptors
  - **DRD2** (dopamine receptor 2) modulates locomotion, reward, reinforcement, risk-taking, memory, and learning
  - **DRD2/ANKK1, DRD4** 7+ repeat associated with risk-taking
  - **SLC6A3** (solute carrier family 6) encodes a dopamine transporter; terminates the action of dopamine
  - **5-HTT, 5-HTTLPR** Dopamine and serotonin transport

Linking Genes to Cognition

	Social Intelligence	Memory	Fast/Slow Thinking	Creativity
5-HTT, 5-HTTLPR Dopamine & Serotonin Transportation			✓	✓
BDNF Neuroplasticity		✓		✓
COMT Val(158)Met, Rewards, Altruism, Gambling	✓	✓	✓	✓
DRD2 Open to experience	✓	✓		✓
DRD2/ANKK1 Risk-taking	✓	✓	✓	✓
NRG Neuregulin, Neuronal development				✓
OXTR Oxytocin Optimism, Empathy	✓			
PDYN Addiction			✓	
SLC6A3, T102C Dopamine transport, impulse control		✓	✓	

Thinking Fast and Slow



- Daniel Kahneman, Nobel Laureate in Economics, 2002
- Decision-making function: two thinking systems are used to make choices
  - Fast, intuitive thinking
  - Slow, rational thinking
- Helps to explain bias and prejudice
  - Why there more chance we'll believe something if it's in a bold type face
  - Why judges are more likely to deny parole before lunch
  - Why we assume a good-looking person will be more competent

Study: Thinking Fast and Slow
A. Loss Aversion

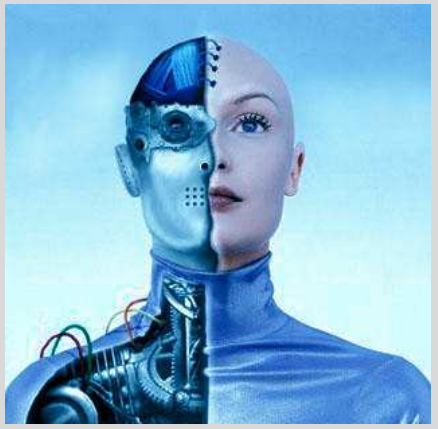
- Loss Aversion: loss avoidance vastly preferred to gains
- Neural Processes: reward processing, reward anticipation, action-taking, risk-taking and risk-avoidance, impulse control, addiction, and propensity for gambling
- Genes: 5-HTTLPR, COMT Val(158)Met, T102C, DRD2/ANKK1, PDYN
- Instruments (open-source PEBL software)
  - Loss Aversion Task: prospect theory
  - Iowa Gambling Task: real-life decision-making

Study: Thinking Fast and Slow
B. Optimism Bias

- Optimism Bias: overconfidence, being inaccurately optimistic about outcomes
- Neural Processes: reward processing, positive mindset, attitude towards new experience
- Genes: 5-HTTLPR, COMT Val(158)Met, T102C, DRD2/ANKK1, OXTR
- Instruments
  - Schowmaker's Confident Decision Making test
  - Blavatskyy's Experimental Test of Overconfidence
  - Critch's Credence Game

Study: Thinking Fast and Slow
C. Thinking Systems

- Thinking systems: Fast (immediate gut response) and slow (relaxed and deliberative)
- Neural Processes: adrenergic regulation of the hormone epinephrine and the neurotransmitter norepinephrine related to the “fight or flight” response, sympathetic nervous system arousal
- Genes: ADRB1, ADRB2
- Instruments
  - Fight-or-Flight Response Test
  - Fight or Flight Questionnaire

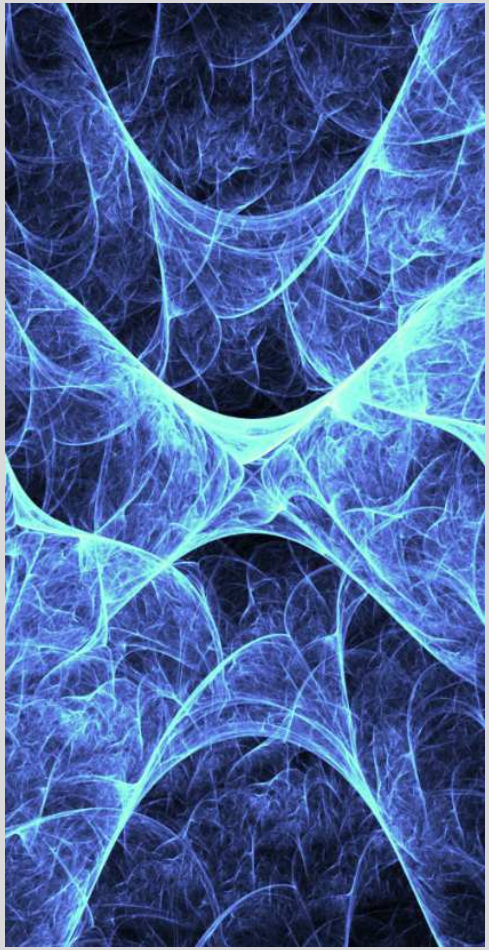


Important Role of Creativity

- Growing field of multi-disciplinary study
  - Biology: natural selection, genomics, neurology
  - Psychology: how the imagination works, cognitive processes employed in creativity
  - Philosophy: Metaphysics (existence definitions, role of consciousness and intentionality), Ethics (Is creativity valuable for its own sake apart from what it produces? Is creativity a virtue?), Aesthetics

5 Steps in the Creative Process

1. **Preparation**: Becoming immersed in the area
2. **Incubation**: Allowing the ideas to turn around unconsciously
3. **Insight**: the "Aha!" moment when things start to make sense
4. **Evaluation**: Deciding whether to pursue the insight
5. **Elaboration**: Translating the insight into its final form



Source: Csikszentmihalyi , Creativity: Flow and the Psychology of Discovery and Invention, 1996

Study: Quantified Creativity

- Creativity: The ability to make or bring something new into existence (*Webster*)
- Neural Processes: Neuroplasticity, dopamine and serotonin transportation, neuregulin (neuronal development), neurotrophic factor (neuron and synapse growth), risk-taking, openness to experience
- Genes: BDNF, 5-HTT , COMT, NRG, DRD2/ANKK1, DRD2
- Instruments
  - Kirton Adaptation Innovation Inventory
  - Buffalo Creative Process Inventory
  - Creativity journal
  - Consumer EEG tracking of gamma spikes

Study: Memory Updating

genomera Heal the world. Groups Studies Instruments Profile melanie

Processing Reality: Impact of Dopamine Modulation on Memory Filtering IN DESIGN

You are a Data Participant

Change Role

Objective: To determine if genetic variants related to dopamine processing in the brain impact the processing of memories according to their relation with ongoing reality

Description

Our brains are able to adapt to the unexpected using an inbuilt network that makes predictions about the world and monitors how those predictions turn out. An area at the front of the brain, called the orbitofrontal cortex, plays a central role and studies have shown that patients with damage to this area confuse memories with reality and continue to anticipate events that are no longer likely to happen.

This study seeks to determine if genetic variants in the dopamine processing pathway impact this process in normal, healthy volunteers.

This study is being conducted in conjunction with the Center of Cognitive Neurorehabilitation at the Geneva University Hospital in Switzerland and based on ongoing research on the underlying mechanisms impacting the processing of memories according to their relation with ongoing reality.

Goal: 100 member cohort

- Genotype: COMT, DRD2, SLC6A3 (~5 SNPs) (neurotransmitter modulation)
- Phenotype: memory test (20-25 minutes)
- Background questionnaire

CORTEX

A Journal Devoted to the Study of the Nervous System and Behavior

Neural response to the behaviorally relevant absence of anticipated outcomes and the presentation of potentially harmful stimuli: A human fMRI study

Louis Nahum, Stéphane R. Simon, David Sander, François Lazeyras, Armin Schnider

Received 4 June 2009; received in revised form 12 August 2009 and 15 October 2009; accepted 23 November 2009. published online 11 January 2010.

Source: http://genomera.com/studies/aging-telomere-length-and-telomerase-activation-therapy

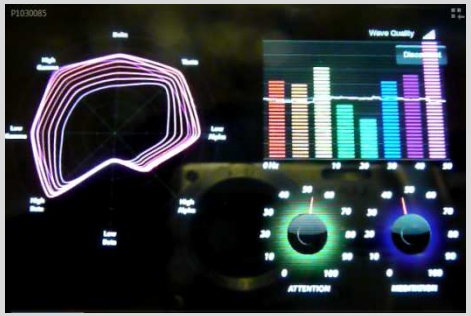
Augmenting the Brain

24/7 Consumer EEG, Eye-tracking, Emotion-Mapping, Augmented Reality Glasses

Consumer EEG Rigs

1.0

2.0



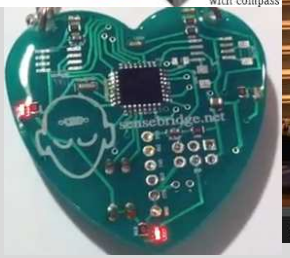
Augmented Reality Glasses

Source: Swan, M. Sensor Mania! The Internet of Things, Objective Metrics, and the Quantified Self 2.0. J Sens Actuator Netw 2012.

Building Exosenses

Extending our senses in new ways to perceive data as sensation

Magnetic Sense: Finger and Arm Magnets

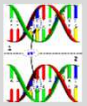


Eric Boyd – Heart Spark
http://sensebridge.net/projects/heart-spark/
The North Paw- A Haptic Compass Anklet
http://www.youtube.com/watch?v=D4shfNufqSg

Nancy Dougherty – Serendipitous Joy
Smile-triggered EMG muscle sensor
with an LED headband display

Big Health Data Streams

'Omics' Data Streams



Genome:
SNP mutations
Structural variation
Epigenetics ✓

Microbiome ✓

Transcriptome

Metabolome

Proteome

Diseasome ✓

Environmentome ✓

Traditional Data Streams

Personal and Family Health History ✓

Prescription History ✓

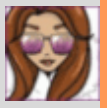
Lab Tests: History and Current ✓

Demographic Data ✓

Standardized Instrument Response ✓

Quantified Self Data Streams

Self-reported data: health, exercise, food, mood journals, etc. ✓



Mobile App Data ✓

Quantified Self Device Data ✓

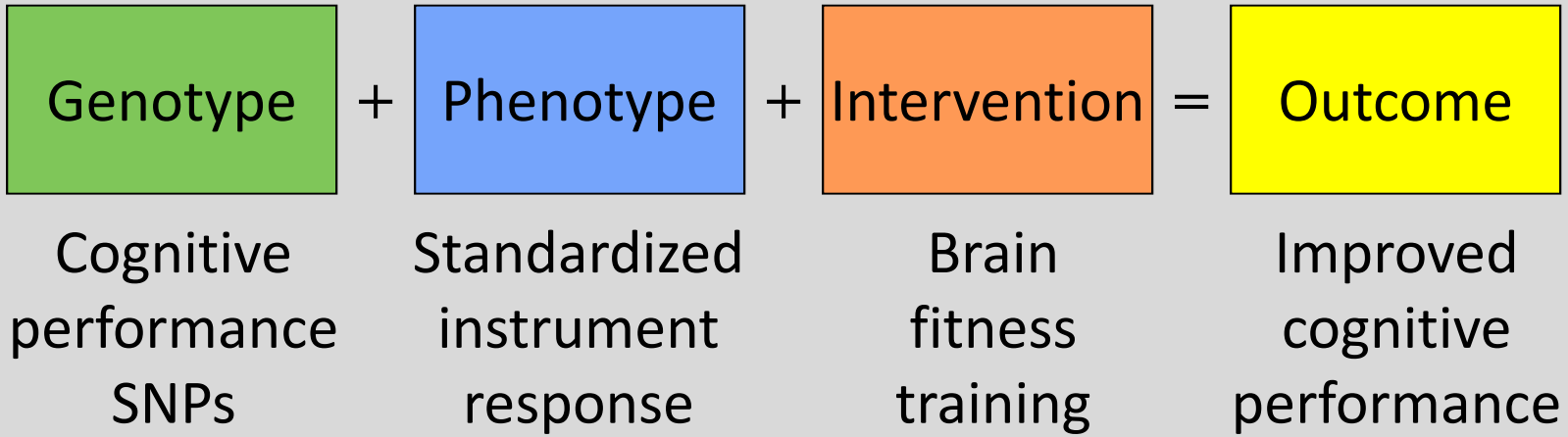
Biosensor Data
Objective Metrics

Legend: Consumer-available ✓

Swan, M. Health 2050: The Realization of Personalized Medicine through Crowdsourcing, the Quantified Self, and the Participatory Biocitizen. J Pers Med 2012, 2(3), 93-118.

DIYgenomics Study Methodology

- Goal: biophysical performance optimization and pre-clinical disease prevention
- Generalized hypothesis: Genetic polymorphisms may result in out-of-bounds phenotypic marker levels which may be improved through intervention



Source: Swan, M., Hathaway, K., Hogg, C., McCauley, R., Vollrath, A. Citizen science genomics as a model for crowdsourced preventive medicine research. J Participat Med. ***2010,*** *Dec 23; 2:e20.*