

Dyscontrolled adaptive potential hypothesis
of psychiatric disorders and
significance of simulating schizophrenia *in silico*
in the era of machine learning.

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"Dyscontrolled adaptive potential hypothesis" of psychiatric disorders.

- "Pathophysiology of some psychiatric disorders is explained by excess of potentially adaptive brain mechanisms that become dyscontrolled."
- Abilities and related symptoms of schizophrenia:
 - Theory of mind - derangement of ego
 - Imagination - development of delusion
 - Causality estimation - delusion of reference, apophenia
 - Alertness - paranoia, delusional mood

"Dyscontrolled adaptive potential hypothesis" of psychiatric disorders.

- Explains resistance of psychiatric disorders to natural selection.
 - Humans have gained some brain mechanisms over evolution at the cost of also gaining disorders.
- A real "strength model" approach that could help patients recover once symptoms are alleviated.

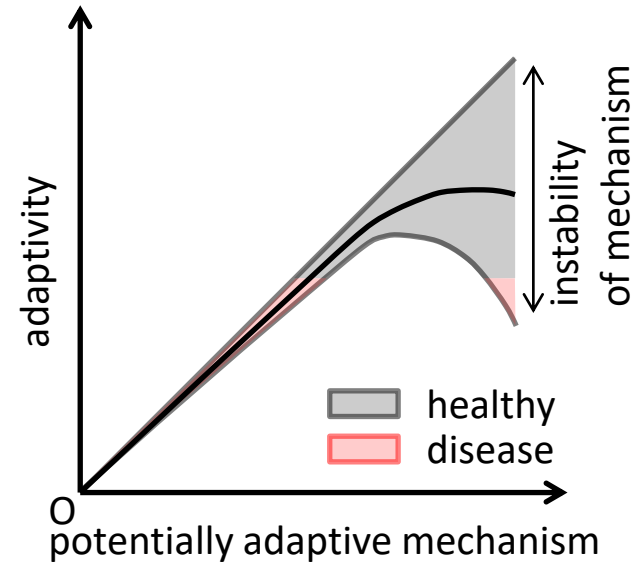


Fig1. dyscontrolled adaptive potential hypothesis

Machine learning overview

- Machine learning is rapidly surpassing human performance in several limited tasks.
 - Image recognition/classification
 - Automatic speech recognition (ASR)
 - Reinforcement learning (game play, driving, etc...)
- However, artificial general intelligence (AGI) has yet to be achieved.

Neuroscience and machine learning

- Past machine learning breakthroughs by incorporating findings in neuroscience.
 - Neural network, back propagation, parallel computing, etc...
- Ongoing attempts to more closely imitate human brain architecture for AGI.
 - Whole Brain Architecture Initiative, Hierarchical Temporal Memory, end-to-end Neural network ASR, etc...

Psychiatry and machine learning

- Dyscontrolled adaptive potential hypothesis suggests...
 - Understanding psychiatric pathology and related adaptive mechanism could help improve machine learning.
 - AGI would acquire psychiatric disorder-like behavior.
 - Requires "diagnosis" and "treatment".
 - The more difficult a machine is to control, the more capable and efficient it potentially is.
 - Pathophysiology of psychiatric disorders at network level is found by chance.

Psychiatry and machine learning

- Psychiatric research could drive machine learning, and *vice versa*.
- As machine learning tackles problems with higher function, psychiatry has more to do than neuroscience.

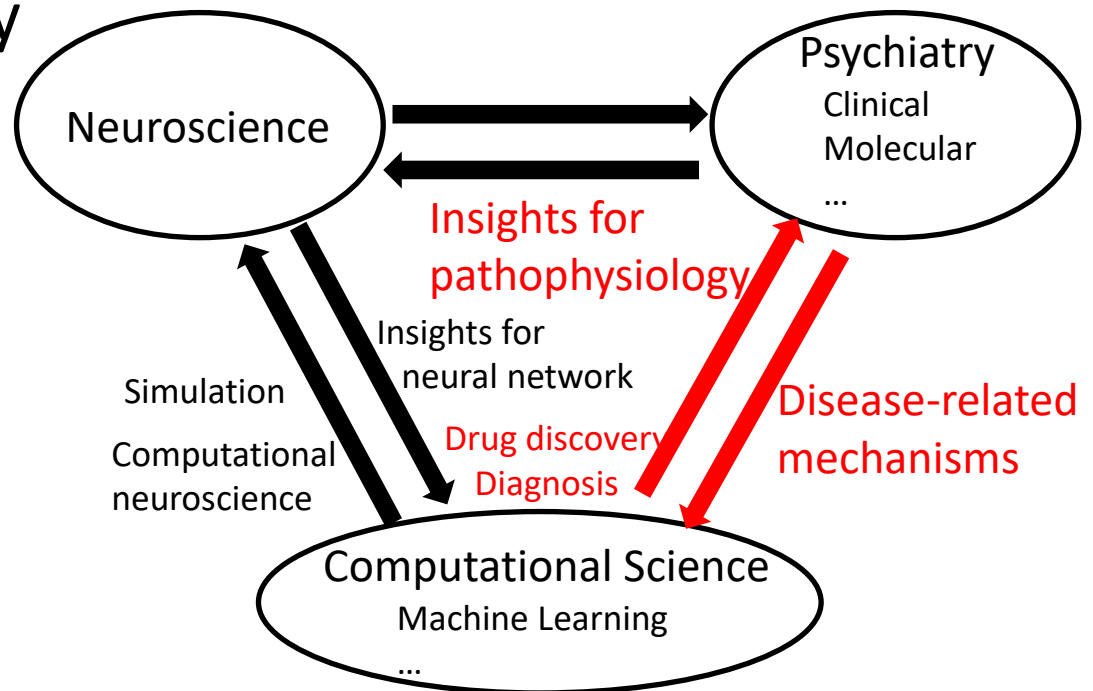


Fig 2. Inter-disciplinary beneficial effects.

Known behaviors of machine learning that resemble psychiatric symptoms

- Stacking of generative adversarial networks – incorrigibility of schizophrenia.
- Variational autoencoder - visual hallucination.
 - Visual output from trivial seeds.
- Google DeepDream – visual hallucination.
- "Edge of chaos" phenomenon - functional time course in prodromal stage of schizophrenia.
 - Deterioration after transient high performance.
- Strange attractor of chaos - incorrigibility in schizophrenia.
- Stacking at Local minima - incorrigibility of schizophrenia or stereotypy of autism spectrum disorder.
- Overfitting - impairment of generalization in autism spectrum disorder.
- All current specialized machine learning systems - restricted interest of autism spectrum disorder.

Abnormal behaviors expected in Schizophrenia in Silico (SiS)

- Behaviors resembling schizophrenia symptoms.
 - Hallucination.
 - Derangement of ego.
- Quantitative and dynamical characteristics of schizophrenia.
 - Nonlinear time course.
 - Robustness of progression after onset.
 - Populational properties over simulation trials such as distribution of severity.

Requirements for SiS implementation

- Bi-directionality with top-down connection.
 - Enables chaotic property and predictive ability.
- Energy-efficiency (parsimony).
 - Machines still fall behind humans.
- Other network architectures.
 - Hierarchical architecture, actor-critic architecture, etc...
- Other insights from computational neuroscience.

Machine learning implementation to be modified for SiS

- Automatic speech recognition (ASR) and natural language processing (NLP)
 - To be embedded with top-down predictive connection, as no such currently available.
- Reinforcement Learning (RL)
 - Deep Q Network (Alpha Go), Asynchronous Advantage Actor-Critic, etc...
 - To be embedded with predictive ability.
- Anomaly detection
 - Hierarchical Temporal Memory, etc...
- Short-term prediction
 - PredNet, Ladder Network, etc...
 - To be embedded into ASR or RL.

Summary

- Some psychiatric disorders may be related with potentially adaptive brain mechanisms.
- Embedding predictive mechanisms into existing speech recognition or reinforcement learning architecture could simulate symptoms and quantitative characteristics of schizophrenia *in silico*.
- The above simulation could not only elucidate schizophrenia pathophysiology, but also drive breakthroughs in machine learning.
- Fields of psychiatry and machine learning both benefit by translational research in this way.