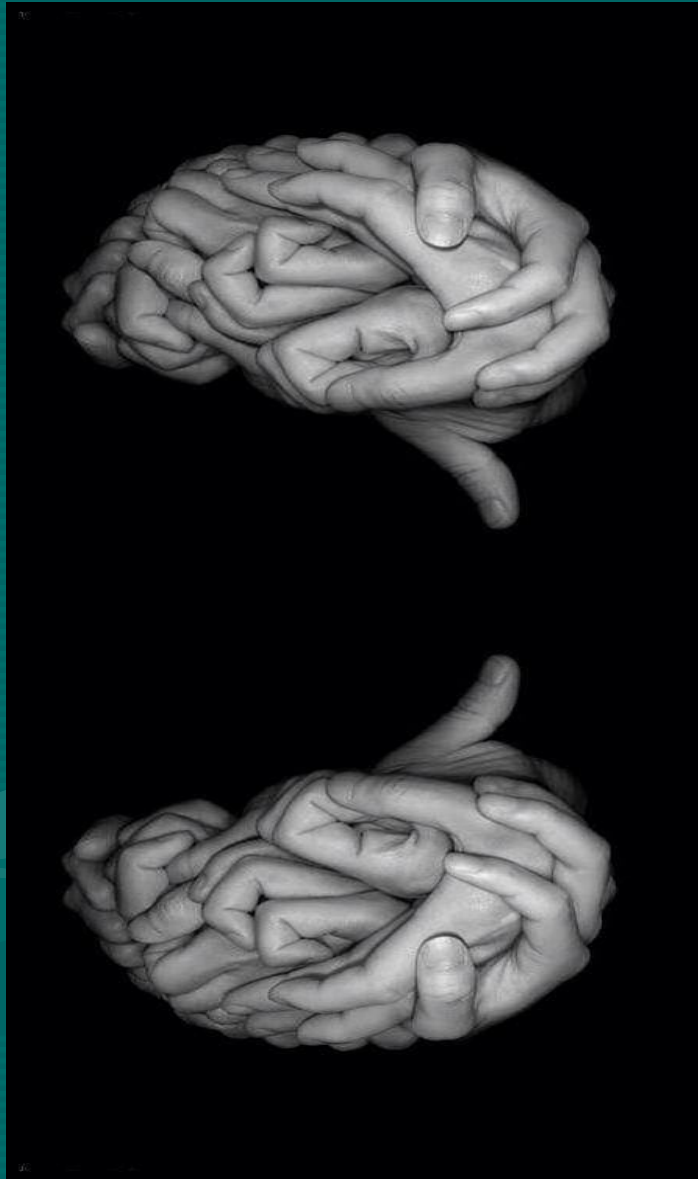


# Critical Thinking and Creative Thinking : Two components of Scientific Thinking



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# Introducing Concepts : Thinking



**Cogito, ergo sum** (Latin)

by René Descartes, usually translated into English as

**"I think, therefore I am".**

The phrase originally appeared in French as *je pense, donc je suis* in his *Discourse on the Method*, so as to reach a wider audience than Latin would have allowed.

## Understanding the Criticality

As per Wikipedia ( [https://en.wikipedia.org/wiki/Critical\\_theory](https://en.wikipedia.org/wiki/Critical_theory))

Critical theory (German: *Kritische Theorie*) was first defined by **Max Horkheimer** of the Frankfurt School of sociology in his 1937 essay "Traditional and Critical Theory", in which it is described as a social theory oriented toward critiquing and changing society as a whole, in contrast to traditional theory oriented only to understanding or explaining it.

He described a theory as *critical* insofar as it seeks

**"to liberate human beings from the circumstances that enslave them."**

# Critical Thinking : Components

- Criticality here is concerned with
  - proper scrutiny,
  - deep enquiry, and
  - the order of thought
- The method : Question
  - to obtain clarity in thought,
  - to withhold poorly supported judgments, and,
  - to apply systematic examination of a person's own beliefs and prejudices .

# Critical Thinking : Significance in the era of Intuitiveness , Competition and False claims

Critical thinking becomes even more important in the era of constant and rapid change, in a world of overwhelming information and contradictory claims, traditions, and interpretations that we encounter every day ( specially in Popular Culture and Mass Media Platforms)

# Critical Thinking : An attitude

which includes ( and also criticises)

- (i) logical reasoning
- (ii) being objective and fair-minded ( unbiased)
- (iii) encourage one constantly to question and recognise the limits of what one really knows, including consciousness of everyone's natural egocentric dispositions and the possibility that one can be wrong (humility);
- (iv) to be not afraid of thinking even if one's own justified reasoning leads beyond the mainstream (courage);
- (v) being able and willing to try to understand another's points of view, even very distant from ours, constantly reminding ourselves that it is we who can be wrong (empathy);
- (vi) not to be hypocritical, to employ the same rigorous standards to ourselves and to others, (integrity);
- (vii) perseverance;

# Critical Thinking Movement ( in Education ) : Three Waves

(a) First Wave : 1970 - 1982( Establishing Formal Methods)

It can be described as a logical one, when the building blocks of critical thinking skills were made of formal and sometimes informal logics. Reasoning, formal models, and validity of claims were the notions were included in Academic institutions

## Critical Thinking Movement ( in Education ) : Three Waves

Second Wave : 1983 - 1993 ( Leading to an era of Superspecialization )

In this the emphasis was placed on the other end of the continuum established by the first wave

from (pure) objectiveness of formal systems towards heuristic, innovative, quick fix, remunerative ideas-dependent on some (practical) ideas of few psychological and sociological studies ( supposed to be in some respect interesting, heuristic-based, or based on gut-feeling or emotional phenomena and their impact on cognition )



## Critical Thinking Movement ( in Education ) : Three Waves

Third Wave : 1993 - onwards ( Combining the First Two —  
Leading to the rise of Creative Thinking )

Both Critically investigate and apply heuristics ( creative )  
knowledge

Integrating Cognitive findings and Symbolic ( Logical) Reasoning

Having Depth into Breadth

## Three AI Debates

Stanley P. Franklin, 'Artificial Minds', February 1997, MIT Press

The Book 'Artificial Mind' discusses

Animal minds, Allan Newell's SOAR, **the three Artificial Intelligence debates**, John Holland's genetic algorithms, Wilson's Animat, Brooks' subsumption architecture, Jackson's pandemonium theory, Ornstein's multimind, Marvin Minsky's society of mind, Pattie Maes's behavior networks, Gerald Edelman's neural Darwinism, Drescher's schema mechanisms, Pentti Kanerva's sparse distributed memory, Douglas Hofstadter and Melanie Mitchell's Copycat, and Agre and Chapman's deictic representations.

## Three AI Debate : Topics of Debate

**First Debate : Is Intelligence Possible on Silicon Chips (Machines)**

Second Debate : Connectionism and Symbolism is a better model of Mind ( Pattern Recognition Vs Rule based Inferencing)

Third Debate : Representation or no Representation ( Embodied and Situated Cognition )

# First Phase : Artificial Intelligence in 1980s

- The Concept of Production Engine and Inferencing System
- The development of Declarative Languages like LISP ( based on Functional Programming Style) and PROLOG ( based on Predicate Calculus)
- The idea of Problem Solving was to represent Problems into Computational Structures ( which were based on mathematical and logical Theorems ) and manipulating those structures to get the result or inferences.
- The first AI debate talks about 'Can Silicon Chips be Intelligent?'

## Problems in first phase : Which Problem to Solve: Actual or Idealized?

- There was an actual Problem
- There was some known Models ( with some variable parameters ) which could be solved
- The Mismatch between the Problems at hand and the Models based on Idealized Problems.
- Select the correct model was the keypoint.

## Second Phase:

### Rise of Domain Experts ( Example : Behavioral Economics)

- Daniel Kahneman : Thinking Fast and Slow
- “Odd as it may seem, I am my remembering self, and the experiencing self, who does my living, is like a stranger to me.”

Daniel Kahneman (Hebrew: דניאל כהנמן (born 5 March 1934) is an Israeli-American psychologist and winner of the 2002 Nobel Memorial Prize in Economic Sciences, notable for his work on behavioral finance and hedonic psychology.

With Amos Tversky and others, Kahneman established a cognitive basis for common human errors using heuristics and biases (Kahneman & Tversky, 1973, Kahneman, Slovic & Tversky, 1982), and developed Prospect theory (Kahneman & Tversky, 1979). He was awarded the 2002 Nobel Prize in Economics for his work in Prospect theory. Currently, he is professor emeritus of psychology at Princeton University's Department of Psychology.



# The Two Phases :

## The Deductive and Inductive Models

- Deductive reasoning starts with a statement or hypothesis and then tests to see if it's true through observation, where Inductive reasoning starts with observations and moves backward towards generalizations and theories.

# The Deductive and Inductive Models

— Deductive Inferencing ( Problem Solving)

Theory

Hypothesis

Observation

Confirmation

— Inductive Inferencing ( Problem Solving )

Observation

Pattern

Hypothesis

Theory



# The Third Phase : Rise of Creative Thinking

## Top down and Bottom up in a loop

- **To Solve a Complex Problem ( Like Vision Problems)**
- **David Marr's posthumously published *Vision* (1982)** influenced a generation of Researchers from various domains, such as neuroscience, psychology, and computation
- In *Vision*, Marr describes a general framework for understanding visual perception and touches on broader questions about how the brain and its functions can be studied and understood.

# David Marr - Vision ( 1982)

- The central theme of the book is the notion of different levels of analysis—in Marr's framework :
- the computational level ( why - the purpose )
- the algorithmic level, and
- the hardware implementation level

# The Top Down approach Vs The Bottom Up Approach: Need for Looping

- Vision is not what we get from signal ( Image Processing )
- It is a degree of match from the mental image what we want ( expect) to see.
- The hypothesis was to navigate in the physical world our vision system has developed, hence the information processing for vision derives prior knowledge about the physical world and see how it can fit to the present stimulation

## Creative Problem Solving : The Analytic approach Vs (and) The Synthetic Approach

- Analyse the Problem ( Generally Real life Problems are not divided into domains)
- Collecting Relevant Knowledge from different domains  
Construct the The hypothesis ( Synthesis )
- Test the Hypothesis ( Validate the Solution )

# Creative Problem Solving: The Generative Framework

- The Structure of Mind and The Structure of Language
- The Infinite Meaning Vs Finite Words
- The Generative Framework

# Creative Problem Solving: The Systems Approach : The Simulation of the System

- The Structure and the Function ( Simulation )
- The Dynamic ( Changing Structure )
- Multifunctional Systems

# Handling Nonlinearity

- Dividing Nonlinear into Multiple Linear Systems
- Second Order and Higher Order Systems Synthesis



# Challenges for Higher Order Systems

- Defining Regularity and Predicting the Change
- Multiple Suboptimal ( or Pareto-optimal ) Solutions
- Changing Contexts and Goals



# Some open Debates

- Quantitative Vs Qualitative
- Syntactic Vs Semantic
- Structure Vs Function
- ..... and Many more

Let us Think Critically

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