

**BUT AS FOR CERTAIN TRUTH, NO MAN HAS
KNOWN IT
NOR WILL HE KNOW IT; NEITHER OF THE GODS,
NOR YET OF ALL THE THINGS OF WHICH I SPEAK.
AND IF BY CHANCE HE WERE TO UTTER
THE FINAL TRUTH, HE WOULD HIMSELF NOT
KNOW IT:
FOR ALL IS BUT A WOVEN WEB OF GUESSES.**

- XENOPHANES

A WOVEN WEB OF GUESSES

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Report Documentation Page

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Proposed to the 8th ICCRTS

**A WOVEN WEB OF GUESSES, CANTO ONE:
Network Centric Warfare and the Myth of the New
Economy**

**A WOVEN WEB OF GUESSES, CANTO TWO:
Network Centric Warfare and the Myth of
Inductivism**

**A WOVEN WEB OF GUESSES, CANTO THREE:
Network Centric Warfare and the Virtuous
Revolution**

Introduction

Canto One: The NCW business analogy is highly problematic. Important and often adverse insights have been ignored.

Canto Two: The NCW thesis perpetuates a discredited theory of knowledge and knowledge development, known as naive inductivism, that has long exerted powerful influence over military.

Canto Three: Exciting opportunities exist if we replace inductivism with critical rationalism. Unlike inductivism, critical rationalism is consistent with profound insights into the nature of logic, information, knowledge and reasoning. In short, the prerequisite to a revolution in military affairs is a revolution in the way we think about thinking.



**A WOVEN WEB OF GUESSES,
CANTO ONE:**

**Network Centric Warfare and the
Myth of the New Economy**

The NCW Business Analogy

“The organizing principle of network-centric warfare has its antecedent in the dynamics of growth and competition that have emerged in the modern economy.”

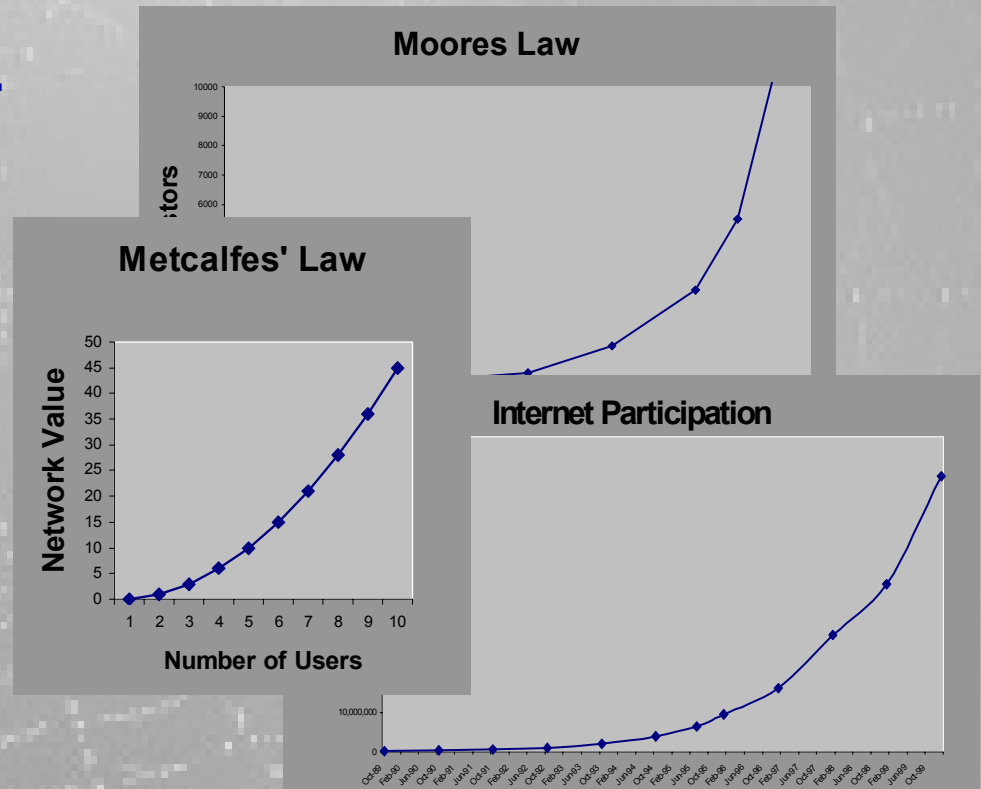
**- Arthur K. Cebrowski and John J. Gartska
“Network Centric Warfare: Its Origins and Future”**

“It is for this reason that developments in the commercial sector are significant and worthy of note, for they provide insights into the potential power of information superiority in the conduct of military operations.”

**- David S. Alberts et al
*Network Centric Warfare: Developing
and Leveraging Information Superiority***

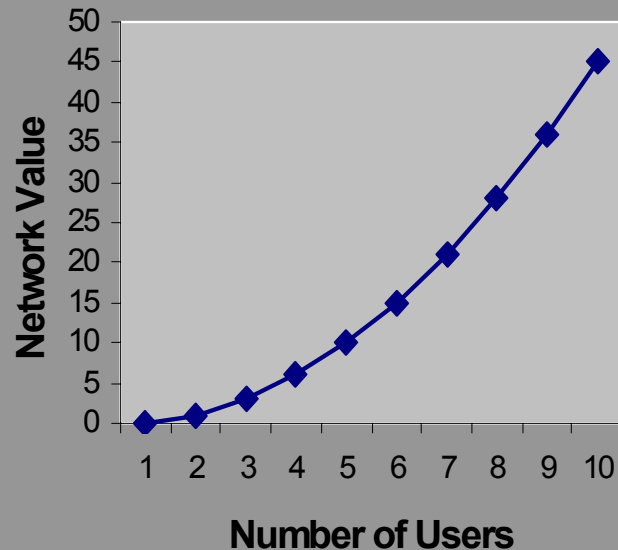
New Economy Theory

- **Asserted that we were witnessing a technology-driven revolutionary change in the economic order and the conditions of business.**
- **Two technological innovations were responsible: the semiconductor and the Internet.**
- **Three trends drove the revolution:**



New Economy Theory

Metcalfes' Law



- The key strategic insight for the producers of standards-based goods in the information age.

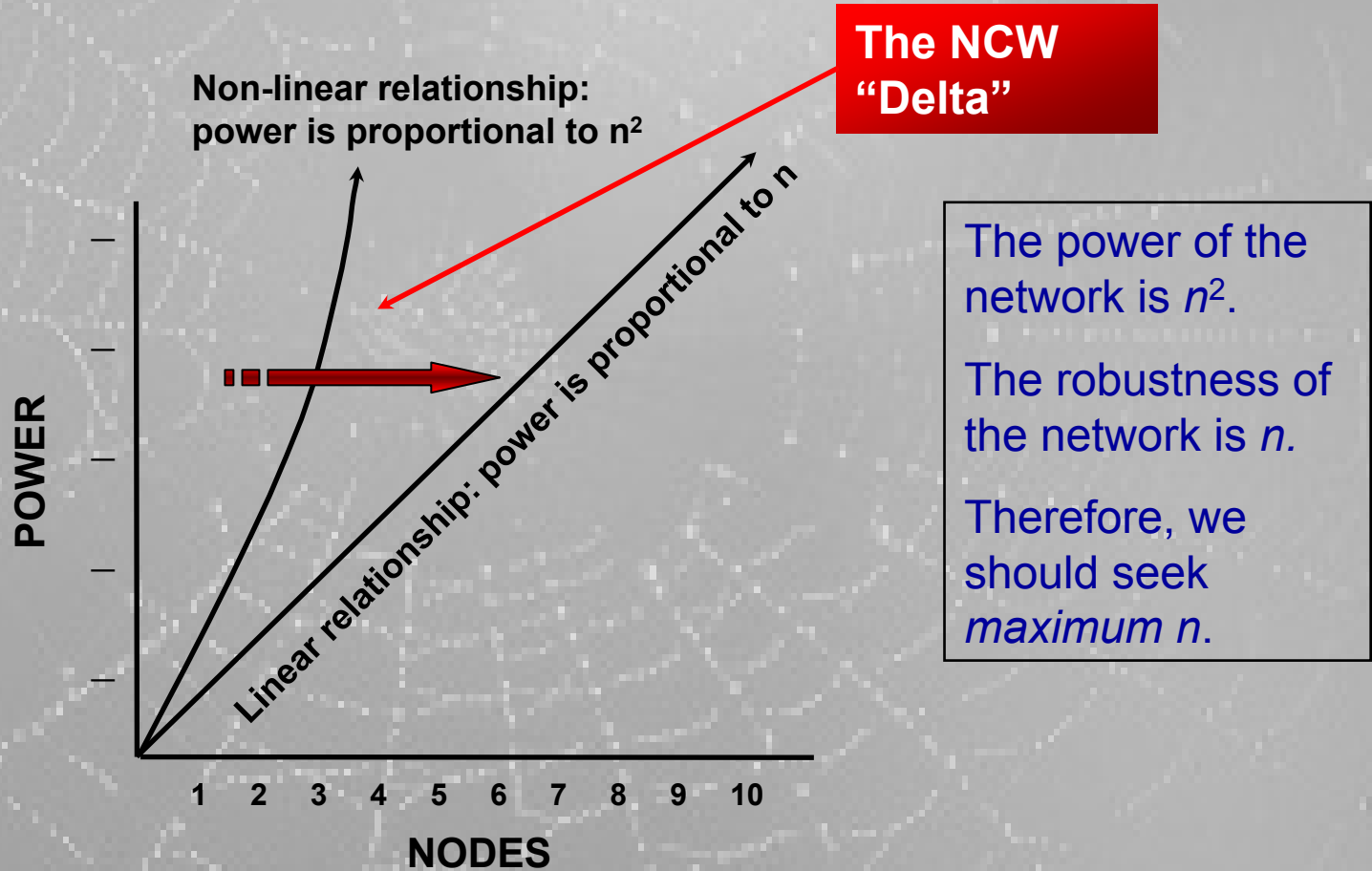
- Explained why:

- Cassette beat Eight-Track
- VHS beat Beta
- DOS beat Macintosh

- The lesson for business: “Move fast: get your standard out first, give it away for free if necessary, hit critical mass before the competition does, extend the user base and then leverage Metcalfe’s advantage into monopoly status and a mansion in Seattle.”

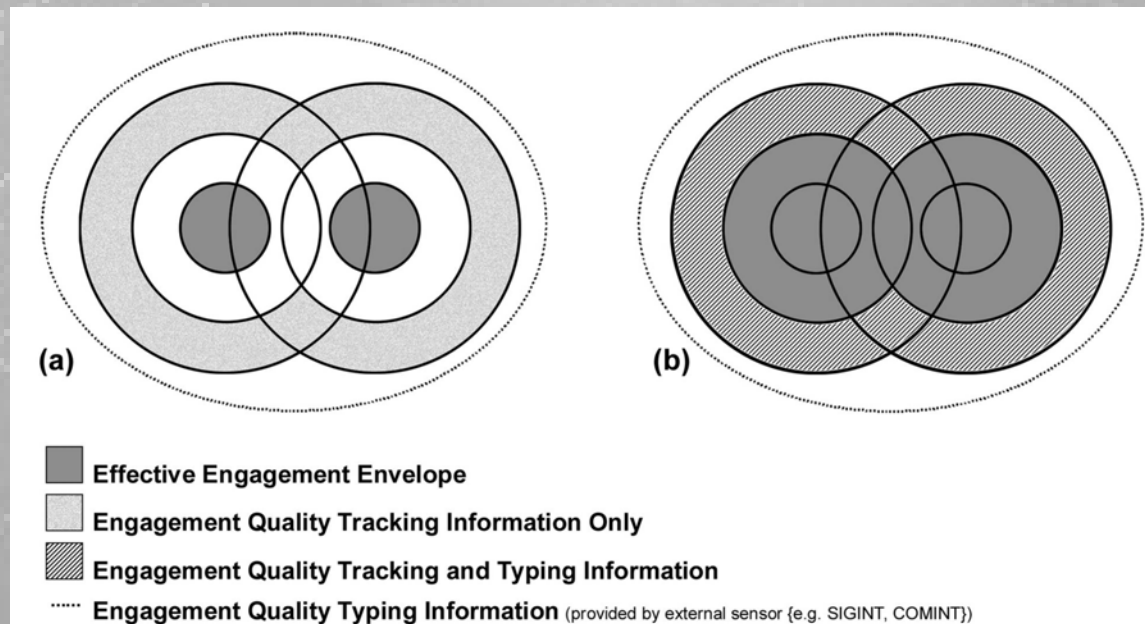
“The value of a network will increase with the square of the number of users of the network.”

The NCW Business Analogy: The Analogy in a Nutshell



The NCW Business Analogy

The Analogy in Another Nutshell



“The potential increase in total combat power associated with a network-centric operation is represented by the increased area of the effective engagement envelope. This simple example illustrates the application of Metcalfe’s Law to military operations.”

- David S. Alberts et al

Network Centric Warfare: Developing and Leveraging Information Superiority

Restating the Analogy: Overview

- **Seven New Insights:**
 - **The confusion over value**
 - **Metcalfe's Law is a policy trap**
 - **Metcalfe's Law is a capability trap**
 - **Metcalfe's Law breaks down at sufficiently large 'n'**
 - **The gains are asymmetrical**
 - **The net is not an organizational solvent**
 - **The problem of capital rationing**

Restating the Analogy: The Confusion over Value

The ‘Common Sense’ Definition of Metcalfe’s Law

The value of a network increases with the square of the number of users of the network.

Metcalfe’s Law Clarified

The *utility of the goods and services necessary to participate on a network* increases with the square of the number of users of the network.

Metcalfe’s Law in the NCW Literature

“Network-centric computing is governed by Metcalfe’s Law, which asserts that the “power” of a network is proportional to the square of the number of nodes in the network. The “power” or “payoff” of network-centric computing comes from information-intensive interactions between very large numbers of heterogeneous computational nodes on the network .”

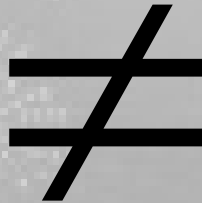
Or in Other Words....

The *power of transactions carried out on a network* increases with the square of the number of users of the network

Restating the Analogy: The Confusion over Value

Metcalfe's Law Clarified

The utility of the goods and services necessary to participate on a network increases with the square of the number of users of the network.

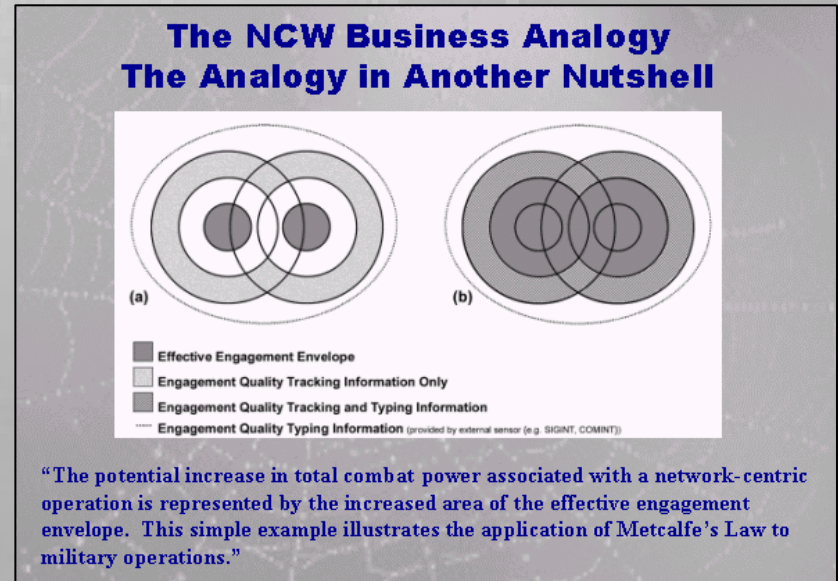
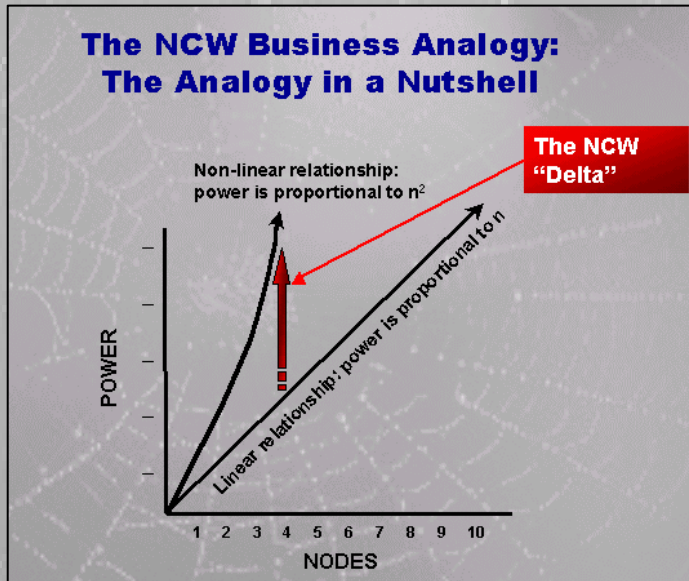


Metcalfe' Law in the NCW Thesis

The power of transactions carried out on a network increases with the square of the number of users of the network

Metcalfe's Law only governs our choice between competing networks, and says nothing about the value of the interactions that a network enables.

Restating the Analogy: The Confusion over Value

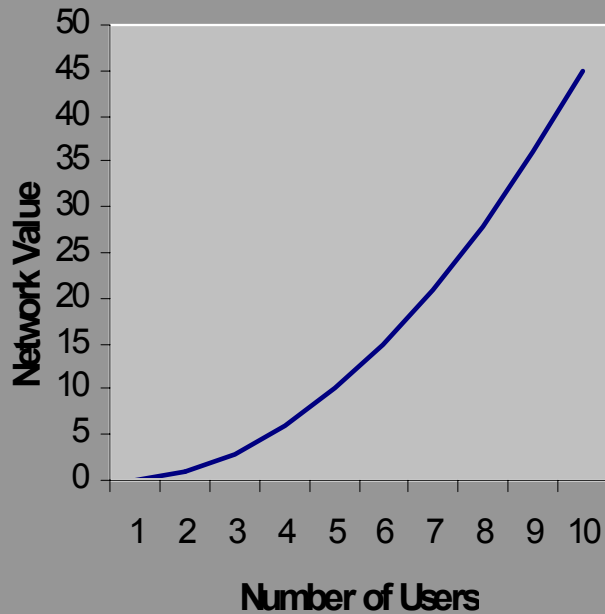


Neither of these two fundamental assertions of the NCW business analogy, which play the loose role of ‘business case’ for the ubiquitous network can be justified.

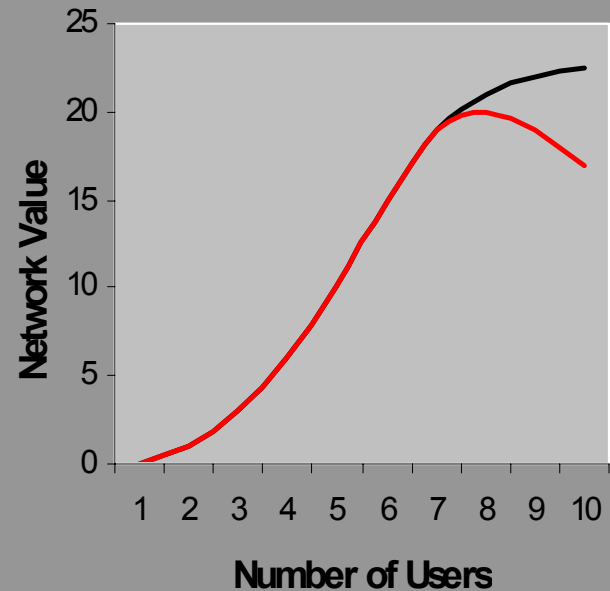
There never was a ‘business case’ for ubiquitous networking.

Restating the Analogy: Metcalfe's Law Breaks Down

Metcalfes' Law: The NCWView



Metcalfes' Law: The Reality

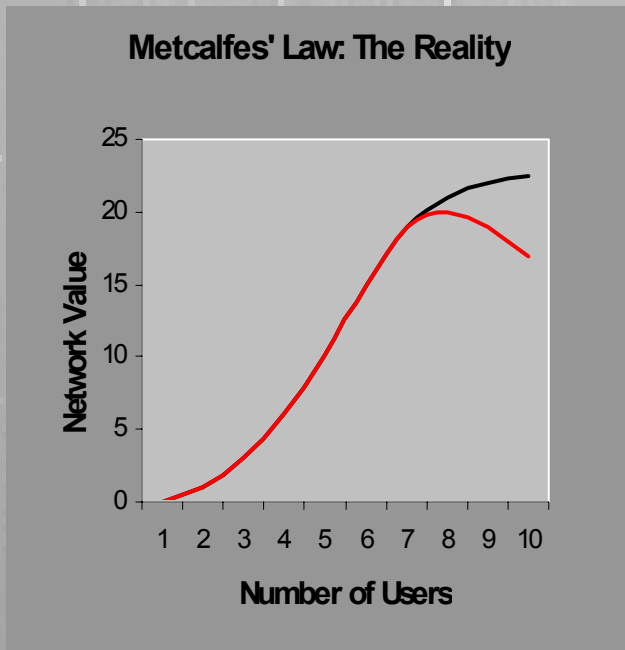


n^2 = “power of the network”

n = “robustness of the network”

As it turns out, networks get ‘chubby’....

Restating the Analogy: Metcalfe's Law Breaks Down

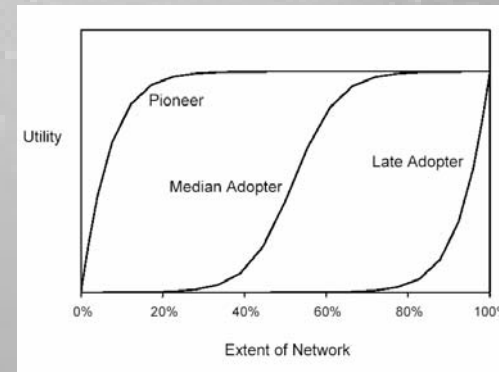
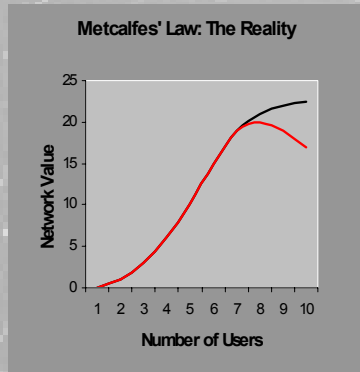


- Metcalfe's Law breaks down at sufficiently large 'n' due to congestion and difficult search.
- Elegant mathematic results and human limitations show that there is no final solution to either problem.
- The military symptoms are chronic bandwidth deficiency, information overload, tension over push vs. pull and post vs. process and increasing costs for information management and 'data fusion'.
- We are already there.
- Two military lessons:
 - Metcalfe's Law cannot even, strictly, govern our choice of networks.
 - Our networks and our information sharing requirements must be designed with conscious limits.

Restating the Analogy: Additional Insights

- **We show how the phenomenon of “lock-in” actually makes networks a threat to friendly forces.**
- **We show how “path dependency” actually introduces an important new source of risk in network design and adoption that must be considered by decision-makers.**

Restating the Analogy: Additional Insights



The Gains are Asymmetrical

We submit that the NCW programme is a sustained exercise in centralization, in a functional and geo-military sense. This is neither necessarily good nor bad, but it must be entered into critically.

We predict that the military network will be constructed primarily to satisfy the needs of centralized controllers, and not the needs of operators.

Restating the Analogy: Additional Insights

- **We show how Coase's theory of the firm and the problem of complete contracts argues against the prospects for radical network-enabled force restructure.**
- **We show how the phenomenon of capital rationing fundamentally compels us to behave differently than our commercial cousins, insofar as IT investments are concerned.**

The Lesson's of the Restated Analogy

- **Ratchet down the rhetoric.**
 - We are overstating the implications of the military network.
- **There are no silver bullets.**
 - War is not network-centric: war is a complex equation.
- **The business case is not manifest.**
 - Metcalfe's Law does not pertain to the value of net-enabled transactions.
- **Ubiquity is contra-indicated.**
 - Metcalfe's Law self-destructs. We must limit the network(s).
- **Command networks centralize.**
 - Beware the implications of centralization.
- **Networks are a threat to friendly forces.**
 - Lock-in and path dependency must be addressed.
- **The organizational implications are limited.**
 - Networks do not revolutionize transaction costs.
- **The decisions will be difficult.**
 - Beware the implications of capital rationing in a complex programme.



**A WOVEN WEB OF GUESSES,
CANTO TWO:**

**Network Centric Warfare and the
Myth of Inductivism**

Canto Two

The Tenets of NCW:

- **A robustly networked force improves information sharing.**
- **Information sharing and collaboration enhance the quality of information and shared situational awareness.**
- **Shared situational awareness enables self-synchronization.**
- **These, in turn, dramatically increase mission effectiveness.**

“The key to understanding the roles of and the relationships among battlespace entities is to focus on processes that turn raw data into information, and information into knowledge.”

Network Centric Warfare

p. 127

**....but there is a
ghost in this
machine.**

Canto Two

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Naive Inductivism:

- **Objective observation of the facts regarding a phenomenon under investigation.**
- **Inductive generalization from the facts, producing a universal theory of the phenomenon.**
- **Empirical justification of the theory, producing a quantitative measure of certainty.**
- **Reliable prophesy.**

Canto Two

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Naive Inductivism is the methodological basis for:

Our Theory of Principles of War

Canto Two

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Naive Inductivism is the methodological basis for:

The Estimate, OPP and IPB

Canto Two

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Naive Inductivism is the methodological basis for:

The OODA Loop (Observe→Orient →Decide →Act)

Canto Two

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Naive Inductivism is the methodological basis for:

The Cognitive Hierarchy (Data→Information→Knowledge→Wisdom)

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It is the model of rationality that the theories of naturalistic decision-making and “Sensemaking” take for granted and seek to augment.

Canto Two

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It is the methodological basis for the NCW thesis, its four tenets and for the related theory of Effects-Based Operations.

Canto Two

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And it is why some may feel free to refer to us as
“heterogeneous computational nodes”.

Canto Two

Naive Inductivism:

Objective Observation
Inductive Generalization
Empirical Justification
Reliable Prediction

**Sir Francis
Bacon**



Science is Inductivism

1600

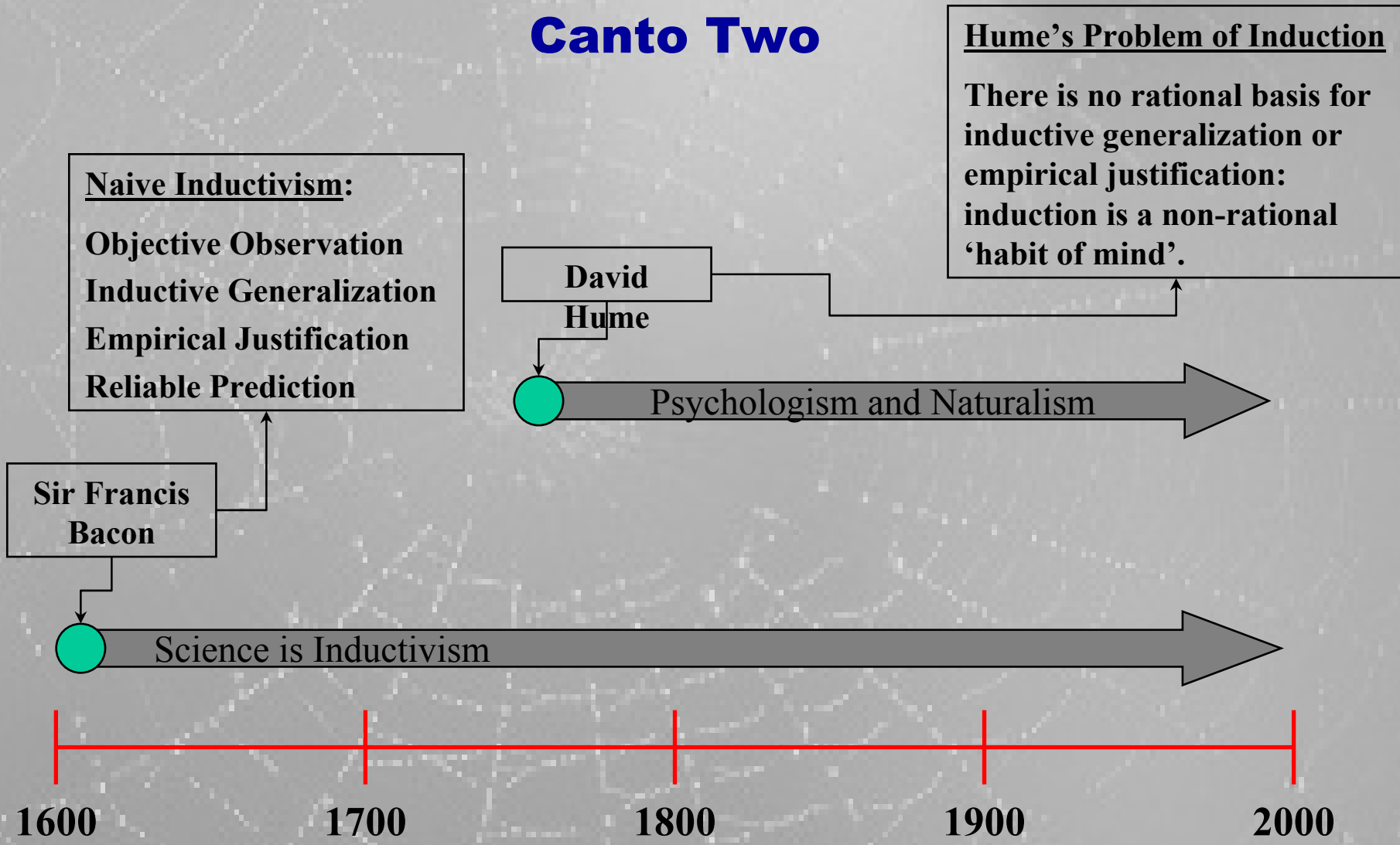
1700

1800

1900

2000

Canto Two



Naive Inductivism:

- Objective Observation
- Inductive Generalization
- Empirical Justification
- Reliable Prediction

Hume's Problem of Induction

There is no rational basis for inductive generalization or empirical justification: induction is a non-rational 'habit of mind'.

David
Hume

Sir Francis
Bacon

Psychologism and Naturalism

Science is Inductivism

1600

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Canto Two

In the works of Jomini, Clausewitz and Fuller, and in Alberts et al and the NCW thesis, we find a consistent tension: military theory is trying to solve Hume's Problem of Induction, without abandoning Inductivism.

- The debate over war as art or science.
- The concept of military genius
- The debate over rational versus naturalistic decision-making theory
- The NCW theory of 'sensemaking'.

These are all only necessary if we cling to Inductivism.

David Hume

Psychologism and Naturalism

Sir Francis Bacon

The Military Enlightenment begins

Methodological Tension

NCW

Science is Inductivism

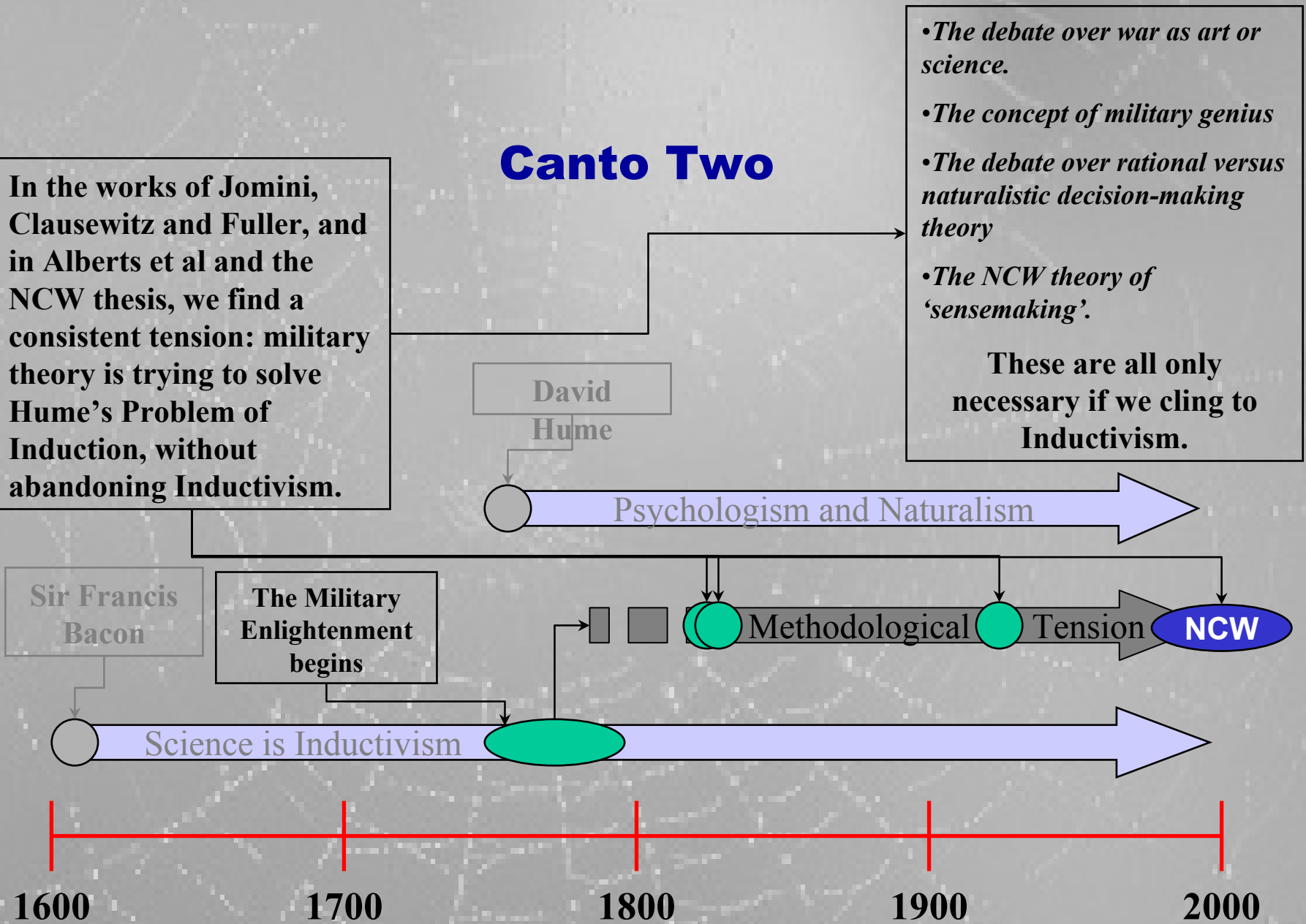
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Canto Two

Naive Inductivism:

Objective Observation

Inductive

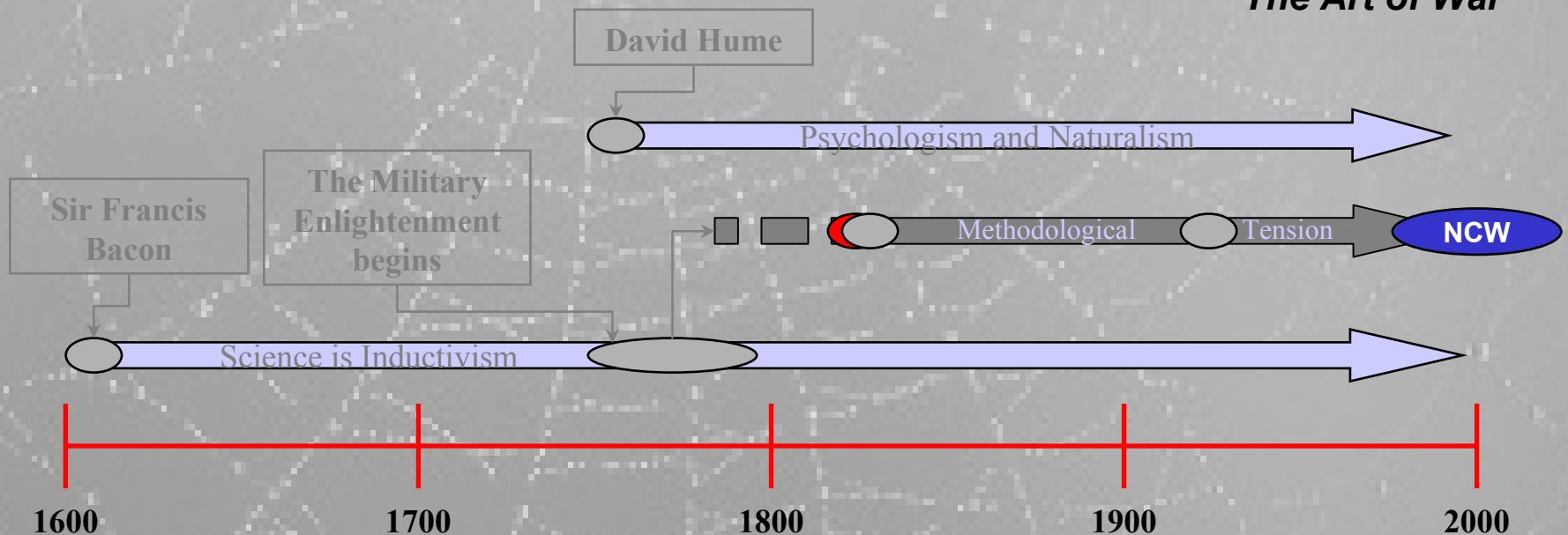
Generalization

Empirical Justification

Reliable Prediction

“One of the surest ways of forming good combinations in war would be to order movements only after obtaining perfect information of the enemy’s proceedings.... As it is unquestionably of the highest importance to gain this information, so it is a thing of utmost difficulty, not to say impossibility....”

- Antoine Henri de Jomini
The Art of War



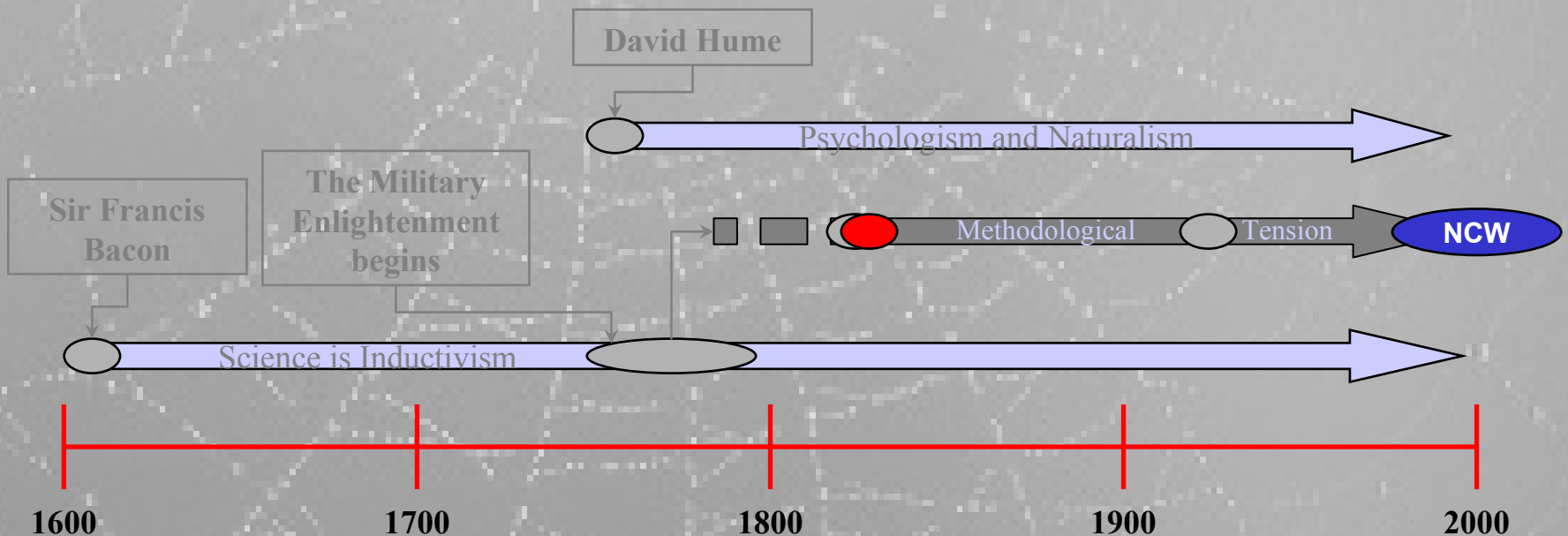
Canto Two

Naive Inductivism:

Objective Observation
Inductive
Generalization
Empirical Justification
Reliable Prediction

“Of course these truths must be rooted in experience.
No theorist, and no commander, should bother himself
with psychological and philosophical sophistries.”

- Carl von Clausewitz
On War



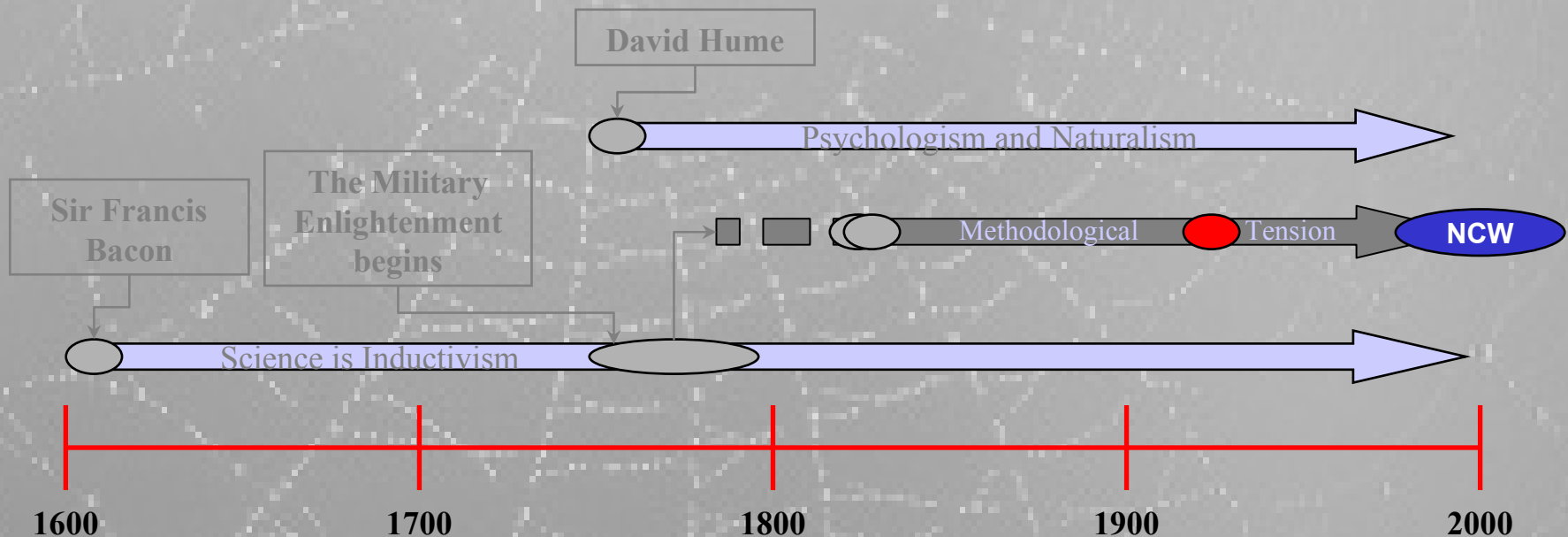
Canto Two

Naive Inductivism:

Objective Observation
Inductive
Generalization
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Reliable Prediction

“In brief, by means of the inductive method we attain to science by collecting facts, by sorting these into categories, by extracting their values, and on these values erecting theories. By putting these theories to universal tests, by degrees we extract laws which form our working principles, our weights and measures of war.”

-- JFC Fuller



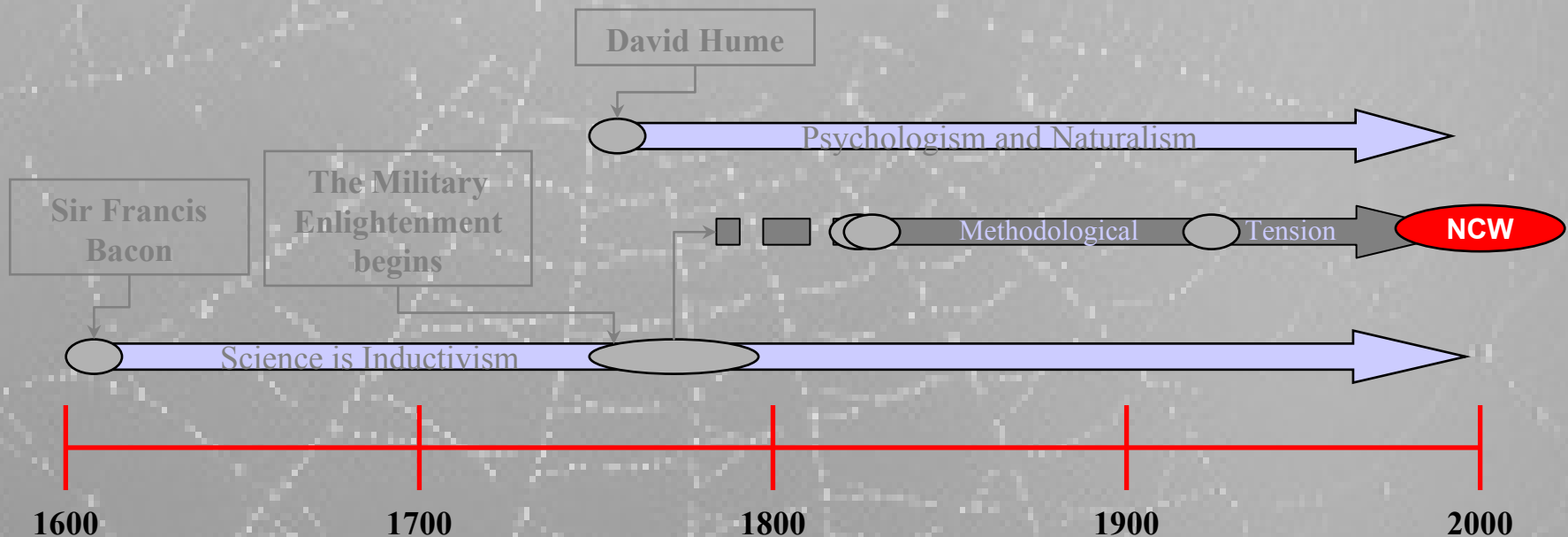
Canto Two

Naive Inductivism:

Objective Observation
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“The key to understanding the roles of and the relationships among battlespace entities is to focus on processes that turn raw data into information, and information into knowledge.”

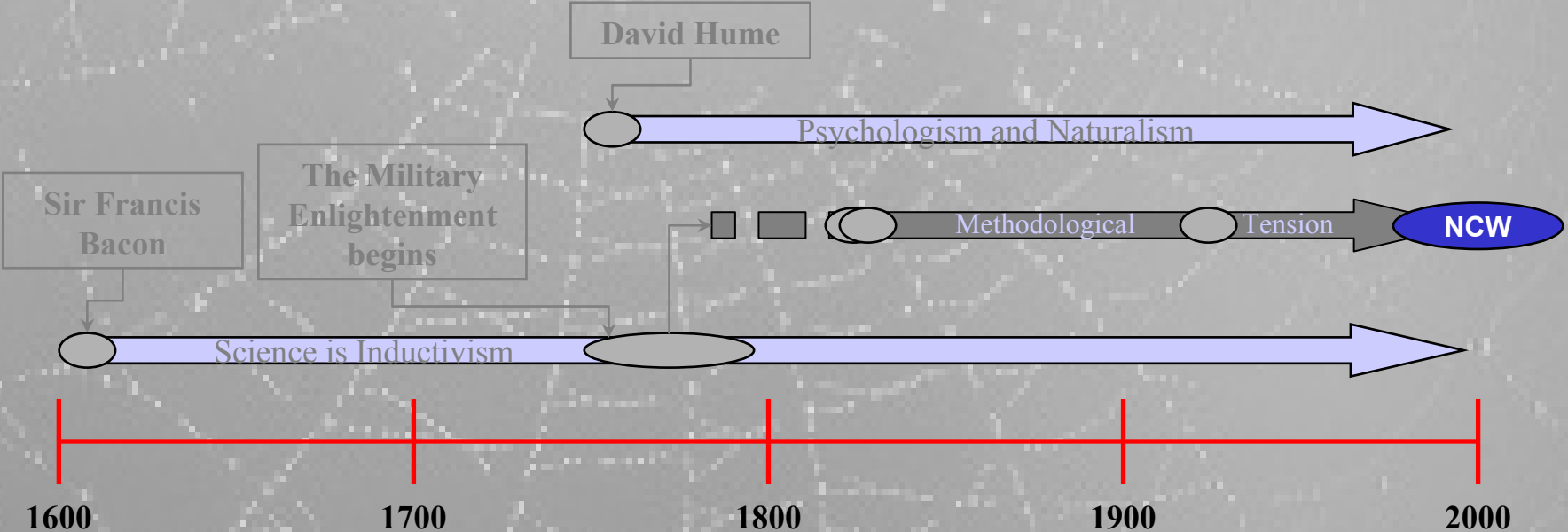
- Alberts *et al*
Network Centric Warfare, p127



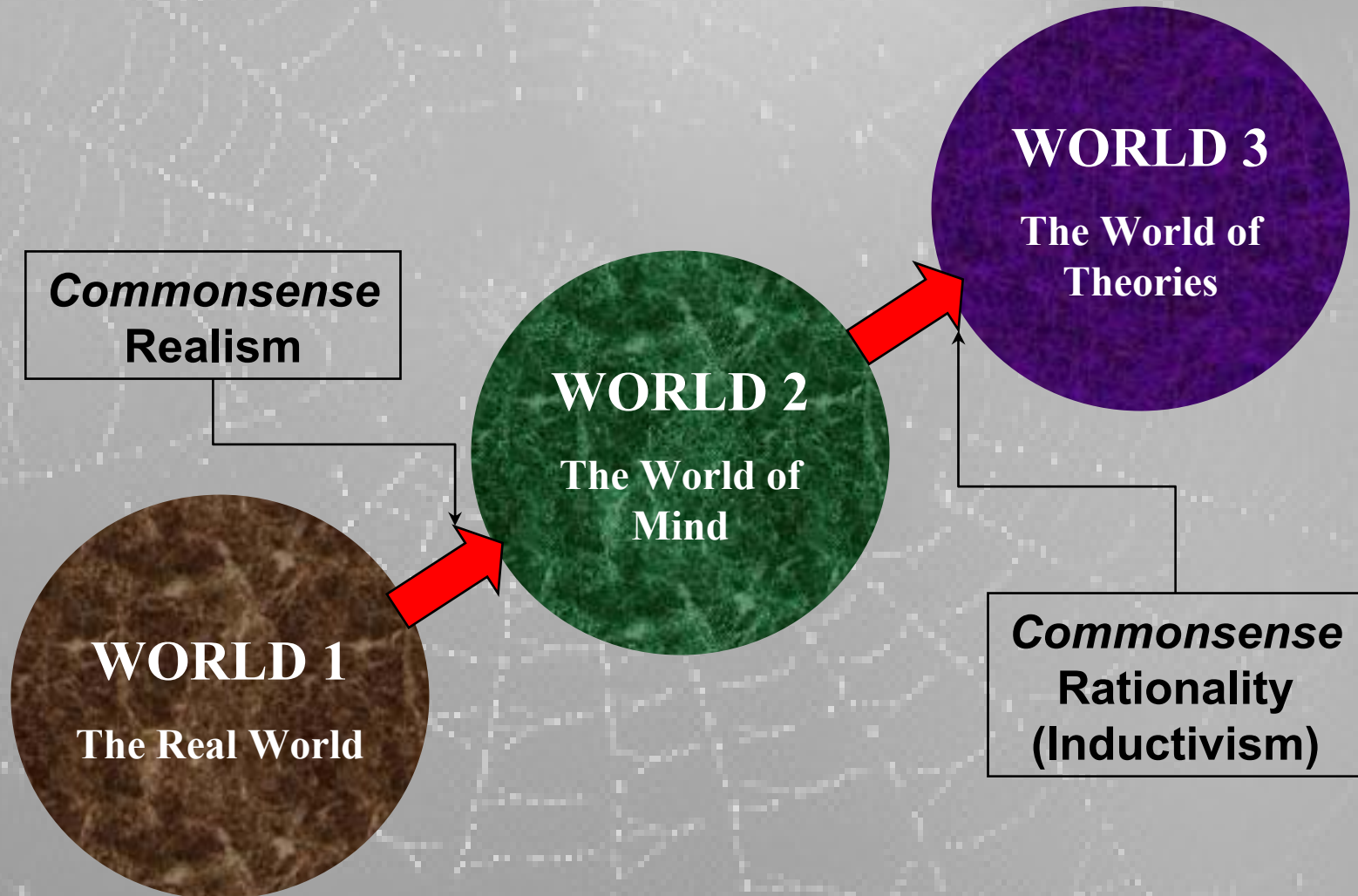
Canto Two

Inductivism is refuted and unnecessary, for there is an alternative method.

Sir Karl Popper

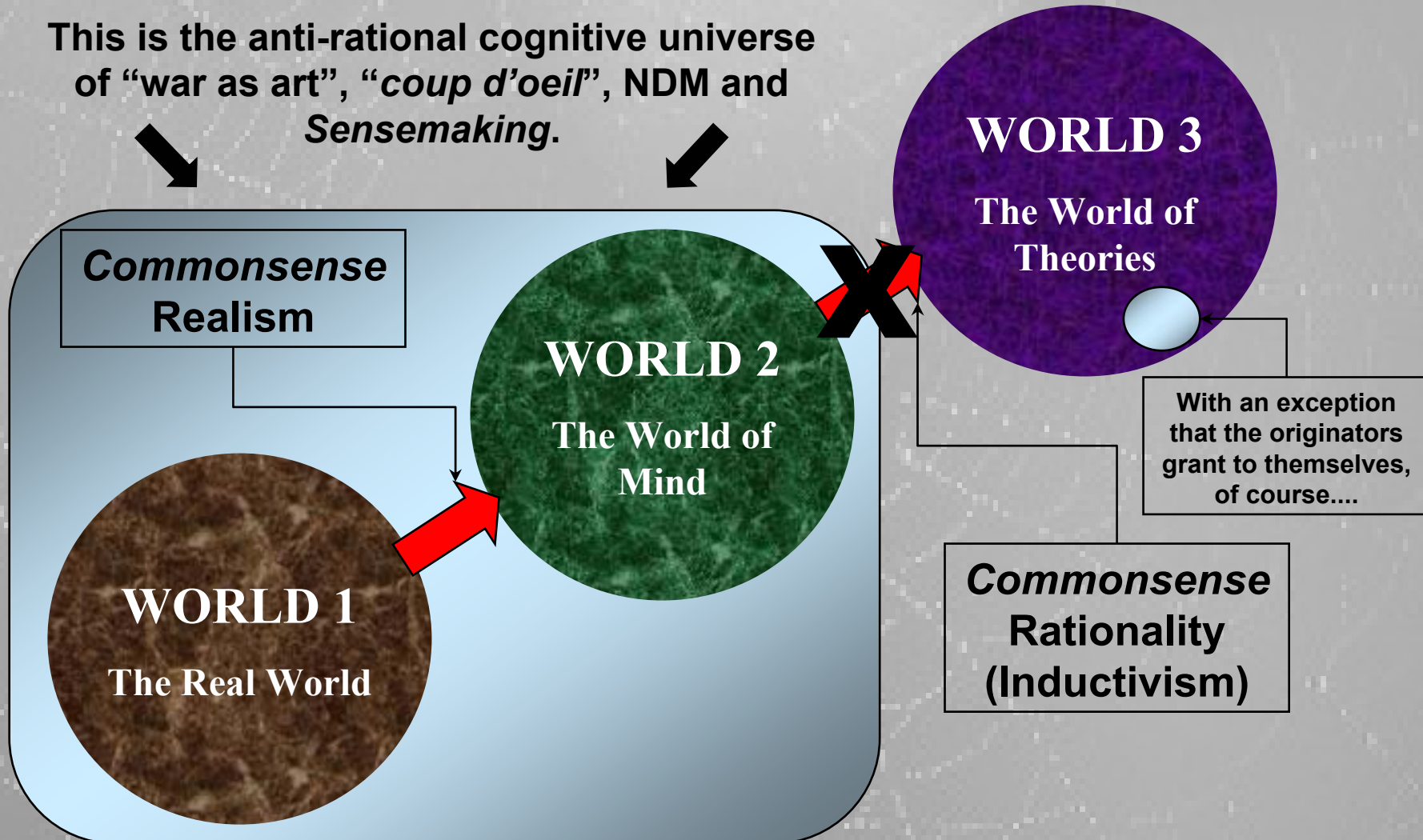


Canto Two: Farewell to World 3



Canto Two: Farewell to World 3

This is the anti-rational cognitive universe
of “war as art”, “*coup d’oeil*”, NDM and
Sensemaking.



Canto Two

The choice before us is not simply an intellectual affair, or a matter of taste. It is a moral decision. For the question whether we adopt some more or less radical form of irrationalism, or whether we adopt the minimum concession to irrationalism that I have termed 'critical rationalism', will deeply affect our whole attitude towards other men, and towards the problem's of social life.

**-- Karl Popper
*The Open Society and its Enemies***

Canto Two

Naive Inductivism:

- X Objective observation of the facts regarding a phenomenon under investigation.**
- X Inductive generalization from the facts, producing a universal theory of the phenomenon.**
- X Empirical justification of the theory, producing a quantitative measure of certainty.**
- X Reliable prophesy.**

Canto Two

The epistemological and methodological basis of the NCW thesis is refuted and unnecessary: the truth does not lie buried in the data, and knowledge is not the end result of an exercise in “information processing” in either a logical or psychological sense. There is a *rational* alternative.

Against the Tenets of NCW

1. A robustly networked force improves information sharing.

It is not the network, or its robustness, that determines the quality of information sharing. What matters is the nature of our thought processes, our attitudes toward the information we may theoretically have access to and to its sources, the situation we are in and our requirements for information.

Canto Two

The epistemological and methodological basis of the NCW thesis is refuted and unnecessary: the truth does not lie buried in the data, and knowledge is not the end result of an exercise in “information processing” in either a logical or psychological sense. There is a better alternative.

Against the Tenets of NCW

2. Information sharing and collaboration enhance the quality of information and shared situational awareness.

Information and awareness can never be made non-problematic, by any known process, not even just a little, least of all by refuted Inductivism and objective probability.

Canto Two

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Against the Tenets of NCW

2. Information sharing and collaboration enhance the quality of information and shared situational awareness.

It is perfectly reasonable for different observers to possess different conceptions of the situation, notwithstanding a homogeneity of facts. This is so even by the standards of Inductivism, for *inductive* inferences are not *necessary* inferences.

Canto Two

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Against the Tenets of NCW

2. Information sharing and collaboration enhance the quality of information and shared situational awareness.

And finally, this tenet is potentially dangerous. We may share information and collaborate all we like. We may come to a perfectly harmonious agreement in all respects. And we may still be dead wrong.

Canto Two

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Against the Tenets of NCW

3. Shared situational awareness enables self-synchronization.

Shared situational awareness is neither a sufficient nor necessary condition for the behaviour described as self-synchronization.

Canto Two

The epistemological and methodological basis of the NCW thesis is refuted and unnecessary: the truth does not lie buried in the data, and knowledge is not the end result of an exercise in “information processing” in either a logical or psychological sense. There is a better alternative.

Against the Tenets of NCW

4. These, in turn, dramatically increase mission effectiveness.

The case for this conclusion has simply not been made.

Canto Two: The Bottom Line

The Conventional View

“The key to understanding the roles of and the relationships among battlespace entities is to focus on processes that turn raw data into information, and information into knowledge.”

The Reality

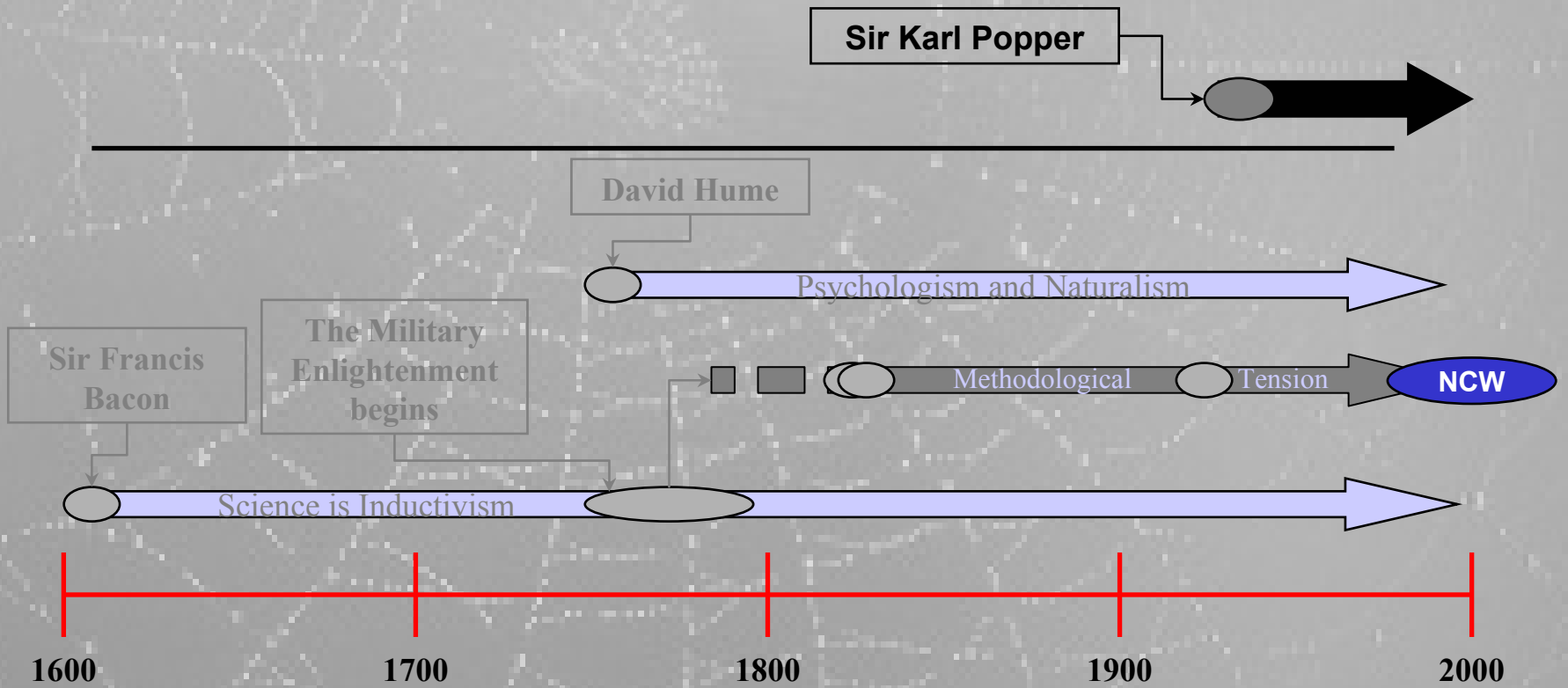
As no such processes exist, we have a crisis in contemporary military theory.



**A WOVEN WEB OF GUESSES,
CANTO THREE:**

**Network Centric Warfare and the
Virtuous Revolution**

Canto Three



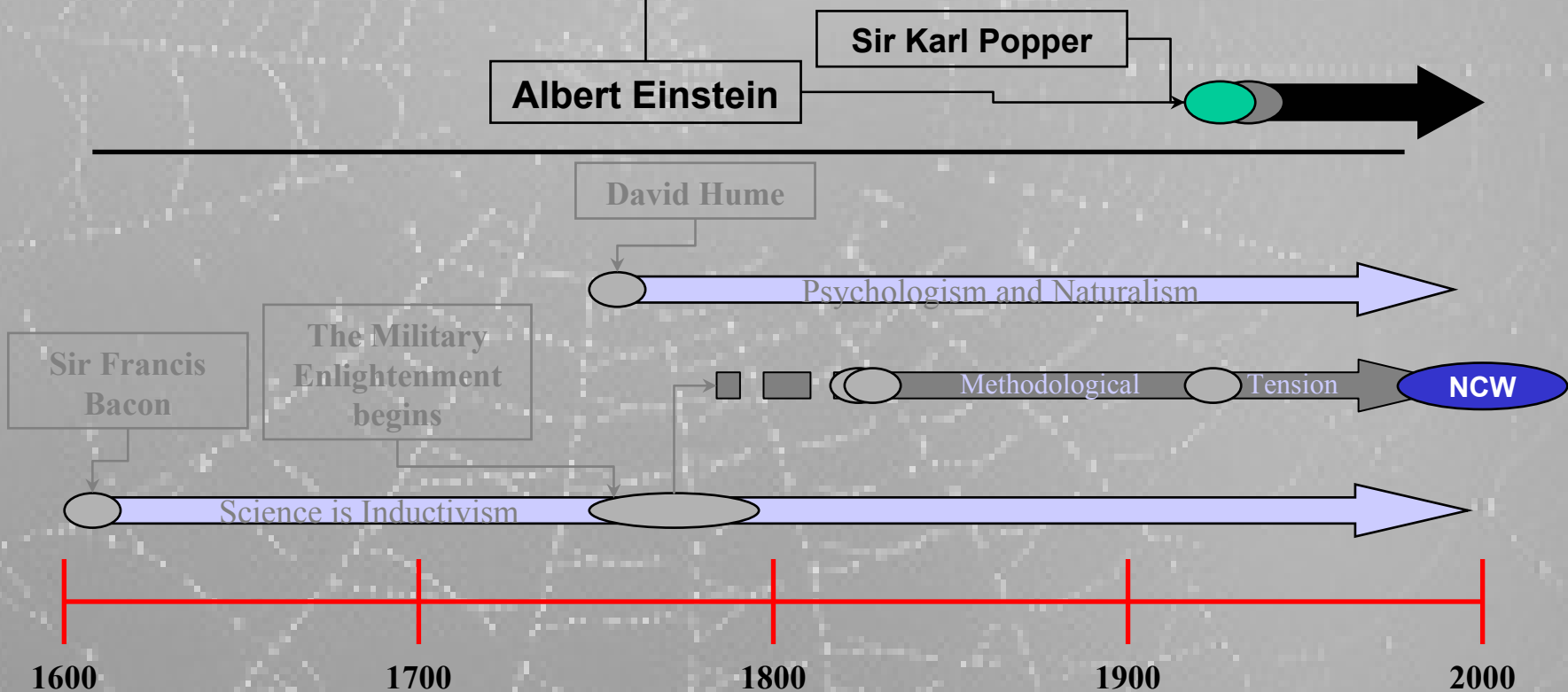
Canto Three

“Physics constitutes a logical system of thought which is in a state of evolution, whose basis cannot be distilled, as it were, from experience by an inductive method, but can only be arrived at by free invention.”

- *Physics and Reality*

Let us consider the case where a single decision maker could have the collective knowledge of targets; a unified picture of the battlespace and the time needed to process all of the information and transmit the targeting orders to each actor. Under these conditions, an optimal decision could be reached.

- Network Centric Warfare, p106



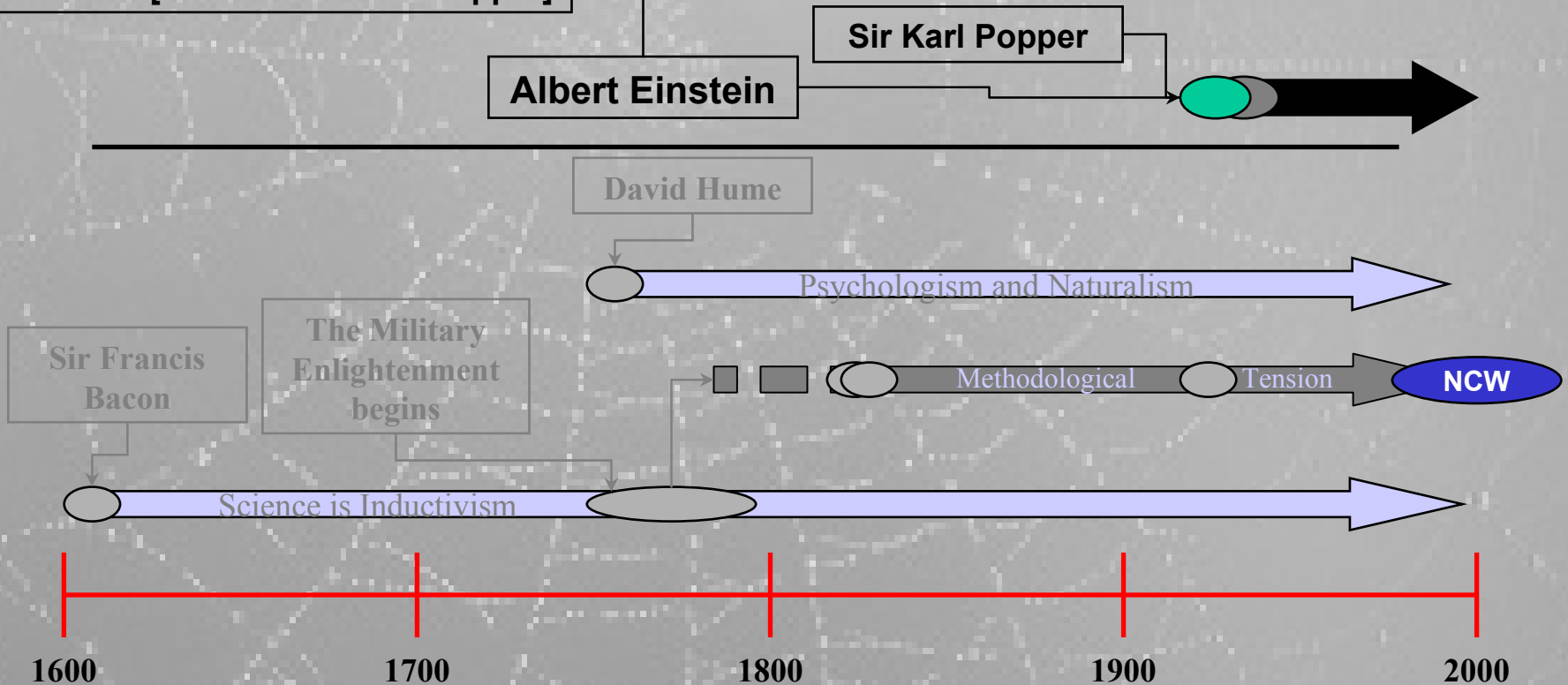
Canto Three

“Altogether I do not like the now fashionable positivistic tendency of clinging to what is observable..., and I think (like you by the way) that theory cannot be fabricated out of the results of observation, but that it can only be invented.”

[In a letter to Karl Popper]

Let us consider the case where a single decision maker could have the collective knowledge of targets; a unified picture of the battlespace and the time needed to process all of the information and transmit the targeting orders to each actor. Under these conditions, an optimal decision could be reached.

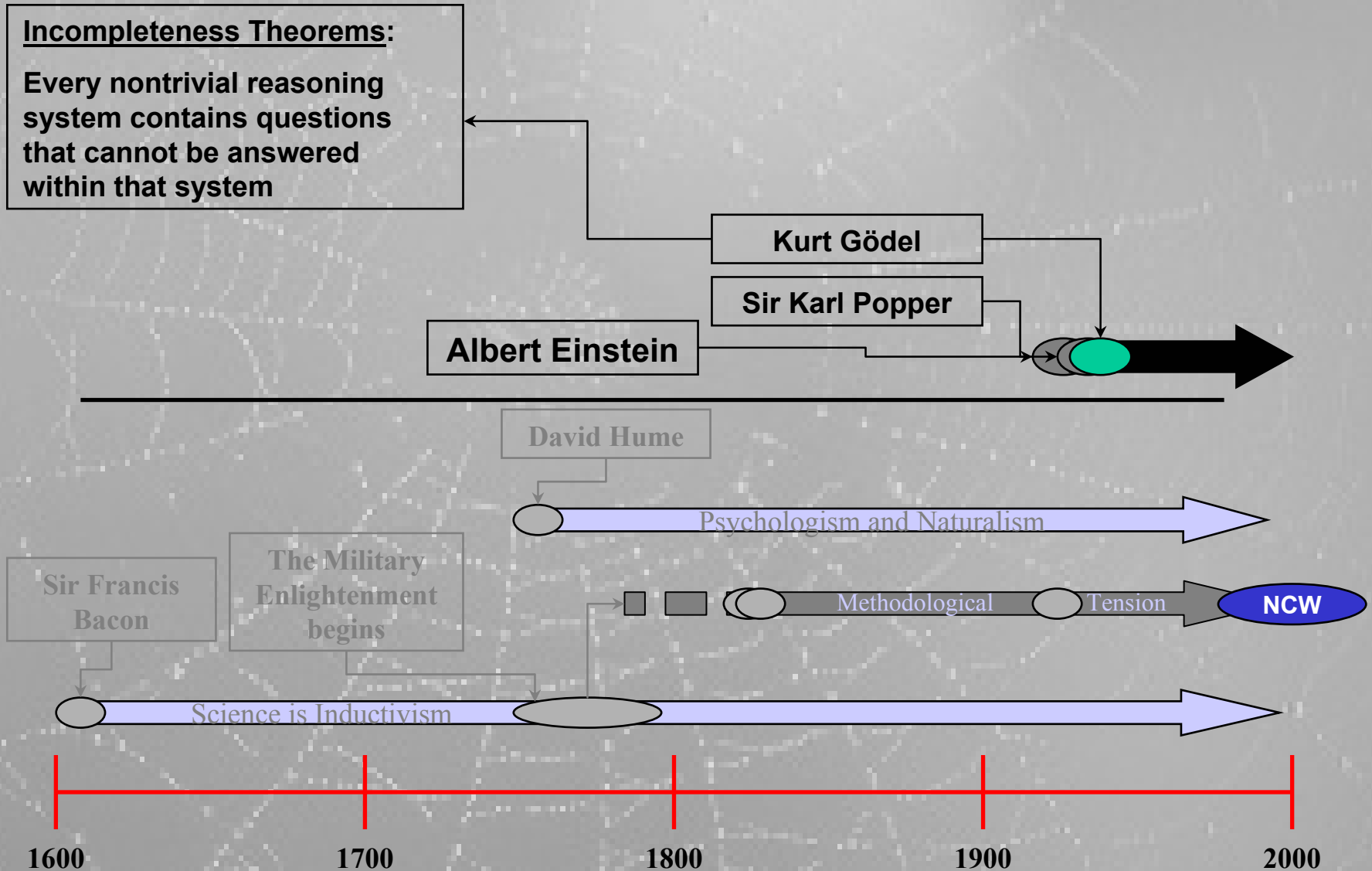
- Network Centric Warfare, p106



Canto Three

Incompleteness Theorems:

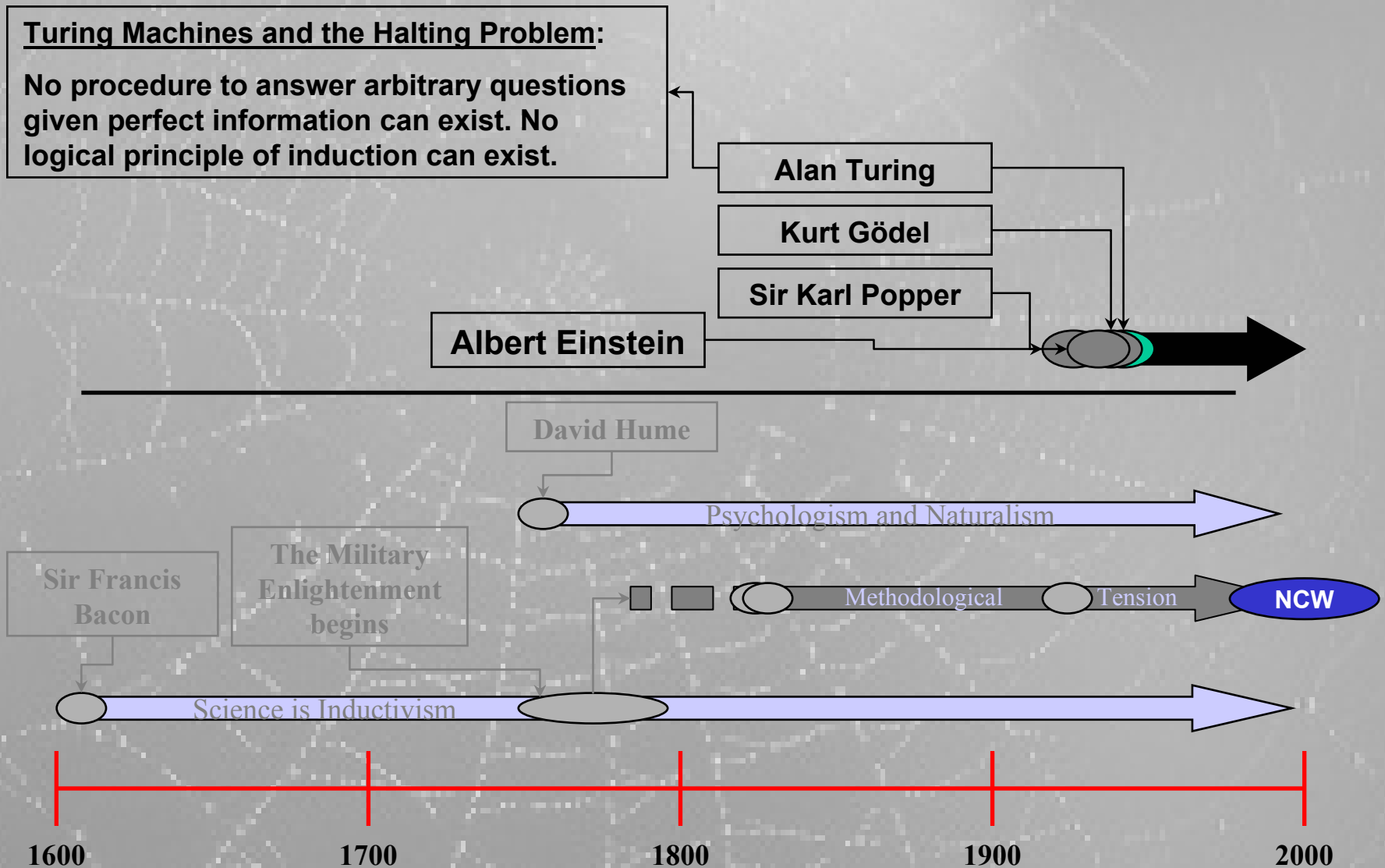
Every nontrivial reasoning system contains questions that cannot be answered within that system



Canto Three

Turing Machines and the Halting Problem:

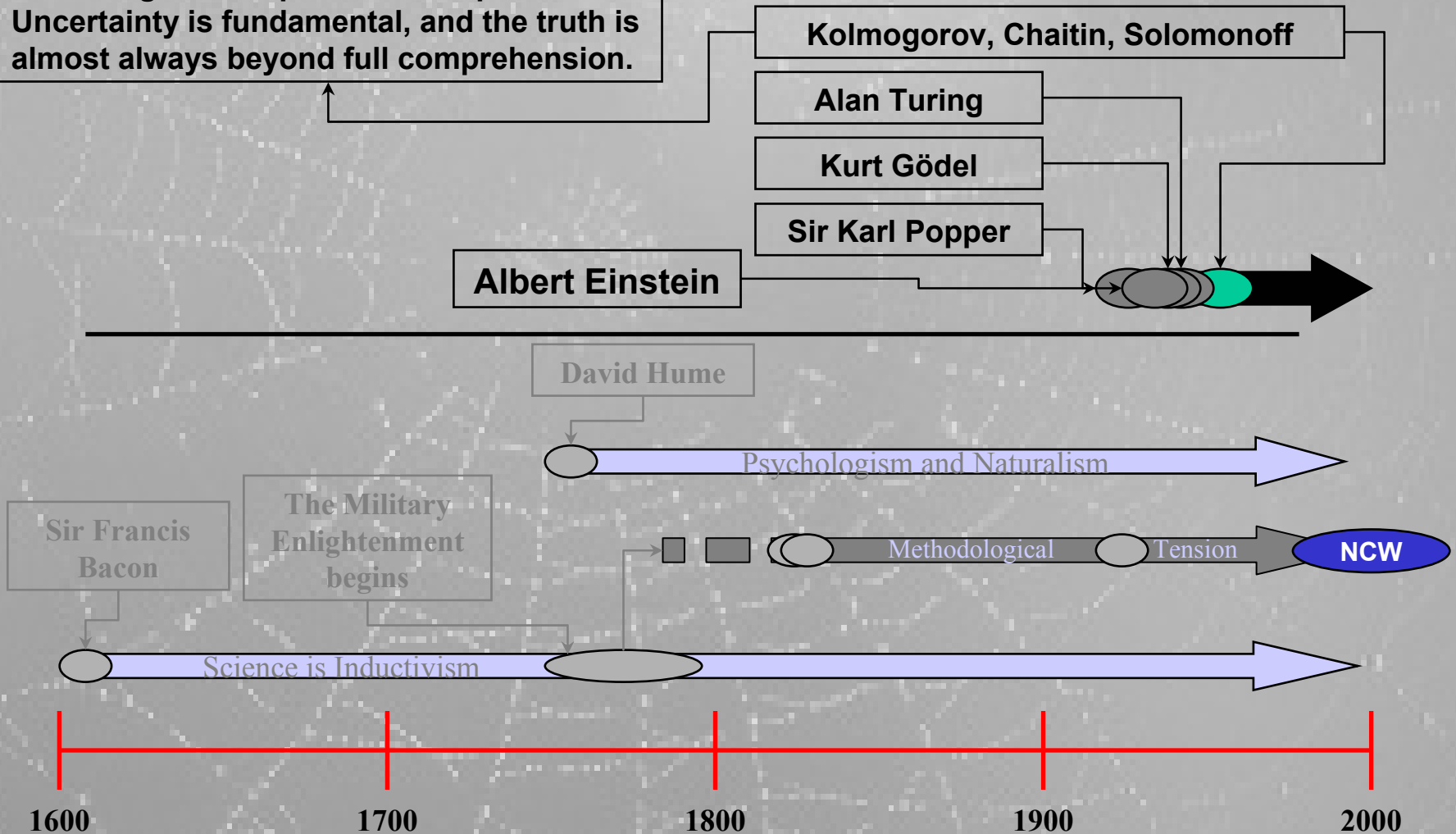
No procedure to answer arbitrary questions given perfect information can exist. No logical principle of induction can exist.



Canto Three

Algorithmic Information Theory:

Knowledge development is compression.
Uncertainty is fundamental, and the truth is almost always beyond full comprehension.



Canto Three: The Morals of the Story

- **No principle of induction has ever been furnished. It turns out that no such principle can possibly exist.**
- **The single answer is not inevitable in principle given sufficient information. Providing the same facts simply does not produce 'shared understanding' and thereby enable 'self-synchronization'.**
- **Uncertainty is proven to be fundamental, it is not a mere residue of insufficient information.**
- **The truth might be out there, but it almost always lies beyond full comprehension. It often lies beyond any comprehension at all.**
- **We are left to simplify, approximate, for the truth is almost always beyond full comprehension. We normally cannot even know if one of our simplifications is closer to the truth than another.**

Canto Three: A Related Insight

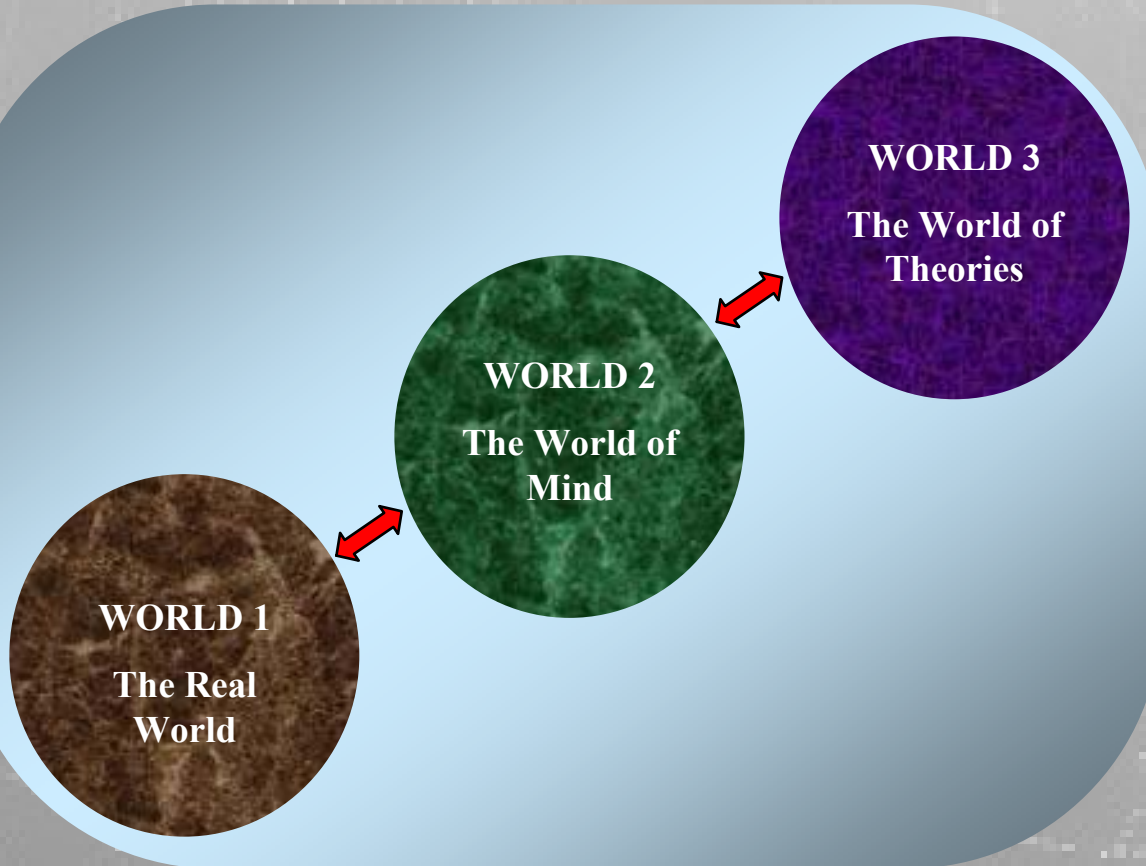
“Researchers succumb to predictable illusions in evaluating whether sets of assertions are consistent ... This procedure avoids overloading memory, but it yields illusions of consistency and of inconsistency. These illusions modify our picture of human rationality.”

**- Philip Johnson-Laird *et al*,
Illusions in Reasoning about Consistency**

To rely on intuition alone for making decisions is to invite disaster. Reason must play a role.

Beyond Canto One Welcome Back to World 3

This is the way to World 3:



Knowledge grows by a process of conjecture and refutation, or of trial and the elimination of error.

It is not:

$O \rightarrow O \rightarrow D \rightarrow A$ or

$D \rightarrow I \rightarrow K \rightarrow W$

but:

$P_1 \rightarrow TT \rightarrow EE \rightarrow P_2$

Canto Three: Critical Rationalism

“... science grows, and may even approach the truth, not by amassing supporting evidence, but through an unending cycle of problems, tentative solutions -- unjustifiable *conjectures* -- and error elimination; i.e., the vigorous testing of deductive consequences and the refutation of conjectures that fail.... More generally, criticism is installed as the hallmark of rationality, and the traditional justificationist insistence on proof, conclusive or inconclusive, on confirmation, and on positive argument, is repudiated.”

Cambridge Dictionary of Philosophy

Canto Three: Surprising Consequences

The revolution in information technology is akin to a substantial leap forward in experimental capability (and execution is an experiment).

Uncertainty remains fundamental.

Fog and friction remain fundamental.

Mass and momentum remain valid components of military force structure and operations design and conduct.

But we may now test more conjectures more rapidly and in more ways.

And 'situational awareness' does not relate to the facts of the situation at hand and their purported meaning, but to our problems, their proposed solutions, and their potential consequences.

Canto Three: Surprising Consequences

**Whereas an inductivist seeks
to**

“make the right decision”

**A critical rationalist seeks
to**

“make the decision right”

Critical Rationalism:

‘Rationalizes’ our decision and decision-support processes.

Unifies deliberate and hasty planning, and planning and execution.

Clarifies the relationship between Commander and Staff.

Clarifies the role of the semiconductor in planning.

Obviates naturalistic decision-making theory and sensemaking.

Recognizes the great value of diversity.

Canto Three: Surprising Consequences

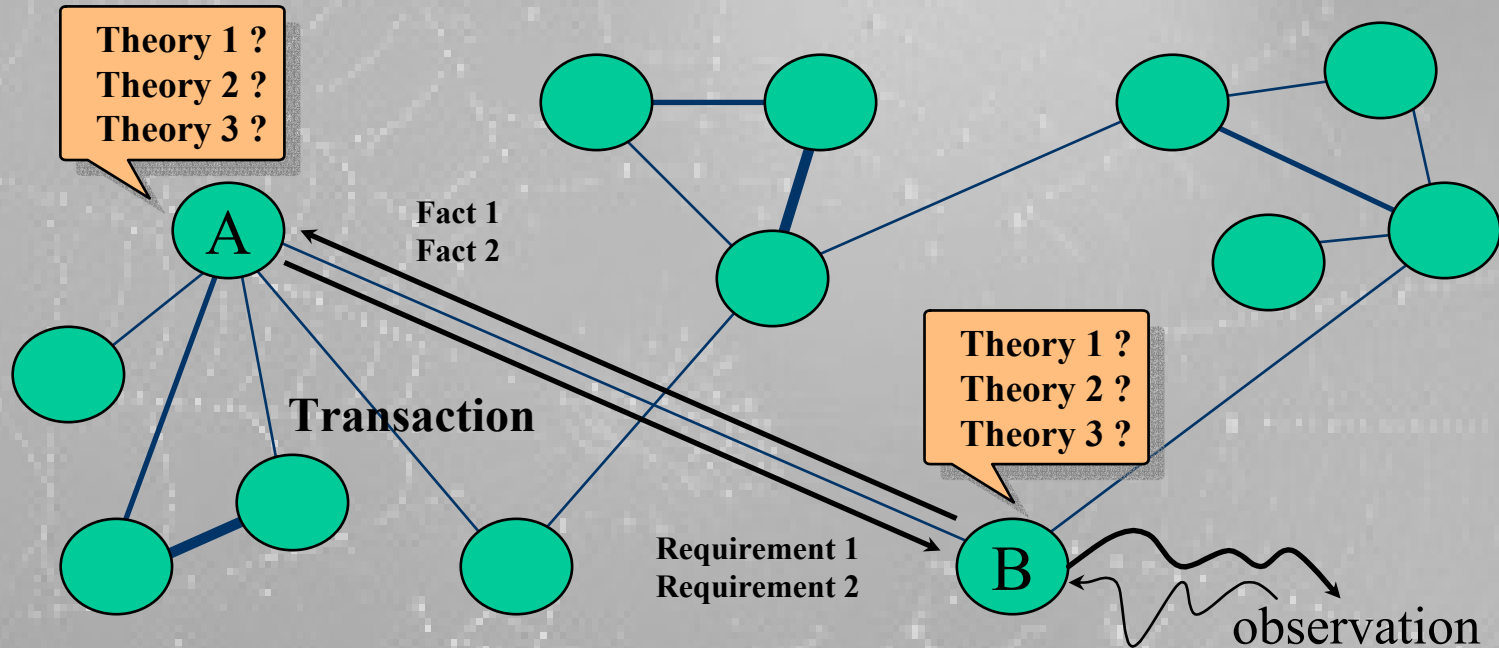
There is nothing *common* about the *operating picture*.

We create our own understanding of the situation and we impose our own meaning on the facts. We each have our own unique and personal operating picture.

It is not the commander's task to eliminate these diverse operating pictures, but to identify and manage any contradictions between them.

To the extent that we employ a homogeneous database, our decision to accept it is voluntary, and its purpose is not to *create a common understanding*, but to *provide an agreed basis for exchanging and comparing* our conjectures and the results of our tests.

Canto Three: Surprising Consequences



The value of a network is the collective value of the transactions it supports. The value of transactions lies in their ability to refute theories and the importance of so refuting them. Value is not ascribed according to relative distance from truth.

It is not the “information age”. It is the “communication age”.

A Few of the Opportunities

Testing theories against negative as well as positive information.

Evaluating theories against one another for consistency.

Deductive determination of the consequences of theories.

Evaluating theories for internal consistency.

Managing multiple competing theories of explanation.

Assessing theories of action against theories of explanation.

Knowledge bases of theories that have worked well in the past.

Collection tasking for multiple competing and complementary requirements for evidence.

Collaboration tools that assist in comparing different sets of theories relating to different local contexts.

Formal Ontology is the field dealing with knowledge representation.

Picking up the Pieces

“I hope I have made clear the distinction between a scientific revolution and the ideological revolution which may sometimes be linked to it. The ideological revolution may serve rationality or it may undermine it. But it is often nothing but an intellectual fashion.”

- Karl Popper, Myth of the Framework.

The revolution we seek, virtuous in light of modern understanding, is a transformation in how we think about thinking.

This is a change that is compelled by deep and highly influential results concerning the nature of logic, information, knowledge and reasoning.

It is a revolution that awaits us still.

**BUT AS FOR CERTAIN TRUTH, NO MAN HAS
KNOWN IT
NOR WILL HE KNOW IT; NEITHER OF THE GODS,
NOR YET OF ALL THE THINGS OF WHICH I SPEAK.
AND IF BY CHANCE HE WERE TO UTTER
THE FINAL TRUTH, HE WOULD HIMSELF NOT
KNOW IT:
FOR ALL IS BUT A WOVEN WEB OF GUESSES.**

- XENOPHANES