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2010

# The Biology of Reality Testing - Implications for Cognitive Education

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# The Biology of Reality Testing

## and its implications for cognitive education

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February 5, 2010

*We derive our beliefs...*



**Roger Bacon (1268)**

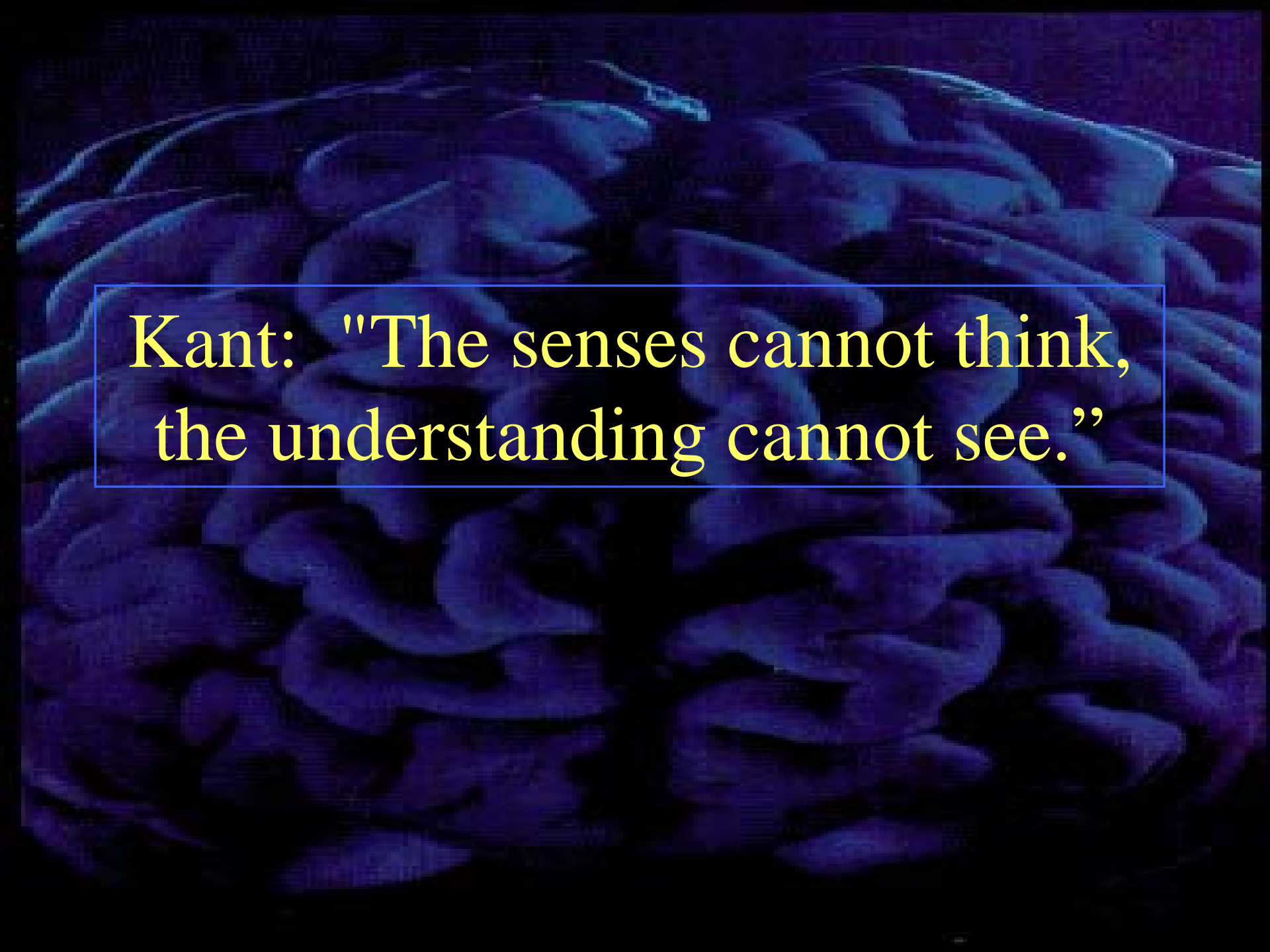
*“...through argument and experience.*

*Argument brings conclusions and compels us to concede them,*

*but does not cause certainty nor remove the doubts*

*in order that the mind may remain at rest in truth,*

*unless this is provided by experience.”*



Kant: "The senses cannot think,  
the understanding cannot see."

# Traditional Paths to “Truth”

- **FEELING**

- Emotion, autonomic arousal

- **AUTHORITY**

- social referee; more knowledgeable other

- **REASON**

- “understanding cannot see”; apparent coherence; textual integrity; external validation

- **SENSORY PERCEPTION**

- “senses cannot think”; correspondence; internal validation

– Felipe Fernández-Armesto ..



# TRUTH is a BELIEF

**Belief** is the psychological state in which an individual is more-or-less confident in the **validity** of a proposition.

(confidence can translate into biological fitness)

**Validity** can be more-or-less **internal**

(limited generality; e.g., individual enhances self-confidence) or **external** (broad generality; e.g., enhancing social confidence)

# VALIDITY

- ***INTERNAL VALIDITY*** (*narrow context*)
- ***Confidence*** in percept can be increased by **consistent reconfirmations** of personal experiences; highly reliable repetitions.... Private; enhances **self-confidence**

- ***EXTERNAL VALIDITY*** (*broad context*)
- ***Confidence*** in percept requires that it is perceived to be of enlarged generality, applicable to comparable situations in other individuals or contexts.... Social, shared experience; enhances **social confidence**

# HOW IS BELIEF ESTABLISHED?

This report explores the proposition that teaching effectiveness can be enhanced by accommodating the key differences between **two complementary and deeply engrained modes of reality testing, each predominantly centered in different hemispheres of the brain.**

*Correspondence*

*Coherence*



## HOW IS CORRESPONDENCE ESTABLISHED?

- Establishing ***CORRESPONDENCE*** involves matching perceptions of world based on sensory input – to the “real world.”
- A cascade of *error-detecting* mechanisms exists from neuromuscular reflexes through intentional consciousness, involving expectations
  - For example, “error-related negativity” in brain waves are detectable before consciousness awareness of an error (Falkenstein)

# HOW IS COHERENCE ESTABLISHED?

- Establishing *COHERENCE* involves categorizing percepts, creating narrative flow in context with previous and ongoing parallel and collateral percepts (a wholly internal process)
- We have a capacity to assemble multiple specific percepts into plausible, coherent sequences
  - For example, left hemisphere “interpreter,” assembling wholes from fragments (Gazzaniga 1999; Turk et al. 2003)

# **MOTIVATION for ESTABLISHING CONFIDENCE**

***REALITY-TESTING*** becomes progressively urgent as dissonances are revealed between a percept and the experience base.

**As the experience base expands personal beliefs must be reconciled with shared beliefs throughout socialization.**

***OPTIMIZATION*** comes in to play when the real or perceived **COST** of assimilating or accommodating new percepts is greater than the real or perceived **BENEFIT**

# DISORDERS of BELIEF?

*Distinguishing remembered or imagined experiences from ongoing experience is not trivial*

- The neurophysiological substrate of memory and imagination are almost identical
- “Flashback” can appear to be a new experience



# DISORDERS of BELIEF?

**Acceptance of experience that doesn't correspond to external reality:** kinds of hallucinations; Bonnet's Syndrome (filling in scotoma); dismorphic body; pareidolia. (False positive (confident match with memories); Type I Error; overly trusting, gullible)

**Denial of experience that corresponds to external reality:** agnosias: eg, visual (left occip), associative, anosognosia (denial of dysfunction / right cerebral cortices), prosopagnosia (faces) (False negative (failure to match with memories); Type II Error; overly skeptical, wary)



# HOW IS CONFIDENCE ESTABLISHED?

*Reality testing* becomes progressively urgent as the experience base expands and personal beliefs are reconciled with shared beliefs throughout socialization.

*For example:* dream content can be taken for reality until the enlarging experience base creates a crisis of belief : “it *must* have been a dream.” **OR** new highly validated experience can reintegrate older invalidated experiences that were “meaningless at the time” ... a kind of novelty blindness

# RECALLED IMAGINATION, IMAGINED MEMORIES

Episodic **memory** and plausible personal **imagination** share a consistent network of associated brain regions connected in a distributed network of neural modules

...some of which may support self-schema and familiarity processes, and contribute to the brain's ability to distinguish real from imaginary memories.

Hassabis et al., 2007



# REVIEW and LIMITATION

*Confidence* in the validity of any percept throughout development is related to the interplay of these key processes.

As organisms develop, the experiential “reference base” of previous percepts is enlarged and refined.

**Motivation to enlarge the “reference base” is more or less intentionally energized by two variables: the real or apparent NEED for additional experience and the COSTS AND BENEFITS of obtaining that experience.**



# Metaphoric aside

**LIKE GENES, percepts can be individual or clusters;**

**They are pleiotropic (individuals serve multiple functions)**

**The narratives they contribute to are polygenic (have multiple inflowing streams of information)**

**They can compete with each other for expression**

**They are enabled or disabled by epigenetic interactions with the present environment, including stressors**



## COHERENCE is COMFORTING

“A world that can be explained even with bad reasons is a familiar world. But on the other hand, in a universe divested of illusions and lights, man feels an alien, a stranger. . . .”

Albert Camus

A “predictable” world is *much* less stressful

**correspondence and coherence**  
**evidence and theory**  
**past and future**

**These two domains – one rooted in the past, the other in imagination– collaborate in creating a “sense of confidence in a belief,” not least, one’s *self*.**

**Increasing the degree of confidence in the validity of a belief enhances biological fitness ... ecologically, there is an “optimal” cost/benefit ratio for a given level of confidence**

**Organisms often continue to try to increase confidence depending on *perceived* urgency and resources ... and can become addictive (“search and solve” is pleasurable)**

# **An Aside on Chance and Necessity: the intrinsic imperfection of knowledge**

**Our inner world, *umwelt*, of necessity provides an abstraction *at best*.**

- **Experience and neuroplasticity are limited**
- **Seven +/- two items in short-term memory**
- **Neuronal activity recycling time**
- **Lateral inhibition ... extrapolation and interpolation ... a neurological “confirmation bias”**

# PHYSIOLOGY

## **Autonomic, affective, and cognitive integration of feedback representations of arousal:**

- **anterior cingulate cortex** is implicated in generating autonomic changes, while
- **insula and orbitofrontal cortices** may be specialized in mapping visceral responses.
- **ventromedial prefrontal cortex** is recognized to support processes of internal (self-) reference that predominate in states of rest and disengagement and which putatively serve as a benchmark for dynamic interactions with the environment.

(Critchley 2005)



# PHYSIOLOGY

**STRESS RESPONSES** are evoked by **REAL** or **PERCEIVED** challenges to an organism's ability to meet its needs

**SUBCLINICAL STRESS** is evoked by modest challenges to homeostasis, including **COGNITIVE DISSONANCE**, an apparent mismatch between internal perceptions and external reality; challenges to the narrative that confers biologically valuable confidence.

# Stress modulates neural function

STRESS is a coordinated suite of responses to real or perceived challenges to an organism's ability to meet its needs

As Camus observed, a predictable world is less stressful

Novelty evokes more or less stress depending on the perceived urgency of its challenge: information is **ASSIMILATED** or **ACCOMMODATED** by an organism's world model.

# Stress modulates neural function

- It is of interest that the system specialized for establishing **CORRESPONDENCE** is localized in the **RIGHT HEMISPHERE**, also associated with selective activation by novel percepts.
- **SUCH NOVELTY** is uniquely associated with activation of autonomic functions (affect, stress) that proactively **ALERT** to novelty and reactively **COPE** with novelty, seeking to return to equilibrium with as little cost as possible



Are beliefs more important than truth?

## TRUTH and STRESS



**SELF-DECEPTION** serves a vital function (Daniel Goleman's use of Ibsen's term: "Vital Lies" 1985)

**"You can't handle the truth!"** (Jack Nicholson in In "A Few Good Men," 1992)

**DENIAL** ---The more-or-less "...willing suspension of disbelief..." (Wordsworth) – is that the *function of art?* ... to provide a safe zone for exploring the otherwise troubling, stress-evoking truth?

*Or of myth?* ("theory used to be an "enchanted circle")



## LEFT HEMISPHERE

**Coherence:** creates a consistent belief system – works to “save appearances”

(Ramachandran 1998)

Probabilistic reasoning

(Osherson et al 1998)

Abstract object recognition

(Marsolek 1999)

Activated by familiar percepts

(Goldberg 2001)

## RIGHT HEMISPHERE

**Correspondence:** “skeptical,” tests reality and if damaged, confabulation runs rampant

(Ramachandran 1998)

Deductive reasoning

(Osherson et al 1998)

Specific object recognition

(Marsolek 1999)

Activated by unfamiliar percepts

(Goldberg 2001)





**"Our life is an apprenticeship to the truth that around every circle another can be drawn; that there is no end in nature, but every end is a beginning, and under every deep a lower deep opens"**

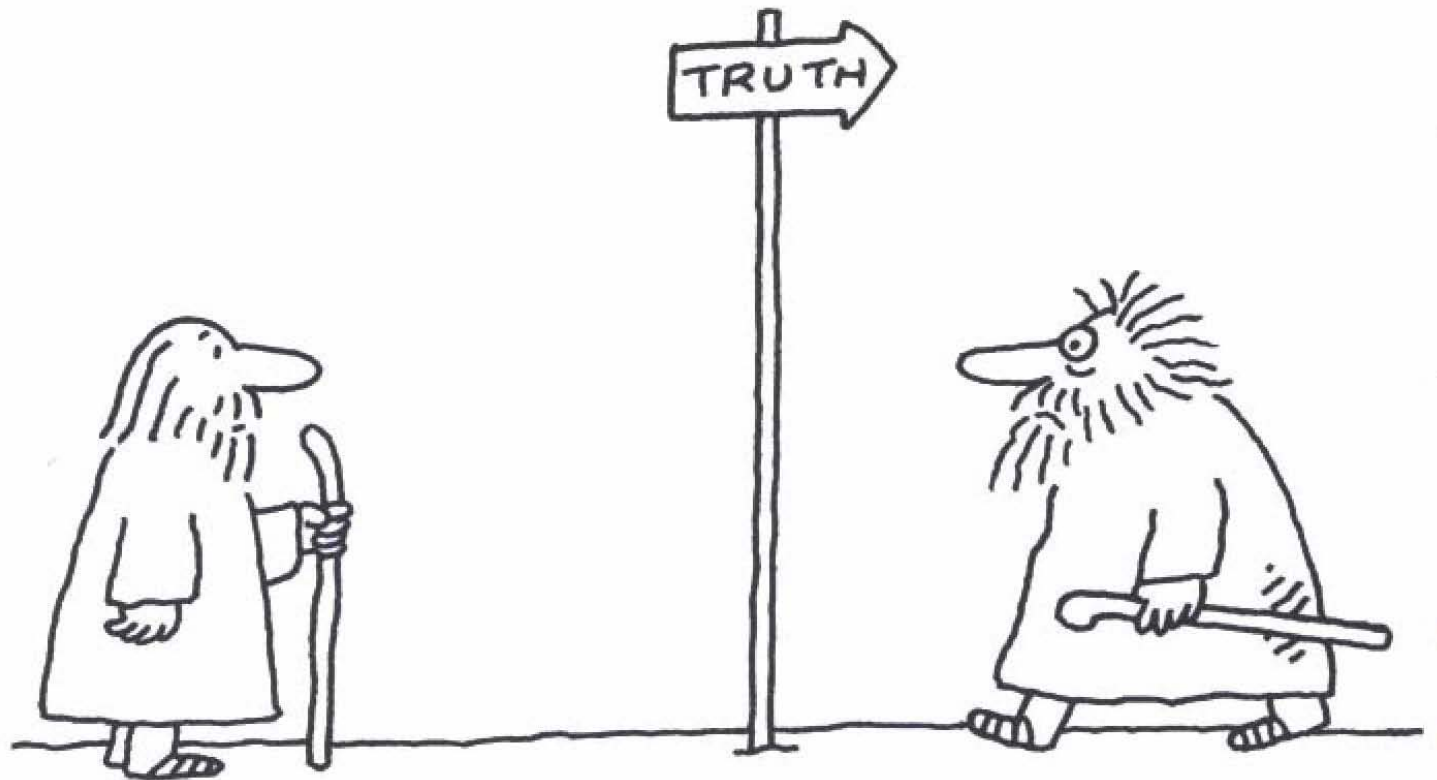
--Ralph Waldo Emerson

# Take-home

- Establishing *correspondence* and *coherence* are separate but complementary processes with unique neurological substrates
- Neurological substrates are differentially subject to real or perceived stressors and are enabled and impaired by different levels of stress.
- Stress profiles of “controllable” vs. “uncontrollable” stress have different dynamics.



# Can we handle the truth?



*C. Barvotti*