
THE NATURAL HISTORY OF TRUTH: The Neuropsychology of Belief*

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ABSTRACT. The pursuit of truth is woven into the fabric of every organism*. Any estimate of how best to survive and thrive in the reality in which we are immersed requires a sense of self, of the world, and of their relationship to each other. I wish to explore the idea that this pursuit has at its heart two complementary modes of reality testing utilizing separate cerebral systems which deal, respectively with the correspondence of experience with the world and the coherence of the experience with previous experiences: □is it real□ and □does it fit?□ At multiple levels of the nervous system, confidence in the validity of a belief depends on these two processes working independently and in concert.

I wish to explore the biological significance of
□belief□ and □truth□ from the integrative

perspective of ethology. That is, the lenses of developmental biology, ecology, evolutionary biology, and physiology will be focused on the process of extracting meaning from experiences.

Two complementary cerebral processes ordinarily work in lockstep to provide us with varying degrees of confidence in the strength of ensuing beliefs: These processes involve an estimation of the validity of correspondence and coherence. Such estimations of validity guides the continuing reconciling of intentions, expectations, and actions at every level of the nervous system, invoking energetically more expensive higher levels only when lower levels are inadequate. A third cerebral area reveals itself only in extraordinary circumstances and appears to evoke □hypergnosia, □ an overwhelming and sometimes ecstatic sense of truth.

Correspondence □ involves □reality-testing□ of a percept, the cerebral representation of a [fragment of experience \[in the world\]](#). □Coherence□ involves □theorizing, □ that is, reality-testing of a percept by how well it relates to previous and ongoing parallel and collateral experiences. As organisms develop, the □reference base□ of previous experiences is enlarged and refined. A valid correspondence is consonant with a theory; a valid theory is corroborated by correspondences. In large measure, these mutually supportive cerebral processes are lateralized in different hemispheres of the brain. Their function is more-or-less balanced, but asymmetrical influence on confidence can be evoked by developmental circumstances that range from the willing suspension of disbelief to expectations and other cognitive biases that can undermine our effectiveness in the real world.

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I

SEEK and SOLVE

□ **ALL men by nature desire to know. An indication of this is the delight we take in our senses; for even apart from their usefulness they are loved for themselves**
...□ opening lines of Aristotle's *Metaphysics*

- Aristotle's opening comment from *the Metaphysics* gives us a starting point for an exploration of the natural history of belief. The "need to know," like all motivational systems, varies in perceived urgency and is energized accordingly. The vast amount of adaptive change, including coping with environments that do not meet our expectations, occurs at nonconscious levels as a hierarchy of progressively more demanding automatized coping responses are activated. Dissonance that cannot be resolved with these relatively inexpensive mechanisms, may evoke an increasing sense of urgency until the threshold to consciousness and active problem solving is attained.

The map for this enterprise seems to be a landscape of circularity, as the congenital and acquired

pathways that are found constantly change and are being changed by experience.

Humans are not alone in their need to know. All organisms must develop some sort of sense of their competencies, boundaries, and the environment in which they must make their way. But as humans we seem to be extraordinary in the delight we take. Aristotle also identifies a self-reinforcing dimension, what Konrad Lorenz calls autotelic (1981) when speaking of play.

Beliefs are learned and like most learning they enable organisms to express the behavioral patterns they have acquired as a result of experience. Most (but certainly not all) experience is of the change is the relationship between an organism and its environment, sometimes attributable to necessary developmental change in the organism, but especially the result of changes in the environment (and organisms are part of their own environments).

Beliefs are organized relative to the environment in which they deploy adaptive actions, but also relative to each other. These relationships, sometimes ephemeral connections, reflect causation as best as possible and constitute a sort of theory. A bias that guides future actions and is in return reformulated every time an action is less than optimal. Much like the theorizing enabled by accumulated sensory information, curiosity often flourishes best in safe zones, when needs other than curiosity are not flooding the system: Klaus Held (2002) suggests that such "...curiosity was transformed for the first time with the Greeks into the striving for a knowledge that no longer had as its justification the promise of better orientation within individual, particular life-worlds. Aristotle introduced the term *theôria*... for this kind of knowing." (Held 2002:89).

The need to know, however, while serving the developing human, may be distracting if pursued obsessively: the organism need not be perfect, only relatively competitive to participate in the evolutionary race.* At a certain point, when the cost of assimilating and accommodating new information exceeds benefit, we may just choose to "let the mystery be" (Dement, I. 1992).

We may take great pleasure from exercising curiosity and seeking and solving mysteries, but there is also what Rudolph Otto (1923) called the *Mysterium Tremendum et Fascinans*. This is something wholly other than a merely fascinating mystery: it evokes the awesome, ineffable, sense of the *numinous*, and when apprehended, can sweep over one like a tide or burst upon us evoking a frenzy or ecstasy. As we become able, there are many mysteries of which we can speak. The fixed need to know and the flexible sharing of knowledge is the gene-culture co-evolutionary spiral. (Lumsden).

Knowing is apparently intrinsically satisfying. Abraham Maslow (1966) regarded it as one of "the richest sources of esthetic raptures, of semi religious ecstasies, of experiences of awe and ... among the ultimate joys of living." But ecstasy and joy have some corollaries in biology and in the instance of "knowing" Maslow might regard it as anxiolytic, but more recently we can say that it is at least in part because information, as it penetrates more deeply into the integrative centers of the brain, may stimulate progressively more opioid receptors (e.g., Biederman & Vessel. 2008).

Novelty presents itself relentlessly, and always optimizing, that is, assessing cost and benefits: we attend to those elements that promise to repay our interests the most. All confrontation with novelty evokes some measure of activation of the pathways that enable the stress response in the autonomic

nervous system and, much like muscle tone, we find what for us is at a given time the optimum autonomic tone. This tone enables rapid responses to coping with novelty, much like our muscles, to take advantage of apparent opportunities or avoid unnecessary challenges.

The resolution of a confrontation with novelty or unexpected events is the adaptive process described by Piaget as, "one of continuous assimilation of internally mediated consequences of the organism's action on the environment and the resulting accommodation of these action schemes into the previously formed structure" (Hutcheon 1996:373, citing Piaget 1980:89).

If we agree with Einstein that mystery is the key to art, science, and religion, then science, by increasing the mystery of which we are aware, can be viewed as a great "machine of spirituality." As Popper (1968) said, "our knowledge is finite but our ignorance is infinite" "The more we learn about the world, and the deeper our learning, the more conscious, specific, and articulate will be our knowledge of what we do not know, our knowledge of our ignorance." ~~[For this, indeed, is the main source of our ignorance—the fact that our knowledge can be only finite, while our ignorance must necessarily be infinite.]~~

The seek-and-solve strategy of growth and development results in progressively effective competencies at every level of the organism and also an enlarging reservoir of experiences to act as reference points to enable more effective coping with present and future needs. In their own developmental and experiential time, our understanding of the realities of the world enlarges. Consciously or otherwise, we appreciate their part in the causes and consequences of behavioral patterns. As patterns become consolidated and more reliable in the present, they also become the

filters that evaluate future experiences for their utility and the basis on which we make predictions about possible future needs. They are our beliefs.

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II.

BELIEFS and TRUTHS

"... knowledge itself is power" (Francis Bacon, 1597) . The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human Empire, to the effecting of all things possible. (1627).

Beliefs are states of the organism that enable it to cope with change, and they succeed or fail largely to the extent that they are valid -- or at least more valid than that of their competitors in avoiding danger or securing advantage for itself or its kin. The vast number of beliefs are changes in the organism based on experiences as preliminary as sensory-motor reflexes, encounters of which we are utterly unaware. There is an extraordinary economy in the organism such that only ineffective coping at low levels will recruit the next most energetically demanding levels. We

become aware of dissonances only when they are extreme enough to require conscious awareness. Thus we make our way through the environment, the final arbiter of an organism's ability to compete for limited resources or cooperate in securing resources for its group.

The "need to know" Aristotle addressed in the opening lines of his *Metaphysics* is engrained in all organisms in a changing environment, but it is the mainspring of the human experiment. That is, the extracting of patterns from experience that enable the development of beliefs that enlarge its power over nature at the same time as its capacity to respond to the experience of nature evokes neuroplastic change. The various mechanisms of mind collaborate in this cycle of control and coping with the consequences they create. In all likelihood these evolved in response to a variety of needs and have only recently in our history come to have this uneasy alliance of functions that enables us to believe and assess relative confidence in specific beliefs.

We hold beliefs and we become progressively more-or-less confident in their validity because of how they meet biological needs.

The relative urgency of these needs affects our tolerance for ambiguity and the ease with which confidence is won. Not every belief is rigorously tested, of course, many are scaffolds that enable temporary stability while a more elaborate cognitive structure is built. Other beliefs are recreational or playful, and in support of their potential contribution to development, understanding, and insight, we even suspend disbelief. We hold many beliefs to be relatively harmless in the way that many toys and games are. Play for example, may contribute significantly to the development of useful abilities like eye-hand-coordination, social skills, and

perhaps especially, self knowledge. At first we acquire knowledge that informs us of personal competencies and physical boundaries, but eventually cognitive structures, both simple and the most elaborate we can devise will develop. Pursuing and playing with beliefs as with toys, contributes to competence in sensory perception, cognitive integration, and selection of appropriate actions. But in humans as in other species, as maturation continues, play can become very serious.

Biology of Belief. I wish to explore "truth" and "belief" from the integrative perspective of ethology. I believe(!) that these concepts guide the manner in which we control and are controlled by our environments and are best understood when the lenses of developmental biology, ecology, evolutionary biology, and physiology are brought to focus on our actions. The convergence of these perspectives enables us to extract a richer meaning from our experiences and thereby invest derived beliefs with more confidence. Beliefs are, in this view, "true" in proportion to our confidence in their validity, however validity can never be complete, although its pursuit may be preparation for an apprehension of phenomenal truth. Experiences we wish to explore are also, admittedly, vulnerable to acquired or congenital biases, not least of which are limitations on possible experiences imposed by the sensory and perceptual apparatus we possess. This apparatus is itself shaped by the natural selection imposed on countless generations of organisms meeting needs and then complemented with our individual neurodevelopmental plasticity. With respect to sociality, a critical human need and an overarching element of the human environment in which beliefs are formed and tested, our behavioral plasticity (and corresponding

underlying neural plasticity) can range from a mother-infant bond through passionate participation in a crowd, and is thus imbued with both poignancy and power.

Beliefs serve needs. The need for confidence in a belief is in lockstep with the real or perceived urgency of the need it may serve to mitigate. The □sense□ of urgency is related to the physiological stress effect, which, may be manifest along a range from subclinical to emergency and proportionately *energizes* the appropriate motivational system that serves a particular need. There is a hierarchy of needs, well known to most students of psychology as □Maslow□s Need Hierarchy.□ On a scale of relative urgency from basic biological integrity (health: physiology and homeostasis), to personal safety, need for society, desire for distinction (esteem in the eyes of a potential reproductive partner), to □self-actualization,□ which to a biologist as well as an Army recruiter, involves □being all you can be,□ most specifically to contribute directly or indirectly to kin and the next generation.

Truths are beliefs about which validity is absolute, beyond confidence. Biological fitness, however, does not require perfection, it needs only for a trait, perhaps a belief, to be better than that of competitors. While there are always novel phenomena, unsolved mysteries, there is dissonance -- always a mismatch between reality and our understanding of it. All dissonance -- evokes some measure of the stress response (see below) but unsolved mysteries and inexplicable or extraordinary occurrences can also be haunting and even debilitating. As Camus observed, erroneous beliefs serve needs also: "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..." and as T.H. Huxley (1880) famously observed, "Irrationally held truths may be more harmful than reasoned errors."

Mindful of imperfect senses, reasoning involves corroboration and social validation, and we are confident of our beliefs to that extent. In an uncertain world, however, we can never have sufficient confidence. In such situations (aren't they all) we will deploy our full panoply of strategies or mechanisms and invest progressively more energy in approximating a belief about which there can be no doubt — a truth. We enlarge our confidence in beliefs by testing them against reality, by means of the neurophysiological processes of correspondence and coherence.

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III

REALITY TESTING

"There are two modes of knowing, 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"(Roger Bacon, 1268)*

Correspondence and coherence are venerable constructs in philosophy which may well reflect dispositions and intrinsic biases attributable to the biology of the brain. Correspondence relies on experience of the world and occurs "when the facts and the proposition are identical," "What a man believes upon grossly insufficient evidence is an index into his desires of which he himself is often unconscious. If a man is offered a fact which goes against his instincts, he will scrutinize it closely, and unless the evidence is overwhelming, he will refuse to believe it. If, on the other hand, he is offered something which affords a reason for acting in accordance to his instincts, he will accept it even on the slightest evidence. The origin of myths is explained in this way." (Bertrand Russell 1912) from his "Roads to Freedom"). That is, external "reality" matches its internal representation. "Knowledge is the conformity of the object and the intellect," said Averroës in the 12th century.

Correspondence began and continues to rely on (almost) random encounters with the world (as in infants) and then perceptions and curiosity. It is basically inductive and its processes provide the experiential premises of our inner representation of the world organized as cause-and-effect theories. First sensory contact of an organism with the world creates an impression □ a sensation which participates in the internal representation of the world. Internal representations then evoke responses that more or

less effectively cope with the environment, based in part on a previous experience, we behave in the most likely way to be successful, and much of this is coordinated by local mechanisms distributed throughout the body at the far reaches of the nervous system. There appears to be intrinsic pleasure that instantiates the seek-and-solve paradigm.

The economy of the body, mentioned earlier, will resist activation of a hierarchically higher mechanism to interpret and cope with a mismatch only when peripheral mechanisms have not resolved it. Dissatisfaction will lead to the problem being kicked upstairs to a higher hierarchical level, often energized by a growing stress response. Progressively more unresolved dissonance and the problem may evoke the most costly procedures of all, involving conscious attention. There is a large and rapidly growing literature of error-detection (van Veen and Carter 2006) encouraged by a distinctive signal (□error related negativity□ detected by eeg) and associated with the activity of the anterior cingulate cortex (van Veen and Carter 2002).

Functions of specific areas of the brain are becoming better known by means of emerging radiological techniques, although many researchers remain very wary of structure/function correlations. Still there are observations that may inspire hypotheses about specific brain functions humans use to test reality.

When the verbal centers of the left hemisphere (in a split-brain patient) do not have access to what was shown to the right hemisphere, they will make up a story. A right hemisphere lesion will lead to uncontrolled left hemisphere confabulating -- improvising plausible stories to rationalize missing data. In *spontaneous confabulation*, memories of past experiences

(rather than ongoing realities) dominate narratives (Schnider 2003), recalling the deep neurological relationship between memory and imagination (see Schachter et al. 2007).

Coherence involves "the quality or state of logical or orderly relationship of parts;" leading to a "united" or "orderly" whole. The process is internal and works with the percepts that correspondence provides. To ensure orderly integration of and access to experience, "narrative integration" of input is essential. At its best, our apparently continuous stream of consciousness is actually a series of frames, of "stills," of "snapshots" -- what Oliver Sacks called cinematic vision (Sacks 2004).

Internal representations of the world must "fit" with all preceding and collateral representations. Coherence is integral to cognition at every level, not least one's ineffable self, but is most publically manifest as our ability to create narrative: theories or stories based on likely causes and consequences. The need to narrate was put well by Kathryn Morton (1984): "A warp in the simian brain," she wrote, "made us insatiable for patterns--patterns of sequence, of behavior, of feeling--connections, reasons, causes: stories... Nothing passes but the mind grabs it and looks for a way to fit it into a story....Feverish for order... "

Coherence strengthens our confidence in internal representations by assimilating perceptions consistent with that model, reconciling internal contradictions, and accommodating anomalies. Coherence is basically deductive and can act to "inform" perceptions about what to expect. The power of expectations, we are learning in recent years, is a formidable, if not the key element of

conscious or non-conscious placebo effects (for example, Stewart-Williams and Podd. 2004).

A narrative is a more-or-less linear sequence of ideas, and a theory is a narrative about causal relationships. It is by means of testing predictions informed by theories that infants develop, and it is this mode of operation that grows with us and serves the scientist and the infant. Gopnik and colleagues have developed a powerful metaphor with their work on "the scientist in the crib" (for example, Gopnik et al. 1999). Agnes Arber (1954) points out that "when a scientist has a belief based on observations, its consistency with related beliefs based on other observations is an indication of the confidence we may have in its possible 'truth'" (p70). As Coleridge put it, "The imagination, organizing (as it were) the flux of the senses... gives birth to a system of symbols. . . consubstantial with the truths of which they are the conductors."

Confidence. When dissonances are significant enough to evoke levels of stress activation to a level that gets our attention, we either dedicate some effort to obtaining more or better data, enhancing coherence by utilizing new data, or considering more coherent reconfigurations of the data we have. As the literature of cognitive dissonance theory abundantly shows, stress often leads us to selectively neglect or enhance key information, and while our resulting model may not be accurate, it may be sufficient, and stress levels are reduced to the extent we are successful.

The processes of reality testing leading to confidence can motivate additional empirical testing: curiosity and exploration. They also encourage more elaborate or parsimonious narratives or texts into which experience is woven. The desire for confidence can range, of

course, from the frivolous to deep concern about one's "immortal soul."

When there is a perceived urgency of the need for increasing confidence, the activity invested in both establishing correspondence (by interacting with the environment) and coherence (by considering alternative narratives) may become intense. For example, Aouizerate (et al. 2004) identified obsessive collecting as one of the ways obsessive-compulsive disorder presents. In their review, they find stress-provoking erroneous internal perceptions as the central phenomenon and identify structures most prominent in their contribution to the disorder, including orbitofrontal cortex, the anterior cingulate cortex, the dorsolateral prefrontal cortex.

At higher levels of cognition, the two reality-testing processes may become asymmetrical when we are not satisfied with experiential evidence or the internal scheme for the organization of the evidence. To the extent that the urgency is perceived, elements of the autonomic nervous system -- the stress response - become engaged and energize the appropriate motivational system for meeting this particular need for increased confidence, the compass for which is "truth."

These sibling strategies are also, in Robert Sternberg's view key to the concept of intelligence. □... the more intelligent, adaptive person has achieved a higher degree of external correspondence and internal coherence in his or her knowledge based and belief structures. People think unintelligently to the extent to which they make errors in achieving external correspondence or internal coherence□ (Sternberg 1997:1031).

The tests of reality attributable to correspondence and coherence proceed in a progressive mutually

corroborating spiral of interactions, working together to provide confidence in the reality of a belief. As organisms that evolved to maximize biological fitness, beliefs need not be true, but simply *more valid* than those of competitors.

□ Truth □ is a necessarily unattainable goal that keeps efforts to enhance validity steering in what seems the most useful direction at any particular point in our progress. The processes of acquiring, sharing, and applying knowledge, like judgments about what could or should be known, are subjects of endless discourse. But there is little that penetrates the depth of our concern about the meaning of knowledge or illuminates the fragility of the boundary between knowledge and its absence as failures of the accustomed system manifested in the disorders of knowing.

Under Construction

IV

AGNOSIA and HYPERGNOSIA

□ *We work in the dark □ we do what we can □ we give what we have. Our doubt is our passion and our passion is our task. The rest is the madness of art.* □

Henry James

We may be more or less confident about our beliefs as processes of the senses and mind enable, but extraordinary extremes of the process

of establishing or utilizing beliefs can be instructive. Neurologists are familiar with an extensive array of failures of one or more parts of this process attributable to trauma or disease of the brain that leads to an inability to recognize the reality of specific kinds of experiences. This is agnosia, a state in which a person may not be able to recognize stimuli even though the sensory system is unimpaired itself. These are unlike everyday failures of knowing such as when an experience may be so unique that it does not accrue sufficient confidence to be taken seriously or in "attentional blindness" (e.g., Simmons, 2000), a common outcome of a percept being rejected for failing the test of coherence.

Among the most interesting of agnosias is *anosognosia*, a denial of illness or debility, often subsequent to right hemisphere brain trauma or stroke, is a striking example of a mismatch between one's perceptions and reality. It involves a denial ranging from indifference to striking vehemence, often despite (apparently) clear evidence to the contrary. Spontaneous anosognosia was characterized by Schnider (2003) as an "inability to adapt thought and behaviour to ongoing reality."

Hypergnosia, on the other hand is an extraordinarily intense confidence that an experience is true. It is particularly informative because of its extreme nature. The pursuit and solution of mystery can be imbued with intense urgency and the ensuing stress response powerfully energizing --- a pleasure that seems a heartbeat away from ecstasy. Einstein described the search for the insight that reconciles disparate ideas in terms that would credit a mystic in recalling "the years of searching in the dark for a truth that one feels but cannot express; the intense desire and the alterations of confidence and

misgiving, until one breaks through to clarity and understanding, are only known to him who has himself experienced them" (in Beveridge, 1950:81). Apparently, when confidence exceeds a certain threshold, the resolution of stress can provide a remarkable "release." Einstein echoed the great physiologist, Claude Bernard: "those who do not know the torment of the unknown cannot have the joy of discovery." The neurologist/essayist Oliver Sacks recalled seeing the periodic table of the elements: "The actual presence of these elements reinforced the feeling that these were indeed the elemental building blocks of the universe that the whole universe was here in microcosm. I had an overwhelming sense of truth and beauty when I saw the periodic table. I felt that this was not a mere human construct, arbitrary, but an actual vision of an eternal cosmic order, and that any future discoveries and advances, whatever they might add, would only reinforce, reaffirm, the truth of its order" (1999). Dostoevsky spoke of an "eternal harmony" that he occasionally experienced: "There are moments, and it is only a matter of five or six seconds, when you feel the presence of the eternal harmony ... a terrible thing is the frightful clearness with which it manifests itself and the rapture with which it fills you" (Alajouanine 1963).

We can see the steps taken and eloquently expressed by such intellectuals and scholars, but surely this intense experience is known to many who have abruptly discovered (or invented) a sense of ineffable and powerfully emotional insight.

The emotional component that might emerge when the processes of correspondence and coherence have gone as far as they could in an individual might be an extreme expression of the

perceptual and cognitive pleasure described by Biederman & Vessel (2006). They observed an increased density of receptors for opioids at the deepest association areas where contact with stored information was possible, thereby enabling a new stimulus access to a large reservoir of information. With their theory in mind, it is reasonable to speculate that these everyday pleasures can increase in intensity, perhaps orchestrated in part by the processes of the stress response, such that the excitation that began with an innocent perception could thereby gain access to the corpus striatum with its multiple loops connecting emotional centers to higher cortical areas and thereby link powerful emotional surges with enhanced insight.

A sense of possessing a transcendent belief that is □ truer than truth, □ often with a deep sense of peace and joy, seems to accompany the belief one has merged with the truth they sought. As Polanyi put it, "the personal participation of the knower in the knowledge he believes himself to possess takes place within a flow of passion. □ The passion becomes the final corroboration: □ We recognize intellectual beauty as a guide to discovery and as a mark of truth" (1958:300). This can be far more powerful than the satisfaction of a long sought understanding. It can be a uniquely explosive response in the spirit, corresponding perhaps, to d'Aquili and Newberg's "hyperlucid state of absolute unitary being" (AUB) with its □ extremely strong sense of reality that is in fact said to be "more real than baseline reality" (1999) In d'Aquili's view, while a baseline sense of reality needs sustained social corroboration, AUB can persist without it. This resonates with what Joseph Campbell (1968) termed □ aesthetic arrest: □ □ We may dance toward it and away, achieve glimpses, and even dwell in its beauty for a time; yet few are those

that have been confirmed in that knowledge of its ubiquity which antiquity called *gnosis* and the Orient calls *bodhi*: full awakening to the crystalline purity of the bed or ground of one's own and yet the world's true being. Like perfectly transparent crystal, it is there, yet as though not there; and all things, when seen through it, become luminous in its light (p 66). But does such an experience, transformative though it is, constitute belief? Or might the pursuit of confidence in beliefs simply be a preparation for deeper insights?

Agnosia and hypergnosia point to the manner in which the central nervous system coordinates the integration of correspondence and coherence in the pursuit of confidence. This pursuit also involves the three major integrative capacities of the brain — motivation, affect, and cognition — and the role of the physiological stress response in orchestrating their activity.

V

THE NEUROPSYCHOLOGY of BELIEF

Seeking the mind with the mind -- is this not the greatest of all mistakes?

Sengtsan (3rd Zen patriarch) Hsin

Hsin Ming: —Inscribed on the Believing Mind— By Sengtsan, third Chinese patriarch

<http://www.mendosa.com/way2.htm>

△

The direction taken here is in the spirit of the proposal by Johnstone and Glass (2008). Their research with brain-injured adults persuaded them that spiritual experience involves the interaction of multiple specialized neuropsychological structures. They noted that brain activity that coordinates ongoing and remembered experience are ordinarily highly coordinated. Thus, either trauma that impairs right parietal cortex function or conscious suppression of the same site, can enable a sense of selflessness that may then be interpreted by activity of the left temporal lobe in terms of remembered, culturally interpreted and instilled constructs. Indeed, reality testing itself involves biologically validated momentary experiences interpreted in terms of past experiences. In this relentlessly self-correcting updating of the meaning of experience, we conduct the vital business of distinguishing internal imagery from external stimuli.

It is notable that several important neuropsychiatric syndromes are associated with dysfunctions in the processes of reality-testing (correspondence), story-telling (coherence), or their integration. The role of the left cerebral hemisphere in creating coherence has been famous since Ramachandran and Blakeslee's charming and compelling *Phantoms in the Brain* (1998). They support the view, largely based on the evidence of disinhibition (release of a neural structure from the inhibitory influence of another site), that the left hemisphere includes structures that work to establish coherence.

Several lines of evidence converge on this view of reality testing. Notably, the phenomenon of anosognosia, mentioned above. In Ramachandran's (1996) view, the right hemisphere detects discrepancies between information from sensory input and information residing in cerebral schemas (probably residing in the left hemisphere); it then helps determine the salience of information and whether or not it should be relayed further for possible action. Excellent descriptions are provided by Ramachandran (1996) who describes and discusses related agnosias. In schizophrenia there is evidence that poor insight into one's disorder is related to anosognosia, (Lele & Joglekar 1998), as well as evidence that different neural pathways are engaged during novel recognition memory in patients with schizophrenia compared to healthy individuals (Crespo-Facorro et al. 2001).

In normal circumstances, gaps in the continuity of a narrative (and thus confidence in its veracity) can be accomplished by *interpolation*, in which the next best information available is plugged into place, much in the way the blind spot in the back of the retina uses information from adjacent cells to "fill in." Additionally, the process of *extrapolation* can enable predictions based on past experience, a plausible trajectory of events, likely facilitated by the extraordinary access imagination and memory have to each other (Hassabis et al 2007). [Indeed, the likely origin of abstractions such as time is likely based on experience and its representations \(Boroditsky and Ramscar 2002\)](#)

How are people able to think about things they have never seen or touched? We demonstrate that **abstract knowledge can be built analogically from more experience-based knowledge**. People's understanding of the abstract domain of time, for example, is so intimately dependent on the more experience-based domain of space that when people make an air journey or wait in a lunch line, they also unwittingly (and dramatically) change their thinking about time. Further, our results suggest that it is not sensorimotor spatial experience per se that influences people's thinking about time, but rather people's representations of and thinking about their spatial experience.

PMID: 11934006 [PubMed - indexed for MEDLINE] When gaps attributable to a failure of the right hemisphere's interaction with the left, special efforts are taken to maintain an apparently seamless and satisfying narrative. The processes responsible most likely coincide, at least in part, with a left hemisphere process nicknamed "the interpreter" by Gazzaniga (2000), a capacity "to make an inference about both internal bodily states and external actions of ourselves and others . . . a powerful system that is at the core of human belief formation . . ." (Gazzaniga 1992:113).

Information about left hemisphere functions suggest an important role in establishing a *sense* of coherence, even at the cost of interpolating implausible elements as it accommodates whatever fragments of experience it has access to. Apparently the comfort of a narrative that does not possess

gaps is sufficiently valued that conflicting percepts go unattended. This can evoke a sense of familiarity and stability (Ramachandran 1996) that reduces stress. High confidence also has distinct biological value if it allows access to and executes behavioral patterns that advance fitness. Ambivalence or indecision can undermine the effectiveness of individual behavior, and in social contexts, doubt can be contagious, undermining social and cultural undertakings predicated on confidence in the general validity of specific beliefs.

A significant contribution to the development and maturity of these processes may be play, including play in which there is a "willing suspension of disbelief," Samuel Taylor Coleridge's (1817/1985) hallmark of artistic creation -- overlooking the quality of coherence in the service of an enlarged insight. Like all play, the creation and appreciation of aesthetic objects is best undertaken in a safe environment, free of uncontrolled stress. Coleridge contrasted his view with that of his friend Wordsworth's advocacy of paying particular attention to novelty as a way of "awakening the mind's attention from the lethargy of custom" (Coleridge 1817/1985)

Much of the neuropsychological momentum for viewing the left hemisphere as an organ of coherence comes from evidence of disinhibition. Other information, clues in real or apparent support for the narrative of left hemisphere specializations for coherence, are needed from other sources where the shadow of possible confounds attributable to states of disease or damage are less dark. Of interest in this regard are

clues such as the left hemisphere's superiority in dealing with abstract object recognition as opposed to the right hemisphere's superior ability in specifics (Marsolek 1999), and its abilities in probabilistic as opposed to deductive reasoning, seen more clearly in the right hemisphere (Osherson et al 1998). Interestingly, after appropriate priming, a solution to a semantic problem presented to the right hemisphere by means of the left visual field was more likely to evoke a sense of sudden insight, than when presented to the right hemisphere (Bowden & Jung-Beeman, 2003). Apparently the □Aha!□ sense of sudden insight reported by participants, involved enhanced activity in the right superior temporal gyrus, as revealed by functional magnetic resonance imaging (Bowden et al. 2005).

Right hemisphere function in validating or at least enhancing confidence in beliefs appears more involved with a monitoring function. Correspondences of the organism's experience with the real world begins at the sense organs where a cascade of feedback loops enables countless adjustments to fine tune the organism to the circumstances it finds itself in. For example, the muscle spindle, a complex peripheral sense organ embedded in muscle, is continually responding to mismatches between the environment the motor program that anticipates general needs, and fine details of muscular action needed to cope with precision. Activities here and above continually inform higher centers of control of the ongoing negotiations, and only the detection of errors that cannot be adjusted at lower levels get very far

upstream This may constitute a nested hierarchy of interactions between the organism and its environment.

Stress. All behavior is an evanescent extension of morphological and physiological potential. The stress response consists of a host of coordinated physiological (including neurobehavioral) mechanisms specialized to cope with real or perceived challenges to real or perceived biological needs (Greenberg 2002). Needs in biology can be nicely correlated with the basic "need hierarchy" proposed by psychologist Abraham Maslow. For example, the psychological construct of □self-actualization□ corresponds to □maximized fitness,□ ideas linked by the motto □be all you can be.□

The motivational systems that serve these needs are neurologically ancient and highly integrated. Motivational systems, often thought of as □driving□ behavior are ever ready to be activated and guide the system to meet the current need. This state of readiness, however, is translated into adaptive activity only when the resources required to meet a perceived need are insufficient. The signal of insufficiency is the stress response. The physiological stress response is both a cause and a consequence of seeking and solving mysteries and its responses can range from mild autonomic arousal through dramatic panic. As mentioned above, it is evoked by even mild dissonance (Hadley 1996) such as discrepancies between perceptions and expectations (Goldstein 1987).

According to D.E. Berlyne (1960), novelty, uncertainty, or conflict are all particularly

effective in elevating arousal, presumably to cope with the mismatches they represent between resting and stimulated state. In his review of psychoendocrinology of stress, Seymour Levine (1993) observed that an adrenocortical stress response is evoked in proportion to the degree of discrepancy between current and prior experience of specific aspects of the environment. Selective activation of specific brain centers is at the heart of what Gerald Huether termed "the central adaptation syndrome" (1996), in which higher associative brain structures are affected by as much as they affect the deployment of the stress. In his conceptualization, brain centers that detect stress can initiate compensating actions considering both the urgency of the demands upon the organism and the perceived prospect for effective coping, particularly an assessment of the controllability of the situation. These same brain sites are subject to modification. The theory underscores the ability of the stress response to interact with and orchestrate adaptive responses as well as the initiating neurology.

In their recent review, Dedovic (et al. 2009), observed that a consistent consequence of the psychological stress (of difficult mental arithmetic) diminished activity in orbitofrontal regions (assigning emotional valence to stimuli, decision making, planning, expectations, and intuition). Bechara (et al. 2000) considers the orbitofrontal cortex vital to the decision making that is guided by "somatic markers" (afferent feedback signals

including emotions) that occur at many levels.

Some view this area as part of the limbic system, and other limbic areas (hippocampus) also had suppressed activity. The anterior cingulate cortex of the frontal lobe, on the other hand, was more active. This is a site associated with empathy, error-detection, and the assessing and modulating of emotional responses as well as the many autonomic functions influenced by the stress response. In the hierarchical scheme described earlier, progressively more expensive (in terms of arousal and attention) coping mechanisms are not recruited unless necessary.

Stress and Cognition. With respect to the influence of autonomic activation on cognition, a striking part of acute uncontrollable stress that underscores the sometimes paradoxical aspects of the response to stressors is the effect of the initial catecholamine release into body and brain. The catecholamines released (dopamine, norepinephrine, and epinephrine) reallocate internal resources to cope with emergency circumstances. These neuromodulators activate the amygdala (emotional expression and learning) while they suppress activity in the prefrontal cortex (associated with foresight and planning) (Arnsten 1998). The secondary longer-term coping response involves the steroid hormones of the adrenal cortex. de Kloet et al. (1999) observed that while the hormones of the stress response normally protect the brain and are necessary for cognition, damage in specific parts of the brain can be caused by extreme stress. Part

of this apparent paradox is resolved by the fact that there are two kinds of adrenal cortical steroid hormones, which affect the brain in different ways. Activation of receptors for these hormones in the brain usually favor adaptive coping behavior involving changes in attention and selection of appropriate responses, but if levels of activation of the two corticosteroid-receptor types are unbalanced by disproportionate secretion of the two hormone types, maladaptive responses can be evoked. Further, the stage of ongoing information processing (acquisition, consolidation, retention) affects the manner in which the brain will respond to the hormones

Stress is also a mainspring of creativity, which like most adaptive processes is energized by mild to moderate stress: it affects attention which may evoke close focus on possible stressors or a wide net of attention across a larger spectrum of stimuli. This rapid alternation of cognitive strategies --searching the repertoire and focusing on a specific option -- recalls "fight or flight," a snap decision made as intensity increases with apparent urgency of the situation. Under such pressures, familiar things may be seen in new ways and new phenomena may be seen free of perceptual bias, such as inattentional blindness.

As an organism's resources are reallocated by the stress response to cope with the ongoing or anticipated challenge. In an echo of the fight or flight response, distress is manifest when the consequences of the stressor are perceived as dangerous to biological fitness, while eustress is experienced when the challenge represents

an opportunity to enhance one's prospects
, depending on expectations, emotional
valence, and perceived controllability of the
stressors.

VI

ENVOI

"always becoming, never
is." (Schiller)

This view of truth, like most of an organism's
critical functions, is one of dynamic relationships
between inner and outer worlds, between memory
and imagination, and between valid particulars
and plausible generalities. A cascade of
subsequent approximations by which our
relentless ambition to achieve it is, in the words
of Schiller, "always becoming, never is" *
(quoted by Greenberg 2004)

BIBLIOGRAPHY

Alajouanine, T. 1963. Dostoevsky's epilepsy. *Brain* **86**:209-221.

Alexander, J. K., Hillier, A., Smith, R M., Tivarus, M. E.,
& Beversdorf, D. Q. 2007. Beta-adrenergic modulation of

cognitive flexibility during stress. *Journal of Cognitive Neuroscience* **19(3)**:468-478.

Allman, J. M., Watson, K. K., Tetreault, N. A., & Hakeem, A. Y. 2005. Intuition and autism: a possible role for Von Economo neurons. *Trends in Cognitive Sciences* **9(8)**:367-373.

Amat, J., Evan, P., Zarza, C., Watkins, L. R., & Maier, S. F. 2006. Previous experience with behavioral control over stress blocks the behavioral and dorsal raphe nucleus activating effects of later uncontrollable stress: role of the ventral medial prefrontal cortex. *Journal of Neuroscience* **26(51)**:13264-13272.

Amos, A. 2000. A computational model of information processing in the frontal cortex and basal ganglia. *Journal of Cognitive Neuroscience* **12(3)**:505-519.

Aouizerate, B., Guehl, D., Cuny, E., Rougier, A., Bioulac, B., Tignol, J. & Burband, P. 2004. Pathophysiology of obsessive-compulsive disorder: a necessary link between phenomenology, neuropsychology, imagery and physiology. *Progress in Neurobiology* **72(3)**:195-221.

Arbor, A. 1954. *The mind and the eye*. Cambridge University Press, New York.

Arnsten, A. F. T. 1999. The biology of being frazzled. *Science* **280(5370)**:1711-1712.

Bandler, R., Keay, K., Floyd, N., & Price, J. 2000. Central circuits mediating patterned autonomic activity during active vs. passive emotional coping. *Brain Research Bulletin* **53**:95-104.

Baram, T. Z., Yi, S., Avishai-Eliner, S., & Schultz, L. 1997. Development neurobiology of the stress response: multilevel regulation of corticotropin-releasing hormone function. *Annals of the New York Academy of Sciences* **814**:252-265.

Bechara, A., Damasio H, Damasio AR. 2000. Emotion, decision making and the orbitofrontal cortex. *Cereb Cortex*. **10(3)**:295-307

Bechtereva. N. P., Shemyakina, N. V., Starchenko, M.G., Danko, S. G., & Medvedev, S. V. 2005. Error detection mechanisms of the brain: background and prospects. *International Journal of Psychophysiology* **58(2-3)**:227-234.

Beggs, J. M., & Plenz, D. 2003. Neuronal avalanches in neocortical circuits. *Journal of Neuroscience* **23(35)**:11167-11177.

Beggs, J. M., & Plenz, D. 2004. Neuronal avalanches are diverse and precise activity patterns that are stable for many hours in cortical slice cultures. *Journal of Neuroscience* **24(22)**:5216-5229.

Berlyne, D. E. 1960. *Conflict, Arousal, and Curiosity*. McGraw-Hill, New York.

Berridge, K. C. 2003. Pleasures of the brain. *Brain and Cognition* **52**:106-128

Biederman, I. & [Vessel](#), E. 2006. Perceptual pleasure and the brain. *American Scientist* **94 (3)**:247.

Blakeslee, S. 2008. Flesh made soul. *Science and Spirit* **19(2)**:26-31.

Blanke, O. 2004. Out-of-body experience and autoscopia of neurological origin. *Brain* **127(2)**:243-258.

[Boroditsky L](#), [Ramscar M](#). 2002. The roles of body and mind in abstract thought. *Psychol Sci*. **13(2)**:185-189.

Bowden, E. M. & Jung-Beeman, M. 2003. Aha! Insight experience correlates with solution activation in the right hemisphere. *Psychonomic Bulletin & Review* **10(3)**:730-737.

Bowden, E.M., Jung-Beeman, M., Fleck, J., & Kounios, J. 2005. New approaches to demystifying insight. *Trends in Cognitive Sciences* **9(7)**:322-328.

Burghardt, G. M. 2005. *The Genesis of Animal Play*. MIT Press, Cambridge, MA.

Campbell, J. 1968. *The Masks of God: Creative Mythology*. The Viking Press, New York. p. 66.

Camus, A. 1942. *Le Mythe de Sisyphe* (translated by Justin O'Brien in 1955).

Carlyle, T. 1909-14. Characteristics. *The Harvard Classics* **25(3)**: Paras. 40-58.

Charmandari, E., Kino, T., Souvatzoglou, E., & Chrousos, G. P. 2003. Pediatric stress: hormonal mediators and human development. *Hormonal Research* **59(4)**:161-179.

Conway, M. A., Pleydell-Pearce, C. W., Whitecross, S. E., & Sharpe, H. 2003. Neurophysiological correlates of memory for experienced and imagined events. *Neuropsychologia* **41**:334-340.

Cotterill, R. M. J. 2001. Cooperation of the basal ganglia, cerebellum, sensory cerebrum and hippocampus: possible implications for cognition, consciousness, intelligence and creativity. *Progress in Neurobiology* **64**:1-33.

Crespo-Facorro, B., Wiser, A. K., Andreasen, N. C., O'Leary, D. S., Watkins, G. L., Boles-Ponto, L. L., & Hichwa, R. D. 2001. Neural basis of novel and well-learned recognition memory in schizophrenia: a positron emission tomography study. *Human Brain Mapp* **12(4)**:219-231.

Critchley, H. D. 2005. Neural mechanisms of autonomic, affective, and cognitive integration. *Journal of Comparative Neurology* **493**:154-166.

d'Aquili, E. G. & Newberg, A. B. 1999. *The Mystical Mind*. Fortress Press, Minneapolis, MN.

Daffner, K. R., Scinto, L. F., Weitzman, A. M., Faust, R., Rentz, D. M., Budson, A. E., & Holcomb, P. J. 2003. Frontal and parietal components of a cerebral network mediating voluntary attention to novel events. *Journal of Cognitive Neuroscience* **15**(2):294-313.

Dai, D. Y. & Sternberg, R. J. 2004. Beyond cognitivism: toward an integrated understanding of intellectual functioning and development. *Motivation, Emotion, and Cognition*. Erlbaum Associates, Mahwah, NJ, pp. 3-38.

de Kloet, E.R., Oitzl, M.S. & Joëls, M. 1999. Stress and cognition: are corticosteroids good or bad guys? *Trends in Neurosciences* **22** (10):422-426.

Delacroix, E. *Journal*. 1893-1895. Cited by Etienne Gilson. 1957:132. Dedovic, K., D'Aguiar, C., and Pruessner, J.C. 2009. What stress does to your brain: a review of neuroimaging studies. *Can. J. Psychiatry*. **54**(1):6-15.

Dellu, F., Piazza, P. V., Mayo, W., Le Moa, M., & Simon, H. 1996. Novelty-seeking in rats - biobehavioral characteristics and possible relationship with the sensation-seeking trait in man. *Neuropsychobiology* **34**(3):136-145.

Diamond, D. M. 2005. Cognitive, endocrine and mechanistic perspectives on non-linear relationships between arousal and brain function. *Nonlinearity in Biology, Toxicology, and Medicine* **3**:1-7.

Fink, G.R., Halligan, P.W., Marshall, J.C., Frith, C.D., Frackowiak, R.S., & Dolan, R.J. 1996. Where in the brain does visual attention select the forest and the trees? *Nature* **382**(6592):626-628.

Fink, G.R., Marshall, J.C., Halligan, P.W., Frith, C.D., Frackowiak, R.S., & Dolan, R.J. 1997. Hemispheric specialization for global and local processing: the effect of

stimulus category. *Proceedings of the Royal Society B: Biological Sciences* **264 (1381)**:487-494.

Gazzaniga, M. S. 1992. *Nature's Mind*. Basic Books, New York.

Gazzaniga, M. S. 2000. Cerebral specialization and interhemispheric communication. *Brain*, **123(7)**:1293-1326.

Goldstein, D.S. 1987. Stress-induced activation of the sympathetic nervous system. *Baillieres Clin. Endocrinol. Metab.* 1:253-278.

Goldstein, D. S. 1990. Neurotransmitters and stress. *Biofeedback and Self-Regulation* **15 (3)**:243-272.

Gopnik, A., Meltzoff, A. N. & Kuhl, P. K. 1999. *The Scientist in the Crib*. William Morrow, New York.

Graybiel, A. M. 1997. The basal ganglia and cognitive pattern generators. *Schizophrenia Bulletin* **23 (3)**:459-69.

Greenberg, N., Carr, J. A., & Summers, C. H. 2002. Causes and consequences of the stress response. *Integrative and Comparative Biology* **42(3)**:508-516.

Greenberg, N. 2004. Play and the brain. In R. Clements & L. Fiorentino (Eds.) *The Child's Right to Play: A Global Approach*. Greenwood Publishing Group, Westport, CT, pp. 307-327.

Hadley, M. E. 1996. *Endocrinology*. 4th ed. Prentice Hall, Upper Saddle River, NJ.

[Hassabis, D.](#), [Kumaran, D.](#), [Vann, S. D.](#), & [Maguire, E. A.](#) 2007. Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences of the United States of America* **104(5)**:1726-1731.

Held, K. 2002. The origin of Europe with the Greek discovery of the world (Translated by Sean Kirkland). *Epoché* **7(1)**:81-105.

Herman, J. P., Figueiredo, H., Mueller, N. K., Ulrich-Lai, Y., Ostrander, M. M., Choi, D. C., & Cullinan, W. E. 2003. Central mechanisms of stress integration: hierarchical circuitry controlling hypothalamo-pituitary-adrenocortical responsiveness. *Frontiers in Neuroendocrinology* **24(3)**:151-180.

Hermans, D., Martens, K., De Cort, K., Pieters, G., & Eelen, P. 2003. Reality monitoring and metacognitive beliefs related to cognitive confidence in obsessive-compulsive disorder. *Behavior Research and Therapy* **41**:383-401

Huether, G. 1996. The central adaptation syndrome: psychosocial stress as a trigger for adaptive modifications of brain structure and brain function. *Progress in Neurobiology* **48**:569-612.

Hutcheon, P. D P. 1996. *Leaving the Cave: Evolutionary Naturalism in Social-Scientific Thought*. Wilfrid Laurier University Press, Ontario, Canada. (p. 373)

Huxley, T. H. 1880. "On the Coming of Age of the Origin of Species," in *Darwiniana*. Appleton, New York.

Joachim, HH. (1906/1939). 1954. Cited by Agnes Arbor in *The Mind and the Eye*, Cambridge University Press, p. 70.

Johnstone, B. & B.A. Glass. 2008. Support for a neuropsychological model of spirituality in persons with traumatic brain injury. *Zygon* **43(4)**:861-874

Kester, K. B. & Pickle, Jr., J. W. 2000. Knowing in part, trusting in more: an essay on truth and reality in science and religion. *Soundings* **83(3-4)**:781-801.

Kitzbichler, M. G., Smith, M. L., Christensen, S. R., Bullmore, E. 2009. Broadband criticality of human brain

network synchronization. *PLoS Computational Biology* **5(3)**:e1000314.

Kounios, J. Fleck, J. I., Green, D. L., Payne, L., Stevenson, J. L., Bowden, E. M., & Jung-Beeman, M. 2008. The origins of insight in resting-state brain activity. *Neuropsychologia* **46**:281-291.

Lele, M. V. & Joglekar, A. S. 1998. Poor insight in schizophrenia: neurocognitive basis. *Journal of Postgraduate Medicine* **44(2)**:50-55.

Levine, S. 1993. The psychoendocrinology of stress. *Annals of the New York Academy of Science*. **697**:61-69.

Li, C. T., Poo, M. & Dan, Y. 2009. Burst spiking of a single cortical neuron modifies global brain state. *Science* **324**:643-648.

Lorenz, K. Z. 1981. *The Foundations of Ethology*. Springer-Verlag, New York.

Lumsden, C. J., 1991. Aesthetics. In M. Maxwell (Ed.) *The Sociobiological Imagination*. State University of New York Press, Albany, NY, pp. 253-268.

Luu, P. & Posner, M. I. 2003. Anterior cingulate cortex regulation of sympathetic activity *Brain* **126(10)**: 2119-2120.

MacLean, P. D. 1994. Human nature: duality or triality? *Politics and the Life Sciences* **13(1)**:107-119. Contribution to a symposium on "The Duality of Human Nature."

MacLean, P. D. 1997. The brain and subjective experience: question of multilevel role of resonance. *Journal of Mind and Behavior* **18(2-3)**:247[145]-268[166].

Marsolek, C. J. 1999. Dissociable neural subsystems underlie abstract and specific object recognition. *Psychological Science* **10(2)**:111-117.

- Maslow, A.H. 1943. A theory of human motivation. *Psychological Review* **50(4)**:370-396.
- Mateo, J. M. 2008. [Inverted-U shape relationship between cortisol and learning in ground squirrels. *Neurobiology of Learning and Memory* **89\(4\)**:582-590.](#)
- Mattson, M. P. 2008. Hormesis defined. *Aging Research Reviews* **7**:1-7.
- McEwen, B. S. 1999. Stress and hippocampal plasticity. *Annual Review of Neuroscience*. **22**:105-122.
- McEwen, B. S., Sapolsky, R. M. 1995. Stress and cognitive function. *Neurobiology* **5(2)**:205-216.
- Miller, M. B. & Valsangkar-Smyth, M. 2005. Probability matching in the right hemisphere. *Brain and Cognition* **57**:165-167.
- Morton, K. 1984, December 23. □The Story-Telling Animal. □ *New York Times Book Review* (Web archive).
- [Nesse, R. M. & Berridge, K. C. 1997. Psychoactive Drug Use in Evolutionary Perspective. *Science* **278\(5335\)**: 63-66.](#)
- Newberg, A. & d'Aquili, E. 1997. Wired for the ultimate reality. *Science & Spirit* [[article](#)].
- Osherson, D. N., Perani, D., Cappa, S., Schnur, T., Grassi, F. & Fazio, F. 1998. Distinct brain loci in deductive versus probabilistic reasoning. *Neuropsychologia* **36(4)**:369-376).
- Otto, R. & Harvey, J. W. (translator). 1923/1958. *The Idea of the Holy: An Inquiry into the Non Rational Factor in the Idea of the Divine*. pp.12-13. reprinted Oxford University Press.

Peoples, L. L. 2002. Perspective: will, anterior cingulate cortex, and addiction. *Science* **296(5573)**:1623-1624.
<http://www.sciencemag.org/cgi/content/full/296/5573/1623>.

Piazza, P. V., Deroche, V., Deminiere, J. M., Maccari, S., Le Moal, M., & Simon, H. 1993. Corticosterone in the range of stress-induced levels possesses reinforcing properties: implications for sensation-seeking behaviors. *Proceedings of the National Academy of Science of the United States* **90(24)**:11738-11742.

Qiu, J., Li, H., Yang, D., Luo, Y., Li, Y., Wu, Z., & Zhang, Q. 2008. The neural basis of insight problem solving: an event-related potential study. *Brain and Cognition* **68**:100-106.

Ramachandran, V. S. 1995. Anosognosia in parietal lobe syndrome. *Consciousness and Cognition* **4**:22-51.

Ramachandran, V. S. 1996. The evolutionary biology of self-deception, laughter, dreaming and depression: some clues from anosognosia. *Medical Hypotheses* **47**:347-362.

Ramachandran, V. S. & Blakeslee, S. 1998. *Phantoms in the Brain*. William Morrow, New York.

Ranganath, C. & Rainer, G. 2003. Neural mechanisms for detecting and remembering novel events. *Nature Reviews Neuroscience* **4**:193-202.

Rickelman, B. L. 2004. Anosognosia in individuals with schizophrenia: toward recovery of insight. *Issues in Mental Health Nursing* **25(3)**:227-242.

Russell, B. 1912. *The Problems of Philosophy*. Oxford University Press. 1959/1972; hypertext prepared 1998 by A. Chucky. <http://www.ditext.com/russell/russell.html>.

Sacks, O. 1985. *The Man who Mistook his Wife for a Hat*. Summit Books, New York.

Sacks, O. 2002. Brilliant light: a chemical boyhood. Essay on Fathom.com <http://www.fathom.com/feature/35266/>.

Sacks, O. 2004. In the river of consciousness. *New York Review of Books* **51(1)**.

Salamone, J. D. 1994. The involvement of nucleus accumbens dopamine in appetitive and aversive motivation. *Behavioral Brain Research* **61**:117-133.

Schacter, D.L., Addis, D.R. & Buckner, R.L. 2007 . Remembering the past to imagine the future: the prospective brain. *Nature Reviews: Neuroscience* **8**:657-661

Schnider, A. 2003. Spontaneous confabulation and the adaptation of thought to ongoing reality. *Nature Reviews Neuroscience* **4**:662-671.

Shidara, M. & Richmond, B. J. 2002. Anterior cingulate: single neuronal signals related to degree of reward expectancy. *Science* **296 (5573)**:1709-1711.

Simmons, D.J. 2000. Attentional capture and inattention blindness. *Trends in Cognitive Sciences* **4(4)**:147-155.

Smith, S. D., Tays, W. J., Dixon, M. J., & Bulman-Fleming, M. B. 2002. The right hemisphere as an anomaly detector: evidence from visual perception. *Brain and Cognition* **48(2-3)**:574-579.

Smith, S. D., Dixon, M. J., Tays, W. J., & Bulman-Fleming, M. B. 2004. Anomaly detection in the right hemisphere: the influence of visuospatial factors. *Brain and Cognition*. **55(3)**:458-462.

Sternberg, R. J. 1997. The Concept of intelligence and its role in lifelong learning and success. *American Psychologist* **52 (10)**:1030-1037.

Stewart-Williams, S., Podd, S., & Podd, J. 2004. The placebo effect: dissolving the expectancy versus

conditioning debate. *Psychological Bulletin* **130**
(2):324-340.

[Tsigos, C.](#), & [Chrousos, G. P.](#) 2002. Hypothalamic-pituitary-adrenal axis, neuroendocrine factors and stress. *Journal of Psychosomatic Research* **53**(4):865-871.

Vallee, M., Mayo, W., Dellu, F., LeMoal, M., Simon, H., & Maccari, S. 1997. Prenatal stress induces high anxiety and postnatal handling induces low anxiety in adult offspring: correlation with stress-induced corticosterone secretion. *Journal of Neuroscience* **17**(7):2626-2636.

van Veen, V. & Carter, C. S. 2002. The anterior cingulate as a conflict monitor: fMRI and ERP studies. *Physiology & Behavior* **77**(4-5):477-82.

Van Veen, V and C.S. Carter. 2006. Error detection, correction, and prevention in the brain: a brief review of data and theories. *Clin EEG neurosci* **37**(4):330-335.

Waltz, J. A., Knowlton, B. J., Holyoak, K. J., Boone, K. B., Mishkin, F. S., de Menezes Santos, M., Thomas, C. R., & Miller, B. L. 1999. A system for relational reasoning in human prefrontal cortex. *Psychological Science* **10**(2):119-125.

Wolford, G., Miller, M. B., & Gazzaniga, M. 2000. The left hemisphere's role in hypothesis formation. *The Journal of Neuroscience* **20**:RC64:1 of 4. of which they are the conductors."

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. ENDNOTES

I.

opening lines of *Metaphysics* by Aristotle, translated by W. D. Ross, Book I, Part 1.

<http://www.classicallibrary.org/aristotle/metaphysics/book01.htm>

Dement, I. 1992. Let the mystery be. On *Infamous Angel*. Songs of Iris/Forerunner Music Inc/ASCAP, Warner Brothers. On web at http://www.coquet-shack.com/lyrics/Dement_Iris/Let_The_mystery_Be_1289.htm

□ The more we learn about the world, and the deeper our learning, the more conscious, specific, and articulate will be our knowledge of what we do not know, our knowledge of our ignorance. For this, indeed, is the main source of our ignorance--the fact that our knowledge can be only finite, while our ignorance must necessarily be infinite □ Karl R. Popper. 1968. *Conjectures and Refutation*. HarperCollins Publishers, p.28.

II.

Nam et ipsa scientia potestas est. [For knowledge itself is power. Francis Bacon, *Meditations Sacrae*. 1597. Of Heresies (similarly, The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human Empire, to the effecting of all things possible. *New Atlantis*, 1627).

□ 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. His exile is without remedy since he is deprived of the memory of a lost home or the hope of a promised land □ 1942. *Le Mythe de Sisyphe* translated by Justin O'Brien in 1955. (Camus 1942/1955)

III

Roger Bacon, (1268) *Opus Majus*,, Part VI, chapter I, trans. R. B. Burke, *The Opus Majus of Roger Bacon* (1928), Vol. 2, 583. Available at

http://www.todayinsci.com/B/Bacon_Roger/BaconRoger-Quotations.htm 7/3/2009

Bertrand Russell (1912) "Roads to Freedom"

Averroës 12th century opus, *Destructio destructionum* (trans in 1328 and 1526).

Coleridge, S. T. 1816. Lay sermons. *The Statesman's Manual*. Web published by Google Books, and in 1817. *Biographia Literaria*. Chap. 14:314. In *Samuel Taylor Coleridge*. 1985. H.J. Jackson (Ed.). Oxford University Press, New York.

IV

Henry James quoted in analysis by Joyce Carol Oates. The Madness of Art: Henry James's "The Middle Years" *New Literary History* 27.2 (1996) 259-262

V.

Hsin Hsin Ming: □ Incribed on the Believing Mind □ By Sengtsan, third Chinese patriarch
<http://www.mendosa.com/way2.htm> .

VI

□ Perfection of Practice, like completeness of Opinion, is always approaching, never arrived; Truth, in the words of Schiller, *immer wird, nie ist*; never is, always is *a-being*. □ from Thomas Carlyle (1795: 1881), *Characteristics*. The Harvard Classics. 1909-14; Paras. 40-58; available on-line at
<http://www.bartleby.com/25/3/3.html>

"What a man believes upon grossly insufficient evidence is an index into his desires of which he himself is often unconscious. If a man is offered a fact which goes against his instincts, he will scrutinize it closely, and unless the evidence is overwhelming, he

will refuse to believe it. If, on the other hand, he is offered something which affords a reason for acting in accordance to his instincts, he will accept it even on the slightest evidence. The origin of myths is explained in this way." (Bertrand Russell, from his "Roads to Freedom").

[What do we really know? "At Lake Scugog"](#)

[*return to Greenberg home page*](#)
