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Whole-Brain Thinking in Systems Architecting

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ABSTRACT

This position paper[†] explores the role of whole-brain thinking in the context of systems architecting. Brain research indicates that the brain is dual and that each of its hemispheres interprets the world differently; the concept is commonly referred to as right-brain and left-brain thinking, or sometimes R-mode and L-mode for short. L-mode denotes step-by-step linear thinking. R-mode is integrative and holistic. It pays to extend this to systems architecting. For example, there may be two ways to look at complexity, analytically and holistically. Step-by-step analysis is well suited for low-dimensional complexity. As complexity increases methodical analytical skills become overwhelmed and we are bogged down, maybe even forced into complacent partial representation—tunnel vision. Learning to "see" the complex may benefit from a shift from the analytical to the holistic, from L-mode to R-mode thinking, or a better blending of the two. We begin with a cursory review of brain theory and applications thereof in drawing, management and creativity theory, and then follow up with observations of blended L/R-mode thinking in the context of systems architecting. Our hope is to distill from these sources whole-brain mental strategies that may be relevant to systems architects.
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Key words: whole brain; L-mode; R-mode; creativity; complexity; ambidextrous thinking

1. INTRODUCTION

During a lecture on probability theory, Professor George Friedman advises his students to "let the right brain help" [Friedman, 2005]. A few notional excerpts from that lecture are reproduced in Figure 1. At a glance

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†Hopefully, a precursor to formulating generative hypotheses and conducting future experiments.

Systems Engineering

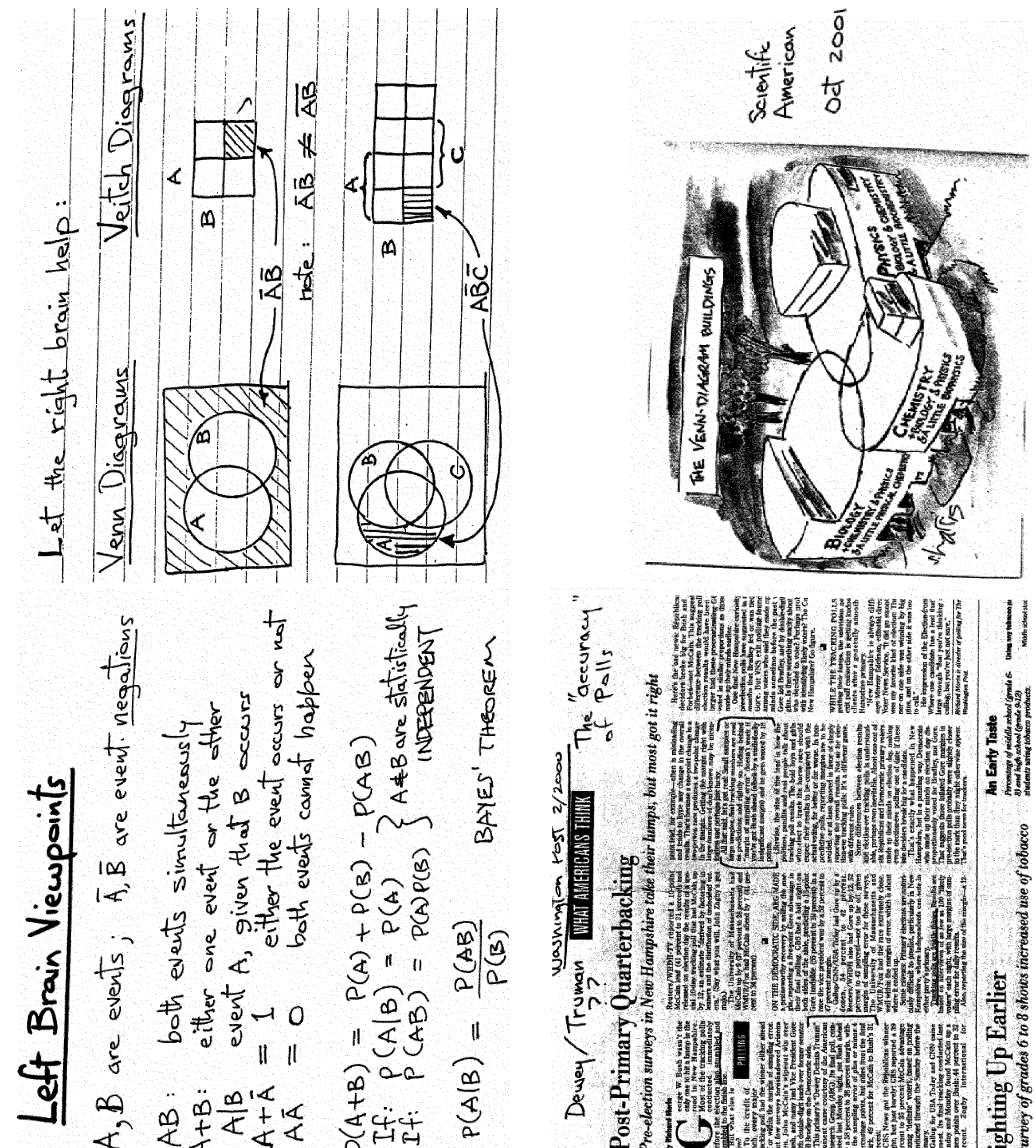

Figure 1. Multimodal lecture notes on Probabilistic Perceptions [Friedman, 2005].

the reader will recognize that Friedman brings multiple interpretations to bear on a subject, and, as any of his students or colleagues may attest to, these multiple perspectives allow him to delve deep into subjects, draw rich world views, make connections, and, habitually, spot insidious inconsistencies lurking beneath superficial plausibility.

This paper was in fact inspired by the, so to speak, *epiphany* that Friedman, one of the great systems architects of our time, is a remarkable whole-brain thinker. Readers may ask what qualifies us, the authors, to speak of such cognitive abilities, or even systems architecting. We approach this paper not as cognitive scientists or as architects per se, but as engineers with one foot in engineering and the other in the arts, a practiced stance which we feel allows us to spot and appreciate a well-honed whole-brain thinker when we see one.

It is our conjecture that architecting benefits from whole-brain thinking, and we set out to explore ways to develop this kind of mental agility, by focusing our attention on that which is normally neglected in engineering curriculum, namely the right-brain and creativity.

For our limited purpose we adopt a weak but serviceable definition of *creativity* as a generative act which extends a general knowledge domain such as arts, science, or technology. Also within this admittedly limited context we introduce our admittedly limited concept of an architect—a *creative* person with an *affinity for the complex whole of things*. Thus, in our view, the architecting of systems benefits from creative thinking, which to a great extent is still an unknown process.

Arguably, creativity engages conscious, semiconscious, and even subconscious brain activity. The not uncommon experience of having dreamed the solution to a particularly vexing problem hints at the latter. However, system engineering *tools* are largely based on analytical thinking that engages primarily the conscious mind and have been thought to mostly involve the left brain, which is well attuned to differentiation and component isolation, symbolization, comparison, measurement, and linear deduction.

Creative ideas are generally conceived through non-segregation (or integration) and recognition of connectivity, and generally start by formation of initially ambiguous, and typically infeasible or vague, amorphous conceptions—through right-brain thinking. We propose that a system architect starts from such stand points and by using a harmonious interplay between the right and left brain arrives, often through several iterations, at a final solution which is both creative and practical.

In other words, this continual iterative process, which involves a constant rethinking and questioning of the central premises and of each of the links involved in the final solution, appears to draw upon both conscious and subconscious abilities [Udwadia, 1986b].

2. THE DEVELOPMENT OF A SYSTEMS ARCHITECT

According to Rechtin [1991], the most reliable method of development of architects is through mentoring and progressive increases in responsibility. Rechtin emphasizes the following relevant qualities, which he characterizes as traits:

1. Communication skills
2. High tolerance for ambiguity*
3. The ability to make good associations of ideas
4. The ability to work consistently at an abstract level*
5. A level of technical expertise
6. A tempered ego; the opposite of arrogance
7. Leadership; gets the most out of others
8. The willingness to backtrack, to seek multiple solutions*
9. The ability to build teams
10. Charisma
11. The ability to read people well
12. Self-discipline, self-confidence, a locus of control*
13. A purpose orientation*
14. A sense of faith or vision*
15. Drive, a strong will to succeed*
16. Curiosity, a generalist's perspective.*

Rechtin [1991, p. 290] goes on to add that if all these "traits were found in full strength in a single person, that would make the architect an astonishing individual indeed!" Yes, this is a tall order, and frankly a tad intimidating. Thus perhaps, Rechtin quickly follows up with an abridged list that is slightly more tractable. This short list is indicated above with an asterisk.

Indeed, we feel the short list is closer to the core. Altogether the emphasis is on energy, attitude, and creativity. Rechtin [1991] actually sums it up as a "world" with a lot of right brain reasoning—a kind of gestalt process, with "taste" and above all creativity.

Furthermore, while the above attributes may be relevant to architecting, we maintain that the major creativity "drivers" operate at both the highest level of human value systems, and in ordinary ways of life (life "styles"). These drivers, therefore, may be listed as follows:

1. Taking joy in the creative process

2. Having grand visions that extend beyond one's life
3. Strong and true intention for making lasting impacts
4. Being self-driven, and having self-confidence
5. Taking time to be silent and empty (free from psychological inertia), an observer
6. Observing deeply and recognizing the limitless possibilities even in seemingly insignificant phenomena
7. Intense focus (living inside your problem) and work with high throughput
8. Enthusiasm (i.e., tolerance for failure—the willingness to backtrack, to seek multiple solutions without loss of enthusiasm)
9. The willingness to seek multiple solutions (be divergent)
10. Detachment from static (preconceived) results
11. Child-like curiosity and freedom to freely associate (anything, not just ideas)
12. Imagination and ease of thinking at abstract levels
13. Ability to design in the infeasible realm and tolerance for ambiguity and incompleteness
14. Being multifaceted (i.e., being a Renaissance person)
15. Having reliable scientific knowledge and experience to attain practicality and optimality through quantitative, analysis based effort (left brain activity).

What sort of person possesses all these qualities? Many of these attributes are right-brain related, but a few, especially the last one, involve left-brain thinking. These two distinguishable ways of thinking (cognitive processes) may be characterized as: (1) quantitative, calculative, comparative, judgmental, (i.e. left-brain thinking) and (2) qualitative, nonjudgmental, visual, and more in tune with nature (i.e. right-brain thinking). Both have purpose and both must be used. The question is how to assign priority to one or the other way of thinking—ambidextrous thinking. Indeed, one could paraphrase Dorothea Brande, to say that you must teach yourself not as though you were one person, but perhaps two [Brande, 1934]. Udwadia [1986a] stresses the role of multiple perspectives in assessing a situation as one way in which the left brain-right brain interaction can be facilitated in a continually iterative process of exploration.

Accordingly, we suggest, an architect—a creative person with an affinity for the complex whole of things—is a whole-brain thinker for whom the inception of creative ideas is through right brain thinking, and pragmatic manifestation of those ideas is through concomitant left brain thinking. Of course, creativity and analysis are used at all stages up and down the chain of abstraction of system building. Therefore, the system architecting process is a continual, ongoing inter-*play* between the right and left brain. We will now explore the basis of *ambidextrous thinking* a bit further.

3. SOME BRAIN THEORY

Gabriel Rico provides a very readable recount of developments in brain duality theory [Rico, 1983]. The discovery of brain duality apparently began with the observations of English physician A. L. Wigan in 1844. In performing an autopsy on a long-time friend and patient, Wigan discovered that his friend, whose behaviour had been normal in every respect until his death, had only one hemisphere. This discovery led him to speculate that if only one hemisphere can constitute a mind—as clearly as had been the case with his friend—then the fact that nature has given us two hemispheres may mean we are in possession of two minds.

One hundred years later, a scientific report described the spread of epileptic discharge from one hemisphere to the other in the brains of monkeys. This paper suggested that the seizure spread largely or entirely by way of the corpus callosum—fibers connecting regions of the left brain with similar areas of the right [Springer and Deutsch, 1993]. This suggested a new last-resort treatment for patients with epilepsy that could not be controlled in other ways: the split-brain operation. William Van Wagenen performed the first split-brain operation on a human in the early 1940s [Springer and Deutsch, 1993]. Post-surgical testing showed surprisingly little evidence of deficits in perceptual and motor abilities. A decade later, Roger Sperry of the California Institute of California, working with split-brain patients, demonstrated that the left and right hemispheres generate two streams of conscious awareness, each to some extent unaware of the other. Sperry was awarded the 1981 Nobel Prize in Physiology or Medicine for this work.

Among other duties, the left hemisphere is responsible for most aspects of communication. It processes hearing, written material, and body language. The right hemisphere processes images, melodies, modulation, complex patterns such as faces, as well as the body's spatial orientation [Kraft, 2005]. Udwadia [1986a] provides a short list of left brain versus right brain functions and points out that multiple perspectives provided especially by the so-called nonexperts (like a product's prospective customers) in a particular field can enhance not just the development of creative solutions but the proper framing of relevant questions and the situations that need to be answered through creative thinking [Udwadia and Mitroff, 1988; Udwadia and Kumar, 1991].

4. SOME APPLICATION OF WHOLE BRAIN IDEAS

This concept of brain duality has inspired many cognitive theories and mental strategies. Together, these theories and strategies blend to paint a picture of possibilities for a would-be whole-brain thinker. Here we list a few that we found to be relevant.

L-Mode, R-Mode. Dr. Betty Edwards' [1979] work may be the most popular brain duality spin-off. Dr. Edwards has used the terms L-mode and R-mode to designate two ways of knowing and seeing—the verbal, analytic mode and the visual, perceptual mode—no matter where they are located in the individual brain. Accordingly, L-mode is a step-by-step style of thinking, using words, numbers and other symbols. L-mode strings things out in sequences, like words in a sentence. R-mode, on the other hand, uses visual information and processes, not step-by-step, but all at once, as in recognizing the face of a friend. Most activities require both modes, each contributing its special functions, but a few activities require mainly one mode, without interference from the other. Drawing is, presumably, one of these activities. Learning to draw, then, turns out to be not learning to draw. Paradoxically, learning to draw means learning to make a mental shift from L-mode to R-mode [Edwards, 1979].

Lateral Thinking. Lateral thinking is the brainchild of Dr. Edward De Bono [1992], a leading international authority on the teaching of creative thinking. Lateral thinking is seeking to solve problems by unorthodox or apparently illogical methods, emphasizing different ways of looking at things [De Bono, 1992]. With vertical thinking you take a position and then you seek to build on that basis. With lateral thinking you move to the side to get a different point of view; out of the usual line of thought; outside existing *grooves* of thinking.

The Geneplore Model. The Geneplore model consists of two distinct processing components: a generative phase, followed by an exploratory phase. The Geneplore model also postulates that the creative process is cyclic as suggested in Figure 2 below.

Cycling between the phases of generation and exploration typically occurs when people engage in creative thinking. For example, a person may retrieve two mental images and combine them [R-mode?], and then interpret the form as suggesting a new idea [L-mode?]. Further examination may lead to the conclusion that the form is incomplete in some respect. Thus the cycle is

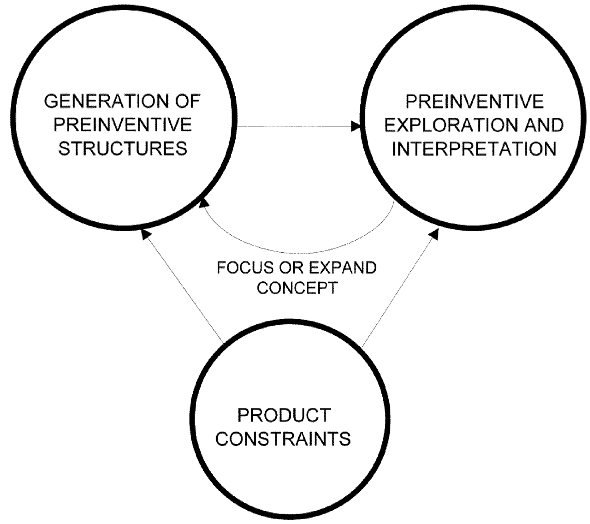

Figure 2. The Geneplore Model [Finke, Ward, and Smith, 1992].

repeated until the adequate refinement and/or expansion is achieved. Constraints on the final product can be imposed at any time as indicated in Figure 2 [Finke, Ward, and Smith, 1992). The significant difference between exploration and search must also be pointed out here. Exploration is a process where one does not know what one will find, or discover, and one tries to use, interpret, and associate what one finds with one's knowledge and experience. Search on the other hand is a process in which one knows what one is looking for. Creativity and whole-brain thinking are tied more to the process of exploration, and much less to algorithmic search processes [Udwadia, 1986a].

The Convergent/Divergent Thinking Model. Psychologist Joy Paul Guilford of the University of Southern California developed the concept of "convergent" and "divergent" thinking [Guilford, 1967]. Convergent thinking aims for a single, correct solution to a problem. Accordingly, when presented with a situation, we use logic to find an orthodox solution and to determine if it is unambiguously right or wrong. IQ tests primarily involve convergent thinking. But creative people can free themselves from conventional thought patterns and follow new pathways to unusual or distantly associated answers. This ability generates many possible solutions, and is known as divergent thinking [Kraft, 2005].

Systems architecting can benefit from both types of thinking. For example, divergent thinking may characterize the start of each iteration in architecting, when many possibilities are generated. A possibility is then considered, and through convergent thinking is given practical meaning. Divergent thinking is engaged again to generate yet other sets of possibilities at a lower level of design. Thus we can imagine that divergent thinking generates nodes of a decision tree, and convergent thinking makes its branches.

5. BREAKING DOWN WALLS

The diverse and eclectic set of cognitive models described here is just a small, somewhat incongruous, sampling in the spirit of affinity for ambiguity, freedom to freely associate, willingness to seek multiple solutions, curiosity, and generalist's perspective prescribed for systems architecting. The field is wide open, intentionally. We continue with a sampling of creativity strategies.

5.1. Creative Strategies (Cracking Creativity)

First of all, creativity should be stripped of its mystique. You *can* exercise your creative 'muscle.' Following are some of the most effective practices:

1. Be inquisitive and curious about natural objects, products, processes, ideas, and concepts. Continually explore, and communicate.
2. Ask higher level questions about the purpose of each of the above.
3. A continual reassessment of the situation, of the questions, and of the solutions—the iterative process of exploration yields understanding at various cognitive levels which mix with one another.
4. Constantly change focus from narrow angle to wide angle views of any situation.
5. Through lateral thinking develop analogies for the phenomena that you observe.
6. Draw sketches, perspectives, diagrams, etc. to pass your thought through your eyes back to your mind.
7. Do visual thinking in 2D, 3D, etc. and have fascination in the process.
8. Make commitments to deliver exceptional systems (pressure of meeting commitments motivates creativity).
9. Pursue your ideas tirelessly and without fear of failure—the least you will get is the experience of living inside your problem.
10. Always pursue multiple projects (going from one project to the next breaks the possibly degenerative thought patterns and motivates lateral thinking).

When asked what makes a creative person tick, advertising legend Carl Ally replied, "The creative person wants to be a know-it-all. He wants to know about all kinds of things; ancient history, nineteenth century mathematics, current manufacturing techniques, flower arranging, and the hog futures. Because he never knows when these ideas might come together to form a new idea" [Von Oech, 1990, p. 6]. Creativity is thus also an attitude of the mind.

Aim for Simple Systems That Perform Complex Functions. Csikszentmihalyi [1996] explains that the ability to move from one trait to its opposite is part of the more general condition of psychic complexity. Complexity is a feature of every system, from the simplest amoeba to the most sophisticated human culture. When we say that something is complex we mean that it is a very differentiated system—it has many distinctive parts—and also that it is a very integrated system—the several parts work together smoothly. A system that is differentiated but not integrated is complicated but not complex—it will be chaotic and confusing. A system that is integrated but not differentiated is rigid and redundant but not complex. Evolution appears to favour organisms that are complex; that is, differentiated and integrated at the same time [Csikszentmihalyi, 1996].

Simplicity, however, not complexity, should be the aim of the architect [Khoshnevis, 2005]. Evolution generally results in the simplest possible systems that perform the most complex functions. Often the challenge of invention is making things simple enough to be practical and economical.

Seek the System. According to Senge [1990] and Udwadia [1986b], the essence of the discipline of systems thinking lies in a shift of mind: in seeing interrelationships rather than linear cause-effect chains, and seeing processes of change rather than static snapshots. While the world is dynamic and circuitous, we tend to look for, and along, straight lines. And therein lurks a potential limitation of systems thinkers—what we see often depends on what we are prepared to see. One of the reasons for this "handicap" stems from language because it shapes our perceptions and, with its subject-verb-object structure, is biased toward a linear view [L-mode]. If we want to see systemwide, we need a language of interrelationships [R-mode] [Senge, 1990; Udwadia, 1986a].

Connect. Also, of paramount significance is a propensity for connecting to the whole—that is, stepping back to see the proverbial forest for the trees, and connecting to it, forging personally meaningful associations, and "orchestrating" a performance by using deep expertise from numerous quarters—something we've observed architects do habitually [Udwadia, 1990].

Get Yourself Engaged. Finally, commitment is a fundamental and most important attitude. In fact, in practice, drive correlates better with successful creative output than skill does [Flaherty 2005]. Drive fuels creativity. Anatole France proclaims: "*I prefer the folly of enthusiasm to the indifference of wisdom.*"

5.2. (Dis)Education of the Hemispheres

In a postscript to teachers and parents, Dr. Edwards [1979] warned that the school world is mainly a verbal, symbolic world, where the R-mode must take a back seat. School decrees how you learn, and Dr. Edwards compares this forced shift to L-mode to a forced change in handedness (which is clearly out of vogue). Gabriele Lusser Rico offers a supportive and poignant vignette (allegedly a true story told by psychologist Richard M. Jones):

> Billy was a sixth-grader. His teacher, reviewing the previous day's math lesson, called on him to define infinity. Billy squirmed in his seat and said nothing. "Come on, Billy, what's infinity?", his teacher insisted. He looked at the floor. Exasperated, she commanded him again to answer, whereupon he mumbled, "Well, infinity is kinda like a box of Cream of Wheat." "Billy, don't be silly" she snapped, and called on Johnny, who was eager to share his learning. "Infinity is immeasurable, unbounded space, time, or quantity," he said. The teacher was pleased, since this was the only appropriate answer she could imagine. Yet there's a rub: Billy had verbalized a complex right-brain image and made a non literal statement. Literally, infinity is nothing like a box of Cream of Wheat, and the teacher, looking for a literal left-brain definition, understandably ignored his answer. But Billy knew something about infinity. Later to a more sympathetic ear, he was able to explain his image: "You see, on a box of Cream of Wheat there's a picture of a man holding a box of Cream of Wheat, which shows a picture of a man holding a box of Cream of Wheat—and it goes on and on like that forever and ever, even if you can't see it anymore. Isn't that what infinity is?" Billy had a rich right-brain understanding of infinity. [...] This is an example of hemispheric dominance and two separate modes of processing the same information [Rico, 1983, pp. 61–62].

As Nobel Laureate Roger Sperry put it, it boils down to the impression that "modern society discriminates against the right hemisphere" [Sperry, 1973, pp. 209–229]. This bolsters the case for whole-brain development. L-mode professes to R-mode "You complete me!", and vice versa.

6. CONCLUSION

Presented with an opportunity to architect, one will have the possibility of proceeding abstractly, verbally, logically [in L-mode], or holistically, wordlessly, intuitively [in R-mode], or with an integrated, iterative interplay of the two—with ambidextrous thinking. We proposed that creativity and whole-brain thinking are vital to architecting, and presented indications of an institutionalized left-brain bias, to prod for educational reform, and emphasize that the road to whole-brain thinking is largely a personal journey. We tried to convince the reader that one can transcend his or her hereto perceived creative limits, and, accordingly, we suggested a few strategies that we hope will inspire the development of a conducive *personal* style—an architecting attitude which places creativity as its cornerstone. We feel it's important to note that there is no single solution to this problem, no single end to this journey. Happily, when developed this way, independently, one's style will be as unique as a fingerprint. Imagine each of us achieving this state of fertile and original productivity; that would be rich for mankind indeed.

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