

The Brain, Experience, and Adult Learning
A Tribute to the Life and Work of David Justice

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During his life David Justice was a committed, oftentimes brilliant, inquirer into the question: How does experience enhance learning? I will never forget him and his bubbling excitement as he shoved book after book into my hands, each time exclaiming: “Barry, we have to talk about this!” In this article I will summarize briefly our many discussions about systems within the brain, how they interact, and the resulting implications for adult learning programs.¹

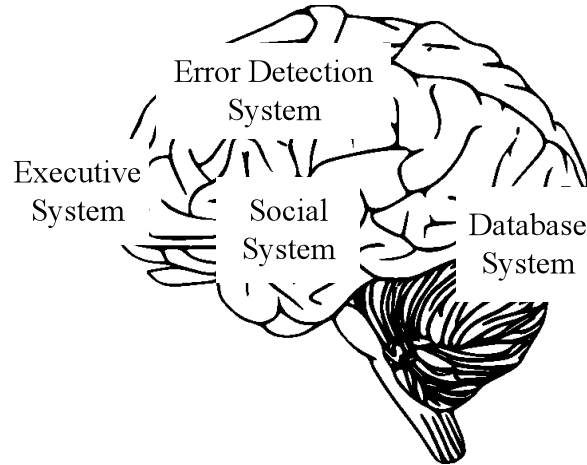
As was his style, David would begin by considering a number of scenarios and questions.

- Scenario 1. Rosella was sitting calmly in the meeting when the marketing strategist began showing slides that chronicled the evolving New York City skyline. As the scenes focused on the former World Trade Center, she felt increasingly nauseous. Why did she have this reaction?
- Scenario 2. As he walked into the Dean’s Council meeting, Tom felt a knot form in his stomach. Something was very wrong. Even before the Dean walked into the room, intuitively he seemed to anticipate her opening statement: “The Provost told me this morning that as a cost-cutting measure the Board of Trustees decided to close our school and convert it into a department within the School of Liberal Arts.” How did Tom know that something was gravely amiss?
- Scenario 3. Dr. Lee casually read the note from the research council: “Because of your research team’s outstanding record of reducing the indirect costs associated with your project, the council is granting a \$1000 bonus for you to distribute as you would like to your team. Please let us know how to proceed.” Without hesitation she replied via e-mail: “Distribute the bonus equally (\$250 each) to the four of us.” Why is this a predictable decision?
- Scenario 4. Ray knew that his presentation on the new product was going badly. Listening to the silence and scanning the disinterested faces around the table, he had to do something differently. But what? Seemingly out of nowhere, an image of Barack Obama conducting a town hall meeting flashed into his mind. Ray quickly refocused the meeting: “Let’s talk about our customers. If they were here with us now in a town meeting forum, what would they say about our products?” How did Ray get this presentation-saving idea?

¹ In our discussions we had an understanding that the brain and body were intertwined such that “the toes are actually a part of the brain.” Similarly we had an understanding that when we spoke of the “brain” we referred to the physical structures and chemical processes that occurred within the brain. When we spoke of “mind” we referred to the conscious awareness that resulted from physical/chemical interactions within the brain. Because consciousness (the mind) arose from processes within the brain-body integration, we talked in terms of a mind-body integration. Although we knew that the brain never really “acted” on its own accord (e.g., “the brain tells the body...”), we could not avoid such overly-simplified characterizations when we tried to describe our understanding of a particular process within the brain. I will try to honor these understandings throughout this paper.

I will discuss each of these scenarios in terms of how a specific system within the brain seems to operate. Describing these areas as if they were discrete, however, violates one of the key features of the brain, its “connectivity.” According to the Nobel Laureate Gerald Edelman, everything in the brain works together; no one part exists in isolation. Imagine the interactivity of 100 people deciding where to go for a group dinner. Now expand this interaction to 100 billion people, the number of neurons in the brain. Keep this interactive cacophony in mind as you view Figure 1, a schematic of the four systems within the brain—four systems that provide insights into the process of adult learning.

Figure 1: Four key systems of the brain²



The Database System

In scenario #1, seven years melted away as Rosella sat watching the slides of the Twin Towers. She recalled that morning in vivid detail—the exact stoplight where she first heard the news, the red polish on her fingernails digging into the steering wheel, her struggle to control waves of nausea as she left a panicked message on her younger brother’s phone in the World Trade Center: “Call me. Now!” Why were her recollections of this day so detailed when memories of other September 11ths were almost impossible to recall?

The answer is best understood by considering the purpose of the brain: It exists solely to optimize the life of the body. For this reason it pays great attention to events that are related to dramatic changes in body state (COBS) because such changes have implications for preserving and optimizing the life of the body. Imagine the massive swings in the state of her body that Rosella experienced between 9:00 AM when she first heard the news, 10:05 AM as she watched the South Tower collapse, and 1:30 PM when her brother called, unharmed.

A small mass of cells located in the posterior region of the brain, the hippocampus, “records”³ the events associated with such massive COBS so that in the future these events can either be anticipated or, better yet, avoided. It seems to “record” this learning in the form a “transcript” of associations involved with the COBS experience. It does so by

² The schematic depicts relative, not exact, positions of these 4 systems.

³ Because no one is really sure how the brain operates, I put words related to brain functions in “quotes” to convey this uncertainty.

triggering changes in the physical structure of the neurons—and the neural synapses—that “fire” during the episode. These changes in physical structure, in turn, establish what researchers call the “long term potentiation” (LTP) of the neuron . As a result of such changes, neurons with greater LTP fire more easily than those with less LTP. In Rosella’s case the neurons associated with the events of 9/11 apparently had a very robust LTP. Even a rather benign stimulus—slides of the Twin Towers—was sufficient to re-trigger the major bodily reactions associated with a day seven years past.

Damasio described how these changes of body state (COBS)—the feelings of what happened to the body—recorded by the hippocampus-centered system are the raw materials, a veritable database, that the brain draws upon during thinking, reasoning, and decision-making. In fact he notes that these experiences—the story of what happened to the body—are the only data available to the brain. As it uses its inexplicable powers to figure out ways to optimize the life of the body, the brain anchors these thought processes in the database of COBS instances recorded by the hippocampus. Drawing on the store of COBS recorded in the brain’s database, according to Damasio , the litmus test for conscious decisions becomes, “how will I feel—what changes in body state will occur—if I pursue this course of action?”

The Error Detection System

In scenario #2, when Tom returned to his office, still shaken by the news from the meeting, he wondered how he knew that bad news was on the way. He hadn’t even seen the Dean prior to the meeting so she could not have cued his reaction. Could it have been something else? Maybe he picked up a difference in the level of activity outside of the Dean’s office? Maybe it was the unusual disorder of chairs in the conference room? Maybe something was missing from the room? Whatever it was, Tom remained clueless about his intuition. He knew that something was wrong but had no understanding of how he knew this.

Over the course of evolution, the brain has developed the capacity to “learn” the complex patterns that are implicit (tangled) within experiences. There is a paradox to this implicit learning: Because it is tacit, it occurs without any conscious awareness of what was learned . For this reason, at any point in time, we actually know a great deal more than we think we know.⁴ In this scenario, prior to the start of the meeting Tom knew that something was amiss but he did not know how he knew this or how he learned it.

The brain accomplishes this feat of learning implicitly (literally learning the patterns “implicit” or tangled within an experience) by virtue of an ingenious system of dopamine neurons. These neurons actually reward the brain for recognizing patterns .

This process may help to explain Tom’s prescience. From the “perspective” of his brain, the Dean’s meeting was an important event because it was associated with many past COBS events (e.g., contentious debates over budget allocations, gut-wrenching personnel decisions, joyous news about faculty awards). For this reason, as he walked from his office to these meetings each week, Tom’s brain possibly “tuned” into events with a heightened “awareness” of the pattern of activities that unfolded— an awareness that might help it “anticipate” or possibly avoid unwelcome COBS experiences. Over the years as events

⁴ Researchers estimate that approximately 30% of the knowledge we use to when we think, reason, and make decisions is “explicit” in that we can state this knowledge and write it down. The remaining 70% is “tacit” or “non-conscious.” This is the knowledge that we don’t consciously know that we know. We often describe such knowledge as “intuitive” R. E. Clark and J. Elen, “When Less Is More: Research and Theory Insights About Instruction for Complex Learning,” in *Handling Complexity in Learning Environments: Theory and Research*, ed. J. Elen and R. E. Clark (New York: Earli, 2006)..

leading up to the meeting fell into patterns—and Tom’s brain correctly anticipated these patterns (e.g., if there was a light buzz of activity outside of the Dean’s office, the meeting began without a hitch)—his brain “rewarded” itself with doses of dopamine⁵ for anticipating the patterns.⁶

When Tom set out for the meeting each week, his brain used these experience-based patterns to create a “remembered present”—literally a detailed script or mental model of the events that his brain anticipated unfolding as he traveled to, attended, and returned from the meeting. This “remembered present” provided a baseline for Tom’s complex “error detection system”.

As long as the pattern surrounding the meeting unfolded as anticipated (e.g., there was the usual buzz of activity outside of the dean’s office), Tom’s brain continued to reward itself with shots of dopamine. If the pattern deviated from expectations (e.g., the anticipated level of activity outside the dean’s office was not present), less dopamine was secreted in the brain. In this case, because the structures in the Error Detection System (e.g., nucleus accumbus, anterior cingulate cortex) were highly sensitive to dopamine and were well connected via spindle neurons to all other brain regions, the absence of dopamine triggered an alarm signal throughout the brain: Something was amiss. This error detection process may explain the angst Tom felt as he entered the meeting.

The Social System

In scenario #3, Dr. Lee’s predictable response was perhaps guided by a unique system of “mirror neurons” that are located in the fusiform face area of the brain. Through the nurturance that humans receive as they grow from infants to adults they develop the ability to be empathetic—to “mirror” the feelings of others. Lehrer suggested that the mirror neuron system provides a basis for moral reasoning and altruism because this system allows us to almost “feel” the impact of our actions on others.

Dr. Lee may have arrived at her “decision” to share the bonus equally with all members of her team by drawing on her COBS database of experiences that were anchored in her Social—or mirror neuron—System. By accessing this system, Dr. Lee could have imagined how she would feel if she were a member of the team and did not receive an even share of the bonus. She might have labeled this image as “unjust.” Based on the COBS reactions that this feeling of being perceived as “unjust” by her team members might have precipitated (via the mirror neuron system), Dr. Lee may have chosen to share the bonus evenly. Because of the nature of the mirror neuron system she possibly arrived at this course of action not by a process of conceptual reasoning but rather by mirroring—almost feeling—the impact her decision would have on other members of her team.

This is a result that is repeated over and over again in experiments where individuals are given the choice of sharing or not sharing a sum of money with another. In each case a sense of “fairness” prevailed as individuals responded in terms of the impact their

⁵ Dopamine is a substance that produces pleasurable feelings.

⁶ This self-reward process for pattern recognition also explains why we may enjoy watching our favorite movie repeatedly. As it “anticipates” the turns in the plot, correctly our brain “rewards” itself with shots of dopamine.

responses might have on others. “If I had \$10 to share, kept \$9, and gave only \$1 to the other person, that person would likely be repulsed by my selfishness.”⁷

The Executive System

In scenario #4, Ray benefited from the workings of the Executive System—a network that is at the same time the most adaptive and the most limited system within the brain. It is the most adaptive because it has the ability to manipulate symbols in a way that extends consciousness into future or “as if” scenarios (e.g., recall how Dr. Lee used the symbol “unjust” to extend her consciousness into the future to imagine colleagues’ responses). The Executive System also has great flexibility because it is networked into every other area of the brain. It is limited, however, by its small “working” capacity—it can only work with 5-7 “bits” of information at any one time (e.g., You may more easily remember a five digit zip code than a ten digit license plate number).

At times this system works in a top-down, command-and-control process (e.g., “issuing a command” to resist a desert that overrides the rush of dopamine triggered in anticipation of how delicious the desert would taste). In most cases, however, this system works not as a command-control center but as a “servant leader.” From this perspective the Executive System “leads” by (a) “selecting” from among the millions available, the pattern that at any particular moment has the greatest potential for optimizing the life of the body, (b) “channeling” resources to actualize this pattern, and (c) “coordinating” the development of the pattern with complementary patterns that exist within other areas of the brain’s intricate neural network.

The Executive System is well-suited for this servant-leader role because with its center in the dorsolateral prefrontal cortex (DLPFC) it has tendrils that reach into every area within the brain. With this high degree of interconnectivity the Executive System can use information from a network of over 100 billion neurons to optimize the life of the body.

As Ray sat in the meeting the Executive System in his brain was deluged with information from millions of neurons. The Social System was literally “feeling the pain” of those seated around the table. The Error Detection System was triggering alarms to indicate that this was not the present (or the presentation) it “remembered” as occurring. Simultaneously the Executive System furiously searched the Database System for another, more adaptive solution. This chaotic search for alternate solutions is often referred to as MAC/FAC or “many are called, few are chosen”.

In most cases the brain does not “select” information or “determine” which information is most adaptive in a particular situation by using a complex decision-making algorithm. Instead, it seems to be guided by an elegantly straightforward procedure that Edelman referred to as “neural Darwinism.” Simply stated, the neural pattern “selected” from the millions of possibilities within the MAC/FAC array is the one that has the strongest COBS association—perhaps as calibrated by the LTP established by the hippocampus—to the situation at hand.

As in Ray’s case the working of the servant-leader Executive System can appear quite random. How did it come up with the Barack Obama town-meeting association? A delay feature built into the DLPFC may have come into play. Think of the servant-leader

⁷ Individuals whose mirror neuron system is defective (e.g., individuals with psychopathy) seem to lack this social sense, this ability to mirror the minds of others J Lehrer, *How We Decide* (New York: Houghton Mifflin Harcourt, 2009)..

Executive System as an operation with a limited capacity—a capacity that is analogous to a small stage in a crowded auditorium where everyone is jostling for time in the spotlight. As individuals push their way onto the stage and then exit, they hang around for a short time backstage waiting for an opportunity to jump back into the spotlight. To do so they may have to adapt. Metaphorically, instead of singing solo they may have to join a group and provide background harmony.

This backstage metaphor illustrates the delay feature within the DLPFC. As an image such as Barak Obama in a town meeting entered the Executive System—via interconnections with the Error Detection, Social, and Data Base Systems—this image may not have made its way into conscious attention—the spotlight. Even so, it may not have been rejected outright. Instead it possibly waited for an instant “backstage.” When another image—Ray’s vision of the group conversation he would like to see happening—entered the spotlight of consciousness, this vision could have overlapped with the Barak Obama town-meeting image. Eureka! The two images combined with enough strength to be “selected”—via a process of neural Darwinism—because the combination of images had the strongest association with the desired COBS (feeling of success) that Ray wanted to achieve in the meeting.

Oftentimes at this point in our discussions David and I would tire of our musings about the wondrous features of the human brain and turn to considering the implications these characteristics had for adult learning programs. When we talked of implications, we typically focused on three broad principles.

Principle 1: Engage learners’ in a rich variety of experiences.

Each system of the brain requires a rich store of experience to operate effectively. The Database System grows as its reservoir of COBS experiences increases. The Social System becomes more intricate as relational experiences with others expand. The Error Detection System becomes more elaborate by virtue of involvement in a wider array of complex experience-based patterns. The Executive System benefits most of all by a having access to a rich experience base—a base that provides a more complex and diverse set of information for the Executive System to draw upon as it “coordinates” the work of the brain and “strives” to optimize the life of the body.

There is a broad research base that supports this first principle . For example, from 1940 to around 1990, despite wide ranging reforms throughout the aviation industry, the percentage of airplane crashes due to pilot error held constant at around sixty-five percent. Since 1990, however, this percentage dropped to under thirty percent. Why the dramatic change? About this time the airline industry shifted from a dependence on classroom-based training to greater use of realistic flight simulators . This decrease in accidents due to pilot error suggests that the realistic experience of recovering from a stalled engine is more effective than listening to a lecture. Others have reached this same conclusion. Edelman from his extensive research on the brain concluded that “[d]oing is prior to understanding” . Likewise, in a meta-analysis of over 800 studies, Hattie reported that having learners practice using information in a variety of different contexts—and receiving feedback on their performance—was among the top five most effective strategies for enhancing learning.

At the University of Connecticut (UCONN) we use a number of different approaches to engage learners in a wide variety of experiences. In our newly revised EdD program, for example, we pair each content course with a practicum or “laboratory of practice.” During each of these course-laboratory sequences, in order to build a rich body of experience as

researchers, candidates use course content to guide their inquiry about problems of practice. In our administrator preparation programs all candidates combine their coursework with a ninety-hour internship that is closely aligned with course materials.

Principle 2: Build learners' metacognitive reasoning skills.

As outlined in this article the Executive System has a two-level role when addressing a problem. First it “selects” from among millions of options the best set of ideas to address the problem. Second it “employs” a strategy for planning, monitoring, and evaluating the use of the ideas selected.

Of these two processes, research indicates that the second or “metacognitive” process has the stronger relationship with performance. For example, Hattie reported that one of the top five approaches to enhancing student achievement involves teaching students to self-regulate (plan, monitor, evaluate) their own work. In a related line of research Feltovich and his associates report that novices and experts “think” differently. In contrast to novices, experts are better able to reason at a meta-level because they use ideas that are (a) more dynamic than static; (b) more systemic than linear; (c) more principled than superficial; and (d) having multiple as opposed to single dimensions.

At UCONN, we are applying this second principle in our courses by focusing less on content as an end in and of itself and more on content as a means to build reasoning skills. In our EdD program, for example, we ask students to identify a problem of practice to use as the focus for their program of study. As they progress through each course we work to expand the complexity of their thought about this problem by improving their ability to weave together first-order factors related to the problem (e.g., lack of resources) with second-order or meta-factors (e.g., cultural norms). We do so by having them diagram their selected problem of practice in terms of interacting systems that include both first and second-order issues. Finally, we build their self-regulation skills by continually asking them to reflect on how they are self-regulating (planning, monitoring, evaluating) their own learning.

Principle 3: Build learners' understanding of how their thinking is limited.

Despite its many wondrous features, the brain also has characteristics that can limit and distort our thinking. For example, sometimes we think too much. Hallinan described how June Siler, sitting on the witness stand, reacted when asked by the prosecutor: “Is this the man who attacked you?” Try as she might to “see the hate I saw in his eyes that night” she was disturbed that she could not. Even so, as she looked at the accused, Robert Wilson, the rational pathways of her Executive System seemingly dominated the tacit dimensions of the Error Control System as she testified, in error: “Yes, that is the man.” Years later, when new DNA evidence surfaced, June returned to court to free the wronged Mr. Wilson. In her second testimony she said that she knew in her gut that he was not the attacker but in the face of the circumstantial evidence, ignored her feelings.

As outlined in separate analyses by Hallinan and Lehrer, the brain “straps” our reasoning and decision-making in many other ways. Sometimes, in our search for meaning we tend to combine random events into meaningful patterns: A deli in New York that sold a winning lottery ticket was deluged the next day with patrons who wanted to buy a ticket from the “lucky” store. We also distort our memories to place ourselves in the best light: When asked to recall their High School GPA, most respondents overestimate their performance. Our thinking suffers from a hindsight bias: Eyewitnesses changed their accounts of Flight 1549 landing in the Hudson River as more details of the event were broadcast. We are easily distracted: Drivers talking on cell phones are four times more likely to be involved in an

auto accident than non-talkers. We are influenced by how we frame issues: In a fictional problem about a flu epidemic in which 200 lived and 400 died, individuals in one group choose the option framed as “200 will be saved if you chose this plan” while individuals in another group rejected the same option when it was framed as “400 will die if you chose this plan.” We tend to organize information by patterns, not by discrete elements: We know what a penny looks like but oftentimes cannot recall a specific feature such as the direction that Lincoln’s profile faces (to the right). Because we are usually more interested in the impression we make than in the factual accuracy of our accounts, we often exaggerate certain details and omit others in our explanations—and then we complicate the error by becoming enamored with our own stretched versions of the truth. When something works well once, we continue doing it, repeatedly: Consider the invariance in your morning breakfast routine. Finally, and perhaps most limiting, we are overconfident. Because we overestimate ourselves, we mis-predict our future behavior: We buy annual memberships to Fitness Clubs—predicting that we’ll go every day—but seldom use the membership as planned. In turn, because we overestimate our abilities we have an illusion of control—a false sense that feeds our preference to do things our own way: One firm indicated that over twenty percent of calls to the service center could have been answered if the callers had read the owner’s manual.

At UCONN when learners grapple with solutions to their problems of practice we ask them to think about their thinking. We ask questions like: How does this solution reflect the ideas covered in this course? Could you have arrived at this strategy without taking this course? If this is an approach you’ve used before, why are you using it again? In your past what worked –or did not work—in similar situations? Are you basing this recommendation on a gut feeling or on a reasoned strategy? Additionally we ask them to view the problems of practice they bring to their studies from many different frames. For example, in our EdD program we ask: What if you viewed this as a problem of leadership? Of policy? Of social justice? Of professional learning? In this way our goal is to help them understand that their thinking process shifts when the frame for their problem changes. We hope that from these experiences they will develop a sense of humility about their own decisions—a humility that will make them pause and think about how they decided upon a course of action and possible limitations of this decision—before launching any strategy.

Final note

David Justice was fond of a quote from the *Critique of Pure Reason*, by Immanuel Kant : “Concepts without percepts are empty; percepts without concepts are blind.” As Kant suggested, any attempt to teach concepts without founding these ideas in a wisdom derived from experiences found in the Database System, the Social System, and the Error Detection System leaves the concept “empty.” Similarly “storing” COBS experiences within the Data Base System without pairing them with symbols and concepts leaves them “blind” to a wider array of possible connections with other COBS experiences. In turn, this blindness limits the ability of the Executive System to weave the items within the Data Base System into “as if” scenarios that can be used to optimize the life of the body. As applied to adult learning programs, helping learners knit wisdom from both concepts and precepts into their thinking can help them improve the quality of their problem solving and decision making.

In full tribute to his work, I encourage all readers to adopt David’s commitment to inquiry and, in so doing, further the conversation on the question that occupied David throughout his rich life: How does experience enhance learning?” As a start at a collective inquiry project, some might chose to explore how the three principles outlined in this article could

be translated into practice. Others could might craft their own principles on how experience enhances learning, distribute these ideas throughout the CAEL network, and invite practitioners to test out the principle's viability within specific programs. Through such a united commitment to inquiry we might collectively derive a rich body of information on how experience enhances learning. In so doing we would add substantively to the legacy of David Justice's life and work.

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