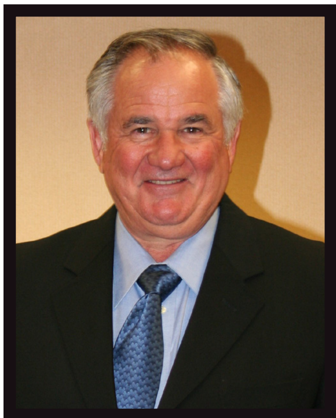
# Kagan Structures are Brain-Based

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**...teaching is generally a delightful experience when we focus on activities that students' brains enjoy doing and do well, such as exploring concepts, creating metaphors, estimating and predicting, cooperating on group tasks, and discussing moral or ethical issues. Conversely, teaching loses much of its luster when we force students to do things their brains don't enjoy doing and do poorly, such as reading textbooks that compress content, writing and rewriting reports, completing repetitive worksheets, and memorizing facts that they consider irrelevant.—Robert Sylwester, 1995**

There is an explosion of recent research and theory which is dramatically increasing our understanding of the brain. Active brain imaging techniques give us windows through which we can view the brain in action. Sophisticated physiological methods, undreamed of but a decade ago, are allowing us to watch the reactions of single neurons as learners react to different kinds of stimuli.

Clearly, teaching will be more effective if it uses methods which are aligned with how the brain best attends to, understands, and retains information. The search is on: Which teaching methods are most brain-compatible? Although some have warned that it is too early at this point to make valid inferences about teaching methods based on brain science, many are making the attempt to build bridges from theory to practice, and educators are being urged through books and workshops to make classrooms "brain-compatible."

A number of principles of Brain-Based Learning have been derived, and educators are attempting to align practice with these principles. It turns out, though, that we do not have to reinvent the wheel. Teaching practices undergo a natural selection process: those which work best survive, those which do not, drop away. Effective teaching practices are effective precisely because they are brain-based. Kagan Structures represent one such case. To a remarkable degree, systematic use of Kagan Structures implements the most important principles of brain-based learning. Without going into a detailed analysis of the underlying brain structures and functions, in this article I point out how Kagan Structures are aligned with the seven most important principles of brain-based learning.

## Article At-A-Glance

## I. Brains Need Nourishment

Brains are small—they weigh about three pounds and are approximately the size of your two fists put together. Although they account for only about 2% of our body weight, they consume about 25% of the body's oxygen and about 25% of the blood glucose. Anything which increases the supply of oxygen and blood to the brain will increase alertness, healthy functioning, and learning.

In the Kagan approach we encourage teachers to use an active structure on the average about every ten or fifteen minutes. Teachers using the Kagan Structures regularly in their classrooms do not experience low energy level dips which are inevitable if students sit quietly for prolonged periods. Kagan Structures are very active. Kagan Structures include movement, interaction among students, and hands-on manipulatives. The class-building structures all have students get out of their seats and move in the classroom. The Silly Sports & Goofy Games are even more active. The movement and interaction, which are characteristic of Kagan Structures, increases breathing rate and heart rate which in turn increases blood and oxygen supply to the brain. Thus the Kagan Structures actually nourish the brain!


## II. Brains Are Social Organs

In a remarkable book, *Friday's Footprint: How Society Shapes the Human Mind*, Leslie Brothers makes the case that our brains have evolved to selectively attend to social stimuli. For example, babies at nine minutes of age are much more likely to turn their heads and eyes to follow a black and white picture if the parts are arranged to resemble a human face than if the same parts are arranged randomly. Single neurons of primates respond selectively and preferentially to social stimuli. Some neurons do not respond to an inanimate object moving but do respond to a person moving; others do not respond to a geometric form, but do respond to a form resembling a hand, and the more the form resembles a hand, the more they respond! In *Mapping the Mind*, Rita Carter displays results of active brain imaging studies which show that brains are far more active learning in interaction with others than when alone, reading or listening to a lecture. Opiate-like substances are released in mammalian brains during care-giving and play, explaining why these activities are so rewarding. Our brains, to a remarkable extent, are social organisms.

If we naturally attend far more to social stimuli, it makes sense to have students interact regularly over academic content—having them discuss, debate, and work together on the content. And Kagan Structures do exactly that! For example, if rather than turning to a text to seek an answer, students are allowed to use Find Someone Who, they are more engaged and enjoy the learning more. If they use Numbered Heads Together rather than responding alone to a teacher's question, they are far more engaged. Thus, because they involve so much social interaction, Kagan Structures actually provide the kind of stimuli which brains crave.

## III. Brains Seek Safety

Our brains have evolved to help us survive. When we are frightened, primitive fight-or-flight-defense alarm systems kick in. The limbic system in the brain, seat of emotions, becomes highly activated and we downshift into primitive modes of functioning which have evolved to give us a survival advantage, but which are incompatible with higher-order cerebral functioning. We cannot do mental math accurately if we are hearing fire engine sirens blaring, see people running in panic, hear people screaming fire, and smell smoke! Higher-level thinking occurs best when we are in a state of relaxed alertness—when we feel safe, our primitive reptilian brain is quiescent and our cerebral cortex is free to function uninterrupted. Anything which creates anxiety or threat creates downshifting and decreases the probability of learning.

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Kagan Structures create a sense of security because they are step-by-step repeatable routines. Predictability creates a sense of security—the untoward is not about to happen. Once students have mastered the steps of Numbered Heads Together, for example, they feel comfortable. They know the rules of the game.

Kagan teambuilding and classbuilding structures are designed explicitly to create social safety. The classbuilding and teambuilding structures allow students to know and support each other and to accept individual differences. Because of the teambuilding and classbuilding structures, students drop their fear of social rejection and their worry about social acceptance—they are free to focus more on the academic content. The Kagan communication building structures also create a safe context for learning. The Kagan communication building structures teach students to express understanding and concern for each other's ideas. No longer fearing rejection of their ideas, students are freer to share and get feedback; the communication building structures create a safe context in which to think and learn. For example, during Paraphrase Passport, every student knows his/her ideas will be listened to and validated, creating a caring, safe context for the exchange of ideas. Thus through teambuilding, classbuilding, and communication building the Kagan Structures actually reduce the risk of downshifting, freeing the brain for higher-level cerebral functioning.

## IV. Brains Are Emotional

Brains are exquisitely designed to respond to emotion. One of the primary ways brains respond to emotions is through the receptors on the cell walls of neurons. Each receptor is a single very large, complex amino acid chain molecule—some approach 3000 times the size of a water molecule. Seventy types of receptors have been identified to date, and each responds to only one type of chemical. For example, some receptors respond to endorphins (which make us feel euphoric), others respond to cortisol (which makes us feel stressed and anxious). A neuron may have millions of receptors on its surface, different numbers of different types—perhaps 10,000 of one type of receptor and 100,000 of another. Thus a particular neuron may be quite sensitive to one type of chemical, but not another. Just as our eyes and ears sense different types of stimuli in the external world, our receptors sense different types of stimuli in the internal world of our bodies—emotional stimuli. Candace Pert aptly calls these receptors "Molecules of Emotions."

Why is sensitivity to emotions so crucial to brain functioning? Emotions are the primitive signals which keep us alive by motivating us to flee from being bitten or eaten, care for and protect our progeny, and hunt for a tasty morsel.

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It is elegantly argued by Antonio Damasio that the very origin of consciousness resides in the brain's capacity for emotion. Awareness of and memory for emotions is adaptive because ability to respond to and remember what produces pain, fear, and pleasure keeps us alive. We pay huge sums to keep our emotional reactions in tune, if only by exercising them vicariously through spectator movies, sports, and drama. Our brains are structured so that which makes us feel is remembered. Take a moment to try this experiment: Close your eyes and remember an incident from your childhood. Odds are strong that it is an incident linked to emotions.

A brain-compatible classroom is one in which emotions are not avoided, but rather elicited in service of learning. Various Kagan Structures help teachers link emotions to the academic content and help students understand and deal effectively with their own emotions and those of others. In Agree-Disagree Line Ups, for example, students learn to take a stance depending on their feelings about an issue, and to listen with respect to opinions of other students who hold different feelings about the issue. In the constructive controversy which results, students find the content more memorable, and also learn to understand better their own emotions and those of others. Similar outcomes occur in Agreement Circles, Corners, and Proactive Prioritizing, and Paraphrase Passport. Anything which elicits and lets students deal effectively with their own emotions and those of others promotes emotional literacy and emotional intelligence while making the academic content more memorable. Kagan Structures are aligned with the simple fact that our brains are emotional—they are fine tuned to selectively respond to and remember any stimuli associated with emotion.


## V. Brains Seek and Process Information

### Brains Attend to Novelty

The attention systems in the brain are activated when novel or unexpected stimuli appear. We become more alert. We attend more carefully. The evolutionary basis for this is obvious: those animals which did not become more alert when novel or unexpected stimuli appeared, did not survive to pass along their genes! One of the greatest sources of novelty is other people. When we interact with others there is always new and unexpected stimuli. Part of the reason we find it so rewarding to interact with others is because we become more alert and engaged in the face of the novel stimuli they present.

Remember the early computer learning programs. The students showed a great deal of initial interest. Each time they got a problem right a little man bounced along the bottom of the screen, as a reward, holding up a sign saying "Great job!" Soon though, students tired of these programs and did not want to play them any more. What was the problem? The predictable programmed stimuli became boring.

In contrast, the feedback of a peer is often unpredictable and so does not wear out as a source of novel stimulation. Kagan Structures have students interact with others on a regular basis. They have students share ideas, respond to each other's ideas, and give each other feedback and coaching. Students are encouraged to use new and unexpected praisers, and to use different gambits as they interact to keep the stimulation high. The stimulation which students provide each other is always fresh. It is in contrast to the stimulation provided by the early computer learning systems.

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The Kagan Structures are compatible with the brain's need for novelty in two ways: First, a teacher using a range of structures is always creating novel stimuli in her or his classroom, quite in contrast to the teacher who always just lectures. Second, most of the Kagan Structures involve interaction, and social interaction is a primary source of novel stimuli. Students in classrooms in which the Kagan Structures are used regularly report the classes to be more "fun." In technical terms what they are telling us is that the Kagan Structures respond to the brain's need for a regular flow of novel and unexpected stimuli!

### Brains are Parallel Processors

Brains are doing lots of things at once. While they process the teacher's words they have energy left over to process a range of additional information. In determining the reaction of a student to a classroom, it turns out that most everything counts—including the teacher's tone of voice, dress, make-up, hair style, as well as the attitudes of other students, seating arrangements, wall decorations and wall color, background music, class context, temperature of the room, and distracting noises. The brain is a multimodal input processor, simultaneously responding to a great range of content.

The need for multimodal input is greater among today's youth than it was a generation ago, because they have become accustomed to a steady diet of multimodal input including MTV, DVD's, video arcades and the Internet. Whereas yesterday's teacher could hold the attention of students with straight teacher talk (because that was the most stimulating game in town), today's teachers rarely can.

Because there is a strong need for multimodal input, if the academic content is presented in only one channel, for example, teacher talk, the rest of the student's processing will be on non-academic content including doodling, memories, fantasies, and attention to the hemline of the student in the seat in the next row! The more the content is presented mulitmodally, the more it will occupy the attention of students, and the more it will be retained.

That is where the Kagan Structures come in. They are multimodal events. They involve interaction, drawing, writing, discussing, constructing, spinning spinners, building with hands-on manipulatives, as well as music and movement. Structures create brain shifts. For example, there may be a quiet Think Time followed by a rapid-paced pair interaction in the form of a RallyRobin followed by the team constructing a Kinesthetic Symbol. With each structure, and often with each step within a structure, different parts of the brain are engaged, so there is more stimulation, the content is approached in more ways, and the brain is allowed to function as it is designed to function—as a multimodal parallel processor.

## Brains Seek Feedback

The 100 billion neurons in the brain each fire not as a simple function of the amount of input they receive, but also as a function of how other neurons in the past have responded when they fired! There are feedback loops even at the neuronal level. Our brains are feedback hungry. If what we do does not make a difference, we stop doing it. The search for feedback is biologically rooted in our need to be an effective organism, to make a difference. A brain-compatible classroom is feedback rich.

The search for feedback is related also to the search for meaning. In our search for meaning, we try something and then check to see if it worked. All of us are scientists from birth, conducting mini experiments to see which behavior produces which consequences.

Traditional worksheet work is feedback poor. Students do not get feedback until the next day, after the teacher has graded the papers. But the brain seeks immediate feedback. The Kagan mastery structures such as Pairs Check or Showdown provide immediate peer feedback and so better assist the brain in making meaning.

The Kagan discussion and interaction structures provide less formal, but nevertheless rich feedback on an ongoing basis as students discuss and interact over the content—as they share their ideas with others they receive a constant flow of feedback. Kagan Structures are brain-compatible in part because they are aligned with the brain's need to receive frequent and immediate feedback.

## Brains Seek Patterns

Although brains respond selectively to new and unpredictable stimuli, they seek predictable patterns. We are comfortable with predictable routines. Seeking patterns is related to our need for safety. For some students, a classroom is not safe unless there are predictable routines.

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A number of Kagan Structures are explicitly designed to help students in their process of seeking patterns in stimuli. Sequencing and Structured Sorts are structures explicitly designed to help students find patterns in stimuli.

Thus, in two ways, Kagan Structures respond to the need of the brain to find patterns: The structures themselves represent a predictable pattern of interaction, and some structures are designed to help students in their search for patterns.

## Brains Construct Meaning

Our brains construct meaning. Facts learned in isolation are soon forgotten; facts which are part of a coherent whole, which have meaning, are retained. Making meaning goes beyond seeking patterns, it involves examining relationships, relating stimuli to other stimuli and categories of stimuli, constructing conceptual models.

A simple experiment was done with infants which beautifully illustrates both how we attend to novel stimuli and how we are born searching for meaning. Infants were shown an apparatus in which a ball rolled down an inclined plane and hit a small bowling pin which fell over, making a noise. The first time the experiment was done, the infants showed a startle reaction when the pin fell over. The next time the experiment was performed the startle reaction was less. Within a few trials the infants had habituated to the stimuli so almost no startle reaction appeared when the pin fell over. At that point the experimenters rigged the apparatus so that the ball rolled down, hit the pin, but the pin did not budge. What did the infant do? It showed a startle reaction! In Piagetian terms, the infant had constructed a

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schema. It had a notion of how things work. Each new roll of the ball confirmed that notion, and was assimilated into the schema. When, however, the pin failed to fall over, the new stimuli could not be assimilated and so the schema had to be accommodated to the new data. In scientific terms, the infant had to revise its working hypothesis! The baby had to make new meaning of the way the world works. From birth we are constantly attempting to make meaning of our world.

A variety of Kagan Structures are designed explicitly to help students make meaning of the academic content. Mind Mapping, Categorizing, Team Statements, Similarity Groups each, in quite different ways, aid students in their search for meaning. Having constructed meaning of the content, it becomes part of a memorable schema. This, in part, is why structures improve academic achievement. The structures are brain-compatible because they assist the brain in its natural search to construct meaning.

Teachers using the Kagan Structures are encouraged to have students process the content very regularly, by writing, drawing, discussing, and debating the content. Structures like Timed Pair Share and RoundRobin are designed to have students interact over and reflect on the content immediately after it is presented. Some processing structures do not involve interaction (Journal Reflections, Metacognition, Guided Imagery) but are designed to assist the brain in doing what the brain craves—to make meaning of new stimuli.

The question is not whether students will try to make meaning of the academic content or not. They will. The question is whether the instructional strategies used in the classroom will help them be successful in this process—if they are brain-compatible in this way. Kagan Structures are.

## VI. Brains Have Style

### Cognitive Styles

Many cognitive style dimensions have been identified (See Box). Ultimately they are all a function of brain structure and function. One of the most extensively studied cognitive style dimensions is the analytic-global dimension. This style finds its brain underpinnings in the left-right hemisphere division because the left hemisphere tends to process information analytically whereas the right processes more globally. Although every individual must be analytic and global and process all information both analytically and globally, individuals differ in their preferences and skills at each type of information processing.

Because students differ in their style abilities and preferences, when presented with stimuli, some students prefer to break it up into its components, to analyze it. Other students prefer to relate it to prior knowledge, to see how it fits in the big picture. Some are only comfortable start-

ing with the whole and taking up the parts in that context; others are content to analyze the parts and later construct from the parts a coherent whole.

Another style dimension is Reflective-Impulsive. This style dimension may be thought of as a top-down dimension depending of the extent there is dominance by the cerebral v. motor and emotional centers in the brain. Does a student act on the content first and then make sense of it, or try to think it through before acting? Neither style is better; each has advantages in some situations and disadvantages in others. (Haste makes waste v. He who hesitates is lost!)

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Because students have many styles, no one approach to content is best. The brain-compatible classroom includes something for everyone. Sometimes an inductive approach to meaning is used, sometimes a deductive approach. Sometimes there is hands-on first; sometimes the hands-on follows the cognitive hypothesizing. Sometimes an analytic approach to content is used; sometimes a global approach. And so on.

And this is EXACTLY what happens when a range of structures are used in the classroom. Some structures appeal to and develop analytic skills (Same-Different) whereas others appeal to and develop global and relational skills (Mind Mapping; Team Statements). Some structures develop inductive reasoning (Find My Rule) others develop deductive thinking (Logic Line-Ups). In our own work with structures, we identify 15 types of thinking and provide structures for each. A classroom which uses a range of Kagan Structures is a brain-compatible classroom because it appeals to and develops each

## Brains Have Style

**Many style dimensions have been identified and researched. Ultimately each can be explained in terms of brain structure and function. Below is a list of some of the most important style dimensions:**

- Impulsive-Reflective
- Auditor—Visual—Kinesthetic—Tactile
- Abstract—Concrete
- Field-Independent—Field-Dependent
- Mastery—Interpersonal—Understanding—Expressive
- Inductive—Deductive
- Sequential—Simultaneous
- Stimulation Seeker—Avoider
- Introvert—Extrovert
- Curious—Adventurous—Harmonious—Responsible

part of the brain and appeals to and develops learners with each type of style.

### Multiple Intelligences

Multiple intelligences theory identifies eight types of intelligences. To some extent each intelligence corresponds to a different part of the brain or at least a different way of using parts of the brain. A brain-compatible classroom includes experiences which stimulate and develop each of these intelligences. In our own work in this area, we have developed 84 MI structures so a teacher may make any lesson a multiple intelligences lesson, engaging and developing each of the eight intelligences. Kagan MI Structures are brain-compatible because they engage and develop different parts of the brain and different types of brain functioning.

### Types of Memory

The brain remembers different types of information differently. For example, learning to ride a bike (procedural memory) remembering a scene from a funny movie (episodic memory) and remembering a list of unfamiliar vocabulary words (semantic memory) involve quite different memory systems. Procedures are usually learned by trial and error, with plenty of practice. Episodes are often remembered effortlessly, with little or no conscious intent, especially if they have an emotional component. Semantic memory can be facilitated by formal memory systems such as peg systems and other mnemonics. Semantic memory which is not related to a meaningful context can be quite difficult, but if sematic memory can be embedded within memorable episodes, it can become effortless.

**Just as the brain processes different information differently, individuals process the same information differently and have preferences for how best to remember information.**

Just as the brain processes different information differently, individuals process the same information differently and have preferences for how best to remember information. One student may remember information easily by using a memorable visual image, a second student might be more comfortable with a peg system, a third may need to draw the content, and yet another student may find making kinesthetic movements to be the most helpful.

Because students have different learning preferences, using a range of structures is the approach most likely to reach the most students. The Kagan Structures for enhancing memory include Acrostics; Chunking; Keywords; Kinesthetic Symbols; Linking; Memory Jingles; Memory Rhymes; Memory Yarn; Picture Pegs; Reservoir Room; Visualize Share; and Window Paning.

## VII. Brains Develop

Human brains are incredibly malleable and continue development for a lifetime. One of the most dramatic miracles of life is embryonic brain development—the developing fetus forms new neurons cells at an astounding 50,000 to 100,000 per second! Even more miraculous, these cells sort themselves into the layers of the cerebral cortex and into cooperating units to ensure efficient brain function.

But this incredible dance of the neurons continues throughout life. For example, if a child hears Japanese and not English, that child will grow up able to pronounce Japanese with native fluency but will be unable to pronounce certain English sounds. The opposite is true if the child grows up hearing English and not Japanese. The brain goes through neural budding and pruning, building far more neural connections than needed with those which are unused dying off. This process goes on even into late teen years and beyond. Taxi Cab drivers in the United Kingdom have a more well-developed hippocampus than do other folks—the hippocampus being a part of the brain which helps process spatial information. After all, they have to find their way around far more than the rest of us. Musicians have larger temporal lobes than non-musicians and those with perfect pitch have even larger temporal lobes yet—the temporal lobe being a part of the brain that processes musical sounds. Importantly, it is not how often a musician practices which best predicts the size of the temporal lobe. Rather, it is how early they began practicing. Monkeys who are trained to repeatedly use some fingers but not others change the sensory connections in the brain so more neurons are dedicated to processing information from the highly used fingers, and fewer neurons are dedicated to processing information from the less frequently used fingers. Many studies involving animals and humans of all ages support the conclusion that the brain is constantly developing and reforming as a function of how much and in what ways it is used. "Use it or lose it" is the operative phrase.

Given this evidence, it becomes obvious that if we want optimal brain development, we must provide students a very broad range of experiences. We cannot predict how each student will work and live in the future, but we can predict that they will all be better prepared if they have a very broad range of experience.

Kagan Structures broaden experience. Across the structures, students work sometimes as a whole class, sometimes in teams, at other times in pairs or alone. Structures involve induction, deduction, synthesis, analysis, as well as many other types of thought. Structures involve music, drawing, acting, movement, interpersonal interaction, and individual think time. They dramatically broaden the range of experience of students, ensuring fuller brain development than if content were presented in only a few ways.

Structures allow also for individual differences in pace and form of brain development. In a structure like Team Pair Solo for example, students who are more developed in a particular skill help others until they are able to perform the skill on their own. The structure fosters individual (brain) development through mediated instruction. Piaget showed that students at different stages of cognitive development advanced when allowed to interact. Because the structures allow the interaction of students at different developmental levels, in that way too they foster brain development.

## In Sum

There are many ways quite apart from the use of Kagan Structures to create a brain-compatible classroom and brain-based learning. But teachers who are using a range of Kagan Structures can be assured they are doing the best of brain-based instruction.