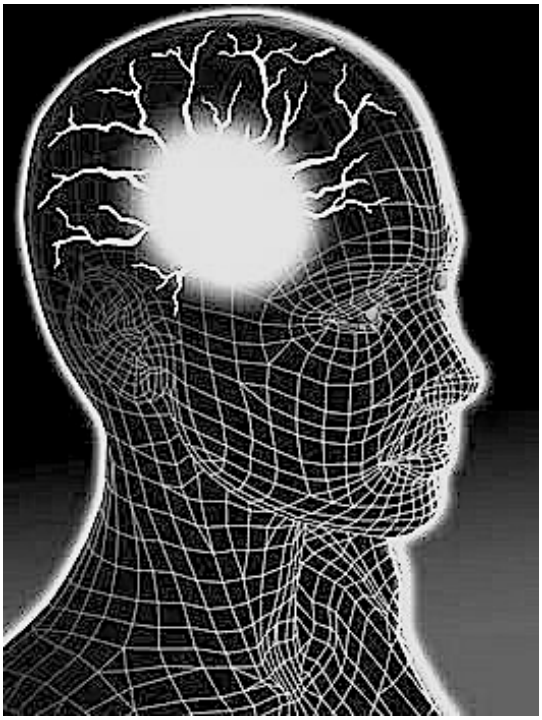
Powerful Classroom Strategies From Neuroscience Research



Learning and the Brain Workshop
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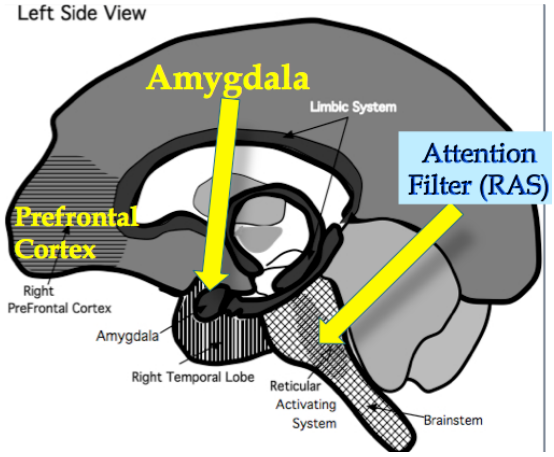
Judy Willis, M.D., M.Ed.
www.RADTeach.com
jwillisneuro@aol.com

Engaging Students from the Start

The Brain's Structures -- Viewed from Left



R.A.D. LEARNING and TEACHING

The first step in understanding how the brain learns is to explore the three main concepts of **R.A.D. learning and teaching**. Each letter in the acronym R.A.D. stands for both a physical feature of the brain and a corresponding word that represents how that brain feature is connected to learning and teaching.

R.A.D. LEARNING and TEACHING
R + A + D
Reach + Attitude + Develop
Reticular Activating System + Amygdala + Dopamine

R = REACH students attention (RETICULAR ACTIVATING SYSTEM)

A = Cultivate a positive ATTITUDE and reduce stress (AMYGDALA)

D = DEVELOP memory (DOPAMINE)

How does the brain pay attention?

Getting and Keeping Students' Attention
The Power of Predictions

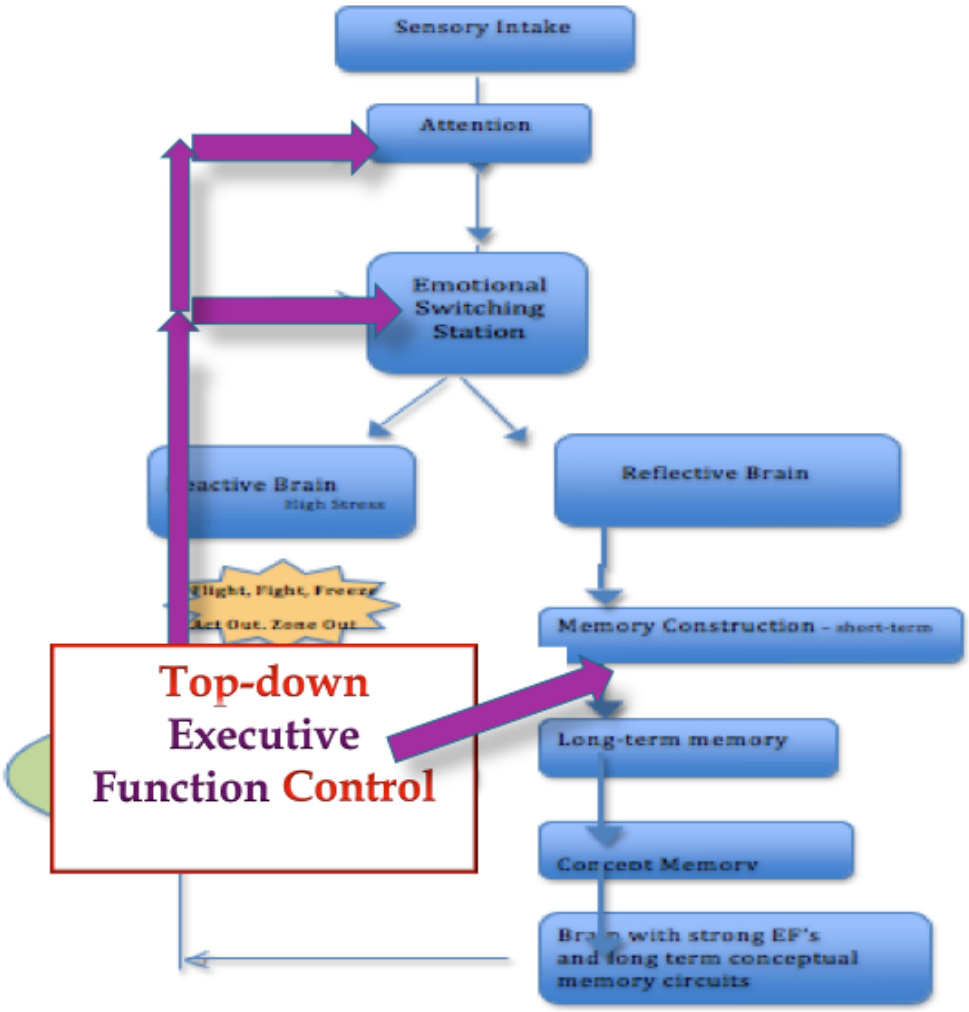
Reach students by making sure that the information they need to learn passes through the brain's sensory filter – the Reticular Activating System (RAS)

Two Big Ideas of the Neuroscience of Learning:
★ The brain functions to promote survival of the animal and the species.
★ To do so, the human brain has evolved to seek patterns and pleasure.

The Reticular Activating System (RAS), which is in the lower part of the posterior brain, filters all incoming stimuli and makes the "decision" as to what people attend to or ignore. Information constantly comes into the brain from the body's sensory receptors. At any given moment we are experiencing sights, sounds, smells, tastes and tactile input. It is impossible for us to be consciously aware of all of this sensory information. Therefore the brain has a filter (the RAS) that selects the sensory information to which we consciously attend.

How does the RAS select which information passes through the filter to gain access to the conscious brain? What are the criteria?

The RAS first prioritizes **novel** stimuli. If there is a **change in the environment**, the related sensory input will likely pass through the RAS. For example, if a fox looks out of his den in the morning and sees an unfamiliar fox walk by, that information will be attended to above other sensory input (e.g. the taste of his food, the sound of birds, the sensation of the breeze on his fur).



Executive Functions You Have That Most Students Do Not

Inhibitory control: block intake of distracting sensory information
Judgment/prioritizing about which sensory input is important
Ability to delay immediate gratification

How can educators influence what the RAS selects?

- *Novelty and Curiosity: Present information in a novel or curiosity-provoking way* so that the RAS selects the educator's input over all other competing stimuli. Often students are criticized for not paying attention. However, a student's RAS is constantly attending to information (e.g. the sound of their neighbor whispering, the texture of their too-tight pants, the ache of their growling stomach, etc.), which may not be the information to which the teacher expects them to attend.

Strategies that provoke curiosity & prediction to promote attention and sustain focus:

- **Speaking** in a different voice (cadence, volume) can catch students by surprise.
- **Moving** in a different way can be unexpected. For example, a teacher can walk backwards before a lecture. This could relate to topics such as: flashbacks in literature, "backward" analysis or hindsight about events leading up to discoveries, historical events, or negative numbers.
- **Suspenseful Pause:** A significant pause before saying something important builds anticipation as the students wonder what you will say or do next.
- **Alterations in the classroom,** such as a new display on a bulletin board, promote curiosity.

How can the principles of advertising support educators in capturing students' curiosity?

Advertisers hope to gain the attention, curiosity, and interest of their audience. For example, the "coming attractions" at a movie theatre are meant to leave the viewer wanting more. The trailers are usually edited in a way that is dramatic and attention grabbing. The trailer provides some indication of what the film is about, but leaves out the majority of the details. This technique creates suspense. The viewer, now enticed, wants to see the full-length movie to see how everything resolves.

Educators can **advertise upcoming lessons** in a similar way. The goal is to provoke curiosity of what's to come. This can be done using a variety of both high and low-tech techniques.

- **Animoto.com or Masher.com**
- **Digital Tools for Students:** has dozens of digital tools and images that can be used to provoke curiosity about a lesson or unit: **http://studentdigitaltools.wordpress.com/**

Sustaining Attention and Engagement

Prediction: After curiosity has been provoked, students will sustain attention if

they are asked to predict what the curiosity stimulating sight, sound, object, statement, picture, question, etc. has to do with the lesson.

It is important that all students make predictions. To make their predictions powerful students needs to "bet" on their predictions.
Options include:

- Writing the prediction on an individual white board or "magic pad" or using an electronic student response clicker.
- **App for student responses:** www.nearpod.com has an app that provides a digital response system for students. It allows students to respond to polls or quizzes, whole class poll data display, and reports on student performance.

Dopamine-Reward System: *Why prediction is so powerful*

Dopamine is usually thought of as a neurotransmitter. **Neurotransmitters** are chemicals in the brain that transmit signals between neurons (nerve cells). Neurotransmitters allow for information to travel from neuron to neuron throughout the brain.

Power of Dopamine
Dopamine, when released in amounts that exceed what is needed for carrying signals across synapses, travels throughout the brain. The extra dopamine now acts as a neurochemical with more widespread impact. Increased dopamine is associated with (it both increases and is increased by) pleasurable experiences and the anticipation of pleasurable experiences. Its release also increases focus, memory, and executive function.

When dopamine levels go up, the following behaviors are more prominent:

- Pleasure
- Creativity
- Motivation
- Curiosity
- Persistence and perseverance

The following activities increase dopamine levels:

- Positive interactions with peers
- Enjoying music

- Being read to, or told a story or anecdote
- Acting kindly
- Expressing gratitude
- Humor
- Optimism
- Choice
- Movement
- ***Feeling the intrinsic satisfaction of accurate predictions and challenges achieved***

How can key points be emphasized throughout a lesson?

The above suggestions are often used at the outset of a lesson to alert students' attention to the fact that something new and important is being introduced. Throughout a lesson however the teacher is usually presenting information that represents varying degrees of importance. For example, in describing human anatomy a teacher might want students to understand the parts of the digestive system. Some anatomical structures are more important for understanding how the digestive system works than others. How can the teacher alert students to the most important information?

- **Color:** The teacher uses a set of colored markers when writing notes on the board. Green could represent that a piece of information is important, yellow could represent even more importance, and red could represent the most important "take home message". The students will also use colored pens or pencils to write their notes. This system also helps students when reviewing information later.
- **Hat:** During an oral presentation, when notes are not being used, a teacher could wear a hat and turn the bill of the hat in different directions to indicate levels of importance.

Key Understandings from Neuroscience About Attention

• Novelty (*pattern* change) promotes attention.

• Prediction (possibility of reward-*pleasure*) sustains attention.

• Expectation of *pleasure* motivates attention, effort and memory. Dopamine release "fuels" *pleasure*.

Things to consider when planning a lesson geared toward reaching and sustaining student attention and engagement:

- Will your information get through the students' RAS filters (low stress - high curiosity/interest)?
- In planning your instruction consider: Does the RAS input signal danger?
- What will arouse curiosity?
- How will all students predict the links between the cause of their curiosity and the topics of the lesson? How will they "bet" on their predictions?

The Impact of Emotions on Learning and Memory

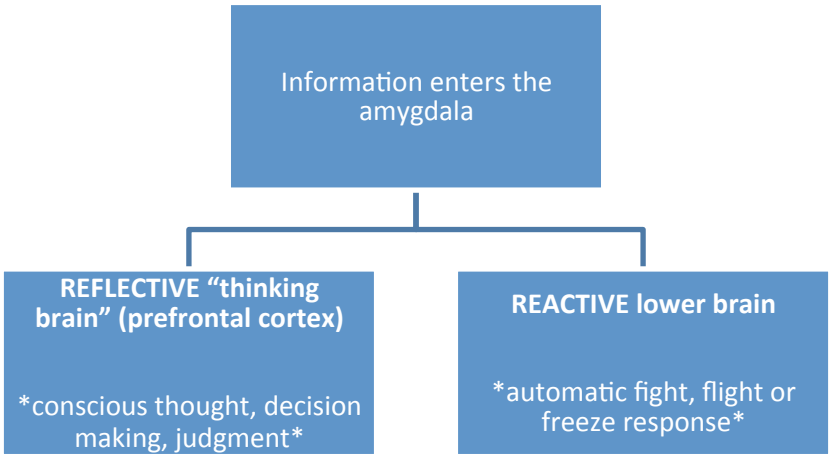
Common teacher concerns:
Some of my students 'act out' or 'zone out' in class. What can I do?
What we do for students who do not "get it" and for those who already "have it"?

This section answers the above questions with information about attitude, the amygdala, and achievable challenge.

The Emotional Filter

Amygdala: The amygdala is a part of the limbic system that is found in the temporal lobe of the brain. The amygdala can be thought of as a "fork in the road" or a "switching station" on the way to the "thinking brain" (prefrontal cortex). Stephen Krashen described this as the "affective filter."

- After information passes through the RAS, it enters the amygdala. The amygdala then directs the information to one of two places.
- The information can be sent to either the lower REACTIVE brain or to the REFLECTIVE "thinking brain" (prefrontal cortex).
- In the reactive lower brain, information is responded to with an automatic fight, flight or freeze response.
- In the reflective "thinking brain" (prefrontal cortex) conscious thought, logic, and judgment can be used to respond to new information.



What determines if the amygdala directs information to the reflective "thinking brain" (prefrontal cortex) or to the reactive lower brain?

When a person is in a state of high or sustained **stress** or **fear**:

- New information coming through the sensory intake areas of the brain cannot pass through the amygdala's filter to gain access to the reflective prefrontal cortex.
- Incoming information is conducted to the **lower, reactive brain**.
- The lower, reactive brain has a limited set of behavior outputs: fight, flight, or freeze animals – "act out" and "zone out" in students. *Be aware of students who act engaged, but are bored or fearful of failing to achieve highest goals.*
- Stress can reduce the ability of the hippocampus and prefrontal cortex to promote efficient working memory, emotional self-control, and attention focus.

Sources of school-related stress:

- Until the prefrontal cortex (PFC) is more mature, students are more reactive than they are reflective, especially when they perceive stress.
- Stress comes in many forms for students:
    - The boredom of already having mastery of the information being taught
    - No personal relevance: not being sufficiently interested in a topic or aware of how the topic relates to a student's own interests or prior knowledge
    - Frustration of previous failures, being confused, and falling

behind. *This is equally stressful for students who get failing grades and for students who repeatedly fail to achieve the goal they (and their parents) set such as #1 in the class or all "A's"*
    - Fear of being wrong if asked to speak in class, answer questions, or present their work orally

Promoting Transfer of Input through the Emotional Filter

Reducing Stress

If stress is reduced, and a person is in a **relaxed and alert state**, information can pass through the amygdala and on to the **reflective "thinking brain" (prefrontal cortex)** for long-term memory and executive function processing. Students can build skills that allow the prefrontal cortex to over-ride the lower brain's reactive impulses.

- Participating in new learning requires students to take risks that are often beyond their comfort zones. Steps should be taken to reduce stress during these times.
- Students can learn how to become aware of their own stress and strategies for relaxing and refocusing.

Teach Students about Their Brains

Learning how the brain processes input helps students develop more reflective PFC control over their reactive lower brains.

Related Articles and Websites:

How to Teach Students about the Brain link:
http://www.radteach.com/page1/page8/page44/page44.html

What You Should Know about Your Brain link:
http://www.radteach.com/page1/page8/page45/page45.html

Promote Growth Mindsets

People with a ***fixed mindset*** believe they are born with a certain amount of intelligence and skill, and that is all they will ever have. They believe that once they fail, there is no point in trying again, because they have reached their

limit.

Those with a ***growth mindset*** believe that people are given a certain amount of intelligence and skill, just as they have a certain body type, but that people have the potential to grow their intelligence and skill with hard work, just like a muscle. (Carol Dweck)

The Video Game Model for Mindset, Engagement, and Perseverance

The Brain Seeks Patterns and Pleasure

Video and computer games are compelling because they offer individualized *achievable challenges and frequent feedback of incremental progress* that are physiologically rewarded with the intrinsic satisfaction produced by the brain chemical *dopamine*.

At the outset, a player is presented with a goal. The player begins at level one, and through trial and error (***feedback***) builds enough skills to ultimately pass level one.

The next level challenges the player's newly developed skills, but ultimately, through sustained effort, practice, and persistence the player succeeds and continues to progress through the levels.

The player receives ongoing feedback and the dopamine boosting pleasure of ***incremental goal progress*** – reaching the next level. She feels the pride of knowing that her effort caused her success (intrinsic reinforcement). The player then seeks the greater challenge of the next level so she can continue to experience the pleasure of dopamine reward.

The Video Game Model in the Classroom

Video Game Model Includes:

- Goal buy-in
- Individualized achievable challenges
- Frequent feedback or awareness of incremental goal progress

Goal Buy-in – Personal Relevance

With goals designed to connect with students' interests and authentic performance tasks that they consider relevant, students want the knowledge tools they need to succeed. Students are then in the ideal state for motivated, attentive learning because they want to know what they have to learn.

Examples of Personal Goal Relevance

- Connect a unit with current events
- Read aloud something curious that relates to the topic at hand
- Personalize information by connecting the topic to a person or place relevant to students (e.g. book author anecdote). Before a lesson or unit, tell a *narrative* about the life of the author, scientist, historical figure, or mathematician when he/she was about the age of your students
- Discuss the "So what?" factor. How the topic connects to the "real world" or to their lives.
- How are they going to use the new information after you teach it to them (e.g. project, performance task, teach it to younger students)?

Your Self-Assessment For Buy-In: How will I promote buy-in?

- How will I gather and use knowledge about my students to inspire their interests in new learning?
- How will I relate the value of the learning beyond the classroom?
- Do I engage students in using what they learn beyond the classroom?
- Do I use the power of questions and "I wonder…" statements to engage students' attention and thinking?
- Do I pursue learning myself so that I model the endless nature of mastering new concepts and abilities?

Achievable Challenge

Lower the Barrier, Not the Bar

What we do for students who do not "get it" and for those who already "have it"?

An **achievable challenge** is one in which a student has the capacity (or skills to develop the capacity) to meet an ambitious goal. As Goldilocks would say, the challenge is "not too hard, not too easy, but just right!" An achievable

challenge exists within Vygotsky's "zone of proximal development".

If a challenge is too easy a student will become bored, which leads to stress, and ultimately disengagement from learning. If a challenge is too difficult a student will experience frustration and hopelessness, which, if sustained or frequent, also leads to excessive stress. However, when facing an achievable challenge that is just within their reach, students avoid the detrimental states of stress, and the amygdala is able to pass information to and from the prefrontal cortex.

Achievable challenges prevent stress by avoiding boredom and frustration: One way of helping students to develop a growth mindset is to provide them with achievable challenges and alert them to their progress.

Achievable challenge lowers stress by reducing boredom and frustration and motivating perseverance and effort.

Students are most motivated by the *expectation* of a dopamine reward when they learn at their individualized levels of achievable challenge. Providing students with achievable challenges reduces the reactive states resulting from the stress of boredom or frustration and promotes the intrinsic motivation of the video game *model*.

In the ideal video game *model* all students would be learning in their personal zone of achievable challenge at all times. Frequent and ongoing assessments would guide the setting and resetting of instruction and skill practice throughout learning with the individual support needed to sustain the student's efforts to overcome setbacks and obstacles.

Although this individualization is not possible for all students, options will increase as technology provides resources for online learning "games", lectures (flipped classroom), and enrichment opportunities for students already at mastery. While some students build basic math facts within their personal zone of achievable challenge with well-designed, interactive online learning programs, their teacher can guide others on inquiry projects and collaborations.

What can teachers do to enable students to work within their achievable challenge level?

<u>Lower the barriers, not the bar</u>:
Communicate high expectations for all students and provide differentiation and support so students can achieve their goals. At the start of a unit clearly define the learning goals, success criteria, and types of assessments. Take time to provide examples of how students' interests will be incorporated into their learning and how their strengths will be included in the assessments.

- Use pre-assessments
- Activate prior knowledge
- Offer flexible groups
- Use scaffolding and enrichment

Scaffolding/Enrichment

- Key vocabulary lists with pictures and definitions, vocabulary pantomime
- Manipulatives for addressing misunderstandings in math
- Reading comprehension strategies to help all levels of readers read appropriately challenging texts (variety of levels of reading and alternatives such as video and audio sources of foundational information). These are explained in more detail below such as learning self-questioning strategies such as turning subheadings of texts into questions to answer as the chapter is read, jigsaw, *"talk back to text",* three color highlighting
- Give students the opportunity to discuss ideas before offering responses to questions (pairs or small groups). This is especially useful for students developing mastery of English as a new language or in foreign language classes before they respond orally in the foreign language.

Increase reading comprehension of challenging texts with the following strategies:
1) "Talking Back to the Text" is an interactive reading strategy that helps students become personally engaged with what they read. Students begin by writing questions and prompts on post-it notes or other small papers that they can insert into their text. Some questions are prediction questions the student will answer before reading while others will be responded to while the student is reading.

- **Before reading** the students writes and answers prediction questions:
    - I think you'll be telling me…
    - I already know things about YOU so I predict.....
- **During reading** students can complete the following questions or prompts:
    - You are similar to what I have learned before, because you remind me of...
    - I would have preferred a picture of...(or sketch/download their own)
    - I didn't know that and I find it interesting because …
    - I disagree because…
    - This is not what I expected which was…
    - This gives me an idea for …
    - I want to know more about this than you have to offer. I'll find out by…
    - I have a different way of interpreting *this* information, which is…
    - I won't let you get away with this statement, so I'll check your source by ……
    - This could be a clue to help me answer the "Big Question" because…
    - I think this will be on the test because…

2) "Highlighting with Three Colors"

3) Improve reading comprehension with the "think-aloud" strategy
At home students should say out loud what they are thinking while reading, solving a problem, or answering questions. You can model this while reading a text in the classroom. Pause to illustrate to your students what you are thinking as you are reading the text.

Online Learning Games for Scaffolding and Enrichment: These can be used for skill practice and feedback at the student's individual level of readiness

- **Edutopia links** to my blogs about *On-Line Learning Games* for foundational knowledge and practice: http://www.edutopia.org/technology-integration-research-evidence-based-programs

Online Learning Game Resources:

- **Graphite is a free service listing** many apps, games, websites, and digital curricula. http://www.graphite.org.
- **EdSurge Product Reviews** https://www.edsurge.com/p

- **ClassroomWindow** classroomwindow.com
- **Ednak**: peer-reviewed tools of education technology http://www.ednak.org/
- **Budget Hero (**http://www.graphite.org/website/budget-hero) is an online game for building foundational knowledge about the United States and financial policy for students in grades 9-12. The website offers over thirty outside resources about budget, policy, and government information. The learning play offers authentic performance tasks about budgetary expansion, taxes and cuts. Students get feedback about the results of their actions.

Newsela.com: Archive of more than 500 articles each **at five reading levels**, organized by category and reading standard. Students take quizzes and view progress

Resources for Learning Differences:

- **Instructional videos for educators/parents:** http://www.uctv.tv/health/ University of California's Health Channel features videos about e.g. autism, brain injury, mind-body connection, nutrition, child development, sleep disorders, stress, teen health, and brain development
- **Learning disability resource recordings**: SERU (Special Education Resource Unit) website. Scroll all the way down to the bottom of the page to find the recordings. http://web.seru.sa.edu.au/Workshops.htm

Frequent Formative Assessment, Ongoing Feedback, & Awareness of *Incremental Progress*

Students will experience the ***intrinsic pleasure of incremental progress*** if they experience ongoing formative assessments with feedback, reteaching, opportunities for self-corrections, and metacognition. With this exposure students can build understanding and progress at achievable challenge levels of success. In general we experience an intrinsic reward when we realize that we are making progress due to our practice and effort. Even noticing small changes can be helpful. For example, having students keep a graph of how their reading fluency improves depending on how much they practice can be very motivating.

The **video game model** gives students the opportunity to recognize both the **intrinsic pleasure** of incremental progress ("I got it" experience) and the cause/effect that putting in **effort** towards practice and review brings them progressively closer to their goals.

Effort=Progress to Goal Graphs

Help your students use graphs to see the connection between their work, practice, effort, and their progress. Goals can range from time spent preparing for tests, number of answers correct on spelling tests, to progressing up rubric levels of proficiency in any subject. Help students build their own goal-directed behavior patterns by selecting the progress points they want to achieve on route to the final goal. Use small post-its or write in pencil when they believe they can reach each goal subdivision. As they progress they examine the accuracy of their projections and revise subsequent goal achievement dates and strategies accordingly. Sample graphs: www.onlinecharttool.com

Analytic Rubrics for Incremental Progress Awareness

Analytic rubrics are consistent with the amygdala positive benefits of the video game model of achievable challenge and incremental progress. Rubrics allow all students to:

- Understand what is expected and how they can achieve steps of incremental progress along the way toward overall goal
- Experience the choice (a dopamine booster) of achievable challenge – where they will focus effort
- Develop metacognitive awareness so they can self-motivate (dopamine from intrinsic gratification)

(REFERENCE: Nancy Pickett and Bernie Dodge. *"Rubrics for Web Lessons."* October 2001)

Rubric Generator Websites
http://www.teachervision.fen.com/teaching-methods-and-management/rubrics/4524.html#ixzz1d2xZeJck
http://www.teach-nology.com/web_tools/rubrics/
http://rubistar.4teachers.org/index.php
http://myt4l.com/index.php?v=pl&page_ac=view&type=tools&tool=rubricmaker
Audio feedback can also be left in documents that are turned in through **turnitin.com**

Your Challenges and Opportunities
Start with One Student

- Start with your achievable challenge – you need the validation of success to keep your dopamine-effort up

- Select one student where your efforts to "individualize" will have evident impact
- Be alert for improvements: ambient classroom noise, tardiness, more participants in discussions, more good questions, less disruptive classroom behavior

Emotion Summary

• Emotions influence where new information is processed in the brain. For learning to become memory it must be directed through the emotional filter (amygdala) along the route to the reflective, higher brain – the prefrontal cortex.

• High stress reduces information flow through the amygdala (emotional filter) to and from the cognitive/reflective brain (Prefrontal Cortex – PFC).

• During high stress, the survival instinct takes reactive control and responses are directed by the involuntary "lower" brain with output limited to fight/flight/freeze responses (act out/zone out).
• The mammalian brain is wired to withhold effort when experience predicts a low probability of success.

• The human brain can be "rewired" to reverse effort withholding when instruction follows the video game ***model*****:** buy-in, achievable challenge, and frequent feedback of *incremental* goal progress.

• The power behind the video game "model's" impact on motivation and perseverance is the intrinsic reinforcement of the *dopamine*-reward response to accurate predictions and feedback of challenges achieved.

• Goals that are clear, personally relevant, and believed to be achievable challenges are needed to promote brain "buy-in" and effort when previous efforts have not yielded goal success.

To promote a positive attitude so that information gets to the prefrontal cortex (PFC):

- Use curiosity promoting questions/demonstrations and make learning personalized for "buy-in"
- Have students work in their zone of "achievable challenge"

- Teach students how to recognize their progress towards a goal

Questions to Consider in Planning Units and Instruction in the Video Game Model

- How will students buy in from interest and relevance?
- What hooks will connect them from the beginning and what will sustain their interest in learning and understanding (predictions, audience relevance)
- How will I sustain awareness of big ideas revisit them throughout (headlines, mind maps)
- How will I use formative assessments to gain feedback about students developing understanding, emotional comfort, and my success?
- How will I provide incremental progress feedback for students?

WEBLINKS

Website showing multiple examples of curriculum contents adapted to the video game model: http://ierg.net/lessonplans/unit_plans.php

Sample RAD lessons/units at ASCD edge Website
http://edge.ascd.org/service/searchEverything.kickAction?keywords=lesson+plans&includeBlog=on&as=127586&sortType=relevance

Memory, Narratives, and Neuroplasticity

Promoting Patterning for Memory Encoding

The process that directs connection of new to existing memory is the brain's pattern seeking, extending, and storing system.

- To survive successfully animals need to understand their environments and make meaning of what they see, hear, smell, touch, and taste all around them.
- The brain is designed to perceive and generate patterns and uses these patterns to predict the correct response to new information.
- Through the brain's process of patterning, we are able to make predictions, anticipate what might happen next, and respond appropriately.

For New Input to "Stick" it must Link to a Similar "Pattern"

- When new information enters the *hippocampus*, if the brain recognizes

anything "familiar" or related to memories already stored in the cortex, these existing memory storage networks are activated.

- These related memories are stored in different parts of the cortex depending on which sensory receptors initially responded to the input.
- For example, the memory of ducks quacking is stored in the area of the cortex related to auditory input. If you were listening to a lecture about mallard ducks, the new information you were hearing would enter your hippocampus. Related memories about ducks (e.g. the sound of ducks quacking, the image of ducks you saw in a pond, a fact you once heard about the properties of feathers) would "meet" the new information about mallard ducks in your hippocampus.
- The consolidation of the pre-existing related memories and the new information is the process of encoding short-term memory.
- If no prior memory is stimulated and there is nothing to meet the new input in the hippocampus, the new input, with nothing to link to will be lost.
- The consolidation of the pre-existing related memories and the new information is the process of encoding short-term memory.
- Short-term memories are temporary and will only be converted to long-term memories if they are mentally manipulated in the prefrontal cortex. (Activities that require mental manipulation are described later in this document in the section called "Mental Manipulation").
- Once the information has been converted to long-term memory, when someone mentions something about a duck, your network of relational memories will be triggered and available to you.

Patterning Practice Builds Literacy, Numeracy, and Efficiency of working Memory

Pattern Recognition Awareness: Following are ways that students can build their skills in recognizing patterns across a variety of subject areas:

- Guide students to recognize patterns in story lines, or recognize trends or patterns in economic markets
- Recognizing patterns also helps them connect concepts
- Biology: students learning about the sensory pathways in the brain can be taught to recognize the pattern of the pathway of each sense (i.e. they all travel from sensory receptors, to cranial nerves, to the thalamus, to higher cortical areas)

- History: students might pick out a pattern of civil unrest being followed by civil wars
- Psychology: students might be assigned to watch a movie and pick out a character's pattern of behavior that is consistent with a diagnosis
- Geography: students can identify climate patterns related to seasonal changes in earth axis tilt relative to the sun

Patterning Web Resources (last checked June 2013)

Cyberchase is an interactive game where children can seek patterns
http://pbskids.org/cyberchase/math-games/cyber-pattern-player/

Early elementary pattern recognition worksheets:
http://www.kidzone.ws/prek_wrksht/math-readiness/patterns.htm
http://www.kidslearningstation.com/preschool/pattern-worksheets.asp

Brain Nook is a free (except premium level) virtual world with patterning activities and games to learn math and English http://bit.ly/hdLSy6 (and teachers can track student progress)

Pattern recognition computer board games for upper elementary through high school:
http://boardgamegeek.com/geeklist/44918/brain-burning-pattern-recognition-games

The website http://www.ehow.com/info_7820555_interactive-pattern-games.html provides descriptions and links to interactive pattern games for all ages.

Cyber Pattern Player http://pbskids.org/cyberchase/games/patterns/
is an interactive game that teaches children that patterns can be heard as well as seen

On the **Set** website (http://www.setgame.com/), upper elementary - adult players identify "SETs" of four individual features (color, pattern, shape, number)

Free On-Line Learning Games (www.zondle.com) has 12,000 topics created by teachers (or you can make your own) and students. Students can use almost any internet-connected device (e.g. phone, netbook, etc.) to communicate their responses

Invention Playhouse/Smithsonian
http://www.inventionatplay.org/playhouse_puzzle.html

Maximizing Successful Memory Links

The brain's ability to recognize related stored memories in response to new information or decision-making is frequently an automatic process. However, if students have not been made aware how their prior knowledge connects with new information, they are unlikely to activate the memory stores that relate the new input. Make memory relationships more efficient, effective, and transparent by **activating prior knowledge.** Prior knowledge is data that students have already acquired through formal teaching, personal experience, or real world associations. Teachers should "activate" this prior knowledge by alerting students to what they already know that connects to what they are going to learn. This is consistent with the way the brain makes these connections through pattern recognition and pattern matching.

Prior Knowledge Activation Strategies:

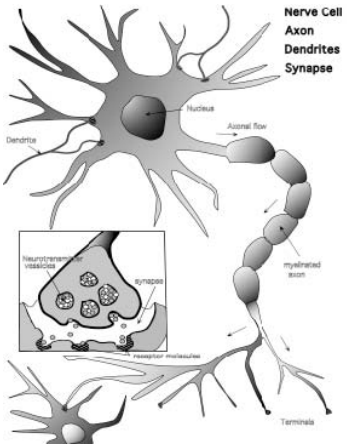
- Bulletin boards that preview
- Personal/cultural connections
- Give pre-unit assessments
- Show videos or images that remind students of prior knowledge
- Hold class discussions starting with high interest current events
- Remind students about previous exposures (cross-curricular, spiraled curriculum). Find examples of cross-curricular topics and web-links at **http://www.cyberbee.com/intclass.html**
- Have students brainstorm about what they already know and what they want to learn about a new unit. This could be done with informal class discussions or with the KWL chart. When they discuss what they learned, they could connect it back to other topics in the class and discuss how the similarities and differences

Graphic Organizers

Graphic organizers are consistent with the way the brain stores information in related categories. Retrieval is better when learners know how information is organized e.g. categories. Thus, visual maps and organizers are most effective when students have input into aspects of their design and organization. Introducing a variety of graphic organizers gradually over the grades and using similarly structured ones from year to year helps students build their comfort and appreciation for these tools.

Samples of graphic organizers can be found at these websites:
http://www.enchantedlearning.com/graphicorganizers/
http://www.eduplace.com/graphicorganizer/
http://www.ncrel.org/sdrs/areas/issues/students/learning/lr1grorg.htm
http://www.teach-nology.com/web_tools/graphic_org/
http://www.inspiration.com/freetrial/index.cfm
engaging in some stretching movements will help working memory processing to proceed more successfully.

Neuroplasticity is the process through which thoughts and actions change the brain



Scientists previously believed that many parts of the brain only change during the "critical stages" of infancy.

- Research now suggests that all parts of the brain are malleable throughout our lives.
- Specifically, when a region of the brain is stimulated repeatedly (which happens when we practice and use information), the connections between neurons (nerve cells) in that memory circuit are increased in number and durability.
- These strengthened connections, if used consistently, become useful, long-term memories.
- Conversely, if a neural pathway is not used, it will be pruned (removed).

Durable Neural Networks of Memory

Information that we learn must become integrated into durable, long-term memory circuits of connected neurons to become consciously retrievable and sustained. This means that the learner has to "do something" with the information so the neural network will be activated. It is the electrical current that flows through the network when it is used that promotes the neuroplastic changes that will sustain the learning as memory.

1) Symbolize: Making a symbol is "translating" knowledge into another mode and cannot be done successfully without understanding**.** Translating incorporates meaning making as information is symbolized in the arts, skits, narratives, videos, blogs, web-pages, diagrams, etc.
2) Summarize/Synthesize: Concise summarizing; haiku, tweet, make test questions
3) Categorize/Pattern: Similarities/differences, analogies, lists

1) Symbolize

- **Create a narrative** – students can write and share a story, blog, PowerPoint, website, skit, or video about the reading
    - **With iPads:** ***Explain Everything*** and ***ShowMe*** are two apps that allow students to create and share information in a multisensory fashion
    - **Voki** (www.voki.com) A Voki is a presentation tool whereby students can create a character and enter text for the character to say. The presentations can be published and shared. Voki also includes special options for teachers.

- **Humor and personalization** can be used to make even the driest of facts memorable. For example, one of my previous workshop participants told an amusing story about a lonely piece of new information that entered a brain. It felt lost and sad until it found its family amongst the related memories in the hippocampus. Illustrating the story adds a further level of mental manipulation.
- **Teach the new information to someone else**: Understanding something well enough to teach it to another person requires a clarity of thought and understanding that ultimately supports the "teachers" long term memory of the concept.

2) Synthesize/Summarize/Prioritize

Pair-share or collaborate: Students experience a greater level of understanding of concepts and ideas when they talk, explain, predict, and debate about them within a small group, instead of just passively listening to a lecture or reading a text. Students, depending on age and topic, can listen to directed lecture with focused attention for only 10 - 20 minutes without some type of break. Having students take a moment to process information and communicate with the student next to them is an excellent, dopamine-raising mini-break.

Use "twitter" or "text message" style writing to create concise summaries. Younger children can make "phones" (decorated towel or toilet tissue roll) and practice short overseas calls to someone in "a far away country – real or imaginary" but need to keep toll charges down with short call planned in advanced. A brief summary can go a long way! Just think about how much meaning can be found in a perfectly crafted haiku.)

Twitter Summarizing

'Tweet' ________________________ 140 characters or less (including spaces, punctuation, numbers, etc.).

— —
— —
— —
— —
— —
— — — — — — — — — — — — — — —

3) Categorize/Pattern/Commonalities

Similarities and differences: Just as survival depends on recognizing the changes in an animal's expected environment, people are also responsive to remembering information by identifying similarities and differences. Researchers have found that identifying similarities and differences is the most effective way of committing information to memory.

Create analogies and similes

Long-term Memory Summary

• The brain constantly changes through ***neuroplasticity*** (building, strengthening, or pruning of networks of memory).

• The brain adapts and improves in response to the environment and results of predictions it makes.

• When newly encoded short-term memory circuits are activated by mental manipulation (categorizing, graphic organizers, analogies) or by application (use) neuroplasticity acts to develop them into long-term memory networks with increased strength, durability, and speed of retrieval of the memory circuits.

• Memory circuits used together, to perform novel tasks or solve new problems, become linked into larger circuits of durable *concept* knowledge available for transfer to novel applications now and in the future.

Mental Manipulation Websites

Create an Animoto video online to summarize information from class or readings (www.animoto.com)

www.MakeBeliefsComix.com includes summarizing, story-telling, and plot description activities

With **www.tagxedo.com** students make word clouds for "big ideas" in text

iPadagogy Wheel for Concept Memory:
http://mrjexperience.files.wordpress.com/2013/04/ipadagogy-wheel-001.jpg

Executive Functions – see links below

Executive functions *plus a strong base of core knowledge are the essential skills for success in today's world. They are what need to be strengthened for students to think critically, collaboratively, and communicate effectively.*

Executive Functions:

Goal-development
Attention focus/distraction inhibition

Emotional self-control
Prioritization
Organization
Judgment
Critical analysis e.g. validity
Cognitive Flexibility
Reasoning (Deduction/Induction)

LINKS About Executive Function Focus

Preparing Your Students for the Challenges of Tomorrow
http://www.edutopia.org/blog/prepare-students-challenges-of-tomorrow-judy-willis ***Edutopia*** Staff blog. August 20, 2014.

Understanding How the Brain Thinks: *Edutopia Staff 6-PART Blog Series*
about Building Executive Functions
Understanding How the Brain Thinks (Part 1)
The Brain-Based Benefits of Writing for Math and Science Learning (Part 2)
Improving Executive Function: Teaching Challenges and Opportunities. (Part 3)
http://bit.ly/p1oTbO
Three Brain-based Teaching Strategies to Build Executive Function in Students (Part 4)
http://bit.ly/nCy5Id
Three Strategies for Using the Arts to Build Student Executive Functions (Part 5) http://bit.ly/xFnJO8
Executive Function, Arts Integration and Joyful Learning (Part 6) http://bit.ly/yI2NLa

Beyond the Comfort Zone: 6 Ways to Build Independent Thinking. *Edutopia* Jan 10, 2014.
http://edut.to/1gqKy6X

The Simple Things I Do To Promote Brain-Based Learning In My Classroom in *TeachThough* Oct 2013 http://www.teachthought.com/learning/the-simple-things-i-do-to-promote-brain-based-learning-in-my-classroom/

The Impact Of Creativity On The Brain by Judy Willis M.D., M.Ed., ***TeachTought* Issue 03/16/2014.** http://www.teachthought.com/learning/the-impact-of-creativity-on-the-brain/

What Does Neuroscience Research Say About Motivation And The Brain? In Partnership for 21 Century Skills http://www.p21.org/news-events/p21blog/1318-judy-willis-what-does-neuroscience-research-say-about-motivation-and-the-brain

Building Brain Literacy in Elementary Students in Edutopia.org November 19, 2013.
http://www.edutopia.org/blog/building-brain-literacy-elementary-students-judy-willis

Southwest Airlines Spirit Magazine: Flipped Out: *How the digital revolution is turning learning upside down (including my interview comments)* Southwest Airlines Spirit Magazine / Flipped Out http://bit.ly/146gTM6

Willis, J. A. (2013). Success on Standardized Tests without Sacrificing Authentic Learning. *STEM Magazine*. Jan - Feb 2013
http://issuu.com/carleygroup/docs/stem_magazine_final_jan._2013_web/12

Six Part Video Series from Lower Canada College 2011: One on One With Dr Judy Willis
One on One with Dr. Judy Willis, MD, M.Ed.: Helping Students Develop Their Highest Cognitive Potentials
Part 4: How to teach students about their brains http://bit.ly/y2U3Mp
Part 5: Building the Brain's Executive Functions for 21 Cent Success http://bit.ly/y0cWdZ
Part 6: Parenting to build executive functions in children http://bit.ly/xekaCK.

ASCD Edge Page http://bit.ly/aqDjQp
"ASK Dr. Judy" Free ASCD Archived Brain-Based Learning Strategies Webinars. Video and pdf multiple ed topics http://bit.ly/PDwSK1 **& scroll down**

- *The Essential Neuroscience of Learning* Dec 11, 2012
- *Long-Term Goal Development in Students. Aug 14, 2012*

Exposing neuromyths and emphasizing the value of correlations from neuroscience research to the classroom in *Takepart.com* Jan 14, 2014
http://www.takepart.com/article/2014/01/13/brain-based-teaching-research

"Dr. Judy Willis *Edutopia's* 'Big Thinker on Education'"
http://www.edutopia.org/big-thinkers

Big Thinkers: Dr. Judy Willis on the Science of Learning
http://www.youtube.com/watch?v=J6FqAiAbUFs

Culminating Goal Questions

What have you learned, that if implemented, could have a readily apparent impact on students?

What is a goal you have that would be high yield/high effort?

Note Taking Worksheet

Reach: Get information through RAS attention filter

When information enters the brain through one or more of the sensory organs, it must pass through a brain structure called the **RAS**. The **RAS** is the brain's **attention filter**. It has a limited capacity to admit information. Its first priority is to admit **threatening** information. If there is no threat, it prioritizes **novelty**. This is an involuntary process.

What **derails attention** and keeps information from entering the RAS?	
Strategies that use **novelty** to **capture attention**:	
Strategies that use **prediction** to **sustain attention**?	

Develop Motivation and Memory with Dopamine

The neurotransmitter dopamine has many roles in learning. Dopamine promotes pleasure, decreased stress, curiosity, attention, and motivation. It also contributes to memory formation and retention.

Strategies for increasing **dopamine**: (Dopamine is increased by: movement, enjoying music, being read to, humor, choices, interacting with peers, kindness, gratitude, optimism, making predictions, achieving	

challenges)	

Attitude/Emotion: Get information through the amygdala (emotional filter)
After information passes through the RAS attention filter it reaches the **emotional switching station** called the **amygdala**. For information to pass through the amygdala successfully, the brain should not be in a state of high stress. In a state of high stress, information that enters the amygdala will be directed to the lower brain, which will react with an involuntary fight, flight or freeze reaction. In this state information cannot pass to the prefrontal cortex (PFC) for higher order thinking, nor can information be retrieved from the PFC.

S**tressors** that prevent information from getting through the amygdala:	

The video game model of teaching can help to prevent boredom and frustration

When students fail to find relevance or learning experiences are **below their achievable challenge level** (too easy), they are likely to feel bored. Boredom and frustration are very stressful. When students are bored or frustrated information is not likely to pass successfully through the amygdala. When students work in their zones of **achievable challenge** (not too hard, not too easy) information that they learn will pass **successfully** through the **amygdala** to the PFC. They will be in a positive mood state and motivated to sustain engagement, effort, and perseverance through challenges.

Buy-in strategies:	

Achievable challenge strategies:	
Frequent feedback of **incremental goal progress** strategies:	

Short-term Memory:
After information passes through the amygdala it enters the **hippocampus**. The hippocampus is where short-term memories are formed. Once new information enters the hippocampus it must connect with related information if it is to be consolidated and ultimately retained as long-term memory.

Strategies for **activating prior knowledge**	

Long-term Memory: Mental Manipulation

Long-term memories are formed when information from the hippocampus is manipulated and used in a variety of meaningful ways in the **prefrontal cortex (PFC)**. Neuroplasticity is the process by which the brain strengthens connections that are repeatedly used together. Information that is incorporated into neural connections strengthened by neuroplasticity is more likely to be successfully stored, retrieved, maintained, and applied.

Three main categories of Mental Manipulation: Synthesize, Summarize, Categorize

Mental manipulation strategies: Synthesize (e.g. symbolize, create narratives, videos, webpages, presentations) Summarize (e.g. blogs, tweets) Categorize (e.g. similarities/differences, analogies, graphic organizers)	

Judy Willis, M.D., M.Ed.
www.RADTeach.com
jwillisneuro@aol.com

A *Neuro-logical* Lesson Planner

Judy Willis, M. D., M.Ed.

Unit Title: _____ Subject(s): _____ Grade Level(s): _____ **Lesson Concept/Topic: _____** **Lesson Goals/Objectives: _____**	
Lesson Elements: (and how they will be *Neuro-logical)*	**Your plan:**
Getting Attention: *How will you begin this lesson to engage learners' attention?* The attention filter (RAS) gives priority to sensory input that is different than the expected pattern. Novelty, such as changes in voice, unusual objects, songs playing when they enter the classroom, will ignite students' curiosity and increase likelihood of the related lesson material being selected by the **RAS attention filter**.	
Sustaining Attention: *What will you do to sustain students' attentive focus throughout the lesson?* The brain seeks the pleasure response of making correct predictions. When students have the opportunity to make and change **predictions** throughout a lesson, attention is sustained as the brain seeks clues to make accurate predictions. Individual response tools can be used to make predictions and reduce mistake anxiety.	
Motivation and Perseverance: *Which dopamine boosters will be included in your lesson?*	

The brain seeks the pleasure response to increased dopamine. Incorporating dopamine boosters (e.g., humor, movement, listening to music, working with peers) increases attention, motivation, and perseverance	
Buy-in: *How will you help students see value and relevance in what they are learning – so they want to know what you have to teach?* Positive climate and prevention of high stressors promote information passage through the **amygdala** to the PFC. Motivation and effort increase when the brain expects pleasure. Buy-in examples include personal relevance, prediction, and performance tasks connecting to students' interests and strengths.	
Achievable challenge: *How will you tailor the lesson to address students' differences in readiness, learning profile, and interests?* Differentiation allows students to work at their **achievable challenge level**. The students who understand the new topic, if required to keep reviewing with the group, may become **bored and therefore stressed**. If it is too challenging they will become **frustrated**. By providing learning opportunities within their range of achievable challenge, students engage through expectation of positive experiences.	
Frequent Formative Assessment and Feedback: *How will you monitor students' progress towards acquisition, meaning making, and transfer, during lesson events?* *How will students get the feedback they need and opportunities to make use of it?*	

Effort is withheld when previous experiences have failed to achieve success. Breaking down learning tasks into achievable challenge segments, in which students experience, and are aware of, success on route to learning goals (e.g. analytic rubrics, effort-to-progress graphs) and reflect on what they learned and how they learned, builds their confidence that their effort can bring them closer to their **goals**.	
Short-term Memory Encoding: *How will you activate prior knowledge to promote the brain's ability to acquire new input?* Helping students to realize what they already know about a topic activates an existing memory **pattern** to which new input can link in the **hippocampus.** Graphic organizers, cross-curricular units, and bulletin boards that preview upcoming units are examples of prior knowledge activation tools.	
Mental manipulation for Long-term Memory: *How will students make meaning of learning so neuroplasticity constructs the neural connections of long-term memory?* When students acquire the information in a variety of ways e.g. visualization, movement, reading, listening, and "translate" learning into other representations (create a narrative, symbolize through a video, synthesize into the concise summary of a tweet) the activation of the short-term memory increases its connections (dendrites, synapses, myelin) to construct long-term memory.	

Judy Willis, M.D., M.Ed.
www.RADTeach.com
jwillisneuro@aol.com