The Role of Visual Processing in Reading and Learning

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Visual Processing and Reading: A Quick Pretest

- Rate the following statements in terms of supporting evidence::

1 = Much evidence 2 = Some evidence 3 = No evidence

1. Block Design is a good task to include in a test battery used for the purposes of screening for Dyslexia.
2. Dyslexia involves reversal's in reading and writing letters and "mirror-image" reading.
3. Tasks such as the Bender Visual Motor Gestalt Test and the Developmental Test of Visual Perception (the Beery) are effective means for assessing visual perceptual deficits associated with reading disorder.
4. Letter images are stored in the right hemisphere because the right hemisphere is the visual processor of the brain.
5. Dyslexia is caused by a visual perceptual disorder that can be corrected through vision training provided by a qualified optometrist.
6. The use of Erlin colored lenses can improve a child's poor reading.
7. Reading is an inter-hemispheric process; printed text is processed in the right hemisphere while the linguistic meaning associated with the printed text is processed in the left hemisphere.
8. In some cases, visual training can help to improve reading by improving a child's attention to the visual details of orthography.
9. Orthographic awareness is critical to the development of good reading skills.

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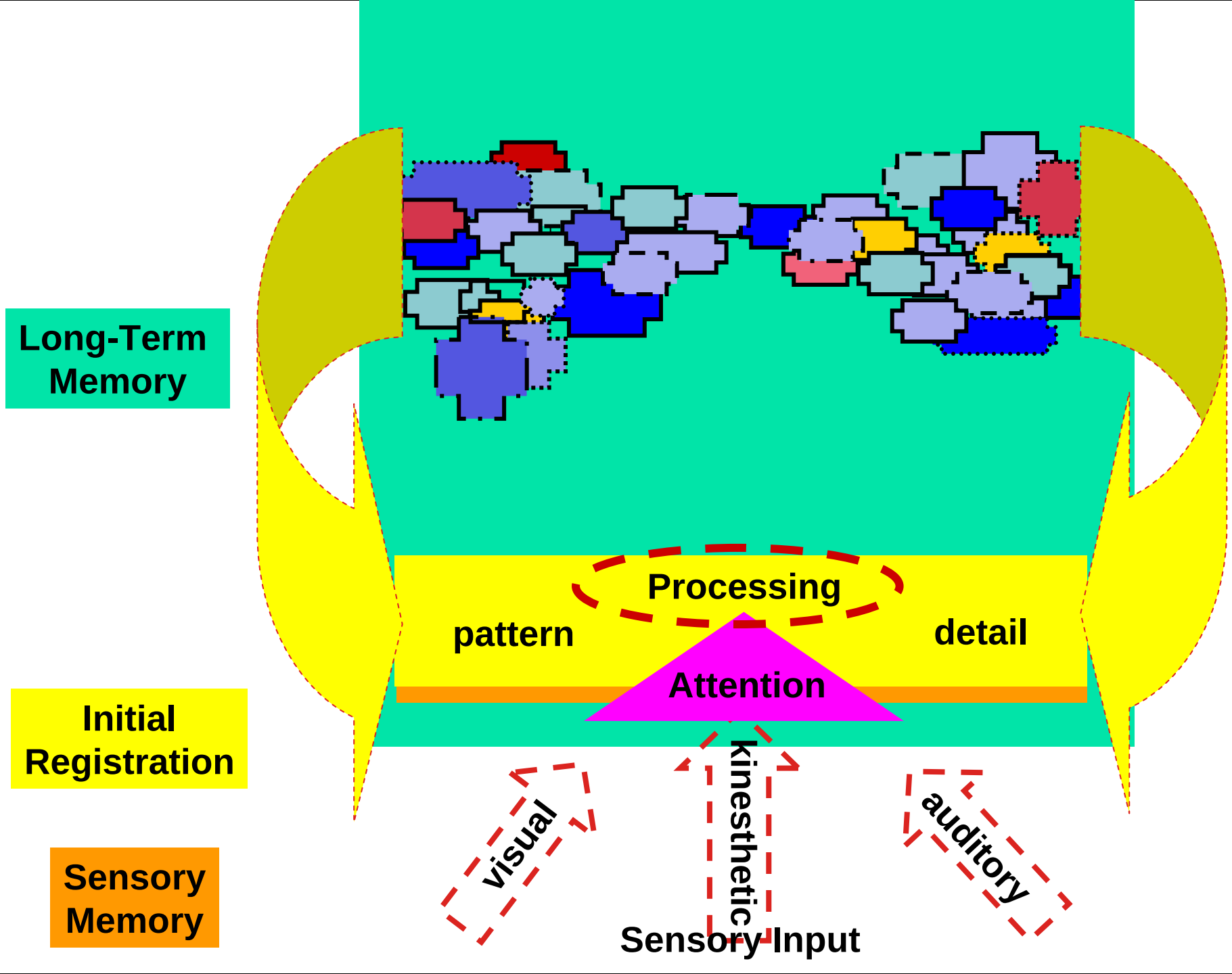
9. Orthographic awareness is critical to the development of good reading skills. (1)

The “Visual Now” Relies on the “Visual Then”

- Experience (stored as visual processing “lexicons”) continues to play the most critical role in visual perception throughout life. Almost all initial registration of visual information in the “now” moment requires access of previously stored information. Overreliance on previously stored information to process information in the “now” moment of initial registration, however, can cause misperceptions. Similarly, inaccessibility of previously stored information can cause misperceptions.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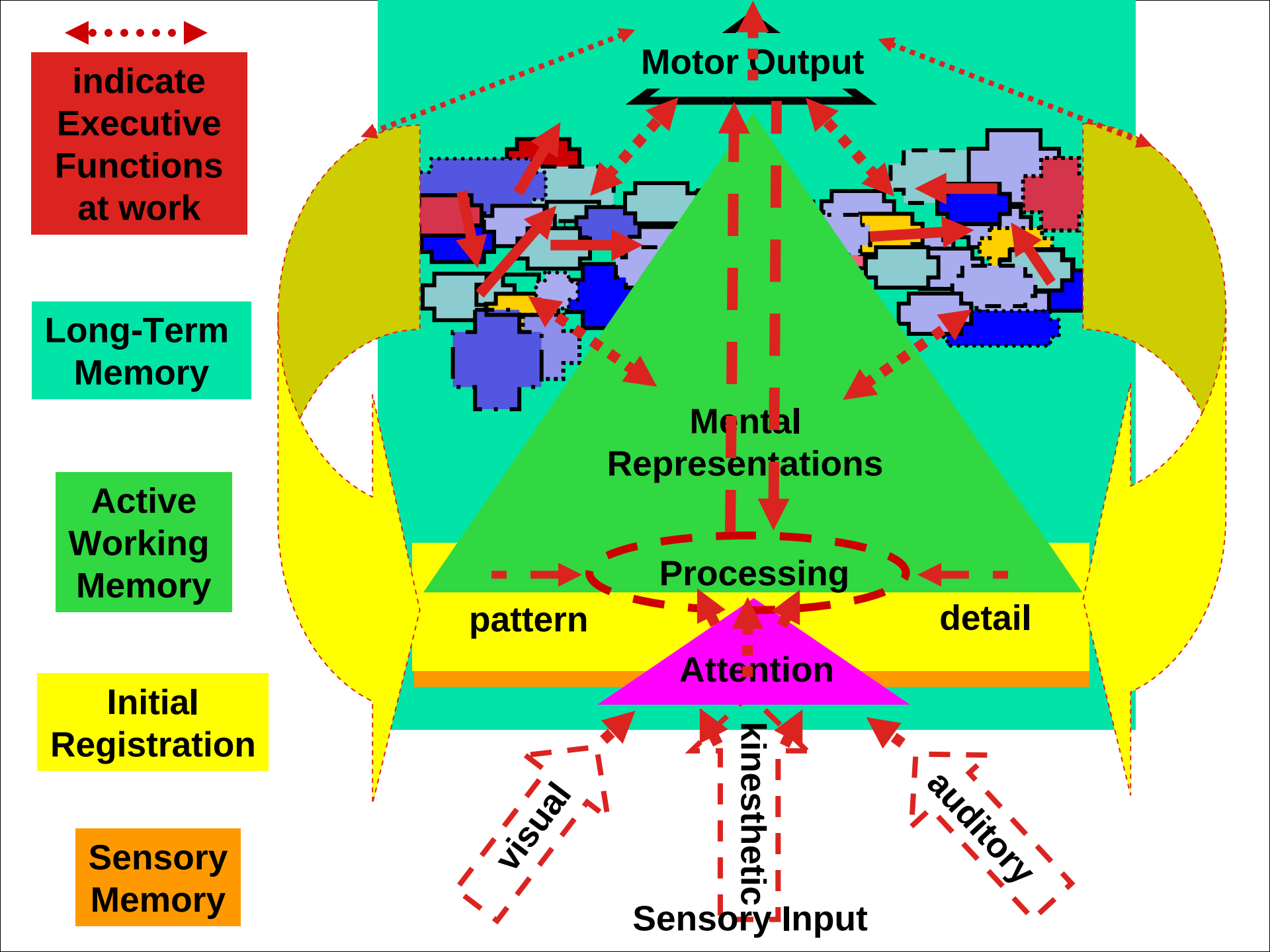
indicate Executive Functions at work
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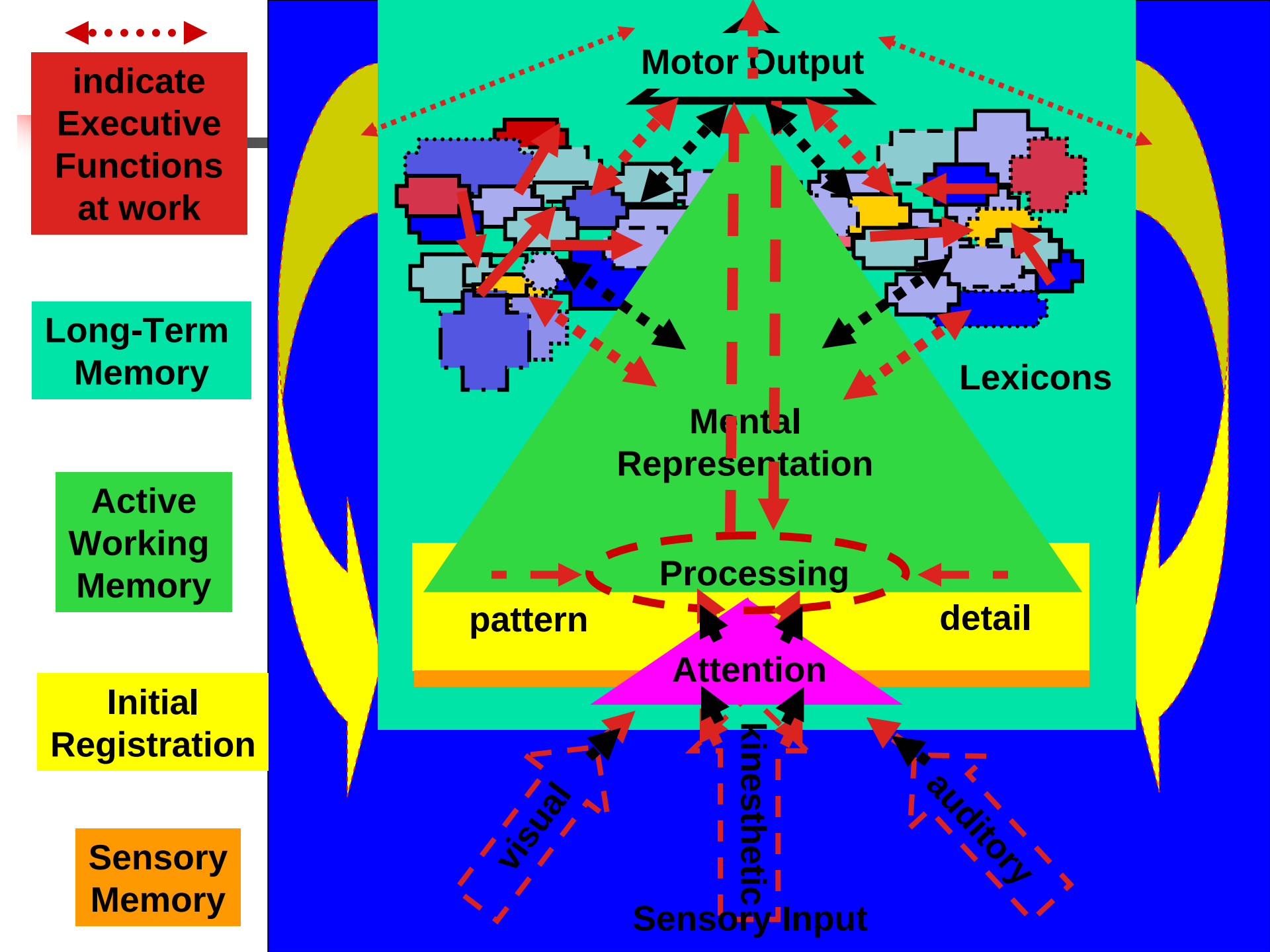
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Active Working Memory
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Sensory Memory
Motor Output
Lexicons
Mental Representation
Processing
pattern
detail
Attention
visual
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Sensory Input

From Sight to Seen:
The Visual Pathways of the Brain

The Primary Visual Pathway

- Stimuli enter the brain through the lens of the eye and are initially processed by the rod and cone cells that line the retina and convert the light impulses into chemical reactions which in turn produce electrical signals.
- These electrical input signals travel two distinct pathways (with multiple subdivisions further down the path).

From Sight to Seen:
The Visual Pathways of the Brain

The Primary Visual Pathway

- The primary visual pathway leads to the superior colliculus in the brainstem where the electrical impulses are reacted to to control eye movements, blinking, dilation of the pupils and visual reflexes such as tracking moving objects.
- This system is responsible for an infant's visual processing until about two months after birth.
- The primary pathway is evolutionarily much older and the earlier to mature in the infant.

From Sight to Seen:
The Visual Pathways of the Brain

The Secondary Visual Pathway

- The secondary visual pathway sends more than a million ganglion cells from each retina through the optic nerve tract to form synapses in the lateral geniculate nucleus (LGN), the visual area of the thalamus.
- From the thalamus, neurons send axons on to the occipital lobes (left and right) of the cerebral cortex to the Primary Visual Cortex (Area V1).

The Visual Pathways of the Brain

The Secondary Visual Pathway

- This secondary pathway is responsible for conscious experiencing and control of visual perception, and begins to take over most visual tasks from the subcortical pathway around age 2 months.
- Each eye sends nerve impulses to the left and right occipital cortex in a contralateral manner, i.e., the right cortex receives impulses from the left half of the visual field of both eyes and the left cortex receives impulses from the right half of the visual field of both eyes.

The Visual Pathways of the Brain

The Secondary Visual Pathway

- The visual cortex has at least 32 different areas specialized for processing different aspects of visual perception (e.g., motion, location, color, object shape, depth). This division of labor allows for parallel processing, i.e., the analysis of many visual features at one time.

Visual Pathways of the Brain

The Two Major Streams of the Secondary Visual Pathway

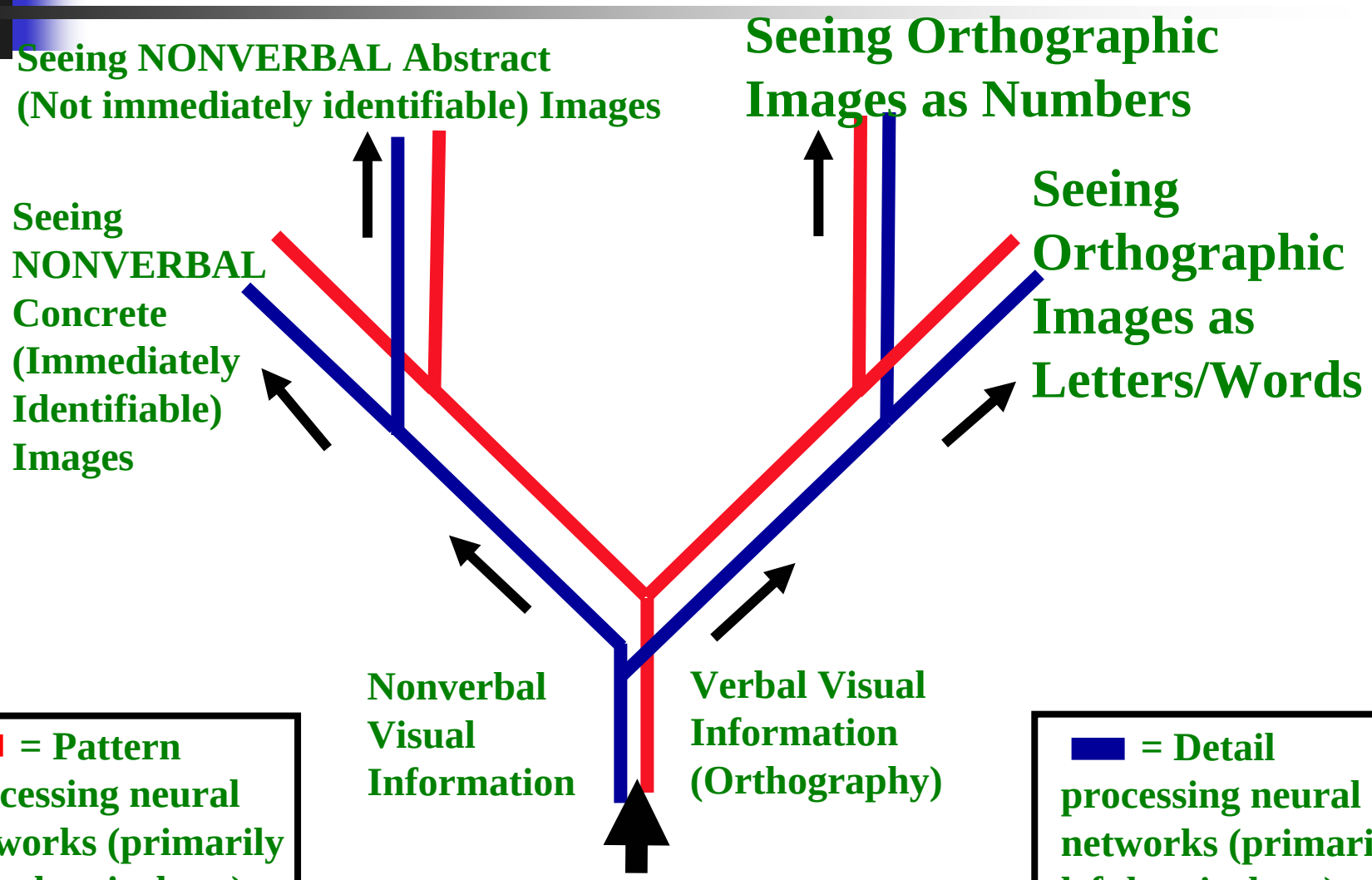
- The “Where” stream is specialized for detecting an object’s speed, direction of motion, and location in three-dimensional space, and for directing eye movements to follow visual targets.
- The “Where” stream flows onward from the primary visual cortex to the parietal lobes.
- The “What” stream is specialized for processing color, shape and size and is used for identifying objects.

Visual Pathways of the Brain

The Two Major Streams of the Secondary Visual Pathway

- The “What” stream flows onward from the primary visual cortex to the temporal lobes.
- The “What” stream further divides into branches that facilitate the recognition of abstract visual features of objects like size, shape, and color, and branches that enable the recognition of familiar classes of objects.
- The “Where” stream matures slightly earlier in development than the What stream. By birth, many more synapses for motion processing have formed than synapses for form perception. By 4 months the first relay in the Where pathway has reached maximal synaptic density, while the What pathway takes until 8 months to reach a similar stage of development.

Visual Information Processing Neural Networks

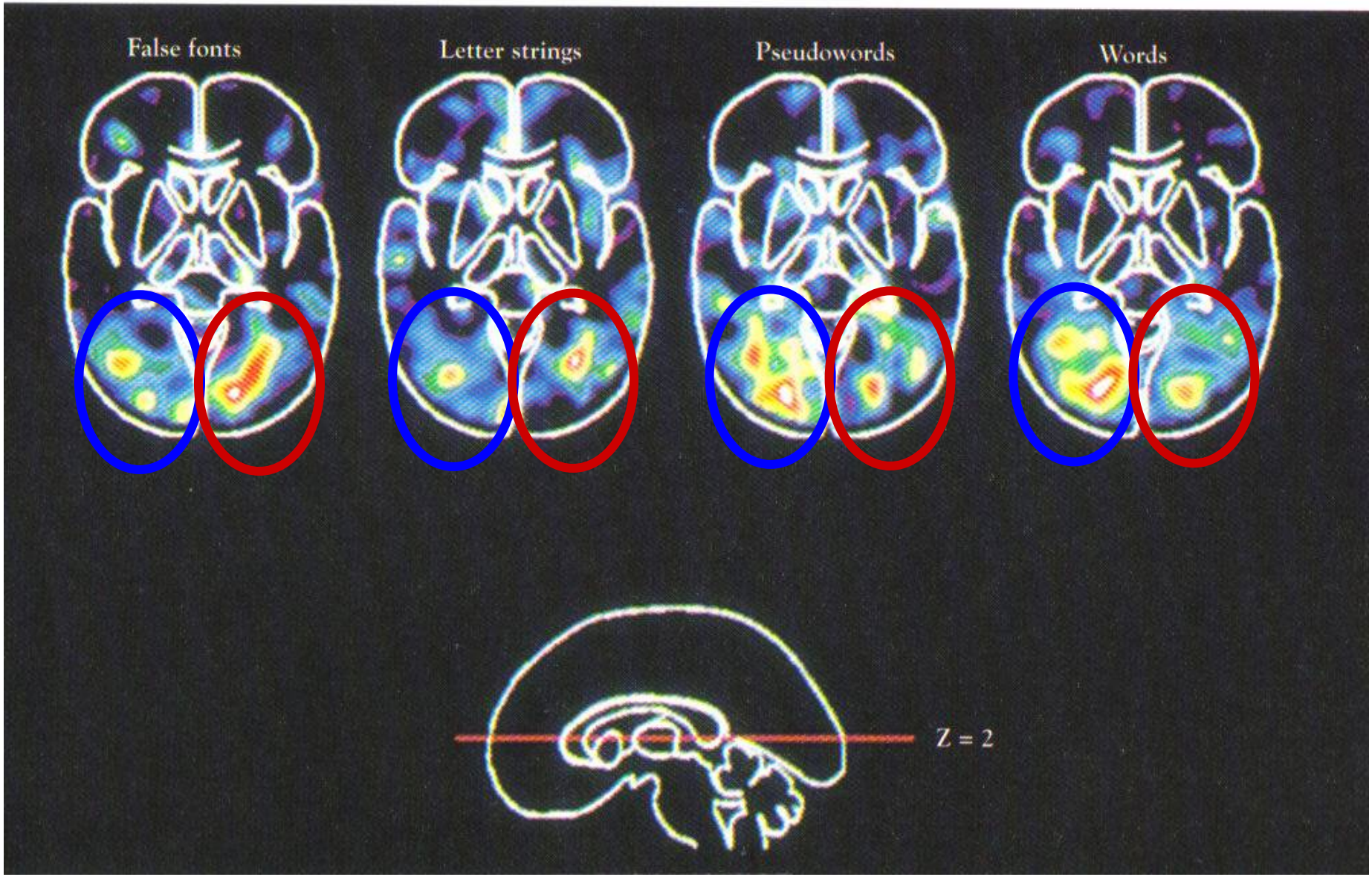


How Brains Process Orthography

Example of the Four Types of Visual Stimuli

Words	Pseudowords	Letterstrings	False Fonts
ANT	GEEL	VSFFHT	ꓤꓥƎ
RAZOR	IOB	TBBL	ꓙϤꓙꓤ
DUST	RELD	TSTFS	ꓤꓷϽꓤ
FURNACE	BLERCE	JBTT	ꓶꓶꓵꓵ
MOTHER	CHELDINABE	STB	ꓤꓤꓣꓙꓱ
FARM	ALDOBER	FFPW	ꓥϤꓷꓤ

How Brains Process Orthography



Visual Pathways of the Brain

The “What” Stream Neural Networks

- After initial processing of all visual input by a common neural network in the primary visual cortex, the What stream engages neural networks that further differentiate visual input:
  - Nonsymbolic Generic Visual Input – this input engages neural networks that further specialize processing based on familiarity of the input:
    - Familiar objects are processed by neural networks that deal with concrete images.
    - Unfamiliar objects or ambiguous visual input is processed by neural networks that deal with abstract images.

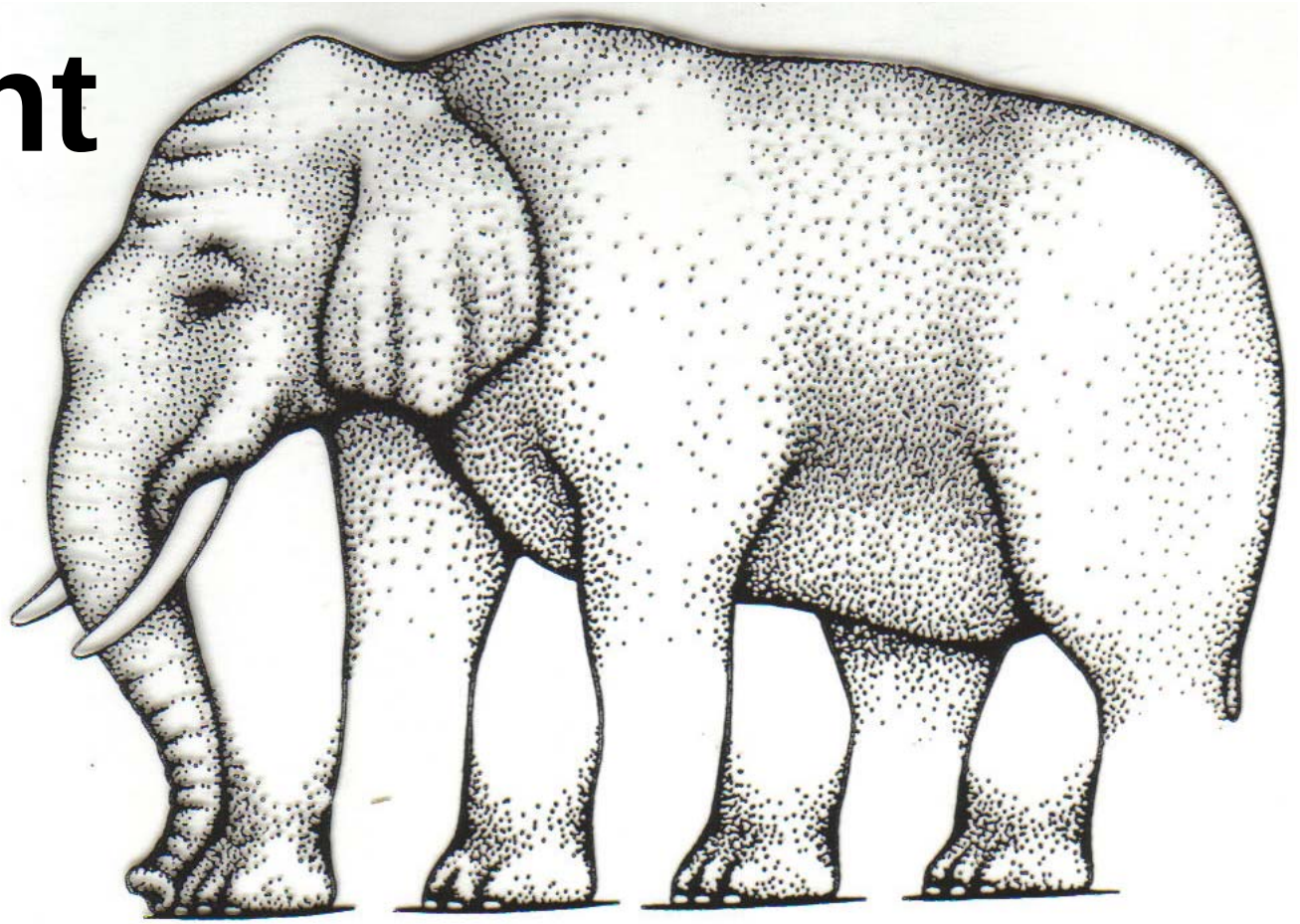
Non-orthographic Visual Processing

Visual Processing

Orthographic

elephant

Non-orthographic



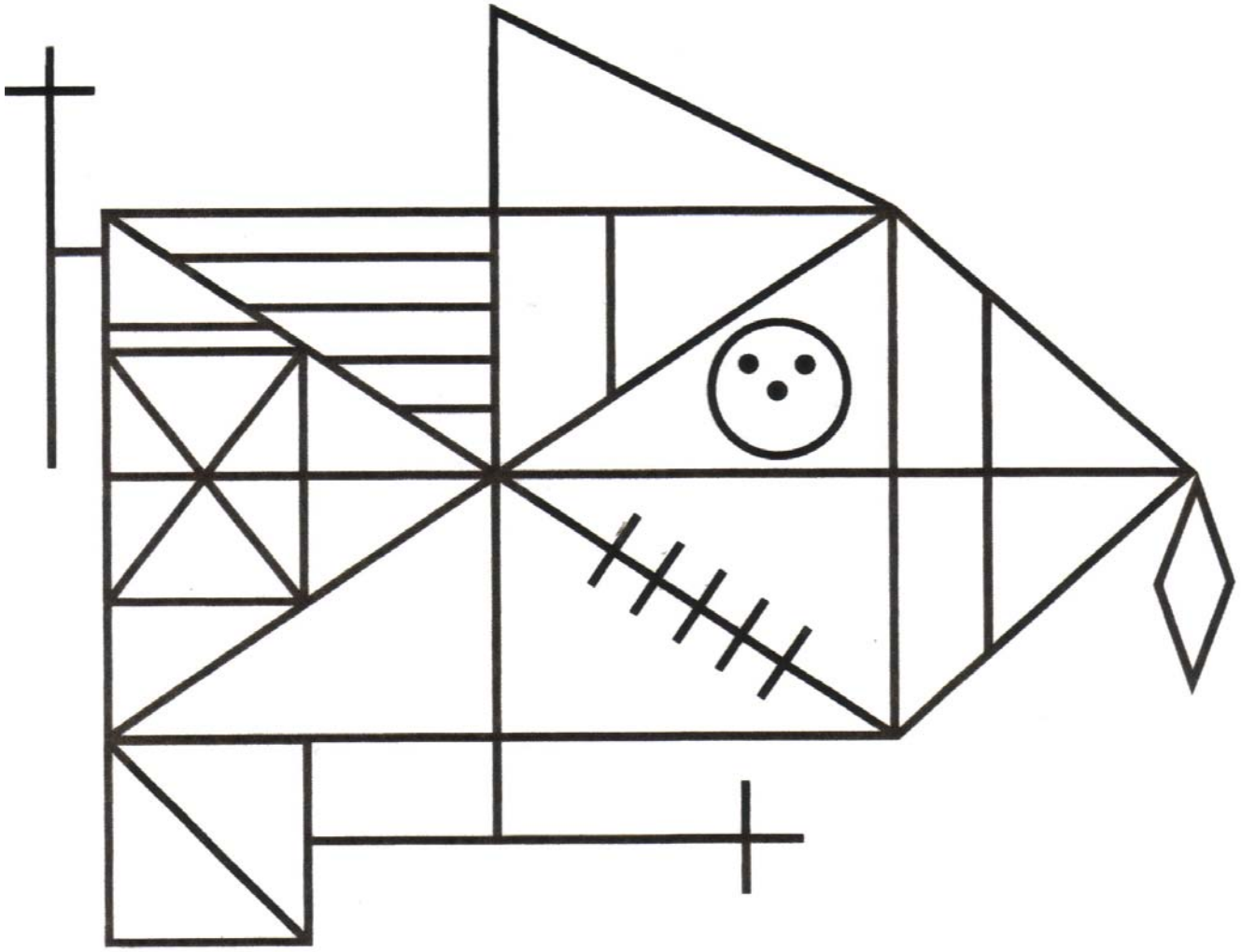
Orthographic Processing

bread

beard

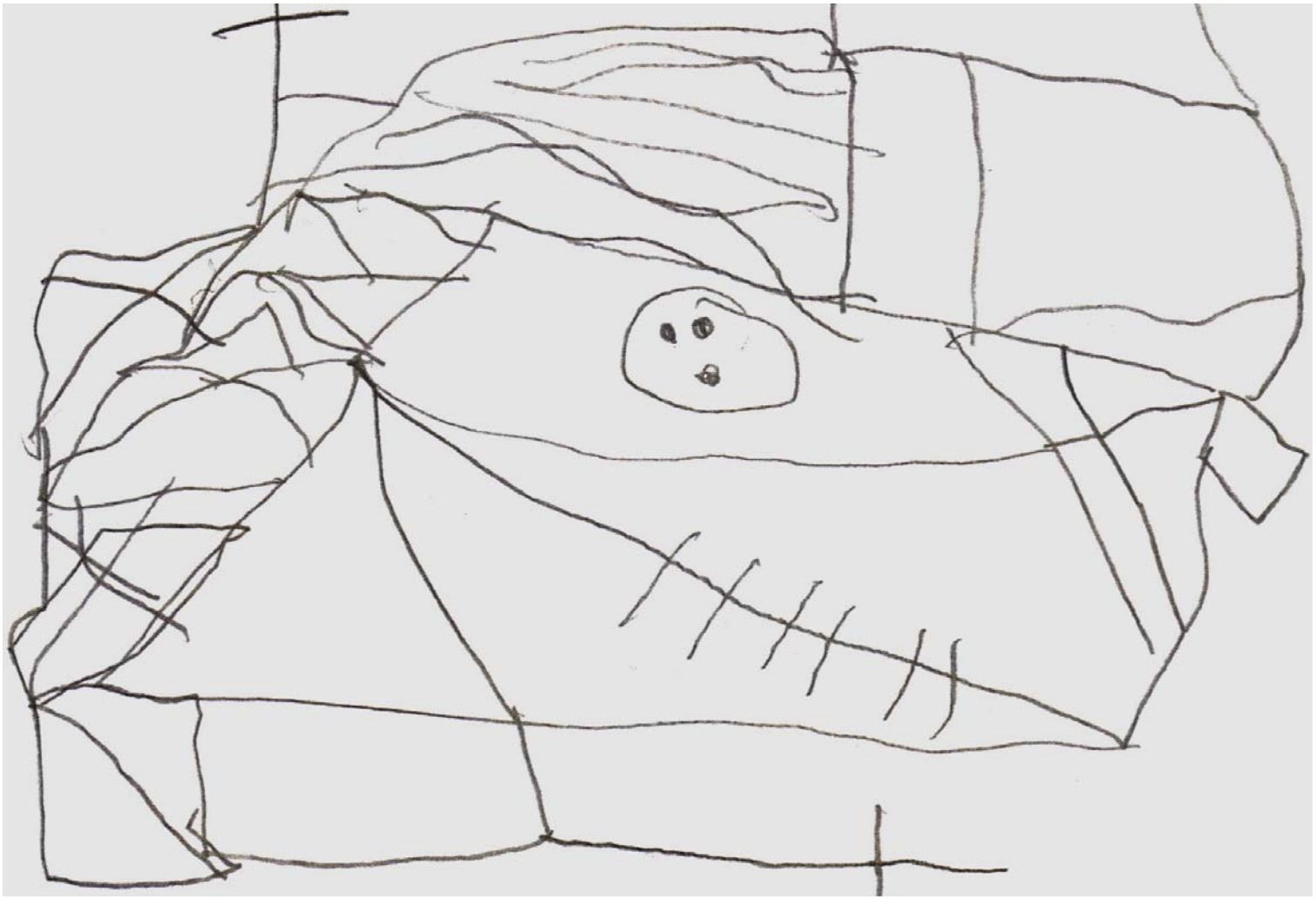
When viewing orthography, detail processing should be the preferred mode for visual processing rather than pattern processing. Although pattern processing can easily distinguish between “rea” and “ear” because the outer contours are different, pattern processing cannot distinguish “bread” from “beard” because the outer contours are the same. Good readers perceive all of the details of every word, thereby avoiding perceptual errors when reading similar words.

- Now draw this:



- James Age 10, Rey Complex Figure

Copy:



Assessing Orthographic Processing Related to Reading

- James' reading scores:

  WIAT-II Basic Reading 111

  WIAT-II Reading Comprehension 102

Assessment of Visual Processes Involved in Reading

- Only measures that assess the processing of letters and words can be used to address visual processes used in reading.
- If a child has no difficulty recognizing letters visually (can consistently discriminate between letters and non-letters) and does not show any signs of confusing the visual features of similar letters (e.g., knows that a “b” is not the same letter visually as a “d” “p” or “q”), visual perception and discrimination for orthography are intact and are not a contributing factor to poor reading, regardless of how the child performs on nonverbal measures of visual perception and discrimination.

Assessment of Visual Processes Involved in Reading

- Example of assessment of verbal visual (orthographic) processing directly related to reading:

  Process Assessment of the Learner (PAL) Receptive Coding task

Assessment of Visual Processes Involved in Reading

- PAL Receptive Coding directions:

  I will show you two words one at a time.

  If the words are exactly the same, say "yes." If the words are not exactly the same, say "no."

good

good

Assessment of Visual Processes Involved in Reading

- Although the PAL Receptive Coding task is a very basic measure, it requires multiple processes for successful responding:
  - Visual perception and discrimination of orthography
  - Immediate visual memory for orthography
  - Attention to orthography
  - Knowledge of orthography and orthographic regularity

Visual Processes Involved in Reading

- The confusion of the names of similar looking letters (saying “b” for “d” or “d” for “b”; saying “q” for “p” or “p” for “q”) is frequently attributed to poor visual perception and discrimination, but these confusions represent verbal interference in associating the proper verbal label with similar looking visual images, not an inability to accurately discriminate the visual differences between the letters. That is, the child who is looking at a b and says “d” is not “seeing” a “d” on the page and accurately naming it “d”, but is seeing a b and misnaming it “d” because of difficulty learning the correct labels to associate with the visual images of b and d.
- Mislabeling errors are best remediated through repeated practice with applying the correct verbal label to the visual image of the letter. This training can take thousands of trails over periods of several weeks or more. Many of these labeling difficulties do resolve with greater development of executive control of verbal labeling as the child increases in age.

Assessment of Visual Processes Involved in Reading

- If a psychologist who observes poor performance on nonverbal visual tasks believes that the child has a perceptual deficit that affects reading as well, the psychologist must recognize that this is an hypothesis that should be tested for adequacy.
- Testing the hypothesis would involve assessing the child's perceptual processes when they are engaged in dealing with orthographic visual input.

Assessment of Visual Processes Involved in Reading

- Informal letter discrimination tasks and formal measures such as the Process Assessment of the Learner (PAL) Receptive and Expressive Coding tasks can be used effectively to test such hypotheses.
- Tasks such as a Matching Familiar Figures subtest are not appropriate tests of the hypothesis because they assess perception and discrimination with nonorthographic images.

Vision and Reading

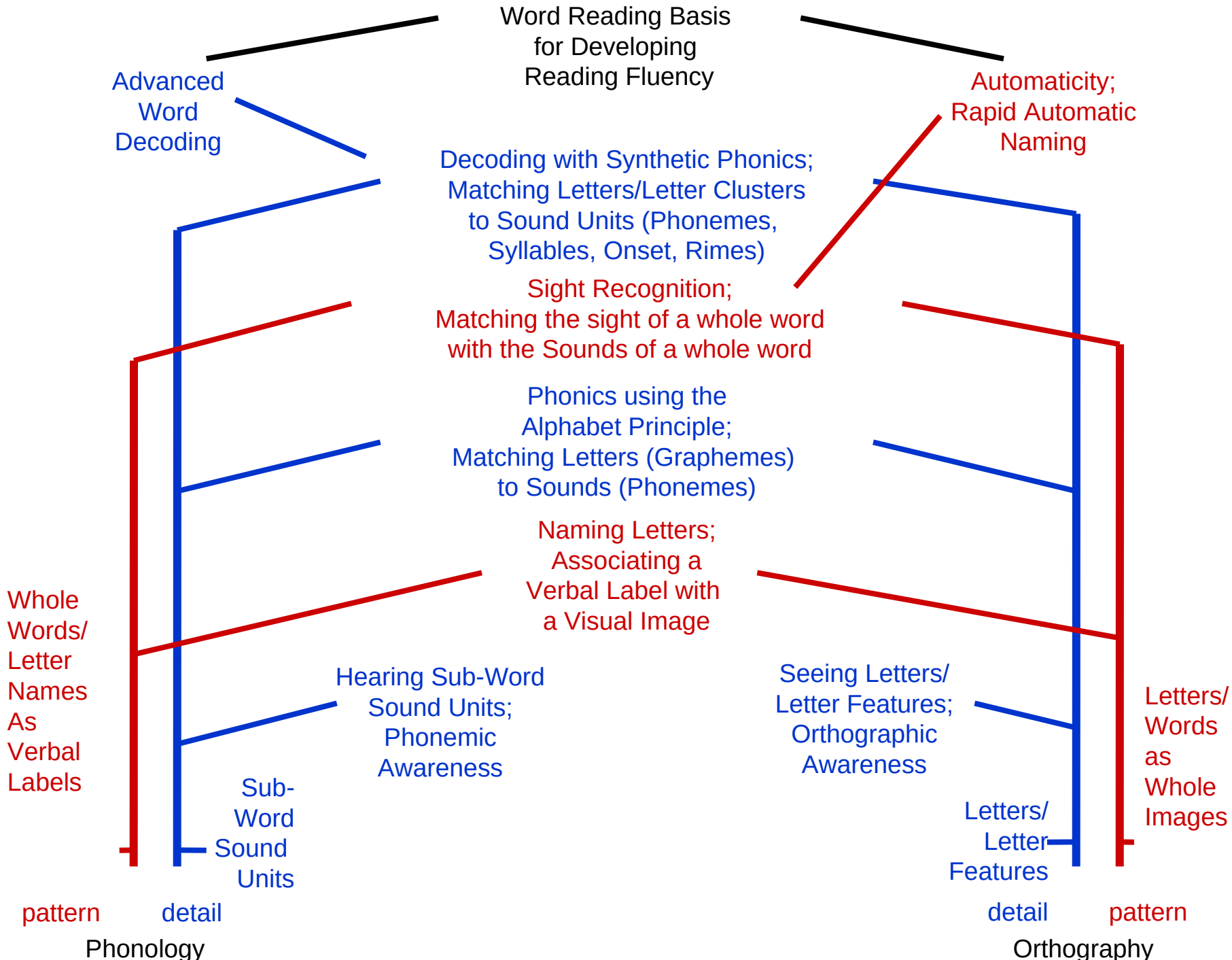
- The following section borrows heavily from the work of Berninger as summarized in Berninger, V.W., & Richards, T.L. (2002) Brain literacy for educators and psychologists:
- Reading requires the ability to extract visual features from written words.
- Beginning readers use the already existing general visual feature extraction system of the “What” pathway.
- With persistent, repeated exposure to letters, synaptic connections compete for space to form a new neural network that is specifically dedicated to the processing of written words; i.e., to processing visual stimuli that are then recoded into language.

Vision and Reading

- The orthographic letter string processing network develops by making connections between units of written and spoken words. "Thus sound codes in speech play a fundamental role in the recoding of visual stimuli into language; these recoded stimuli are stored as orthographic word form representations." (Berninger & Richards)
- The initial extraction of visual letter features occurs in the primary visual cortex of BOTH hemispheres.
- Processing specific to the visual word form occurs in the left inferior occipital-temporal cortex where written symbols are first linked to language symbols.
- Processing in the occipital-temporal area progresses through a series of neural networks in the left hemisphere that become increasingly more specialized in their connections of orthography to language.

Vision and Reading

- The initial left hemisphere networks process real words and pronounceable pseudowords in a similar manner. These networks are able to associate subword letter and letter cluster units with subword sound units.
- Networks further up the neural pathway process verbal labels and semantic content and context.
- Neural networks in the right hemisphere (right lingual gyrus) are also involved in learning to recognize familiar words.

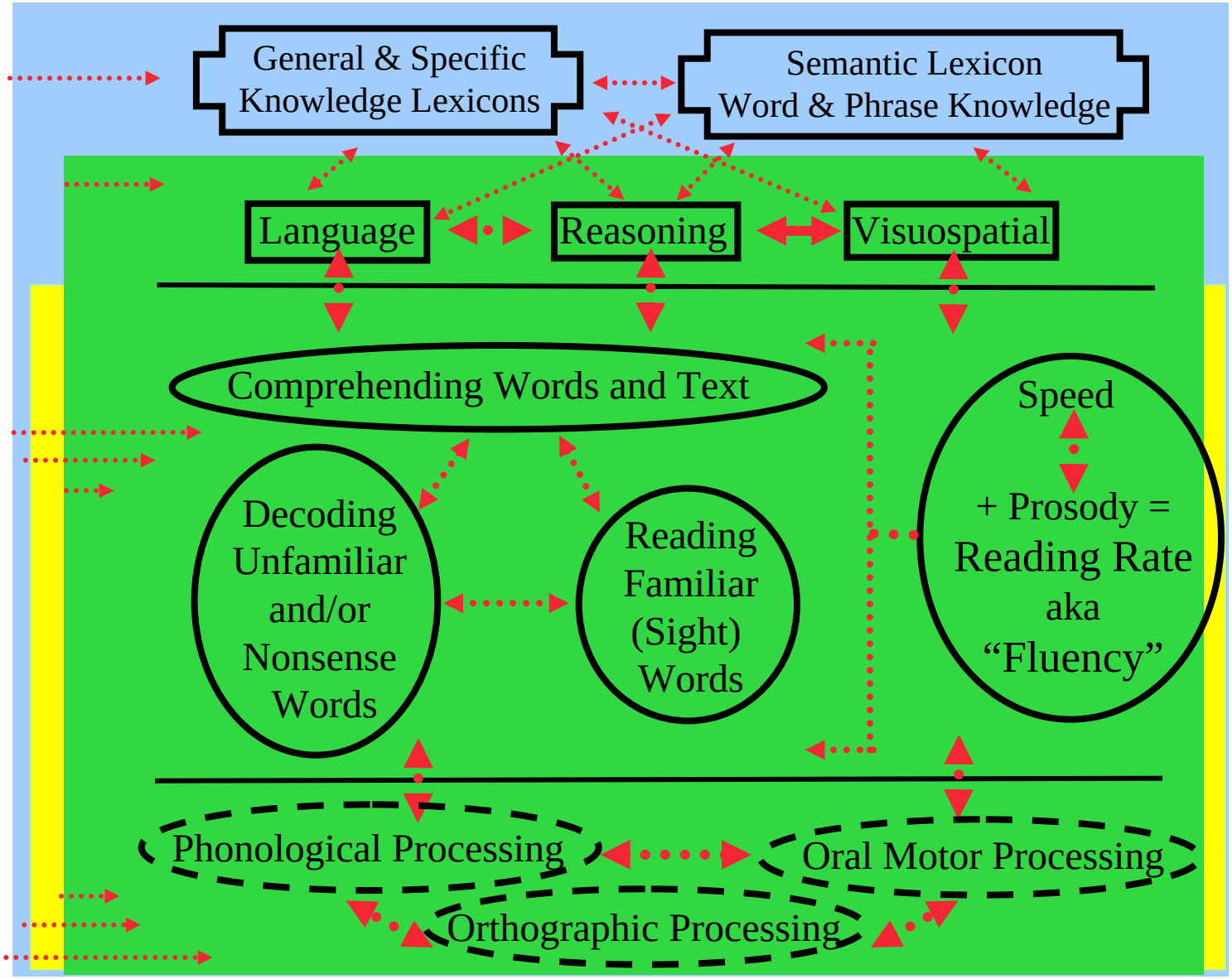

Word Reading Basis
for Developing
Reading Fluency
Advanced
Word
Decoding
Automaticity;
Rapid Automatic
Naming
Decoding with Synthetic Phonics;
Matching Letters/Letter Clusters
to Sound Units (Phonemes,
Syllables, Onset, Rimes)
Sight Recognition;
Matching the sight of a whole word
with the Sounds of a whole word
Phonics using the
Alphabet Principle;
Matching Letters (Graphemes)
to Sounds (Phonemes)
Naming Letters;
Associating a
Verbal Label with
a Visual Image
Whole
Words/
Letter
Names
As
Verbal
Labels
Hearing Sub-Word
Sound Units;
Phonemic
Awareness
Seeing Letters/
Letter Features;
Orthographic
Awareness
Letters/
Words
as
Whole
Images
Sub-
Word
Sound
Units
Letters/
Letter
Features
pattern
detail
detail
pattern
Phonology
Orthography

Further Processing of Visual Input

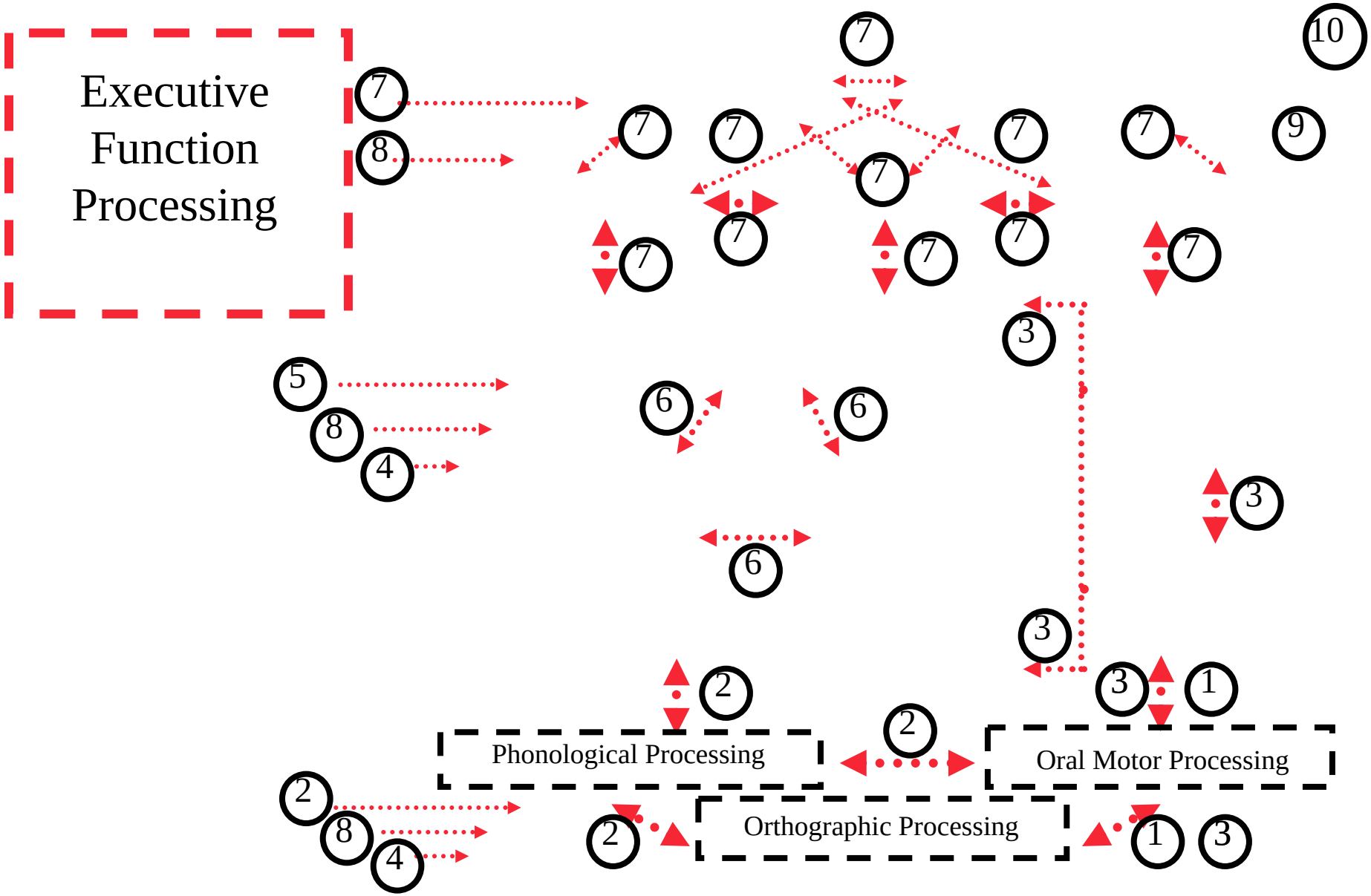
- Initial Registration/Organization/

  Synthesis/Association/Manipulation of visual input in real time: visual perception, discrimination, organization, integration.
- Output in the form of unobservable long term storage processes or in the form of observable motor activity.
- Previous output (stored visual information) shapes selection of new visual input.

Executive Functions and Learning: A Model for Reading



Executive Functions and Reading



Executive Functions and Reading

① Cueing immediate and sustained attention to orthography for accurate letter/word perception and discrimination

② Cueing and coordinating the use of phonological and orthographic processes for accurate word pronunciation

③ Directing efficient oral motor production, prosody, and rate for reading words and connected text

Executive Functions and Reading

④ Cueing and directing the use of attention and immediate memory resources for reading words and connected text

⑤ Cueing retrieval of information from various Lexicons to read words and connected text

⑥ Cueing and coordinating the use of word recognition, word decoding, and reading comprehension skills

Executive Functions and Reading

⑦ Cueing and coordinating the use of abilities and the retrieval of knowledge from Lexicons to create meaning for text comprehension

⑧ Cueing and sustaining the use of working memory resources while reading words and constructing meaning from text

⑨ Cueing and directing the oral expression of meaning derived from text comprehension

⑩ Cueing and directing the use of strategies for reading words and deriving meaning from text

Assessing Executive Functions Related to Reading

- Example of D-KEFS Color-Word Interference Word Reading task:

  “Look at this page...read these words as quickly as you can without making any mistakes.”

green blue green red green

green red blue green blue red blue green blue green

red green blue green blue green red blue red green

red green blue green red blue green red blue red

blue green red blue green red blue green blue red

green red blue red blue green red blue red green

Assessing Executive Functions Related to Reading

- Example of D-KEFS Color-Word Interference Inhibition task:

  "Look at this page...the color names are printed in a different colored ink. You are to name the color of the ink that the letters are printed in not read the word."

Rule:
Name the ink color.

red blue green blue green

red blue red green red

blue green blue red blue red blue red blue red

blue green blue green red green blue red blue green

red green red blue green red green red blue green

blue green blue red green blue red green red green

green blue red blue green red blue green red blue

Assessing Executive Functions Related to Reading

- Example of D-KEFS Color-Word Interference Inhibition-Switching task:

  "This time, for many of the words you are to name the color of the ink and not read the words. But if a word is inside a little box, you should read the word and not name the ink color."

Rules:

1. blue – Name the ink color.
2. red – Read the word.

blue red green red blue

green red green red blue

green blue green blue red green red green red blue

red blue red green blue green blue red red blue

blue red green red red green blue red blue red

blue green blue green red red green red blue green

green red red blue green blue red green green red

Rule:

Name the ink color.

red blue green blue green

red blue red green red

blue green blue red blue red blue red blue red

blue green blue green red green blue red blue green

red green red blue green red green red blue green

blue green blue red green blue red green red green

green blue red blue green red blue green red blue

Executive Functions and Reading

Alana, an 11 year-old child displays adequate word reading skills when reading word lists and adequate RAN performance with letters and words. However, when asked to read a short two sentence text orally, she experiences extreme difficulties with applying both word reading and rapid naming skills; words are skipped, misread, and reread; highly familiar words are decoded instead of sight read, less familiar words are decoded at an extremely slow pace; word misreadings are left uncorrected despite the disconnect between the orally read word and the meaning of the text (e.g., reading “bornes” for “bones”). Despite superior ability to reason with verbal material, Amanda is unable to offer adequate responses to questions about what she just read, even after taking time to reread the sentences silently.

Executive Functions and Direction of Visual Attention

- Lack of attention to important visual information can result in difficulties with the effective processing and use of visual information.
- If the visual input is compromised, additional processing of the information might also be compromised.
- Research has established the critical role that the frontal lobes (attentional control) play in regulating eye movements during reading.

Executive Functions and Direction of Visual Attention

- It is possible that many of the word reading errors of children who possess intact phonological processing systems are related to a lack of attention to the visual details of orthography they are trying to process.
- It is also possible that vision training might be able to improve the reading of these children, not because it changes the way the cortex processes the orthographic input, but because it teaches them to attend better to the details of the visual input as they are reading.

Orthographic Processing

bread

beard

Understanding Eye Movements in Reading

- Rayner (1997) summarized 25 year of research on eye movements:
- Reading involves eye movements called saccades during which the eyes move very rapidly. Saccades are necessary because of the acuity limitations of the visual system.
- Saccades are separated by fixations (periods of time when the eyes are relatively still).
- The purpose of eye movements is to place the foveal region on that part of the text to be processed next.
- The typical saccade travels about 6-9 letter spaces and generally are not affected by the size of print.

Understanding Eye Movements in Reading

- The perceptual span (area in which letters can be processed) extends 14-15 character spaces to the right of the fixation point and 3-4 character spaces to the left.
- The word identification span is smaller than the total perceptual span, typically not exceeding 7-8 letter spaces to the right of fixation.
- Rayner (1997) summarized 25 year of research on eye movements:
- Saccade movement spacing combined with perceptual span length assure that every letter of every word enters the visual field for accurate processing, even though 20-30% of words in a text are not the target of a fixation.

Understanding Eye Movements in Reading

- The size of the spans of effective vision and word recognition are not fixed, but can be modulated by word length.
- Orthography influences the size of the span. The Span for Hebrew is shorter than English, and the spans for Japanese and Chinese are even shorter due to the density (amount of visual detail packed into the character space.

Understanding Eye Movements in Reading

- Reading skill influences the size of the span. Beginning readers have a smaller span than skilled readers and adult dyslexic readers have shorter spans than skilled readers.
- The average fixation during reading is 200-250 milliseconds.
- Readers are capable of visually processing the words during a fixation in as little as 50 milliseconds, leaving 150-200 milliseconds for word recognition processing.

Understanding Eye Movements in Reading

- Rayner (1997) summarized 25 year of research on eye movements:
- About 10-15% of the time, readers move their eyes back in the text (regressions) to look at material that has already been read.
- As text difficulty increases, fixation durations increase, saccade length decreases, and regression frequency increases.

Understanding Eye Movements in Reading

- Variations in fixation time and saccade length are related to cognitive processes associated with comprehension.
- Fixation times vary as a function of the ease or difficulty associated with comprehending the words in the text.
- No useful information is acquired below the line of text being read.

Understanding Eye Movements in Reading

- Spaces between words facilitate fluent text reading.
- When space information between words is not available, reading is slowed by as much as 50%.
- When native Thai readers read Thai text with spaces inserted between the words (Thai is normally printed without spaces) their reading performance was facilitated even though they had no previous experience reading Thai with spaces between words.
- Spaces between words are a useful cue in deciding where to look next.

Understanding Eye Movements in Reading

- Rayner (1997) summarized 25 year of research on eye movements:

  “the facts that we have learned about eye movements in reading and about reading in general from studying eye movements have placed severe constraints on a theory of reading. ... 25 years ago, the view of the skilled reader was one in which reading was only incidentally visual and in which the reader spent most of his or her time generating predictions of upcoming words. Our research, and that of others, has shown that readers are not systematically scanning the text looking for the clues to meaning, but rather they are systematically moving their eyes from left to right across the text fixating on most of the content words (while skipping some function words). We have shown that the region from which readers obtain meaning is rather limited, but that the processing associated with each word is very rapid and that the link between the eyes and the mind is very tight”

Rayner, K. (1997) Scientific Studies of Reading, 1(4), pages 317-339.

Subject: soemthnig ncie

Aoccdrnig to a rscheearch at an Elingsh uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the only iprmoetnt tihng is taht frist and lsat ltteer is at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit a porbelm. Tihs is bcuseae we do not raed ervey lteter by itslef but the wrod as a wlohe.

Reply to something nice:

Subject: too eilsay led atrasy

A mulidutte of cusofend irentent serurfs seem to bilevee taht the oredr of the letetrs in wdros d’esnot mttear wehn you are raindeg as lnog as the frist and lsat leettr are in the crecort pitoison. If so, waht hesiopyeths mghit tehy greanete to epalixn why this citrpyc magesse is etponnexialty mroe dutiflufct to dihecepr by tehm?

I’ll bet it took you more than 11 seconds to read the above passage didn’t it?

Disruption of Visual Development

- Vergence relates to how the eyes move in or out to look at objects at different distances. Vergence problems are associated with strabismus and amblyopia and efforts are made to correct these problems early with surgery, patching and drops.
- Great controversy exists among several professional groups about the effects of, and proper treatment of, mild forms of vergence problems that arise or persist beyond the critical visual developmental period.

Disruption of Visual Development

- Some optometrists regard these vergence problems as the primary source of reading problems and advocate for specific types of visual training to remediate them, citing research to prove their effectiveness alone in improving reading skill acquisition.
- Ophthalmologists, Optic Neurologists, and Educators generally express great skepticism about the claims of some optometrists in regard to the effectiveness of visual training for reading improvement.

Disruption of Visual Development

A Joint Statement of the American Academy of Pediatrics, American Association of Pediatric Ophthalmology and Strabismus, and American Academy of Ophthalmology entitled Policy Statement: Learning Disabilities, Dyslexia, and Vision states:

"Although it is obvious that some children do not read well because they have trouble seeing, research has shown that the majority of children and adults with reading difficulties experience a variety of language defects that stem from complex, altered brain morphology and function, and that the reading difficulty is not due to altered visual function per se.

…Role of the Eyes. Decoding of retinal images occurs in the brain after visual signals are transmitted from the retina via the visual pathways. Unfortunately, however, it has become common practice among some to attribute reading difficulties to one or more subtle ocular or visual abnormalities. Although the eyes are obviously necessary for vision, the brain interprets visual symbols. Therefore, correcting subtle visual defects cannot alter the brain's processing of visual stimuli. Children with dyslexia or related learning disabilities have the same ocular health statistically as children without such conditions. There is no peripheral eye defect that produces dyslexia or other learning disabilities, and there is no eye treatment that can cure dyslexia or associated learning disabilities.

Ophthalmology (1993), 100(12), pages 1867-1869.

Vision and Reading

- Although there is much skepticism in the professional ranks about the possible role of visual processes in reading problems, Berninger & Richards offer a thoughtful discussion of aspects of visual processing difficulties that might be related to reading problems.
- Poor readers might have problems with stability at the end of a fixation pause when processing small print text.

Vision and Reading

- Increasing print size might reduce this problem with fixation stability. Large print books for beginning readers help with learning to program the eyes for navigation along a string of written words, thereby helping to stabilize vision during fixations.
- Poor readers might have lower amplitudes during vergence eye movements that typically allow readers to maintain binocular vision while pursuing a single target in depth. Berninger & Richards suggest that eye patching is sometimes effective in dealing with poor vergence eye movements.

Vision and Reading

- Berninger & Richards also note that:
  - “Little research exists on whether poor readers with abnormal vergence eye movements are the same ones whose eyes should have been patched before age four to correct abnormalities in their binocular vision, but were not.”
  - “Children with reading disabilities in comprehension (not single word reading) may comprehend better when a blue transparent overlay is placed over text; but there is no evidence that Irlen lenses are effective in treating reading disability...Blue filters may aid the transient visual system.”

Vision and Reading

- Berninger & Richards summarize their consideration of the literature on visual processing problems and reading as follows: “...etiology and treatment are separate issues. A process may cause a bottleneck in creating a functional system, but the fix for the bottleneck usually involves more than direct training of the deficient process in isolation. ...we emphasize that there is no research evidence that visual training exercises in isolation improve the reading of these students.” (p.115)

Vision and Reading

Many sources provide checklists for behavior that are thought to be reflect vision problems. Some of the behaviors on these lists are plausible indicators of vision problems that should be investigated by an ophthalmologist. Others are more general indicators of difficulties that could be attributed to multiple sources. As such, they are not specific indicators of vision problems.

Vision and Reading

- Plausible indicators of vision problems include:
  - Complaints that print is blurring after reading for a short time.
  - Complaints that the words are “moving around on the page” after attempting to read for a short time.
  - Complaints of seeing double when reading.
  - Squints, closes or covers one eye.
  - Tilts head extremely while working at desk.
  - Frequent loss of place during reading; difficulty finding the next line of text on the page being read.
  - Comprehension that is normally good becomes very poor as reading is prolonged beyond a short period of time.
  - Frequently becomes tired or sleepy after a short period of reading.

Vision and Reading

- Plausible indicators of vision problems include:
  - One eye turns in or out at any time while trying to focus.
  - Reddened eyes or lids.
  - Eyes tear excessively.
  - Encrusted eyelids.
  - Frequent styes on lids.
  - Headaches in forehead or temples that arise when attempting to read.
  - Burning or itching of eyes after reading or writing efforts.
  - Nausea of dizziness after reading or writing efforts.

Vision and Reading

- Behaviors too general to be good indicators of vision problems include:
  - Displays a short attention span when reading or writing.
  - Frequently omits words when reading.
  - Repeatedly omits small words when reading.
  - Repeats letters within words.
  - Omits letters, numbers, or phrases.
  - Mistakes words with same or similar letters.
  - Repeatedly confuses similar beginnings and endings of words.
  - Confuses same word in same sentence.
  - Fails to recognize same word in next sentence.
  - Fails to visualize what is read either silently or orally.

Vision and Reading

- Behaviors too general to be good indicators of vision problems include:
  - Whispers to self for reinforcement when reading silently.
  - Reverses letters/words in writing.
  - Misaligns digits in number columns.
  - Repeatedly confuses left-right directions.
  - Writes up or down hill.
  - Makes errors when copying from board or book.
  - Writes crookedly, poorly spaced; can't stay on lines.
  - Orients drawings poorly on page.
  - Confuses visually similar elements.
  - Returns to drawing with fingers to decide likes and differences.