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Looking to Listen – Demystifying Central Auditory Processing with Visual Examples

Elizabeth Haley, AuD, CCC-A

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Elizabeth Haley, Au,D, CCC-A, is a clinical and research audiologist. Currently, Dr. Haley is an adjunct professor at Carlow University in Pittsburgh. She previously held joint positions as a clinical audiologist at the UPMC Children's Hospital of Pittsburgh and as a research coordinator in the Pittsburgh's Department of Veterans Affairs Hospital.

After completing her clinical doctorate in audiology at the University of Pittsburgh, Elizabeth returned to pursue a Ph.D. in audiology. Her research interests include: pediatric speech and music perception, neurobiological correlates of language development in children, central auditory processing disorder, language learning in children with hearing loss and knowledge transfer in perceptual learning.

Disclosures

- **Presenter Disclosure**: Financial: Elizabeth Haley is an adjunct professor at Carlow University in Pittsburgh. She accepted an honorarium for presenting this course. Non-Financial: Elizabeth Haley has no relevant non-financial relationships to disclose.
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Learning Outcomes

After this course, participants will be able to:

- Identify two key features of auditory processing and two key features of visual processing.
- Discuss concepts in the visual system and analogous examples in auditory processing.
- Describe an example of visual imagery that can be used to counsel patients with central auditory processing disorders.

Introduction: Healthcare Literacy

- Ability of individuals to **obtain, process, and understand basic health information** and services necessary for **making informed health decisions** (Marshall et al., 2012).
- Healthcare literacy is a critical component of effective healthcare delivery, influencing patient outcomes and overall public health.

Healthcare Literacy

- A meta-analysis indicated a positive correlation between health literacy and adherence to medical treatment (Miller, 2016)
- Patients may forget between 40-80% of the verbal information given during a medical appointment (Tye-Murray, 2020)
- A systematic review estimated limited health literacy could account for an additional 3-5% of total healthcare costs annually (Batterham et al., 2014)
- Individuals with hearing loss may face additional challenges in understanding their healthcare options (Willink & Reed, 2020)

Healthcare Literacy: Auditory Processing

- Basic auditory processing skills significantly impact reading development (Law et al., 2017)
- Relationship between CAPD and other developmental disorders, such as dyslexia, is important for healthcare literacy
- We need to explore other ways to present important concepts in CAP(D) to our patients

Healthcare Literacy: Visual Imagery

- Enhancing Comprehension
- Facilitating Information Retention
- Addressing Language Barriers
- Improving Patient Engagement
- Promoting Health Literacy in Education
- Navigating Health Information

(Monsen et al., 2015)

Central Auditory Processing Disorder (CAPD)

- "A deficit in the processing of information specific to the auditory modality and associated with difficulties in listening to speech, language, and learning. " - Bruton Consensus Conference (2000)
- "Sound localization & lateralization, temporal aspects of recognition, auditory pattern, and auditory discrimination." - American Speech-Language-Hearing Association (2005)

Auditory Behaviors & Characteristics

- Difficulty recalling short-term or long-term information
- Says “huh” or “what” frequently
- Difficulty following verbal multi-step instruction
- Confuses similar words or sounds
- Unusually bothered by loud or sudden noises
- Requires repetition of auditory information
- Struggles with phonics, spelling, or writing
- Difficulty in the presence of background noise
- Does opposite of what is requested

Defining Central Auditory Processing (CAP) Skills

- Auditory Figure Ground (Speech in Noise)*
- Dichotic Listening - Binaural Integration/Separation
- Temporal Processing
  - Gap Detection
  - Pattern Perception
  - **Auditory Closure**
- Phonemic Processing*
- Auditory Vigilance*

Defining Central Auditory Processing

Domain	Difficulty	Behavior/Presentation
Auditory Figure Ground*	- Difficulty listening in noise/reverberant environments	- Can mimic attention problems and/or a peripheral hearing loss
Dichotic	- Combining and/or separating information delivered to both ears at the same time	- May show difficulty shifting attention from one sound source to another - Difficulty with multi-step directions
Temporal	- Involves the rate at which auditory information is processed - Individuals can typically process speech sounds in 25ms; people with a deficit in this category may need up to 300 ms	- Can influence attention, reading, learning, processing of emotional affect in speech, social/pragmatic abilities, etc.

Defining Central Auditory Processing

Domain	Description	Behavior/Presentation
Phonemic Decoding	- Difficulties with articulation, language comprehension, reading, spelling & handwriting	- Can appear like a “dysfluency” in language processing - Mixing up of phonemes - Increased difficulty with longer words, phrases, sentences or passages
Auditory Attention Deficit	- Inattentive/disinterested in auditory stimuli	- Fidgeting, pacing & rapid speech; often confused for “acting out” - Difficulty following directions - “Zoning” in and out when listening
Auditory Memory	- Slower ability to process, forgetful of information learned via auditory modality	- Can co-occur with other dx (e.g. learning disability or cognitive impairment) - Difficulty following multistep directions

Visualizing CAPD – Diagnostic Example # 1

Auditory Closure

Closure

- Cognitive process by which the auditory system fills in gaps in sound information
- Allows listeners to perceive complete auditory stimuli even when parts of the sound are **missing** or **occluded**
- This phenomenon is closely related to the principles of Gestalt psychology, which posits that the human perceptual system tends to perceive incomplete forms as whole, thereby facilitating understanding in complex auditory environments (Roux et al., 2011)

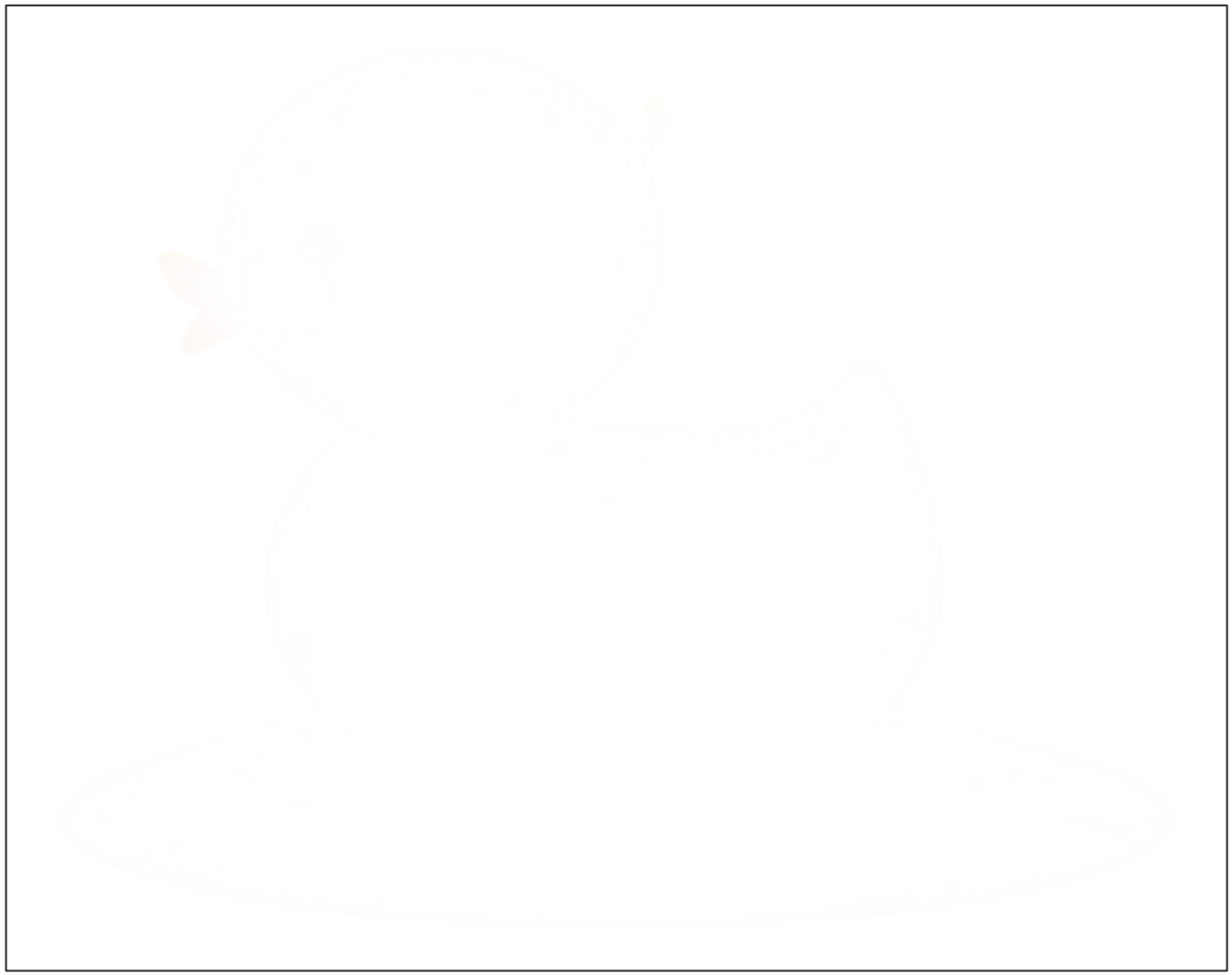
Auditory Closure

- Plays a significant role in how individuals process speech, particularly in noisy environments or when auditory information is incomplete

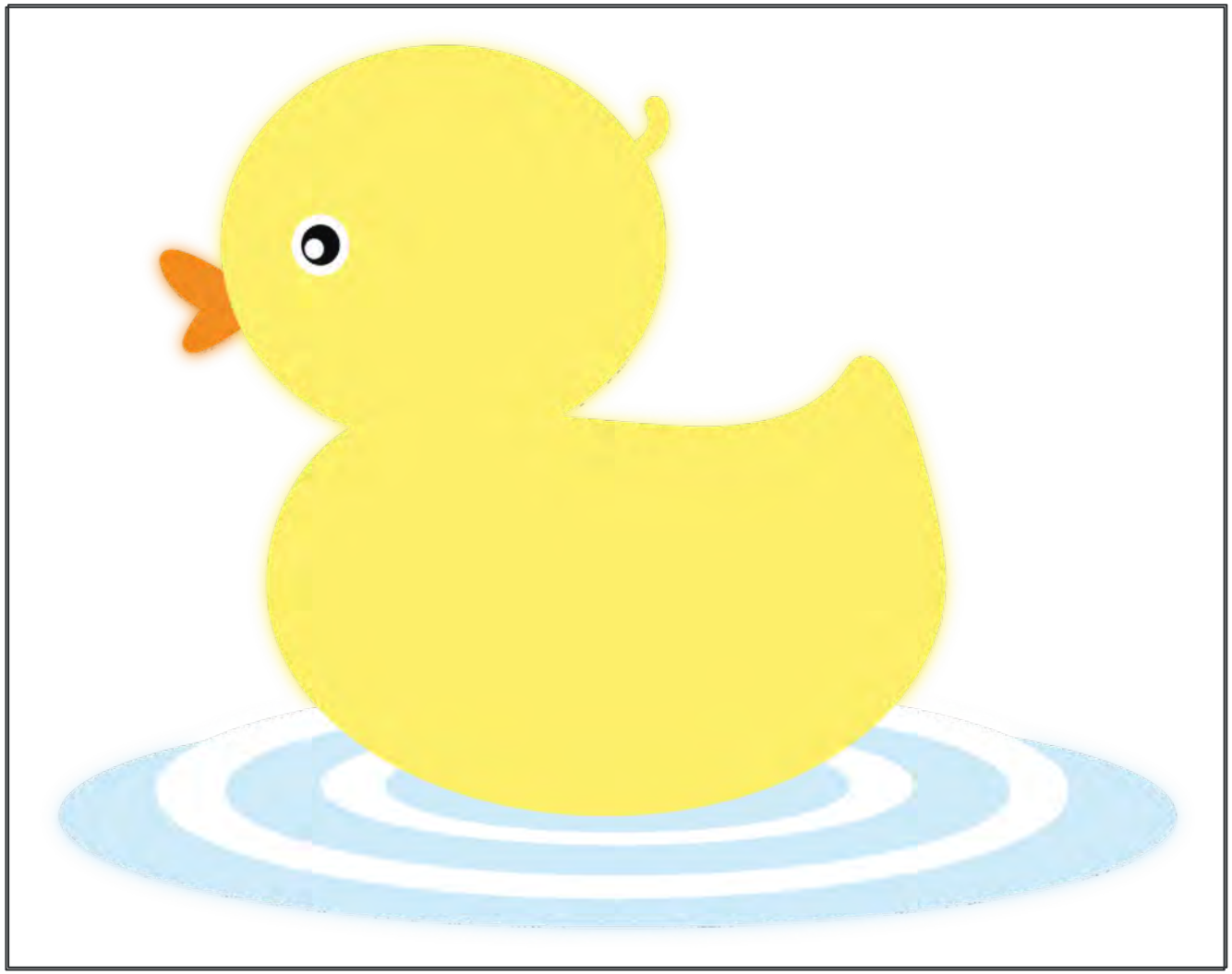
Visual Closure

- Human visual system tends to organize visual elements into coherent wholes, even when parts of the visual information are missing or occluded (Jamshidi & Pati, 2020)
- Impairments in visual closure abilities have been observed in individuals with conditions where deficits in perceptual processing can lead to difficulties in recognizing objects and interpreting visual scenes, including:
  - Schizophrenia
  - Dyslexia

Visual Closure - Example



Visual Auditory Closure - Example



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Auditory & Visual Closure

- Visual cues, such as lip movements, can influence how ambiguous auditory stimuli are perceived, demonstrating the interplay between auditory and visual modalities in achieving closure (Reinisch et al., 2014)
- This cross-modal integration is crucial for effective communication, as it allows listeners to reconstruct missing auditory information based on available visual context

Visualizing CAPD – Diagnostic Example #2

Bistable Perception

Sensory Illusions

- Auditory
- Visual
- Tactile
- Olfactory
- Proprioceptive
- Multi-sensory

Bistable Perception

- Individual's perception of an unchanging stimulus
- Spontaneously alternates between two distinct interpretations
- Sensory systems rely on the comparison between multiple possible interpretations of an input

Binocular Rivalry

- A visual perception phenomenon where the brain alternates between two images presented to the eye
- A valuable tool for studying visual awareness, perceptual selection, and unconscious processing
- The focus of multiple peer reviewed studies

Visual Illusion

- Ambiguous vase-profile illusion, introduced to psychology by E. Rubin in 1915

Stroop Effect

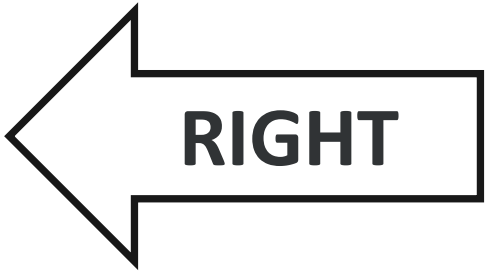
- **Color-Wor**d: Influence of color words on color naming demonstrates how cognitive processes can be affected by prior exposure to incongruent stimuli (Sand & Nilsson, 2017)

Black **Red** **Green** **Blue** **Red** **Yellow**

Stroop Effect - Spatial

- Congruent

- Incongruent



Auditory & Visual Bistablility

- Similarities between processing of ambiguity in the visual system, and in the auditory system have been observed, suggesting that the two systems share common principles of perceptual bistability (Pressnitzer & Hupé, 2006)

Treatment

- **Direct skills remediation** ("bottom-up")
- **Compensatory strategies** (recruiting higher-order skills to help compensate for the disorder "top-down")
- **Auditory Training**
  - Recommended based on type of CAPD
- **Devices**
  - Options based on patient's needs and deficit
- **Environmental Modifications & Listening Strategies**
  - Individualized recs based on patient's needs

Treatment

Domain	Examples of Interventions
Speech in Noise*	Preferential seating
	Environmental modifications
	Reducing signal to noise ratio (remote mic)
Dichotic	Auditory training
	Motor integration
	Communication strategies/environmental modifications
Temporal	Re-enforcing auditory feedback loop
	Auditory training
	Interactive metronome
	Music Therapy
	Communication strategies/environmental modifications

Treatment

Domain	Examples of Interventions
Phonemic Decoding	Reading intervention
	Speech & Language evaluation/treatment
	Re-enforcing auditory feedback loop
	Auditory training
Auditory Attention Deficit	Neuropsychological recommendation(s)
	Interactive metronome
	Reducing signal to noise ratio (remote mic)
	Medical management
Auditory Memory	Memory training
	Teaching strategies (e.g. “chunking” & verbal rehearsal
	Tutoring & teaching comprehension
	Neuropsychological recommendation(s)

Visualizing Central Auditory Processing – Therapeutic Example #1

Priming

Cognitive Priming

- A psychological phenomenon
- Exposure to a previous stimulus influences a person's subsequent responses to related stimuli
  - Initial stimulus activates certain representations or associations in memory
  - Affects how individuals perceive and react to subsequent information or tasks
- Serves as a mechanism for understanding how prior experiences shape current cognition and behavior (Bermeitinger, 2016)

Types of Priming

- **Perceptual priming**: When a person is primed based on the visual features or physical characteristics of a stimulus, like shape or size
- **Semantic priming**: When a stimulus primes a related word or concept based on its meaning, like "doctor" priming "nurse"
- **Repetition priming**: When a stimulus is presented repeatedly, leading to faster processing of that same stimulus later on
- **Conceptual priming**: When a stimulus activates a broader concept or category, influencing responses to related concepts

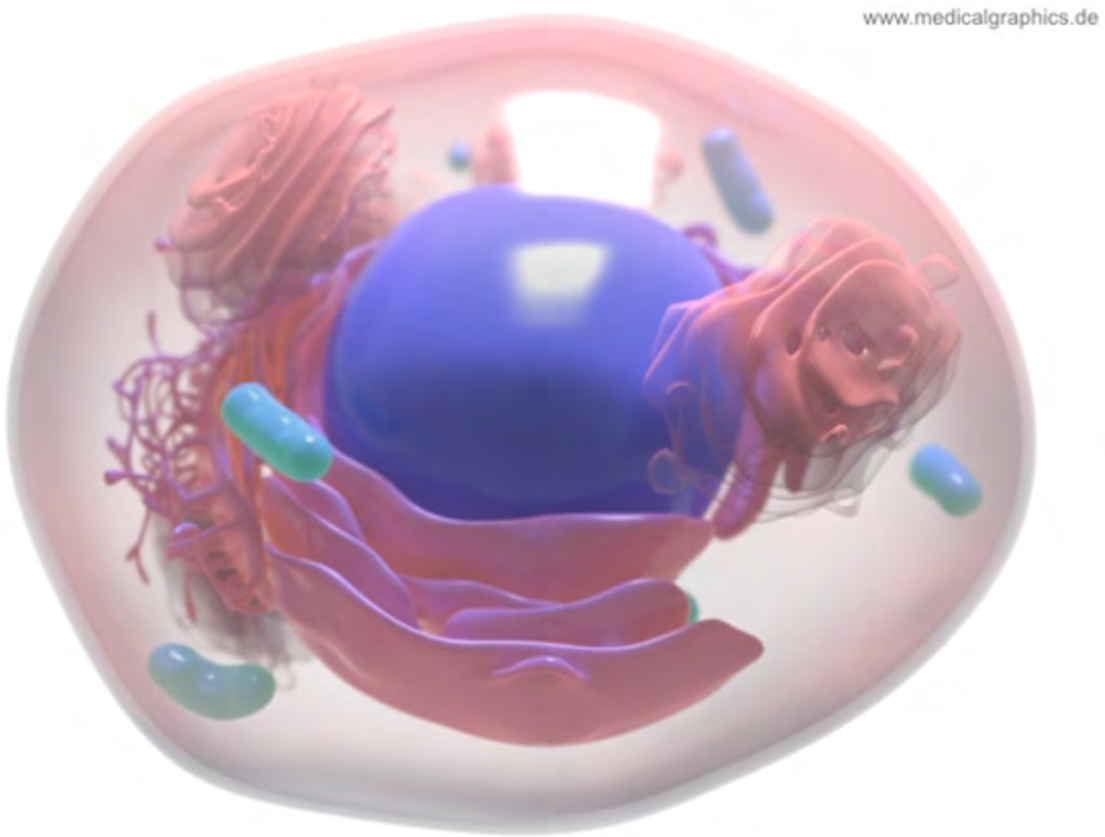
Types of Priming

- **Associative priming**: occurs when a prime stimulus that is related to the target stimulus (like "hot" priming "cold") speeds up the processing of the target stimulus
- **Negative priming**: When exposure to a stimulus that is later instructed to be ignored slows down the processing of that same stimulus when it becomes the target
- **Positive priming**: When exposure to a stimulus speeds up the processing of a related target stimulus
- **Cultural priming**: When exposure to cultural symbols or cues influences how a person interprets or responds to subsequent stimuli

Types of Priming - Other

- **Masked priming**: When a priming stimulus is presented very briefly and then masked, so the participant isn't consciously aware of it, but it still influences their response
- **Affective priming**: When a stimulus with an emotional valence (positive or negative) influences how a person perceives a subsequent stimulus

Priming - Example



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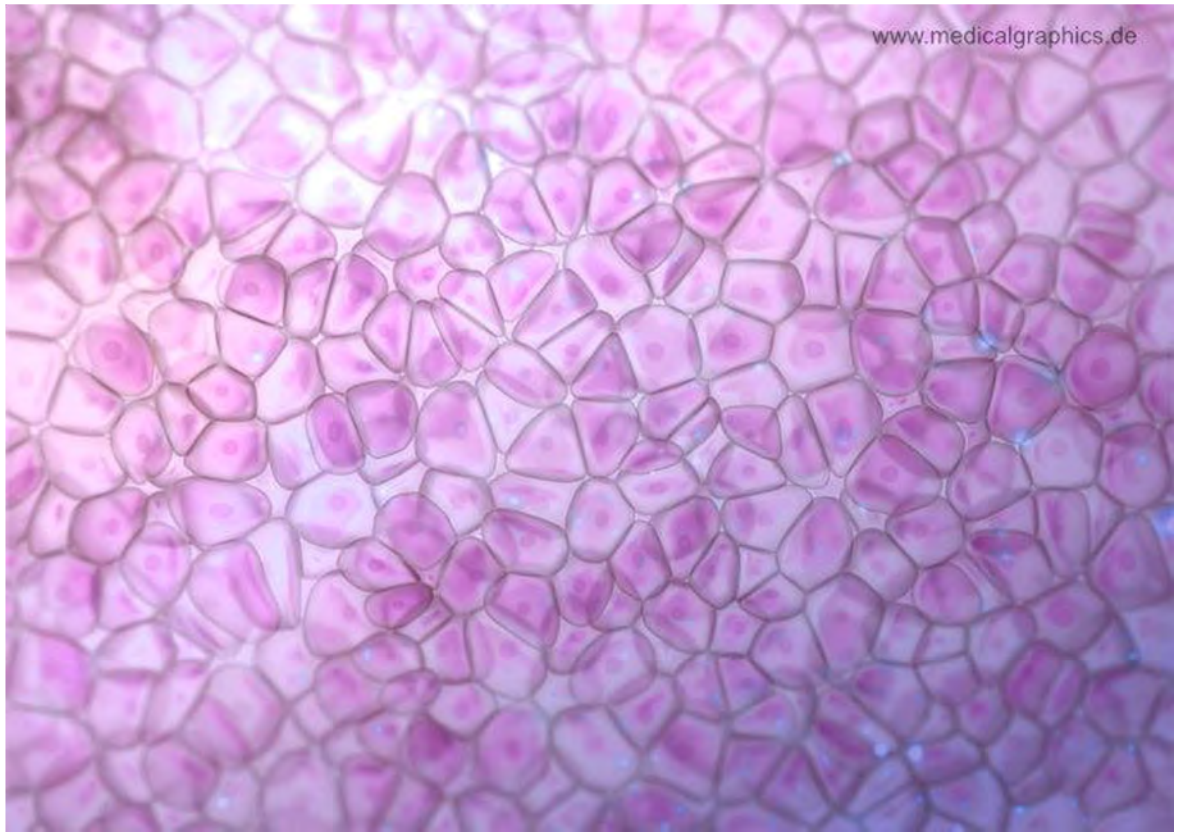

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Visual Priming – Other Examples

- Using the color red to evoke urgency in a sale
- Seeing a logo for a fast-food restaurant before entering a grocery store may make you more likely to buy snacks associated with that brand
- Seeing a picture of a happy face before reading a positive review, making the review seem more positive

Auditory Priming – Other Examples

- If you hear the word "cat" before trying to identify the word "dog", you'll likely recognize "dog" faster because they are semantically related animals
- If you hear a short melody snippet before trying to identify a full song, making it easier to recognize the song due to the familiar musical phrase
- “Yanny” and “Laurel” clip
- Giving a person with hearing loss, the topic or subject of a conversation before speaking

Counseling

- Enhanced understanding of hearing loss and its effects
- Better self-disclosure and self-acceptance of hearing loss
- Greater knowledge about management of communication difficulties
- Decreased stress-related issues
- Increased satisfaction with therapeutic progress
- Increased self-motivation
- Continuation with AR plan and HA use

Informational Counseling

- Inform patient and/or family about processing issues and its consequences
- Present informally as a dialogue
  - Use easy-to-understand language
- Present the most important information first
- Use explicit categorization
  - Categorize pertinent information to discuss “we are going to describe the nature of your hearing loss, then we are going to discuss the problems you might have; then we are going to talk about how we can manage these problems… ”

Final Thoughts

- Visual aids can be used during counseling to help patients understand abstract concepts in central auditory processing

Thank you!
Questions?

Elizabeth Haley, AuD, CCC-A

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