Reflexive- and Reflective-System Learning of Auditory Categories Across the Lifespan

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Introduction

- Bilingualism can delay the onset of dementia by an average of 4.2 years in older adults.¹
- However, adults have difficulty learning a second language because of the new speech categories.²
- Training can help adults learn new speech categories, but most of the training work has been done with young adults.³
- Coupled with age-related declines in sensory and cognitive systems,⁴ it is unclear how effective training is in older adults.
- Research with visual stimuli has clarified memory processes, two of which have been found in the language network as well.⁵

Reflective Learning (Explicit)

- Verbalizable rules for each category
- Anterior cingulate, dorsolateral prefrontal cortex, head of caudate nucleus
- Conjoint, unidimensional strategies

Reflective Learning (Implicit)

- Categories cannot be easily defined by rules; most use information from one stimulus dimension.
- Body and tail of caudate⁶
- Information integration strategy.

Research Goals

- Investigate these learning systems with naturally-occurring auditory stimuli, and across the lifespan.
- Using computational modeling, uncover strategies used in successful learning in younger and older adults, which we cannot gain from just accuracy scores.
- Understanding strategies employed in this task allows us to develop model training programs.

Participants

- 33 younger adults (YA) ages 18-25 from the University of Texas at Austin community.
- 33 older adults (OA) ages 60-90 from the Austin community.
- Participants reported no hearing impairments and individual thresholds were tested at 500, 1000, 2000, and 4000 Hz in at -5 to 40 dB in both ears.
- Stimuli were presented at a suprathreshold level and at a comfortable listening level as judged by the participant.
- Older adults are less than 2 SD from the norm on tests of cognitive impairment.

Methods

- Five syllables found in both English and Mandarin in four Mandarin tonal contexts:
  - /ha/ /de/ /lu/ /ma/ /ni/
  - high-level, rising, dipping and falling
  - 40 stimuli, 5 blocks of training: 1 female, 1 male
- Participants are asked to categorize the tones they hear into the four categories. Feedback was either “correct” or “incorrect.”
- Pitch direction is the tone’s slope, and pitch height is how high or low it sounds.

Modeling & Results

Overall Accuracy

- There is an interaction between Block and Age Group: F(2.761, 176.697) = 4.539, p < .01, *p < .005
- Separating the stimuli into female and male speakers, the categories take on a clearer shape.
- “Separation” is a reflexive process, but category discrimination is a reflexive process.

Unidimensional-Pitch Height Strategy

- Unidimensional and conjunctive strategies are mediated by the reflexive system.
- By the final block, most YA’s use information-integration and conjunctive strategies, whereas OA’s use a unidimensional strategy.

Modeling & Results Continued

Information Integration Strategy

- An information integration strategy can result in the highest accuracy, whereas an unidimensional strategy cannot.
- Information integration strategy is mediated by the reflexive system.

Conclusions

- Participants using separate male and female tone spaces can achieve higher accuracy.
- The proportion of older and younger adult separators is approximately equal.
- The ability to separate perceptual spaces (a reflexive process) is not affected by aging.
- Once older adults separate talker spaces, they do not use the optimal categorization strategy that would lead to the highest accuracy.
- Older adults tend to rely on the pitch height (UDX), whereas younger adults are better able to switch to an information integration strategy.
- Unidimensional strategies are simpler strategies than a conjunctive strategy, and the older adults may be primed with the pitch height information from separating, which may lead to their use of UDX rather than UDY or conjunctive strategies.
- Since older adults tend to categorize based on pitch-height, they are ignoring the tonal contexts.
- This is in line with research showing that older adults have a harder time disengaging from irrelevant stimulus information than younger adults.⁶
- We are investigating ways to enhance tone category learning in older adults.⁷

References