Aging and the Statistical Learning of Grammatical Form Classes

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BACKGROUND

- Research on *implicit learning* shows that young adults learn non-verbal sequential regularities in a serial reaction time task, even without trying to learn or being aware of what they have learned
  - Healthy older adults also learn, but they learn significantly less than younger adults, particularly when the regularities are subtle and probabilistic (e.g., Howard & Howard Jr., 2012)
- Research on *statistical learning* shows that young adults are able to organize words into grammatical form class categories based solely on exposure to the distributional information surrounding the words of an artificial language (Mintz, 2003; Reeder, Newport, & Aslin, 2013)
  - Such statistical learning has not been investigated in older adults
- If these two kinds of learning call on the same underlying mechanisms:
  - They should show similar patterns of adult age differences
  - These age differences could contribute to the age-related deficits observed in language learning in older adults (Hakuta, Bialystok, & Wiley, 2003; Mackey & Sachs, 2011)

AIM: The present study examined whether there are age-related differences in the ability to acquire the grammatical categories of a language through exposure to distributional information

METHOD

PARTICIPANTS

- 20 monolingual English-speaking young adults (21.3 ± 1.6 years old; 7 male)
- 20 monolingual English-speaking older adults (73.6 ± 5.6 years old; 7 male)

STIMULUS MATERIALS

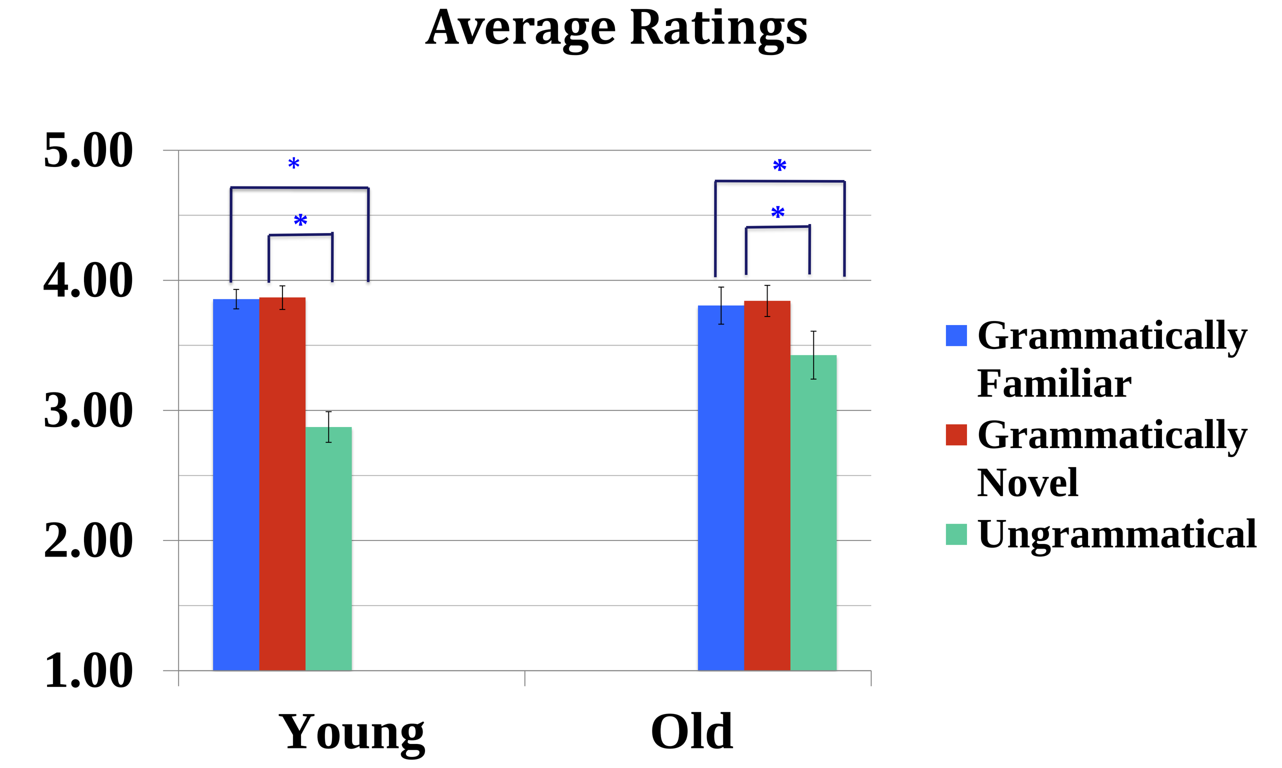
- Artificial language task developed by Reeder et al. (2013) presented as an alien game. During exposure, participants were told to listen to an alien named Zooma practice sentences in a language called "SillySpeak"
- Artificial grammar had the structure (Q)AXB(R), where each letter represents a set of words
  - "X" represented the target category of interest
  - "A" and "B" were the "context" categories, or the distributional cues surrounding X
  - "Q" and "R" were optional flanker categories

- 2 words each in the Q and R categories, 3 words each in the A and B categories, and 3 words in the X category
- Exposure set consisted of 9 of the 27 possible AXB strings
- Two languages: differed only in which words were assigned to each category
- Words of the grammar: *spad, klidum, flairb, daffin, glim, tomber, zub, lapal, fluggit, mawg, bleggin, gentif, frag, and sep.*

PROCEDURE

- Exposure phase: participants listened to 12 minutes of one of the artificial languages; order of the sentences was randomized for each participant and presented via a Python program on a Macintosh OSX laptop. To ensure attention, participants clicked the computer mouse when they heard two adjacent identical strings
- Test phase: participants heard a series of 70 three-word test strings (e.g., "*glim zub mawg*") and rated each string on a scale from 1 to 5
  - "1": string definitely *did not* come from the exposure language
  - "5": string definitely *did* come from the exposure language
- Test strings were of three types:
  - *Grammatically familiar* (20 AXB strings presented during exposure),
  - *Grammatically novel* (26 AXB strings that were withheld during exposure)
  - *Ungrammatical* (24 strings in the form of AXA or BXB)

GROUP GRAMMATICALITY RATINGS

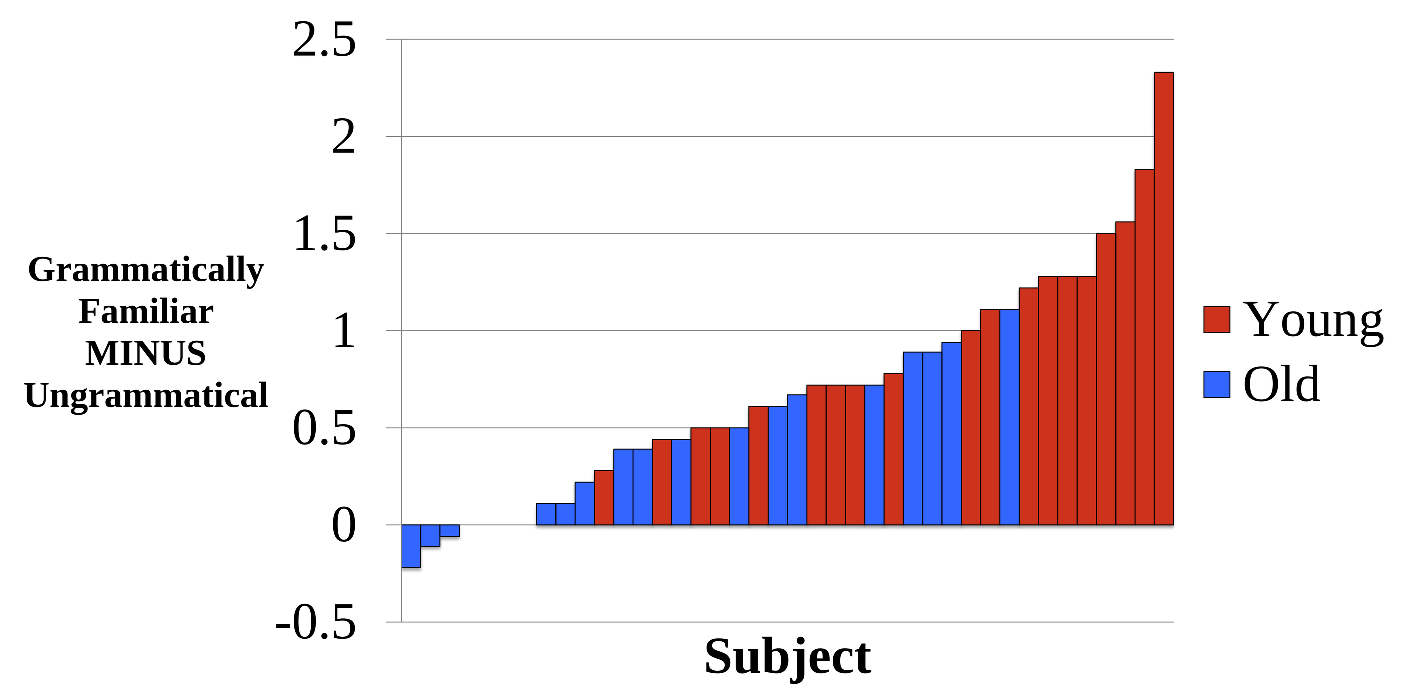


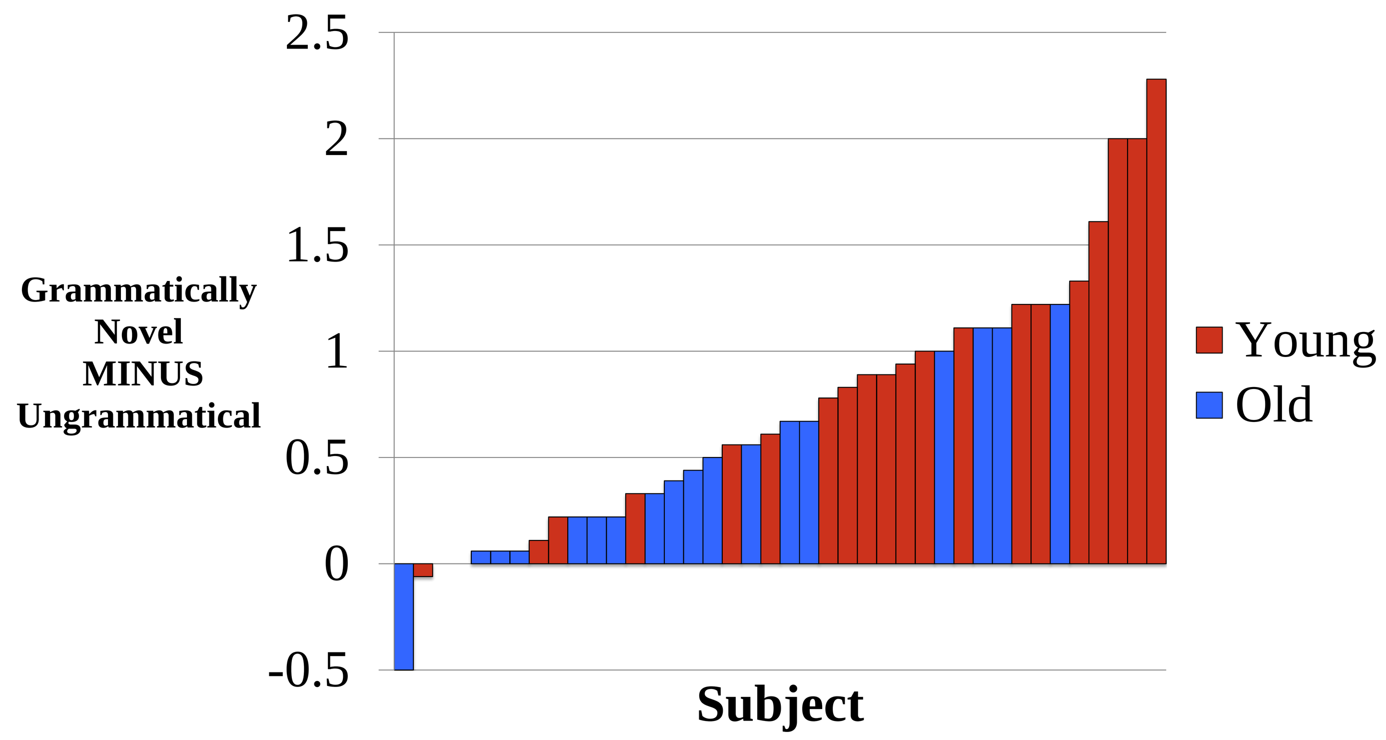
Average ratings on grammatically familiar (GF), grammatically novel (GN), and ungrammatical (UG) sentence strings, where error bars represent +/- 1 SE, and asterisks show significant differences (p<.05)

- Significant main effect of string type, $F(2, 72)=60.686$, $p<.0001$
- String type by age interaction, $F(2,72)=10.989$, $p<.0001$

INDIVIDUALS: RATING DIFFERENCE SCORES

Each bar represents an individual's difference in rating between two conditions





DISCUSSION

- Both young and older groups acquired grammatical categories based solely on the linguistic structure of the input (in this case, the distributional information surrounding the "X" words)
- Older adults' ratings indicated poorer learning than young adults
  - Consistent with previous research showing that older adults are poorer than younger at learning non-verbal probabilistic sequential patterns (Howard et al., 2004)
- Results are consistent with the "distributional learning" hypothesis (Cartright & Brent, 1997; Mintz, 2003; Reeder et al., 2013)

IMPLICATIONS

- The statistical learning measured in probabilistic language acquisition tasks may call on similar brain mechanisms as non-verbal implicit sequence learning; both types of learning are showing similar patterns of age differences
- Age differences revealed here may be related to losses in the basal ganglia
  - Evidence suggests that the basal ganglia are involved in implicit sequence learning, and that this system declines in old age (Simon, Vaidya, Howard, & Howard, 2011; Bennett, Madden, Vaidya, Howard, & Howard, 2011; Doyon et al., 2009; Seger, 2006)
  - Previous research has also linked the basal ganglia to language processing (Ullman, 2001; Newman, Supalla, Hauser, Newport, & Bavelier, 2008)
- The present study also suggests that the age-related declines in second language acquisition seen in older adults in laboratory studies (e.g., Mackey & Sachs, 2011) and in correlational studies of immigrants (e.g., Hakuta, Bialystok, & Wiley, 2003) may be due, in part, to age differences in the ability to use statistical learning to distinguish grammatical categories

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