Are age-related changes in the neural language system non-linear?

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Main Question: Is the preservation of sentence comprehension across the adult lifespan underpinned by an age-related linear change in functional activity?

Previous Findings: Patterns of Neurocognitive Aging

1. Decline vs. Preservation
   - Some functions decline in response to extensive tissue loss in both white and grey matter (GM; Has et al., 2008)
   - Some functions are preserved due to neural reorganisation, such as syntactic comprehension (Tyler et al., 2010):
     - Young adults: left-lateralized network (Tyler & Marslen-Wilson, 2008)
     - Older adults: bilateral activity & preserved performance (Tyler et al., 2010)

2. Linear vs. nonlinear age effects?
   - Linear cognitive decline: age & visual acuity (Baltes & Lindenberger, 1997)
   - Nonlinear cognitive decline: quadratic relationship age & processing speed (Verhaeghen & Salthouse, 1997)
   - Linearity of reorganisation not previously investigated

Present Study

- Combined fMRI and behavioural paradigms measure age effects on relationships between GM, activity, & sentence comprehension
- Syntactic comprehension manipulated with: syntactic ambiguity & syntactic dominance (subjects’ preference in interpreting the ambiguities)
- Three age groups: young, mature and older

Predictions

- Grey matter changes across adult lifespan
- Preserved syntactic processing will be accompanied by bilateral recruitment in older adults (Tyler et al., 2010)
- Main question: does bilateral activity increase linearly with age?
  - Linear: mature group should have intermediate reorganisation reflecting progressive & linear increase in recruitment
  - Nonlinear: 1) mature group may show qualitatively distinct pattern from young or older 2) no linear increase in recruitment across all subjects

Methods

Participants

- 15 younger adults (19-24 yrs); 14 mature adults (45-61); 14 older adults (62-74)

Materials

- 42 dominant ambiguous (Dom), 42 subordinate ambiguous (Sub), and 42 unambiguous (Unamb) sentences

Ambiguity Dominance Examples
Unambiguous her mother told her that crying babies are usually hungry.
Dominant her brother told her that drowning kittens is extremely immoral.
Subordinate her brother told her that drowning kittens are seldom rescued.

Sentence type effect: Subordinate > Dominant > Unambiguous

No age x sentence type interaction:
All age groups had sentence type effect

Behavioural Results

RTs obtained from post-test

Sentence type effect:
Subordinate > Dominant > Unambiguous

No age x sentence type interaction:
All age groups had sentence type effect

Neuroimaging Results

3T Tim Trio. 3mm, 32 oblique slices. Structural sequence: T1

Analyses (SPM5)

Preprocessing: realignment, normalization, spatial smoothing (8mm FWHM). Model included movement parameters and high pass filter.

Whole-brain random effect analyses for each age group (young, mature and older) and all participants

Linear and nonlinear regression for Regions Of Interest (ROIs)

叙kentic processing by age group

Young

Mature

Older

Conclusion

- Older adults recruit bilateral regions to preserve syntactic comprehension
- Age-related functional reorganisation proceeds in a nonlinear fashion
  - GM declines linearly in regions related to syntactic processing, but functional reorganisation does not show a linear response
  - Nonlinear progression included qualitatively different response in mature group: behavioural but no neural effect of syntactic dominance, which may suggest there is a period of adaptation to age-related neural change during middle age
- Future research
  - Include broader age range (especially the 25–45 yrs), to measure the continuous reorganisation pattern as a function of age

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