Word finding problems in ageing: how does the brain cope?

Meredith Shafto & Lorraine K. Tyler
Preserved and impaired language abilities in old age: The interaction of atrophy and activity

Meredith Shafto & Lorraine K. Tyler
Brain-behaviour relationships

Age-related cognitive decline

Wide-spread atrophy

Neural activity


What are the neural underpinnings of language performance in old age?

Sowell et al., 2004

Hedden & Gabrieli, 2004
Why Language?

- Language is important
  - Important everyday skill
  - Efficacy related to cognitive health
  - Older adults worry

- Implications for ageing brain
  - Left-lateralized gives recruitment potential
  - Relatively well-defined models
  - Variability: some spared and some impaired tasks
Language production: Word Finding Failures
Word finding failures in old age

Tip-of-the-tongue states (TOTs): Temporary inability to produce a well-known word, accompanied by a strong feeling of knowing.

TOTs increase in old age (Burke et al 1991)

1. Visual processing
2. Semantic Retrieval
3. Phonological retrieval failure
4. Production

Successful retrieval involves:

Actor
British
“Mr Darcy”
“Colin Firth”

Age-related increase in TOTs linked to atrophy in regions important for phonological retrieval?
TOTs: Faces

- 46 participants, aged 19-88
- 68 Famous faces, pre-tested for TOT susceptibility

Author of a diary documenting life as a Jewish child during WWII.
Ravens matrices

- Nonverbal intelligence task
- Performance declines with age

Which answer fits in the missing space to complete the pattern?

Complete the pattern
Effect of Age

- Age correlated with TOT rate
- Age correlated with Ravens errors
- Age correlated with grey matter
Performance and grey matter

- TOT rate correlated with grey matter in insula

- Ravens (non verbal) correlated with age but not insula grey matter
Region of interest: L insula

Named-Don’t Know

TOT-Named

activity

young

older

Named - Don’t Know

TOT-Named
TOT “boost” and TOT rates

- Larger “boost” affiliated with fewer TOTs across all participants

\[ R^2 = 0.3168 \]
Structure and function

- High grey matter group younger than low grey matter group
- Grey matter loss didn’t affect activity during successful naming
- Larger “boost” affiliated with fewer TOTs across all participants
Summary

- Atrophy explanation for age-related increase in TOTs
- Regional atrophy linked to changes in activity and performance
- Specific Atrophy-activity-performance links
- Phonology: TOT vs RPM
- “Difficulty”: TOT vs Named
Language comprehension: Listening to sentences
Sentence comprehension

- Semantic ambiguity:
  - The *shell* was *fired* towards the *tank*
  - Overall meaning of sentence *not* ambiguous
  - Comprehension involves selecting the contextually appropriate meanings

- Ambiguous sentences require additional processing in regions important for selecting meaning:
  - Left inferior frontal gyrus (LIFG)
  - Left middle temporal gyrus (LMTG)
  - LIFG-LMTG network
Sentence comprehension task

- Participants in 3 groups:
  - Young (18-27), young-old (49-68), older-old (70-85)
- Sentences with or without ambiguous words
- Probe task: word related to sentence meaning?

"The shell was fired towards the tank"
Behavourial results

- Age effect: only older-old slower
- Ambiguous vs unambiguous: no RT difference
Imaging results:
Ambiguous-Unambiguous
Reason for laterality shifts?

- Continued grey matter atrophy?
- Mixed grey matter - activity correlation
- No grey matter – RT correlation

Interactions between regions?
- IFG-MTG correlations – functional network
- No IFG-MTG correlation for old-older
Importance of connections?

White matter proportion

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Response time

- Ambiguous RT
- Unambiguous RT
Preserved performance may be underpinned by neural flexibility.

Younger-older adults had different activity pattern during sentence comprehension.

Both grey and white matter may be relevant for performance.

E.g., response time correlates with white not grey matter volume.

Future issues for understanding the nonlinear effects.

Grey matter: Role of differential hemispheric atrophy.

White matter: Role of specific connective integrity.
Conclusions

Age-related atrophy impacts language processes

Not every aspect of language performance may be maintained by neural recruitment

Limited by process and neural deterioration
Acknowledgements

Lorraine Tyler
Emmanuel Stamatakis
Deborah Burke
Phyllis Tam
Word Retrieval

Visual processing

Semantic Retrieval

Lexical selection

Phonological retrieval

“Colin Firth”

TOT onset: Phonological Retrieval failure

James & Burke, 2000

Cross & Burke, 2004

Phonological retrieval failure

James & Burke, 2000

Phonological Retrieval

TOT onset:
Word finding failures in old age

- Tip-of-the-tongue states (TOTs):
  - Temporary inability to produce a well-known word, accompanied by a strong feeling of knowing and, often, frustration

- TOTs increase in old age (Burke et al 1991)
  - Naturalistic diary study
  - Experimentally induced:

- What process has failed?
  - **Meaning** is retrieved
  - **Sound** retrieval has failed
## What is a TOT?

- **Temporary inability** to produce a well-known word or name
- TOTs are **resolvable** – not permanent retrieval failures
- **Increase in old age**

### Importance of phonology (sound information)

- **Sound (phonology)** of name inaccessible while meaning (semantic) information about person available
- Sometimes **partial** sound information about word available (e.g., initial phoneme or number of syllables)
- **Cueing** with words that share some **sounds** can help resolve

### TOTs in old age

- Older adults have more TOTs - source of concern for older adults worried about their memory abilities
- Older adults have less partial information
- Older adults take longer to resolve
- …But older adults benefit as well as younger from cueing
Relating structure and function

*If age-related increases in TOTs are due to atrophy in regions important for phonological retrieval:*

- All participants: TOT-specific activity in phonological retrieval regions
- Older adults: Differential TOT-specific activity
- Relation of TOT-specific activity to grey matter
Behavioural results

[Graph showing proportions and response times for 'Know', 'TOT', and 'Don’t Know' categories with 'young' and 'older' groups.]

- Proportion response
  - Y-axis range: 0 to 0.6
  - X-axis categories: 'Know', 'TOT', 'Don’t Know'

- Response Time
  - Y-axis range: 0 to 3500
  - X-axis categories: 'Know', 'TOT', 'Don’t Know'

Legend:
- young
- older
VBM analyses: overview

- Segmented, smoothed grey matter probability images used in analyses

- Each analysis: correlates grey matter probability with behavioural scores voxel-by-voxel across subjects

- Output gives voxels with significant correlations of grey matter probability and variable of interest
Imaging Results:
Know-Don’t Know & TOT-Know
Relating structure and function

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fMRI TOT

- 200 Famous faces, pre-tested for TOT susceptibility
Know – Don’t Know
Reason why ym may recruit whole right hemi network

- Rh declines less quickly than LH
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Importance of connections?

### Graphs

- **Top Left Graph**: Comparison of importance values across age groups (young, young-old, older-old).
- **Top Right Graph**: Bar chart showing response times for ambiguous and unambiguous tasks across age groups (young, young-old, older-old).

### Key Points
- Importance values range from 0.25 to 0.3 for young and young-old groups.
- Older-old group shows slightly lower importance values.
- Response times vary significantly across age groups with older-old group showing the highest response times.

### Notes
- The graphs illustrate how connections (importance values) and response times differ across age groups.
- The importance values and response times are likely influenced by factors such as cognitive decline and response speed.

### Analysis
- The importance and response time data suggest that younger individuals might have a higher level of understanding or quicker processing times, while older individuals face more challenges.

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The significance of these findings is crucial for understanding age-related cognitive changes and designing effective communication strategies.
Relating structure and function

- Age-related neural atrophy should affect neural activity during TOTs

- Contrasts of interest:
  - Know-Don’t Know
  - TOT-Know

- Region of interest:
  - L insula region of interest
Grey matter and activity

Inferior frontal

- young L hemisphere
- young-old R hemisphere
- older-old L hemisphere

Middle temporal

- young L hemisphere
- young-old R hemisphere
- old-old L hemisphere

\[ R^2 = 0.2044 \]

\[ R^2 = 0.0005 \]

\[ R^2 = 0.4002 \]

\[ R^2 = 0.0506 \]

\[ R^2 = 0.2509 \]

\[ R^2 = 0.0086 \]
Correlations: IFG-MTG

- **Strong** correlations between 2 regions for young and young-old

- **Weaker, non-significant effect** for older-old