Strategic Promotion of Ageing Research Capacity

Where's that Word?

Word finding problems in older age

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Meeting the challenges of an ageing society

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Difficulties with word retrieval, especially when naming a well-known face or object, is part of the normal ageing process, but older people fear that it could be a sign of encroaching dementia. Surprisingly, little is known about these tip-of-the-tongue situations (TOTs). In this study, groups of older and younger participants were shown a series of famous faces. At the same time, their brains were scanned using Magnetic Resonance Imaging (MRI). The findings from this research help contradict the assumption that TOTs in old age reflect a general memory deficit. Instead, the difficulty appears to be localised, low-level, and specifically to do with word production and the retrieval of the form of words, rather than the higher-level meaning of those words.

Key Findings

- The study found that here were age-related differences in the ability to retrieve words, and a higher incidence in TOTs for older people. When successfully retrieving words though, older adults activated similar regions of the brain to younger adults, and there was no age-related difference in activity in the part of the brain known to be important for word retrieval (the insula).

- When trying to retrieve a difficult word there was a *boost* of activity in the insula. This boost was linked to overall better performance (lower TOT rates), suggesting that the boost of activity helped to overcome retrieval difficulty. However when a TOT was encountered, the boost was over and above that found during successful word retrieval.

- The boost of activity in the insula of older adults was found to be smaller than that of younger adults. Thus, older adults' smaller activity boost during TOTs may explain why they typically have more TOTs compared to younger adults.

- When participants were divided into groups according to the amount of grey matter (important for processing sensory information) in the region of their brain known as the insula, no difference in activity was found when word retrieval was successful.

- However when experiencing difficult retrieval leading to a TOT, participants with lower grey matter content in their insula had smaller boosts of activity compared to the high grey matter group.

Introduction

The Issues

Although many cognitive abilities are preserved across the adult lifespan, a major concern for many older people is that those cognitive functions which decline with age (for example, memory, attention, perception, problem solving, mental imagery) are a precursor to conditions such as dementia. One of the most common problems is an increase in word-finding failures, known as tip-of-the-tongue states (TOTs).

Background

Recent advances in brain scanning (neuroimaging) technology have provided considerable information about the brain's structure and function. This information is invaluable for understanding cognitive change in old age, and has shown that normal ageing is accompanied by a number of notable changes to brain tissue. Changes in the cells and networks which transmit information in the brain (neural declines) have been linked to cognitive declines. However, there is a great deal of variability in both neural and cognitive declines during the ageing process.

Understanding the relationship between the brain and behaviour in old age is very complex. Age-related declines could affect brain activity in a number of ways: for example, weakened regions of the brain may operate less efficiently. This could mean that regions of the brain which typically work together are less able to operate cooperatively. To date, a number of age-related changes have been observed in brain activity, but it is not always clear how these changes relate either to performance or to actual structure.

TOTs

Although TOTs are a source of considerable concern for older adults, very little research has examined the role of the brain in these difficulties, or of other age-related changes to language abilities.

Behavioural research suggests that TOTs may occur when the target word's **phonology** (sound information) is temporarily unavailable. This research indicates that TOTs have a specific cause, known as phonological retrieval failure, rather than reflecting generalised memory failure.

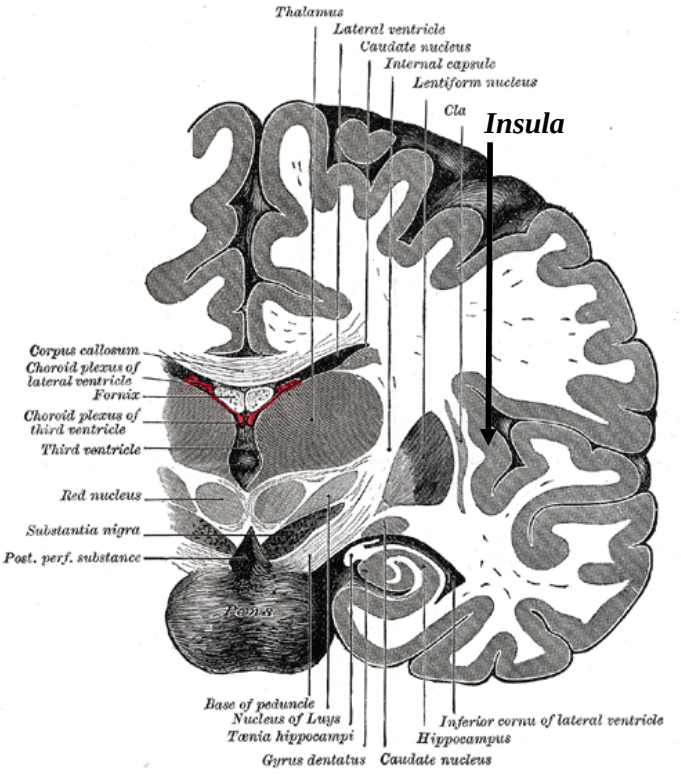
Previous research has also demonstrated a link between age-related increases in TOTs and age-related changes in the left **insula**, a region of the brain important for phonological retrieval.

Aims

The aim of this study was to examine the degree to which age-related changes in the brain have an effect on TOTs through two experiments.

- The first was to investigate the relationship between increasing TOT rates and age-related changes in neural structure and function.
- The second investigated the impact of experimentally controlling phonological availability on neural activity.

A definition **Grey matter** is the outer layer of the brain which contains the ends of nerve cells and is named because it appears grey. The grey matter is in contrast to the white matter, which is the tissue through which messages pass between different areas of grey matter within the nervous system. Grey matter is important for procession sensory information.



The Insula (Insular cortex)
From Gray's Anatomy via Wikipedia Commons

Results

Experiment 1: relationship between neural structure, function, and performance

The first experiment was based on a previous study which linked age-related increases in TOTs to age-related changes in the brain.

A key question is whether age-related changes in the brain are responsible for altering the functional operation of word retrieval in old age, or whether they have a restricted effect. A restricted effect would lead to increases in TOTs but not to changes in successful word production.

This experiment used Magnetic Resonance Imaging (MRI) to examine both brain structure and function in younger and older adults.

Participant at MRI scanner

Participants

The participants were split into two groups of 16 younger and 15 older people, with average ages of 24 (younger group) and 75 (older group) respectively. All completed a number of screening tasks to guarantee that they were physically and cognitively healthy. The characteristics of the groups in terms of these tests were similar.

Another set of questions evaluated the participants' suitability for an MRI study of language function.

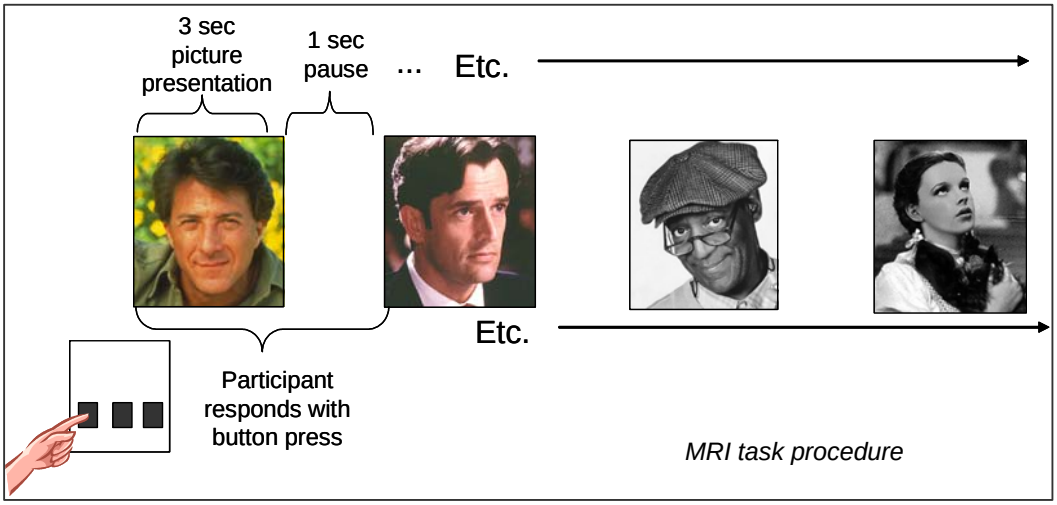
Materials

The test materials included 200 pictures of famous public figures. These were chosen as stimuli because proper names are the most common category of TOT targets for both younger and older adults, and forgetting names is a particular concern for older adults.

The materials were pre-tested to guarantee that over the total set of items, both younger and older adults generated approximately equal numbers of TOTs. Matching on behavioural performance was important for two reasons. First, in order to use MRI data to address the question of whether there are qualitative differences in the processes underlying younger and older adults' word production, it is important that performance is not confused with changes in brain activity. Secondly, it was necessary to guarantee that younger adults, who typically have fewer TOTs, would generate enough TOTs to contribute to the analysis.

Experiment.

The TOT task was based on previous versions of TOT-inducing tasks, modified for use in the scanner. For each trial, a face appeared for 4 seconds, during which time participants were asked to press a button to indicate if they knew the name of the person (*Know*), didn't know the name of the person (*Don't Know*), or were having a TOT (*TOT*) for the name of the person. The task was piloted to make sure that the time allowed was sufficient for making this decision, and participants were given practice both outside and inside the scanner to familiarise them with the task. A representation of the task procedure for four example trials is given overleaf.



MRI task procedure

Behavioural Results

The analysis of the proportion of *Know, TOT*, and *Don't Know* responses showed that although there were differences in the proportions, with fewer TOTs (average 15%) than *Know* (40%) and *Don't Know* (45%) there were no differences due to age. This similarity in TOT rates was a direct consequence of the way the experiment was planned. Also, the analysis of response times showed that TOT responses were slightly slower (average 3 sec) than for either *Know* or *Don't Know* responses (both approximately 2 sec), and there were no differences due to age.

Imaging Results

The imaging data analysis used a technique to highlight differences between MRI images for two different conditions. There were two main comparisons, *Know - Don't Know* and *TOT - Know*.

In the *Know - Don't Know* comparison, a wide range of regions of the brain were shown to be active. This reflects the network of regions needed for word production. The active regions included the left insula, which would be expected because phonological retrieval is necessary during name retrieval. However, older adults activated similar regions to younger adults, and there was no age difference in activity in the insula. This finding indicates that while in normal circumstances there are age-related changes in word retrieval performance (that is, increased TOTs), this does not reflect fundamental changes to the regions and activity involved in *successful* word retrieval (*Know* responses).

In the *TOT-Know* comparison, evidence was found that during difficult retrieval (TOT), there is a *boost* of activity in the insula, over and above that experienced in the successful retrieval *(Know*) condition. However, the older adults' boost of activity was smaller than that of younger adults.

Although this boost was seen during difficult retrieval (TOT) it was linked to overall better performance (lower TOT rates), suggesting that the boost of activity was an effective strategy for overcoming retrieval difficulty. Thus, older adults' smaller activity boost during TOTs may explain why they typically have more TOTs compared to younger people.

When participants were divided into groups according to the amount of grey matter (important for processing sensory information) in the region of their brain known as the insula, no difference in activity was found when word retrieval was successful. However when experiencing difficult retrieval leading to a TOT, participants with lower grey matter content in their insula had smaller boosts of activity compared to the high grey matter group.

Taken together, the findings from this experiment suggest a link between grey matter, neural activity, and word production performance. Age-related changes in the grey matter of regions of the brain which are important during phonological retrieval, did not affect activity during successful retrieval (*Know*). But they did impair the ability of older adults to adapt phonological retrieval processes, so they were unable to generate a boost of activity during TOTs, which may be important for overcoming temporary retrieval failures.

Experiment 2: impact of phonological availability on stages of word production

The results of the first experiment support the view that TOTs are caused by processes during phonological retrieval. In addition to being important for understanding word production in old age, these findings help contradict the assumption that TOTs in old age reflect general memory deficits. Instead the difficulty appears to be local (that is, during a specific stage of word production) and low-level (retrieval of the word form rather than its higher-level meaning).

However, there are at least two sets of processes involved during a TOT: those that lead to TOT *onset*, and those that operate during TOT *resolution*. These stages may interact. In particular, having some partial phonological information available at TOT onset may be crucial for successful resolution. The goal of the second experiment was to examine the processes at work during TOT onset and how they interact with resolution, by directly manipulating phonological availability.

The second experiment was a pilot of a much bigger planned study using a newly installed **magnetoencephalography** (MEG) device. This device enables measurement of brain activity in real time, and provides much greater precision than is available with MRI data.

Phonological availability: Cohort size

A measure of phonological availability which is a characteristic of each object's name is its *cohort* - the set of words which begin with the same sound. For example, *bid, bit,* and *bin* are all part of the same cohort. Previous research demonstrates that the availability of the *initial* sound is critical for determining TOT rate. So it is possible that words from larger cohorts will generate fewer TOTs than words from smaller cohorts because of the increased availability of the initial phonology.

Example Object TOT pictures

Pilot Results

This experiment consisted of an object TOT task using 249 objects, similar to that in the first experiment which used names. The resulting data give some indication of the potential impact of phonological availability on TOT rates.

In this study, *word frequency* was manipulated. Word frequency is known to have an effect on TOT rate: TOTs are far more common for low rather than high frequency words. The size of the target word's cohort, including those words with both low and high numbers of words beginning with the same initial sounds, was also manipulated.

Age differences were only found for lower frequency words. This is in keeping with previous findings that infrequent words are more often the source of TOTs because their phonology is not accessed very often, and so is vulnerable to retrieval deficits. For low frequency words, older adults had a higher average TOT rate compared to younger adults, but this was not true for words from a larger cohort. These preliminary results demonstrate: firstly, that older adults are more affected by words with smaller cohort sizes; and secondly, that this is only the case for low frequency words.

Discussion

A broad conclusion from this research is that not all cognitive abilities are equally affected by age, and that neural and cognitive abilities across the lifespan vary according to the cognitive process involved. A second conclusion is that understanding the neural effects of age requires an understanding of the effect of age on neural *networks*, not just individual regions. In order to fully understand the processes behind age-related changes in word production, this task must be placed in the context of other language abilities and other cognitive abilities.

Difficulties with language are a source of concern for older adults, who worry that changes in their language abilities may indicate the onset of dementia. These beliefs can undermine older adults' self-confidence and encourage social isolation. Additionally, both older and younger adults believe that older adults have deficits in communication skills, leading to condescending communication styles which older adults find insulting and demoralising.

"I can see her now, her name is on the tip of my tongue, just can't remember it"

The results from this research should have beneficial educational effects. The findings have been presented in a number of settings, including specialist and general academic events, as well as community events. Invariably they have generated a great deal of interest and discussion from the audience. These experiences have confirmed that people are not only concerned about cognitive decline including word finding failures, but that they are also deeply interested to learn that old age is accompanied by specific, rather than general declines, and that word finding failures are not a signal of age-related dementia.

Aside from the immediate educational benefit, the research provides critical data for future cognitive ageing research. The results emphasise the importance of combining measures of performance with measures of neural structure and function in order to understand normal cognitive ageing. Moreover, they provide an insight as to the nature of normal cognitive aging. This is important for understanding the range of cognitive development of the fastest growing segment of our population – healthy older adults. It is also critical to understand the limits of healthy ageing if we hope to understand fully the nature of pathological ageing as in dementia.

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The Study

The study received financial support from SPARC of £40,002 and ran for 12 months ending in November 2007. Additional support was provided by the University of Cambridge.

More information about the study can be found on the SPARC website www.sparc.ac.uk and obtained directly from the investigators.

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Disclaimer

SPARC

SPARC is a unique initiative supported by EPSRC and BBSRC to encourage the greater involvement of researchers in the many issues faced by an ageing population and encountered by older people in their daily lives. SPARC is directed, managed and informed by the broader community of researchers, practitioners, policy makers and older people for the ultimate benefit of older people, their carers and those who provide services to older people.

SPARC pursues three main activities:
Workshops to bring together all stakeholders interested in improving the quality of life and independence of older people.
Advocacy of the challenges faced by older people and an ageing population and of the contribution of research to improving quality of life. SPARC is inclusive and warmly welcomes the involvement of everyone with a relevant interest.
Small Awards to newcomers to ageing research, across all areas of design, engineering and biology and at the interfaces relevant to an ageing population and older people. In 2005 and 2006 SPARC received 185 applications for support in response to two invitations for competitive proposals of which 34 were supported.

Executive Summaries

SPARC is supporting its award holders through funding, mentoring, a prestigious dissemination platform, professional editorial assistance, international activities and provision of contacts. Each of the projects has been small, yet the enthusiasm for discovery, and impatience to contribute to better quality of life for older people, has more than compensated for the very limited funding which was provided.

This executive summary is one of a series highlighting the main findings from a SPARC project. It is designed to stand-alone, although taken with summaries of other projects it contributes to a formidable combination of new knowledge and commitment by newcomers to ageing research, with a view to improve the lives of older people. This is a tangible contribution towards ensuring that older people receive full benefit from the best that research, science and technology can offer.