The 2017
Libby Harricks
Memorial Oration

Libby Harricks Memorial Oration number 17

Honouring the Deafness Forum's first president & profoundly deaf achiever

Elisabeth Ann Harricks AM 1945 – 1998

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2017 Libby Harricks Memorial Oration

Dr Piers Dawes

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Introduction to the

19TH LIBBY HARRICKS MEMORIAL ORATION

Christopher Lind, PhD,
Chairperson, Libby Harricks Memorial Oration committee

It is with great pride that I take this opportunity to open this session and welcome you all and our esteemed orator to this, the 17th in the series of Libby Harricks Memorial orations. Prior to introducing our orator for 2015, I wish to speak briefly about the person who has been the inspiration for this series of orations; Libby Harricks.

As some may know, Libby Harricks grew up with apparently normal hearing. Subsequently, as a young wife and mother, she developed a profound hearing loss. She not only educated herself with skills to manage her own hearing difficulties but soon became committed to advocating for all hearing impaired people. She was a founding member and long-term President of Self Help for Hard of Hearing People, Australia Inc. and amongst many other challenges was the inaugural Chairperson of Deafness Forum of Australia. In all of these purely voluntary roles, she worked tirelessly to raise awareness of the need for equal inclusion in life activities for hearing impaired people, and in doing so travelling widely throughout Australia to lobby for this on their behalf. In recognition of her advocacy work, Libby was made a Member of the Order of Australia in 1990.

After her death in 1998, Deafness Forum of Australia, the national co-ordinating body for Deaf and hearing impaired issues, established the annual Libby Harricks Memorial Oration Series to honour her achievements. The Series aims to continue

her vision of working towards gaining appropriate recognition, awareness, and access, for Deaf and hearing impaired people. Over the years, Orations have been presented across Australia, and the Oration series has developed a well-deserved reputation for carrying forward Libby's commitment to raising awareness of issues relating to Deafness and hearing impairment. The reputation of the oration series is undoubtedly due to the great contributions of our outstanding Orators who have presented on a wide range of relevant topics.

In order to reach further than each Oration audience and indeed to make these important contributions available on an on-going basis the Orations have been available from the Deafness Forum of Australia website. I take this opportunity to acknowledge the support of the Libby Harricks Memorial Oration Committee and the Deafness Forum's board of directors, the sponsors and supporters for this event each year. I should note that copies of today's oration will be available in the coming weeks and to note that as of this year all monographs in the series will be available for free electronic download from the Deafness Forum website (www.deafnessforum.org.au).

It is now my great pleasure to introduce to you our 19th Libby Harricks Memorial Orator, Dr Piers Dawes.

2017 LIBBY HARRICKS MEMORIAL ORATION

Hearing and Mind: What should we do about hearing loss to promote cognitive well-being in older age?

Dr Piers Dawes

Piers Dawes studied speech and hearing science at Curtin University in Western Australia before moving to the UK to study for a doctorate in experimental psychology at Oxford University. He is currently a senior lecturer in audiology at the University of Manchester. Dr Dawes's research concerns the impact of hearing impairment on development in childhood and old age, and improving quality of life for adults and children with hearing impairments.

Dr Dawes was a recipient of a US-UK Fulbright award and was awarded the British Society of Audiology' TS Littler prize for services to audiology. Dr Dawes was the founding chair of the British Society of Audiology's special interest group for cognition in hearing, which promotes research and raising awareness of new developments on cognitive issues in hearing science, assessment and intervention. Dr Dawes is joint PI for "Ears, Eyes and Mind: The "SENSE-Cog Project" to improve mental well-being for elderly Europeans with sensory impairment", a €6.2 million EU Horizon 2020 project. Dr Dawes is an associate lead for the NIHR Manchester Biomedical Research Unit in Hearing, and leads a consortium of international researchers (including Nottingham Biomedical Research Unit in Hearing, Leeds University, Wisconsin University, University College London and Cincinnati Children's Hospital Medical Centre) in analyzing hearing and tinnitus data from the UK Biobank resource (N=500,000 UK adults).
https://www.research.manchester.ac.uk/portal/Piers.Dawes.html

Introduction

A recent review of factors that may contribute to the risk of dementia identified mid-life hearing loss as being the most significant risk factor, accounting for 9% of the attributable risk of dementia in the general population (Livingston et al., 2017). The reviewers suggested that identifying and treating hearing loss may offer an important opportunity to prevent dementia and promote cognitive well-being in older age.

In this monograph, I will discuss possible reasons for a link between hearing loss and cognitive function and make some suggestions about what to do about hearing loss in order to promote mental well-being in older age.

Reasons for a link between hearing loss and cognition

The conclusion that mid-life hearing loss accounts for 9% of the risk of dementia in later life was based on combining the results of three similar studies that observed associations between hearing loss measured at base line and the risk of developing dementia over several years following the base line time point. In one of these studies, the authors looked at how levels of hearing loss related to the risk of developing dementia over 11 years in 639 people who did not have dementia at base line (Lin et al., 2011). They found that people with more severe hearing loss at base line were more likely to develop dementia over those 11 years, after statistically accounting for potential confounds such as age.

Longitudinal studies like this one that show an association between hearing loss and risk of dementia followed other cross-sectional studies that showed that hearing level is associated with cognitive performance. In classic studies using data from the Berlin Aging Study, older people had poorer hearing, visual and cognitive function. Interestingly, when the researchers looked at associations between sensory (hearing and visual) function and cognition independent of age, sensory function was associated with around 13% of the variance in cognitive function (Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994). In other words, at any particular age, people with better hearing and vision tended to have better cognitive function. The researchers concluded that the age-independent association between sensory and cognitive function suggested an important link between sensory and cognitive function, and that this link may provide useful insight into cognitive aging.

So there is evidence that hearing loss is associated with both poorer cognitive function and with increased risk of developing dementia. But an important limitation of this research is that the research is observational. The research shows and *association* between hearing and cognition, but it does not provide any insight into how hearing and cognition may be related.

There are three possible explanations for why hearing and cognition may be associated. The first is that there is some direct impact of hearing on cognition. The second is that the impact is the other way around: cognition impacts on hearing. The third possibility is that hearing and cognition are not

directly related, but both are impacted by a common third factor (Figure 1). I'll begin with discussing the third possibility (a common cause) first.

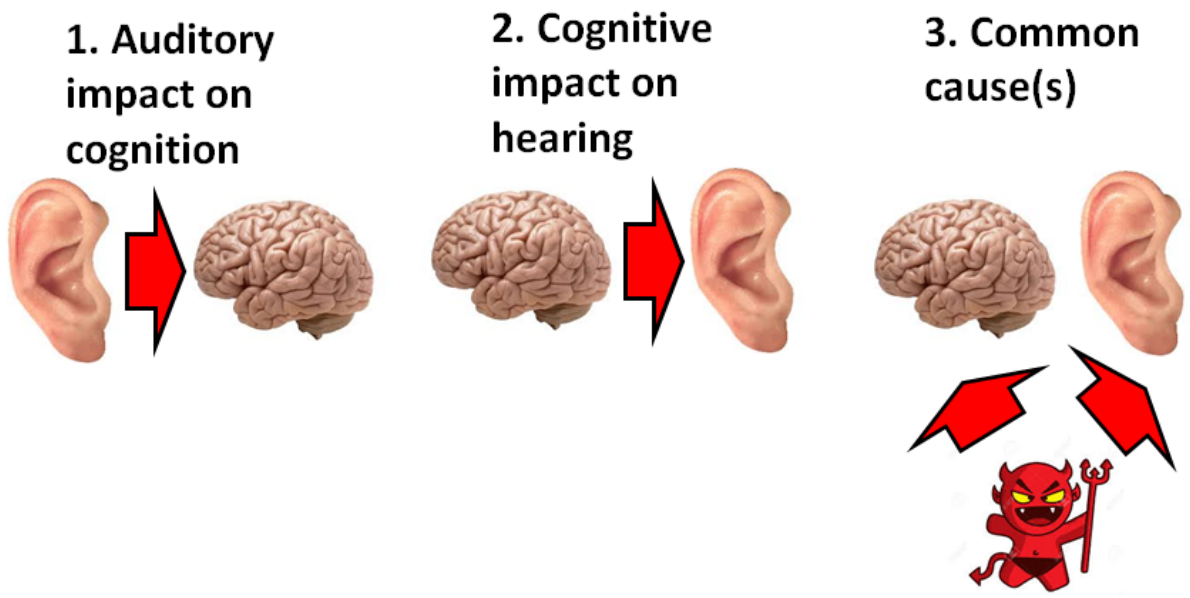

Figure 1. Three explanations for why hearing and cognition may be associated.

Common cause

Individuals age at different rates, and chronological age is only an approximation of someone's biological age. Differences in biological age are due to differences in age-related physiological processes that underlie aging. There is interest in markers of biological age (biomarkers), because these biomarkers could be used to predict mortality and health outcomes including cognitive change and dementia. Biomakers of aging include cardiovascular and respiratory efficiency, muscular strength and sensory function.

Hearing correlates with other biomarkers of aging, and other sensory functions including vision, balance, smell, touch and taste are associated with cognitive function, rates of cognitive decline and dementia risk. Sensory biomarkers are very good markers of age differences in cognitive function. If one takes a large and diverse group of people, around 95% of differences in cognition between individuals are due to differences in genetics, wealth, education and general health. Only around 5-10% of differences in cognition between individuals are due to differences in their ages. Sensory function is an extremely good marker of differences in cognition due to age (Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994).

Some of my colleagues at the University of Manchester were interested in testing whether the shared association between sensory and age-related cognitive change is associated with direct measures of neurophysiological efficiency of the whole brain (Rabbit et al., 2006). In other words, might changes in cognition and sensory function be caused by the same loss of brain health? These

researchers tested cognition in a group of 69 people aged between 62 and 81. The measure of sensory function was a test of balance (the Tinetti Balance test). The direct measures of brain health were age-related changes in brain volume (based on measuring how much the brain had shrunk inside the skull using magnetic resonance imaging (MRI) scans) and blood flow to the brain (carotid and basilar arterial flow).

They found that the direct measures of brain health were associated with 91-99% of differences in cognition between individuals due to age. Differences in balance function were associated with an amazing 100% of the shared variance in brain health and individual differences in cognition due to age. The researchers concluded that sensory function is a good biomarker of how much brain volume and blood flow has been lost, how this loss affects cognitive function and how the loss marks an increased risk of future decline.

Sensory biomarkers (including hearing) are important because they may provide an easy, inexpensive index of brain health that could be used to signal a need for interventions to promote brain health and avoid adverse outcomes including cognitive decline and dementia.

What can we do to preserve hearing and cognition? Or in other words, if hearing and cognitive function do share a common cause, what are the common causes and what can we do about them?

Both hearing and cognitive function are associated with a range of healthy lifestyle factors including aerobic exercise, healthy diet, non-smoking and moderate alcohol consumption (Cruickshanks, Zhan, & Zhong, 2010; Plassman, Williams, Burke, Holsinger, & Benjamin, 2010). In relation to hearing, aerobic fitness and cardiovascular health are associated with better hearing, presumably because cardiovascular fitness prevents microvascular damage impacting on the organs of hearing (Hull & Kerschen, 2010). A diet that is low in saturated fats and high in fruit and vegetables is associated with better hearing (Dawes, Cruickshanks, Vyas, Moore, & Munro, under revision; Spankovich, 2015). Moderate alcohol consumption and non-smoking is associated with better hearing (Dawes et al., 2014), although excessive alcohol consumption is associated with hearing loss. Exactly the same associations of healthy lifestyle factors are reported in relation to better cognition and lower risk of dementia.

And it is not just environmental or lifestyle factors in adulthood that has an impact on hearing and cognitive function. Research by ourselves and others suggest that environmental factors during the pre-natal period and during early childhood (primarily related to nutrition) have a critical, life-long impact on sensory and cognitive function (Dawes et al., 2015).

So there is good evidence for a range of shared environmental factors that impact on both hearing and cognition. Hearing and cognition may also share genetic risk factors. The E4 variant of the apolipoprotein gene is strongly associated with increased risk of Alzheimers dementia. The E4 variant also seems to convey a risk of poor hearing in later life (Kurniawan et al., 2012).

In summary, hearing loss is a marker of cognitive decline and risk of dementia because it represents age-related changes in neural integrity related to common causes. Hearing loss may signal a need

for healthy lifestyle interventions to change trajectories of aging and minimise cognitive decline and risk of dementia.

Cognitive impact on hearing

Another possibility is that hearing and cognition are associated because cognition impacts on hearing. Listening in acoustically complex environments is extremely cognitively taxing. One must focus one's attention on the signal of interest, sustain your attention on the signal and avoid distraction by background noise, follow what is being said and relate what is being said to background knowledge about the topic. A cognitive impairment may therefore impact on listening, and someone may report 'hearing problems' due to problems with cognition rather than problems with hearing.

The sorts of measures that are usually used to assess hearing are also rather cognitively taxing and may be confounded with cognitive function. The gold standard measure of hearing is 'pure tone audiometry' (PTA). PTA involves sitting quietly in a sound proof booth, carefully directing your attention to listen for very quiet beeps and linking the beep with the requirement for a behavioural response (pressing a button). There is some evidence that people with impaired cognitive function struggle with the procedural demands of PTA. Someone may do poorly on PTA at least partly because they have impaired cognitive function rather than due to having a hearing problem. The impact of cognitive function on PTA and other hearing assessments is extremely problematic for i) researchers who want to disentangle cognitive from auditory factors and ii) clinicians who wish to differentially diagnose hearing and cognitive problems.

Auditory impact on cognition

The remaining possibility is that there is a direct impact of hearing on cognition. There are several possible ways that hearing may impact on cognition.

The first is that hearing loss exacerbates 'listening effort', which has an adverse effect on cognition. People with hearing impairment report high levels of 'listening effort' compared to people of a similar age with good hearing (Alhanbali, Dawes, Lloyd, & Munro, 2016). When an auditory signal is degraded (in the case of hearing loss), someone may still be able to follow the gist of a conversation by 'filling in the gaps' and extrapolating from the information that is heard to guess the parts of the conversation that are missed. Unfortunately, 'filling in the gaps' requires extra cognitive effort.

Patrick Rabbit demonstrated the impact of 'listening effort' on cognition in a classic 1966 experiment (Rabbit, 1966). He had a group of young men with normal hearing listen to a list of words that were presented either in quiet or in a background of noise. He then asked the participants to recall the words that had been presented among a list of distractor words. Pat found that although the participants had been able to recognise the words equally well in quiet and noise conditions, their recall for the words heard in the noise was significantly worse than recall for the words heard in quiet. Pat suggested that this might be because the increased effort of listening to

the words in noise prevented participants rehearsing the words in their mind, or prevented them from encoding the words in their memories. Pat Rabbitt subsequently demonstrated the hearing loss results in the same sort of impact on memory performance as listening to words in background noise (Rabbit, 1991). Rabbitt concluded that some behavioural difficulties in older adults may be mis-attributed to low cognitive function when actually the difficulties are due to easily remediable peripheral sensory impairments. The implication is that some behavioural difficulties in older adults may be easily mitigated by effective management of hearing impairment (for example, by providing hearing aids). Effective management of hearing impairment may then improve function, improve quality of life, reduce disability and delay the point at which a person might fit a diagnosis of 'dementia'.

There is good experimental evidence that the impact of listening effort on cognition is 'real', and that listening effort is a common experience among people with hearing loss. But I don't think that 'listening effort' is a good explanation for all of the observations from studies that reported associations between hearing loss and cognitive function. The problems are firstly listening effort might explain why people with hearing loss tend to do more poorly on spoken tests of cognitive function, but it doesn't explain why people with hearing loss do more poorly on visually-based tests of cognition in the absence of any listening demands. Secondly, some studies have suggested that people with hearing loss have faster rates of cognitive decline than people with good hearing. Listening effort would explain an apparent decline in cognition (that could be immediately reversed by providing hearing aids), but listening effort doesn't explain faster than average rates of cognitive decline.

A second possibility for the impact of hearing on cognition is that a chronic state of listening effort leads to permanent changes in the brain that adversely impact on cognition. This hypothesis is based on neuroimaging studies that show that additional brain areas 'light up' in taxing listening conditions, interpreted as showing extra cognitive effort supporting effortful listening. I don't find it very plausible that extra cognitive effort should have a permanent adverse impact on cognition however. Doing cognitively taxing things (volunteer work, brain training, crosswords, Sudoku) is associated with preserved cognition, not with cognitive decline.

A third possibility is that hearing loss leads to reduced auditory input to the brain, leading to de-afferentiation of neurons and an adverse impact on systems that support cognitive function. There is some evidence that changes in the peripheral auditory system lead to plastic changes in representation of sound in the auditory cortex in the brain (e.g. Robertson & Irvine, 1989) but I am not aware of any evidence that changes in peripheral hearing impact on brain systems that support cognition.

A final possibility is that the impact of hearing loss on cognition is indirect. Hearing loss may lead to increased social isolation and lack of cognitive stimulation, depression, and/or reduced self-efficacy. Social isolation, depression and low self-efficacy adversely impact on cognition. This possibility seems quite plausible.

In summary, hearing is a marker of brain health. People who smoke, drink excessively, have a poor diet and do not exercise regularly are at increased risk of hearing loss, cognitive decline and dementia. Cognition affects hearing. Cognitive difficulties impact on listening in challenging everyday listening situations and on performance of hearing tests. Hearing impairment may also impact on cognition by increasing listening effort, inducing adverse neuroplastic brain changes or via depression, reduced social engagement and lowered self-efficacy. Note that all of these possibilities are not mutually exclusive and there is evidence for all of them (at least to some extent for some of them). The relationship between hearing and cognition is complex.

What should we do about hearing loss?

In the second part of the monograph, I'd like to share some thoughts on how we should address hearing impairment to promote mental well-being in older age.

My colleague, Asri Maharani a post-doctoral researcher on the SENSE-cog project described trajectories of age-related cognitive decline according to patterns of sensory impairment using data from European, English and United States longitudinal data sets (Maharani et al., submitted). She modelled declines in episodic memory function according to i) self reported hearing, ii) self reported vision and iii) dual sensory (hearing and vision) impairment. Asri found that people who reported hearing or vision impairment had lower memory performance and steeper decline in memory over time. But people who reported both hearing and vision problems had the poorest performance and the steepest decline. Male sex, lower socioeconomic and educational background were associated with poorer cognition, but there was no interaction between these demographic factors and sensory status. The impact of sensory impairment appears to be similar across the population.

A second analysis as part of our SENSE-cog project was by our colleagues at the University of Bordeaux (Naël et al., submitted). These researchers looked at vision impairment and risk of dementia over 12 years among a sample of nearly 8,000 older adults in France. They found that, as with hearing impairment, vision impairment is associated with increased risk of developing dementia (after statistically accounting for a range of possible confounds). Our colleagues found that people with vision impairment had reduced involvement with cognitively stimulating activities (for example, volunteer work in the community), but that reduced engagement only accounted for a small proportion of the increased risk of dementia for people with vision impairment. There was a very striking interaction with symptoms of depression: people with vision impairment or depression were at slightly increased risk of dementia. But those who had both depression and vision impairment were much more likely to develop dementia.

In summary, both hearing and vision impairment are associated with increased risk of dementia, but those who have both hearing and vision impairment are at most risk. Depression may play an important role in mediating the risk of dementia associated with sensory impairment. There are high risk groups for low cognitive function, cognitive decline and dementia (including males, those from low educational and socioeconomic backgrounds) that we may need to focus on. But the risks

associated with sensory impairments are the same across groups, so interventions to address risk associated with sensory impairment could be the same across groups.

Prevention is better than cure

A range of healthy lifestyle factors – low fat diet, non-smoking, regular aerobic exercise – are associated with auditory and cognitive longevity. In relation to hearing, minimising prolonged exposure to loud sound prevents hearing loss. It is much preferable to prevent hearing loss (and cognitive decline) than to attempt to remedy hearing loss after it has occurred. Healthy lifestyle and environment factors in early childhood, adulthood and older age promote good sensory and cognitive function. In later life, hearing loss is a marker of brain health that could signal a need for healthy lifestyle interventions to improve outcomes in later life.

Improve cognition and reduce dementia risk by treating sensory impairments

Given that hearing and vision impairment may have a direct impact on cognitive decline and risk of dementia, there is an intriguing possibility of reducing cognitive decline and risk of dementia by effective identification and treatment of sensory impairments. In relation to hearing impairment, the primary treatment option is to provide hearing aids.

Modelling the impact of hearing aids on cognitive decline and risk of dementia is extremely challenging because i) such a study would need to be very large (with thousands of participants) in order to detect the small effects of hearing aid use on cognitive change that would be expected, and ii) the study would need to be very long; at least several years in duration (because cognitive decline happens gradually and the incidence of dementia is low). There are also ethical difficulties with conducting a well-controlled study. Because the benefits of hearing aids in improving communication are well established, it would be unethical to give hearing aids to an experimental group and withhold hearing aids from a control group once hearing impairment had been identified among volunteers for the study.

As an alternative to an intervention study, we used observational data to compare the rate of decline in memory performance before and after someone starts using a hearing aid (Maharani et al., under review). We used data from 1,586 people from the US Health and Retirement Survey, a population-based longitudinal study with memory assessed repeatedly over 18 years. Memory was assessed by testing how many words someone could remember from a list of 10 words. We found that memory scores still declined after someone started using a hearing aid, but the rate of decline was about four times slower after someone started using a hearing aid (after statistically adjusting for various possible confounders). After starting using a hearing aid, people remembered 0.03 fewer words per year. Prior to using a hearing aid, people remembered 0.1 fewer words per year.

This study raises the intriguing possibility of mitigating cognitive decline by treating hearing impairment with hearing aids.

Summary

Sensory impairments are markers of brain health. Sensory functions are makers of brain health because they share common neurophysiological bases with cognitive function and are impacted by common factors. There may be additional impacts of sensory impairment on cognitive function, with a possible interaction with depression. The impact of hearing impairment on cognition is complex. We need to take into account interactions of hearing impairment with other sensory impairments (particularly vision impairment) as well as physical, psychological and environmental changes with age.

There are numerous factors that impact on cognitive function and mental well-being in older age. Hearing impairment may have a small but important impact. Take for example, the British Olympic Cycling Team. The figure below shows the Olympic medal count for the British cycling team since 1980 (figure 2). In the 1980's Britain wasn't winning any medals. Things started to improve in the 1990's, and recently Britain has dominated Olympic cycling.

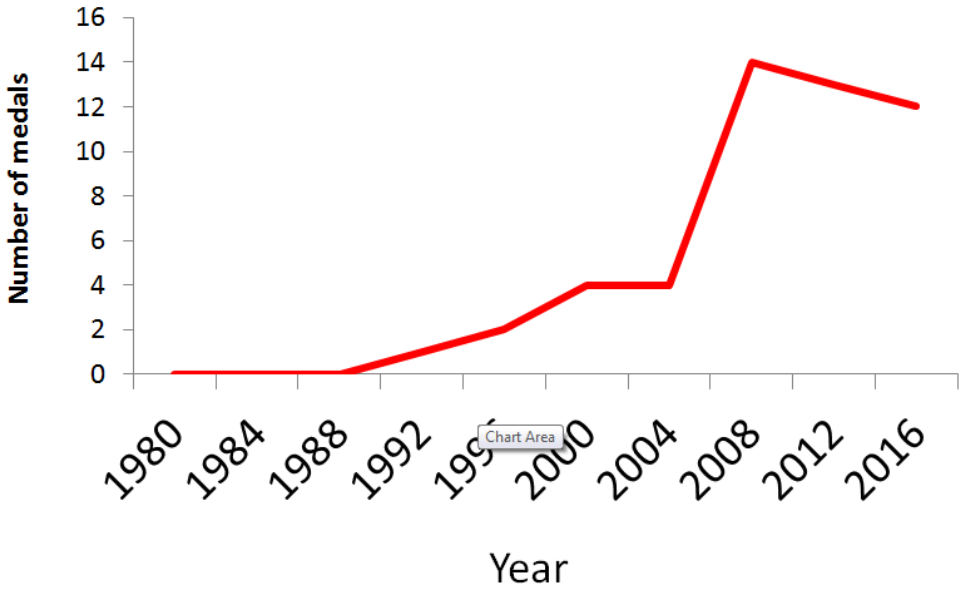

Figure 2. British Olympic cycling medals

One of the reasons attributed to Britain's recent cycling success is a focus on aggregation of marginal gains. Sir Dave Brailsford, performance director of British Cycling's philosophy was that *"*Small improvements in a number of different aspects of what we do can have a huge impact on the overall performance of the team*".*

In relation to mental well-being in older age, we need to do everything we can to prevent hearing impairment. Once hearing impairment has occurred, we need to identify and effectively treat it with hearing aids or other management options. We need to promote healthy diet and exercise. We must promote cognitive stimulation and social engagement. We need to design and build age-

friendly environments that facilitate active engagement in older age. Each of these things may lead to a small individual gain, but if we can do all of these things well, there is potential for a very large combined impact on cognitive well-being in older age.

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