

HEARING WELL TO TRAIN YOUR BRAIN



INTRODUCTION

Methodology

International bibliographic resources were used to analyze a number of international clinical and laboratory studies evaluating the potential benefit of hearing aids in preserving or even enhancing cognitive abilities.

Project Working Group

This review is the result of a study of the scientific literature available on the topic conducted by:
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This publication was made possible thanks to Amplifon's contribution.



ABSTRACT

Although hearing loss can occur throughout life, its prevalence increases considerably with age. Over 40% of people aged 60-69 have significant hearing loss, with this figure rising to almost 90% in people aged over 80 years. With the continued growth of the global population, aided by improved healthcare and nutrition, the number of people aged over 60 years is also anticipated to rise considerably, with United Nations figures estimating 1.95 billion people globally aged over 60 by 2050, representing 21% of the total population. This growth in the aging population is also fuelling an increase in the number of people suffering from dementia. The World Health Organisation estimates that there are currently 36 million people suffering with dementia globally, but expects this figure to more than triple by 2050.

A number of studies have been published that show that people suffering with hearing loss are more likely to develop dementia, with one large study showing that people with mild, moderate, and severe hearing loss had a 2-, 3- and 5-fold increased risk of developing dementia, respectively, compared to those with normal hearing. Although the specific link between the two disorders is not known, it has been suggested that the increased mental workload and the greater social isolation associated with loss of hearing may be major contributors to the increased rates of dementia.

This report assesses the data currently available evaluating the potential benefit of hearing aids in preserving or even enhancing cognitive abilities. The data to date are limited and not conclusive but do suggest a positive benefit from hearing aid use. If it can be demonstrated in a clinical trial that hearing aids help delay the onset of dementia, the benefits would be immeasurable.

01 Social scenario and epidemiology

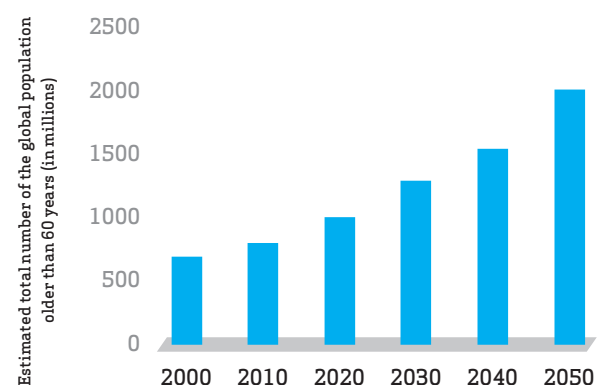
Social scenario and epidemiology

Reviewed by **Prof. Frank R. Lin**, M.D. Ph.D. - Assistant Professor of Otolaryngology-Head & Neck Surgery, Geriatric Medicine, Mental Health, and Epidemiology - Johns Hopkins University - Baltimore, United States.



Owing to the benefits of better nutrition and healthcare, global life expectancy is increasing annually and is expected to continue to do so for the foreseeable future. According to the United Nations, the overall global population will grow from 6.9 billion in 2010 to 9.3 billion in 2050 and the proportion of the population aged 60 years and older will double between 2000 and 2050 (from 10% to 21% of the total population). This equates to an increase from 0.69 billion to 1.95 billion people.

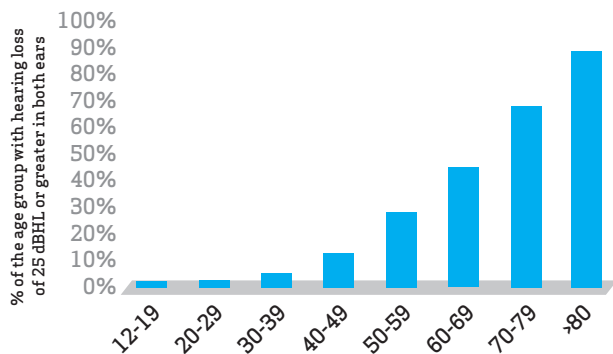
Estimated global population > 60 years old



Graph 1: Estimated growth of the 60 years and older global population (Source: United Nations – Department of Economic and Social Affairs – Population Division).

A potential issue for people as they grow older is that of hearing loss. In a recent study conducted by Lin *et al* in the United States, results showed that the number of people presenting mild hearing loss or greater at both ears increases with age.

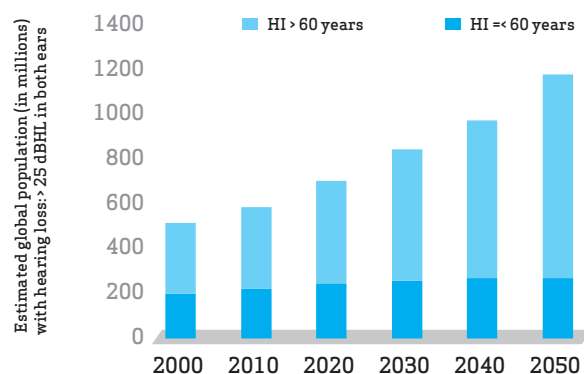
Prevalence of hearing loss per age group



Graph 2: The age effect of hearing loss. From the age of 40 years, mild hearing loss or greater increased nearly 20% per 10 years (Source: Lin *et al*, Arch Intern Med, 2011).

At present, there are 590 million people globally who have hearing impairment. With the continued growth in the global population, this is expected to double by 2050 to nearly 1.2 million people living with hearing impairment. This increase is expected to be more dramatic in people aged 60 years and older.

Estimated global population with hearing loss from 2000 to 2050



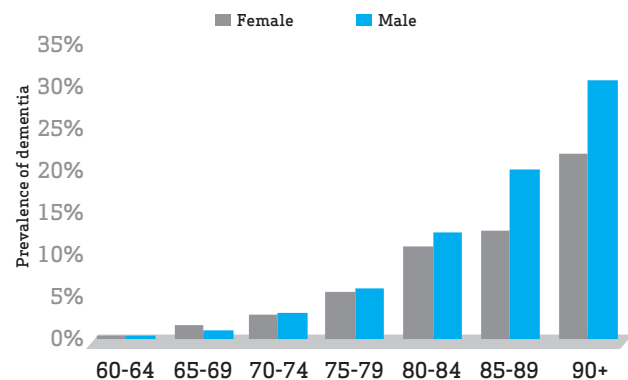
Graph 3: The estimated growth of the global population with hearing loss from 2000 to 2050. The share of the population aged 60 years and older is increasing every decade (Source: Lin *et al*, Arch Intern Med, 2011 and United Nations – Department of Economic and Social Affairs – Population Division).

The use of hearing protection and the overall reduction of noise levels in work environments has had a positive impact on reducing the number of people developing employment-related hearing loss.

Unfortunately, adolescents and young adults (between 12 and 19 years) are listening to MP3 players at loud volumes more frequently and very rarely use hearing protection when they are in noisy environments such as at parties and nightclubs. The number of these adolescents with hearing loss increased by more than 30% in the last 15 years (from 14.9% in 1988–1994 to 19.5% in 2004–2005). An additional health issue that may have an impact on the number of younger adults with hearing loss is diabetes. The global number of adults with diabetes is predicted to increase from 2.8% in 2000 to 4.4% in 2030. The main reason for this increase is the continued and dramatic rise in obesity. Adults with diabetes (20 to 69 years old) have a 21% chance of having hearing loss, while adults without diabetes have only a 9% chance of having hearing loss. Therefore, the increase in the number of people suffering with diabetes, particularly younger people, will also result in an increase in younger patients experiencing hearing problems.

Dementia is also a major health issue that increases with age. From the age of 70 years, the proportion of people with dementia is increasing by nearly 1% per year. This trend is stronger for males than for females.

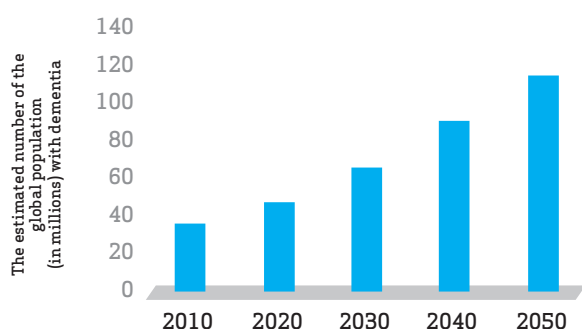
Prevalence of dementia per age group



Graph 4: The prevalence of dementia per age group (Source: Launer *et al*, Neurology 1999).

According to the World Health Organization, the number of people living with dementia worldwide is currently estimated at 36 million. This number will double by 2030 and more than triple by 2050.

The growth of the estimated global population with dementia



Graph 5: The estimated growth of the world population with dementia (Source: Dementia: a public health priority - World Health Organization and Alzheimer's Disease International).

For the World Health Organization, dementia is a major public health priority that therefore requires health care systems around the world to take action.

As a result of better nutrition and health care our life expectancy is increasing, with the global population aged 60 years and older expected to double by 2050. Concurrently the world population with hearing loss is currently estimated at 590 million but is growing at a steady pace. With the growth of the global population, the number of people suffering with hearing loss is expected to reach 1.2 billion by 2050. Finally, the world population with dementia is estimated at 36 million today, with this number expected to triple to 115 million by 2050.

A significant link exists between hearing loss and dementia; a topic which will be reviewed further in the next chapter. Given the dramatic rise in the global population and the expected growth in the number of people with hearing loss, action is clearly required to avoid further inflating the 115 million people expected to suffer with dementia by 2050.

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02 The correlation between hearing loss and cognitive ageing

The correlation between hearing loss and cognitive ageing

Reviewed by **Prof. Frank R. Lin**, M.D. Ph.D. - Assistant Professor of Otolaryngology-Head & Neck Surgery, Geriatric Medicine, Mental Health, and Epidemiology - Johns Hopkins University - Baltimore, United States.



A number of studies have been conducted assessing the relationship between hearing loss and dementia in older patients. These studies show that seniors with hearing loss are significantly more likely to develop dementia over time compared to those with normal hearing.

In one of the first studies published in 1989, Richard Uhlmann and colleagues compared 100 subjects with dementia to 100 subjects without dementia (control group), who were matched in age, gender and educational level. He concluded that hearing loss contributes to cognitive dysfunction in older adults – the greater the hearing loss, the higher the chance of having dementia. Analysis of the data in detail showed that the proportion of patients with dementia potentially due to hearing loss could be as high as 32%. The study also showed that hearing loss was associated with reduced cognitive function, even in patients not suffering from dementia.

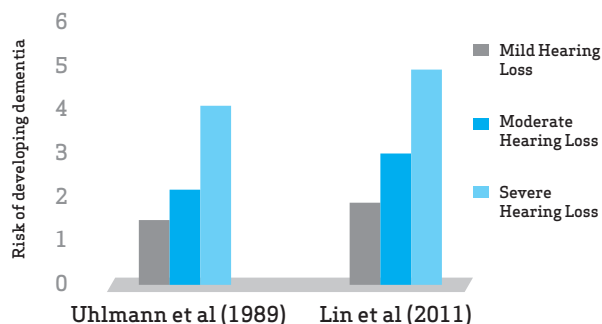
Dr. Uhlmann's work highlighted that, when diagnosing dementia, clinicians need to be especially alert for the presence of hearing impairment. In parallel with this, hearing impairment may be an important risk factor for having dementia and cognitive dysfunction. If so, any correction

of hearing impairment would not "prevent" the progression of dementia, but could potentially improve the symptoms of the disease. This would make the correction of hearing impairment a promising opportunity for the treatment of cognitive dysfunction in elderly persons, particularly since there are currently no means of altering the progression of common dementias such as Alzheimer's disease.

Frank Lin, an otolaryngologist and epidemiologist at Johns Hopkins School of Medicine, and his team conducted a more elaborate study, following 639 patients for 18 years. None of the subjects had cognitive impairment at the beginning of the study, although some did have a certain degree of hearing loss. During the 18 years of follow up, 58 cases of dementia were diagnosed amongst the 639 patients. Compared to individuals with normal hearing, those with mild, moderate, and severe hearing loss, respectively, had a 2-, 3- and 5-fold increased risk of developing dementia.

Even after taking into account other factors that are associated with risk of dementia, including diabetes, high blood pressure, age, sex and race, hearing loss and dementia were still shown to be strongly associated.

Risk of developing dementia in relation to hearing loss (Uhlmann et al, 1989 & Lin et al, 2011)



Graph 6: The risk of developing dementia increases with the level of hearing loss. The study of Uhlmann (left panel), defines mild hearing loss as (21 to 29 dB), moderate (30 to 39 dB) and severe hearing loss as moderate to severe (≥ 40 dB), while in the study of Lin et al (right panel), mild is defined as (25 to 40 dB), moderate (41 to 70 dB) and severe (> 70 dB hearing loss) (Source: Uhlmann et al, JAMA 1989 & Lin et al, Arch Neurol, 2011).

The findings of Lin's group have been confirmed in a recent study by Gallacher et al published in 2012. In this study 1057 men were followed for a period of 17 years and hearing loss was evaluated at the start of the study and then after 9 years, both cognition and dementia were assessed. The authors found a strong relationship between hearing loss and both dementia and cognitive decline. For every 10 dB (A) of

increasing hearing loss compared to the normal hearing level for that age, the risk of developing dementia increased by 2.7 fold. An interesting finding was also that the association with cognitive decline was stronger when tests were administered by interview compared to tests administered by computer.

Although the reason for the link between the two conditions is unknown, the investigators suggest that a common pathology may cause both or that the strain of decoding sounds over the years may overwhelm the brains of people with hearing loss, leaving them more vulnerable to dementia. They also speculate that hearing loss could lead to dementia by making individuals more socially isolated, a known risk factor for dementia and other cognitive disorders.

The reason for the relationship between hearing loss and cognition is still unknown. The investigators suggest in interviews that a common pathology may be the reason for both health issues. They suggest that as hearing loss requires so much "brain effort" over the years to decode sounds into useful information, sufferers become increasingly vulnerable to dementia. Additionally as we develop hearing loss, we withdraw socially, becoming less likely to go out and maybe less likely to be engaged in conversation. One of the major risk factors for dementia is social isolation.

These findings suggest that it is possible to delay the onset of dementia through such simple things as using hearing aids and paying more attention to the prevention and early identification of hearing loss. A critical factor may also be the way that hearing aids are used, programmed and how hearing aid users are counseled by the specialist.

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03 Hearing loss, cognition and hearing aids

Hearing loss, cognition and hearing aids

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In the last decades, there has been a rapid increase in the number of studies showing that the ability to understand speech in challenging situations is influenced by cognitive capacities. These are both bottom-up (the process from the ear to the brain) and top-down (higher level concepts helping in the interpretation of data). Therefore, it is no longer appropriate to disregard the role of cognition in hearing research.

The relevance of cognitive processes depends on the listening demands. When listening conditions are challenging, because of noise or hearing impairment, the need for cognitive processes to help understand speech increases.

There are at least five cognitive functions significantly associated with speech communication. These are:

- a) the speed of information processing;
- b) the ability to use linguistic context;
- c) attention;
- d) working memory (the ability to simultaneously store information and process information in the memory);
- e) linguistic closure (or the ability to read partly masked text).

All of these cognitive functions, except the ability to use linguistic context, decrease with age.

There are a range of studies that have shown that working memory capacity accounts for 20-30% of the variance in people's ability to comprehend speech. Still the ability to read partly masked text accounts for around 30% of the variability in which speech can be understood by adult listeners.

Since there is this overall slowing down of cognitive functioning when the brain is ageing, this implies that older people need a significantly better signal to noise ratio when listening to speech in a challenging environment (e.g. with background noise) than younger people. This is particularly the case when the speech is spoken at a fast rate.

Although also often referred to as 'cognitive dysfunction', dementia should not be confused with a decreased ability of any of the single aspects of cognitive functioning described above. Dementia is much more severe, a non-specific syndrome with many areas of cognitive

functioning affected simultaneously, such as memory, attention, and language. Dementia is characterized by a decline in cognitive functioning which is faster than what may be expected from normal aging and is an irreversible process. In their recent study, Lin et al (2013) demonstrated a significant association between hearing loss and accelerated cognitive decline and cognitive dementia.

As it is known that:

- cognitive functioning plays a significant role in daily life listening;
- cognitive functioning declines with age;
- the prevalence of dementia in our societies is increasing rapidly.

The question rises of whether the effects of hearing loss on cognitive decline can be stopped with early intervention with hearing amplification, for example, when the first signs of communication problems caused by hearing loss are seen.

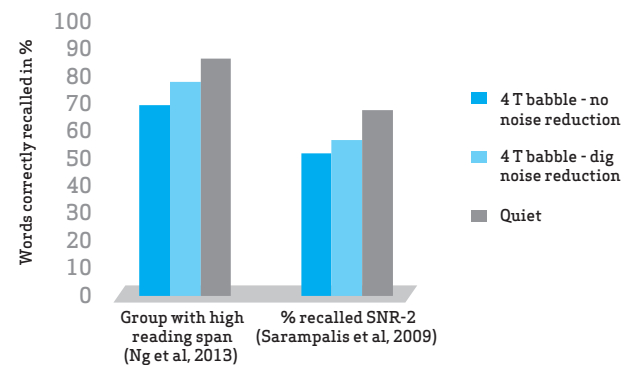
Studies addressing the relationship between amplification and cognition conducted so far either looked at the short term effect of amplification on cognition, or the long term (> 3 months of hearing aid use) effects.

Studying the short term effect of amplification, Gatehouse and colleagues showed that listeners with greater cognitive capacity derived greater benefit from the fast acting compression and listeners with lesser cognitive capacities derived the highest benefit from slow acting volume control. Cox and Xu further elaborated this topic and found that the relationship between an individual's preference for fast or slow acting compression not only depended on the individual's cognitive abilities, but also on the characteristics (i.e. the linguistic context) of the speech they listened to. These studies demonstrate that the patterns for determining the suitability of candidates for hearing aids go beyond their hearing function, into the domain of cognitive capacity and people's differing perceptions of the acoustic environments they encounter in everyday life.

Two studies found that digital noise reduction used in hearing aids had an effect on the recall of the spoken information (how much information you can remember).

Impact of digital noise reduction in word recall task

(Ng et al, 2013 / Sarampalis et al, 2009)

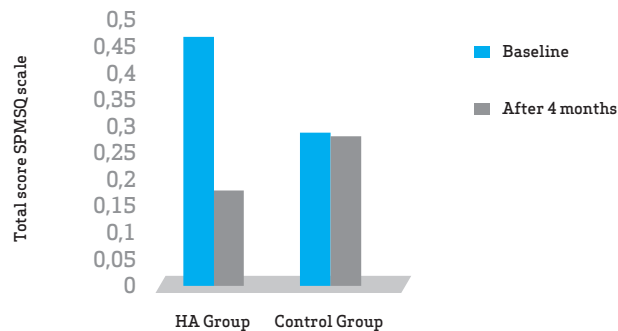


Graph 7: The positive impact of digital noise reduction in hearing aids in word recall (how much information you can remember). Both for Ng (left panel) and Sarampalis (right panel) you see that the best result is achieved in quiet, however digital noise reduction is better than no noise reduction (Source: Ng et al, Int J Audiol 2013 & Sarampalis et al, J Speech Lang Hearing Res, 2009).

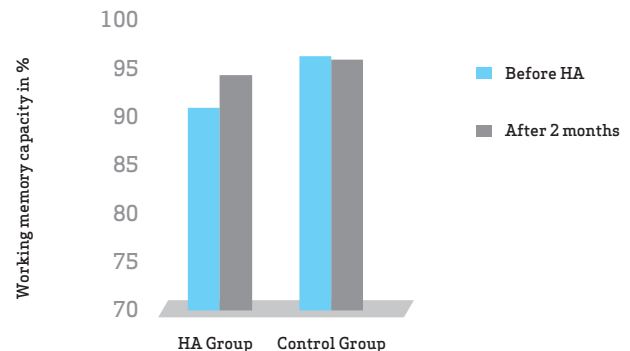
Assessing the long term effect of amplification, there are seven studies, besides Lin et al (2013), which addressed the long term effect of hearing aid use (> 3 months) on cognitive functioning. These seven studies used either patient questionnaires or direct assessment of cognitive functioning to evaluate the long term hearing aid use.

A study by Mulrow (graph 8, left panel) demonstrated that hearing amplification resulted in a significant improvement in mental performance compared to patients without amplification. While, Lehl and colleagues (graph 8, right panel) showed an improvement in working memory capacity with hearing amplification, Acar and colleagues (graph 9, left panel) demonstrated an improvement in overall mental state with amplification and Choi et al (graph 9, right panel) showed an improvement in learning ability.

Improvement on the Short Portable Mental Status Questionnaire due to hearing aid use (Mulrow et al, 1990)

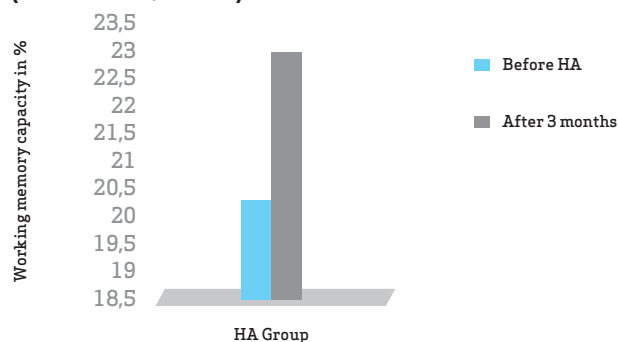


Impact of HA use on working memory capacity (Lehrl et al, 2005)

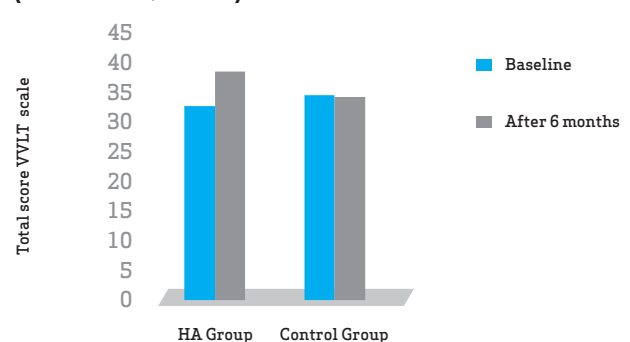


Graph 8: The positive impact of Hearing Aid use on cognition (Source: Mulrow et al, Ann Intern Med 1990 & Lehrl et al, HNO, 2005).

Impact of HA use on MMSE (Mini Mental State Examination) (Acar et al, 2010)



Improvement on the Visual Verbal Learning Test (VVLTL) due to hearing aid use (Choi et al, 2011)



Graph 9: The positive impact of Hearing Aid use on cognition (Source: Acar et al, Arch.Gerontol.Geriatr. 2011 & Choi et al, Clin.Exper.Otorhinolaryn., 2011).

As described earlier, Lin and colleagues examined the role of amplification on accelerated cognitive decline. Although hearing aid use was associated with slightly reduced rates of cognitive decline and risk for cognitive impairment among individuals with hearing loss, these results were not

significant. In other words, evidence supporting the positive long term effect of amplification on cognitive functioning is scarce. Although hearing aids may have a positive effect on overall quality of life, the role of amplification on cognition is less clear and needs further investigation.

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04 Conclusion

Conclusion

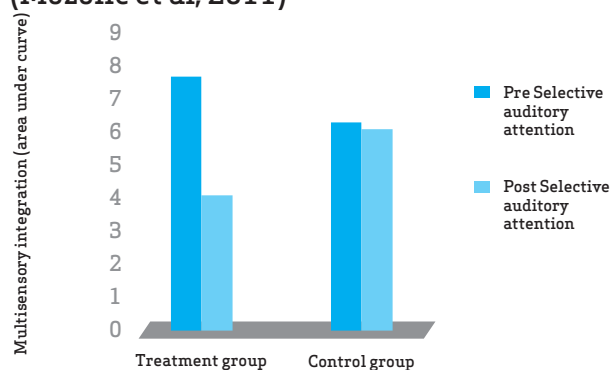
*Reviewed by **Prof. Frank R. Lin, M.D. Ph.D.** - Assistant Professor of Otolaryngology-Head & Neck Surgery, Geriatric Medicine, Mental Health, and Epidemiology - Johns Hopkins University - Baltimore, United States.*



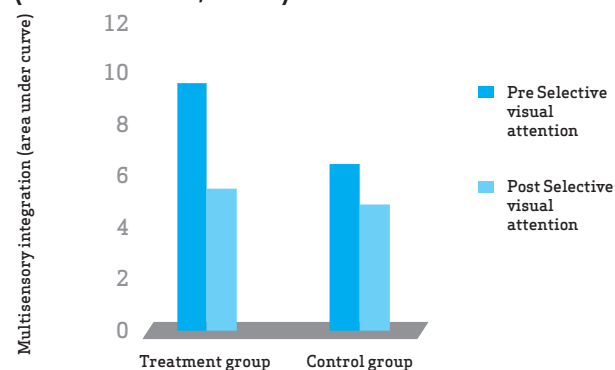
This white paper shows that like much other physical impairment, age-related hearing loss requires concerted counseling, rehabilitation training, environmental adaptation and training. Although there is a large debate on the efficiency of cognitive training, a recent study conducted by O'Brien demonstrates that "speed of processing (SOP) training" results in changes in specific measured brain responses related to attention, allocation and capacity. These results may help define the underlying mechanisms by which training can reverse age-related decline in selective attention control. This study also gives evidence to support the use of non-invasive, non-pharmacological cognitive training to reverse age-related cognitive decline.

Cognitive and memory training in adults at risk of dementia is getting increasing attention. This kind of intervention, in contrast to medical treatment, does not show any negative or adverse effects. Cognitive training proves to be more effective than memory training to enhance cognitive outcomes. Further research is urgently required in order to support the efficacy of cognitive training as a treatment. Mozolic and colleagues evaluated the effect of a cognitive training aimed at helping healthy older adults to suppress irrelevant auditory and visual stimuli. Sixty-six participants received a 8-week training program or an educational lecture control program. Participants who completed the training program showed significant better improvement the control group.

Multisensory Integration Results: Auditory Attention (Mozolic et al, 2011)



Multisensory Integration Results: Visual Attention (Mozolic et al, 2011)



Graph 10: The positive impact of training on suppressing irrelevant auditory and visual stimuli. The treatment group shows a significant improvement while the control group doesn't (Source: Mozolic et al, Neurobiol. Aging, 2011).

This kind of training can be very easy to access and very cost-effective, since computerized cognitive exercise has been successfully implemented in multiple studies. Research suggests that older adults are often the fastest growing users of computer and internet technology.

In the goal of maintaining optimal cognition, remaining socially engaged, enhancing quality of life, and other reasons, regular screening for hearing loss, protecting your ears in challenging environments, and offering appropriate hearing care at the moment that hearing loss and communication problems are detected are very reasonable interventions.

When a 12-year-old child has a hearing loss of 40 dB, every health care provider would conclude that urgent intervention is needed. However, when a 72-year-old person has the same hearing loss, health care providers may be more reluctant to take direct action to provide hearing care.

Frank Lin and his colleague Wade Chien found that only one in seven adults who could benefit from hearing aids used them. This constitutes a significant missed opportunity, given the data demonstrating that hearing aid use is associated with improved cognitive function in elderly patients. Statistical modeling has shown that an increase in hearing loss of 25dB equates to an age equivalent reduction of cognitive function of 7 years.

Another issue is the stigma of old age. Hearing loss is a natural part of aging. But for most people with hearing loss, according to the National Institute on Deafness and Other Communication Disorders, the condition begins long before they get old. Forty-eight million Americans suffer from some degree of hearing loss, while the effects of this hearing loss are felt far more broadly than the patients alone.

If it can be demonstrated in a clinical trial that hearing aids help delay dementia, the benefits would be immeasurable. Should studies establish definitively that correcting hearing loss decreases the potential for early-onset dementia, we might finally overcome the stigma of hearing loss. Get your hearing tested, get it corrected, and enjoy a longer cognitively active life. Establishing the dangers of uncorrected hearing might even convince insurers that covering the cost of hearing aids is a small price to pay to offset the cost of dementia.

Common sense suggests that if you don't have to work so hard to hear, you have greater cognitive power to listen and understand - and remember. And with this the sense of perceived isolation, another risk for dementia, is reduced.

"Hearing well to train your brain"

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