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A Review on the Effect of Normal and Abnormal Ageing on Language

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Abstract

This paper gives an overview of the effects of physical and psychological declines in normal and abnormal ageing on language production and processing. Firstly, it outlines two fundamental aspects of decline in the elderly which affect language: sensory and cognitive deficits. Ageing-related sensory deficits, such as presbycusis and presbyopia, often lead to lack of language understanding, especially in noisy environments, and an increased reading speed. Cognitive declines in ageing, such as decreased processing speed and deteriorated memory, decreases speaking speed and increases tip-of-tongue experiences. Moreover, changes in anatomical structures and physiology that are involved in language, such as changes in hormonal levels during menopause and altered vocal cord may change the lead to presbyphonia, or ageing voice. Genetics of language is also identified which may lead to language disorders in ageing. Apart from normal ageing, declines in language comprehension and cognition in Alzheimer's patients are more severe than those of normal elderly people. Differences in language cognition and production between normal and abnormal ageing are compared. Lastly, factors that increase the chance of healthy ageing and reduced impact on language, such as healthy diet, exercise, and bilingualism, as explained and advice on maintaining healthy ageing is given.

Keywords: Ageing, Alzheimer's Disease, Dementia, Diet, Exercise, Mental Stimulation, Language, Presbycusis, Presbyopia, Processing Speed, Tip-of-tongue

I. INTRODUCTION

Ageing is the time-related deterioration of physiological functions necessary for survival and fertility (Belousov, 2011). Language is a communication system that involves using and organising words by systematic rules to transmit information from one individual to another (Dumper et al., n.d.). The gradual progression of normal ageing brings various impacts on different aspects of language, such as language reception and production; while semantic language abilities (i.e. vocabulary) increase as one age, the sensory and cognitive processing of language may decline, and thus, compensate for the benefit of ageing in language ability (Glisky, 2007). Dementia and Alzheimer's disease (AD) are on the other end of the spectrum of ageing; they drastically impair communication as patients demonstrate, among other signs and symptoms, word-finding problems (anomia), sentence comprehension deficits, and a lack of cohesion in discourse in the context of multiple cognitive impairments (Kempler and Goral, 2008). There are nearly 50 million AD patients worldwide, and this number will almost double every 20 years, reaching 82 million in 2030 and 152 million in 2050 (World Health Organization, 2019). Incidence of dementia and AD is increasing in ageing population, and no effective medical measures are available to reverse AD; therefore, understanding the deterioration of language and communication among elderly is crucial for both academic research as well as the well-being of the ageing population.

This paper provides a general overview on the effect of both normal and abnormal ageing on the sensory reception and cognitive production of language as well as providing some insights towards new research directions and experiments for future scientific pursuit in neurolinguistics.

II. DISCUSSION

1. Reasons for Language Impairment during Normal Ageing

Underlying reasons for language impairment by normal ageing can be divided into two main categories:

1) The gradual sensory deficits: normal physical degeneration of auditory and visual sense organs contribute to difficulties in speech discrimination and reading (Liu and Yan, 2007)
2) A gradual cognitive decline that affects language production, specifically the tip-of-tongue experience due to deterioration of memory and the cortical processing of language (Madhavan et al., 2014).

Therefore, due to both sensory and cognitive factors, older adults need more effort to achieve the same level of language comprehension as younger adults (Wright, 2016).

1.1 Ageing Language Reception

Ageing in adults manifests a general decline in both visual and auditory perception, and these deficits are consistent with effortfulness hypothesis in age-related language studies (Rabbitt, 1991; Tun et al., 2009; Wingfield et al., 2005). This hypothesis proposes that older adults have greater difficulty in sentence comprehension with increased difficulty in the decoding of auditory and visual stimuli than younger adults possibly due to a general decline in sensory sensitivity, such as age-related hearing loss and visual acuity loss.

1.1.1 Auditory Deficits in Ageing

The capacity to understand speech is dependent on the ability to receive auditory information. Age-related hearing loss, or presbycusis, is mainly caused by a gradual loss of hair cells in the inner ear due to prolonged exposure to daily noises (Presbycusis, n.d.), which is estimated to affect approximately 45% of adults aged 60 to 70 and 68% of adults above 70 years old (Lin, Niparko, and Ferrucio, 2011). With presbycusis, sounds often are sensed less clearly and lower in volume, which contributes to a worsen spoken language understanding and in turn, effective response in the language (Presbycusis, n.d.). Therefore, presbycusis negatively affects the perceptual understanding of speech and in turn, its comprehension during ageing.

Also, the phenomenon of mumbled speech can cause difficulty in language understanding in the presence of background noises (Carroll and Ruigendijk, 2013), which can be due to damages to the inner ear nerve connections (Figure 1) (Beck, 2016). In turn, nerve damages lead to a decreased ability in spatial processing in ageing, which is the ability to selectively attend to a certain speech by suppressing other irrelevant sounds (Glyde et al., 2011).

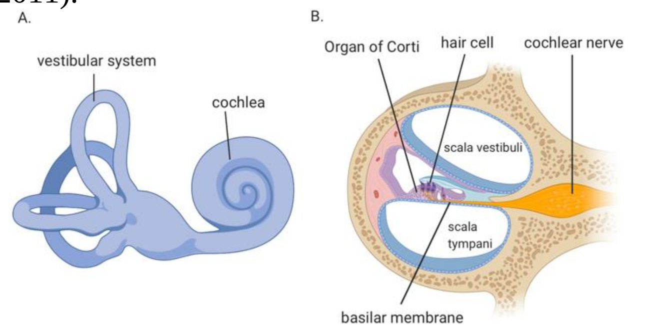

Figure 1: An anatomical display of the auditory sensory organ, or ear. A: a cochlea. B: the internal view of the site of auditory transduction in the cochlea. The Organ of Corti is an inner ear structure that includes rows of hair cells that bend against the tectorial membrane (not shown) when sound waves cause the basilar membrane to vibrate. To deliver an auditory signal, hair cells send signals when they are in contact with the tectorial membrane via the auditory nerve to the brainstem.

Hearing loss can be examined and diagnosed by using audiometric tests, which measure a person's ability to hear different sounds in variable pitches and frequencies (Divenyi, Stark and Haupt, 2005). The table below shows the results from different speech audiometric tests measured in different age groups (Divenyi, Stark and Haupt, 2005). The mean correct speech recognition scores decline with age. For example, in the phonetically balanced word test (PB), the mean score dropped by 13.7%, and the synthetic sentence identification test (SSI) dropped by 31.9% from the age group 50-65 years to 76-90 years. Large variations observed in this study implies that there are other factors besides ageing, such as long-term exposure to high-frequency noises, which may affect sensory deficits.

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Age Group	Speech Audiometric Measure			
(Years)	PB (SD)	SPIN-low (SD)	SPIN-high (SD)	SSI (SD)
50-65	92.0 (13.0)	60.7 (19.5)	97.2 (6.1)	94.5 (6.9)
66-70	82.6 (23.6)	49.5 (26.0)	88.7 (17.2)	80.5 (21.9)
71-75	81.5 (26.1)	47.0 (25.2)	84.8 (23.0)	72.2 (26.1)
76-90	79.4 (19.3)	47.8 (21.1)	88.5 (10.2)	64.4 (21.3)

Table 1: Mean Speech Recognition Scores, in Percent Correct, in Four Age Groups Matched for Audiometric Level. PB: Phonemically balanced word test (No simultaneous competition of sounds was present); SSI: Synthetic sentence identification test (the continuous discourse of a single speaker); SPIN-high: Speech perception in noise test — high context; SPIN-low: Speech perception in noise test – low context (both SPIN tests have babbling from multiple speakers) The figures inside the brackets represent standard deviations (Divenyi, Stark and Haupt, 2005). The standard deviation of each data is quite high, which makes the correlation less reliable.

The age-related auditory deficits are also assessed to address several questions. For example, whether the decline in language reception is particularly because of ageing, or damages in the ear that affect both young and older adults equally. Some studies reported a minimal difference between the perceptual difficulty of young and old adults with hearing loss (Wright, 2016), which reflected that the effect of auditory sensitivity on language comprehension, but not necessarily ageing. However, as Pichora-Fuller and Souza (2003) pointed out, this noticeable difference manifests only in tasks with simple stimuli. On the other hand, some evidence has pointed out a greater understanding compensation in the elderly with hearing loss as they were more disproportionately affected by increasing speaking speed than younger adults with the same condition (Wingfield et al., 2016). Therefore, it is difficult to attribute language impairment solely based on auditory deficits.

Regardless of whether adults suffer more from sensory deficits than younger adults, it is important to understand that the decline in auditory perception does affect language reception and understanding. The difficulty in language comprehension under the presence of noises may be one of the most incapacitating and frustrating elements given the probability to lead to feelings of isolation in ageing (Weger et al., 2006).

1.1.2 Visual Deficits in Ageing

The capacity to understand any written information, and therefore language, is dependent on the ability to recognise visual information. Age-related decline in visual accommodation, or presbyopia, refers to the inability to focus on near objects that can affect the perceptual understanding of written language when reading (Presbyopia, 2016) (Figure 2). It was estimated that presbyopia affects 1.8 billion people worldwide (Fricke et al., 2018). There are two reasons for presbyopia:

1) The lens of the eyes hardens gradually in ageing and the ciliary muscles that control the thickness of the lens gradually lose flexibility both contribute to the effect that light focuses behind the retina and in turn a blurry vision.

2) Also, ageing is associated with increased difficulty in seeing under low illumination and decreased sensitivity to spatial frequencies under illuminated environment (Owsley, 2011). Therefore, such age-related factors all contribute to a poorer perception of displayed language and, in turn, its comprehension contributing to the communication difficulties among elderly.

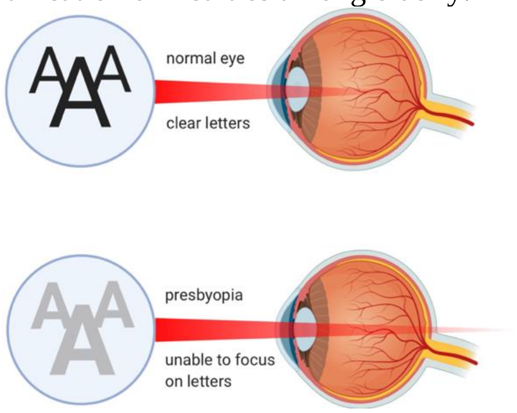

Figure 2: A comparison between normal vision and vision affected by presbyopia. In healthy eyesight, light from the object focuses on the retina which forms a clear image, whereas presbyopic eyes cannot focus light onto the retina, instead, they focus the image behind the retina, so a blurred image will be created (Presbyopia, 2016).

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Some experiments suggest that older adults manifest greater reading difficulty than young adults (Wright, 2016). For example, there is an association between an increase in age and increased reading speed when a written text changes from a typical to atypical font style (Wright, 2016). A possible reason for this correlation could be associated with coordination between visual
ability and motor skills that move the eyes to upcoming words in the text, thereby processing of sentence comprehension based on the visual cues (Wright, 2016). Experimental data showed that older individuals read sentences in a slower, longer fixation time, with more frequency of eye fixations and regressions. It was also clearly shown that the reading comprehension level of older adults is more affected by the change into an unfamiliar font than younger adults (Rayner et al., 2006). For example, their reading time has increased by 29.4% whereas younger adults are only affected by 15.4% in medium range words, and their numbers of fixations have increased by 14.2% whereas younger adults have increased 6.5% (Table 2).

	SRT	FD	NFix	NReg
Sentence type	M S	M S	M S	M S
Young readers				
Times New Roman	2,394. 451	246. 27	9.8. 1.4	0.64. 0.15
Old English	2,830. 448	263. 26	10.7. 1.2	0.65. 0.18
Older readers				
Time New Roman	2,976. 1,373	260. 49	11.1. 3.9	0.91. 0.40
Old English	4,213. 2,446	303. 65	13.6. 6.3	1.01. 0.49

Table 2: An overview of the effect of font change on the speed of reading in young and older adults. SRT: Sentence Reading Time (the duration between the appearance of the sentence and the termination of reading via a button press); FD: Average Fixation Duration; NFix: Average Number Of Fixations, NReg: Average Number of Regression, for the young and older readers reading sentences in Times New Roman or Old English. Note: SRT and FD times are in milliseconds. M: medium range word = 7-10 characters, SD: short range word. The table is produced based on data from Rayner et al.

The results of this experiment can lead to possible social implications in the information presentation of society. As the global population is ageing, advertisement agencies, governments, social media, and other communication channels should adapt themselves to the demands of the changing population, for example, by using more easily font types rather than atypical font styles (Figure 3).

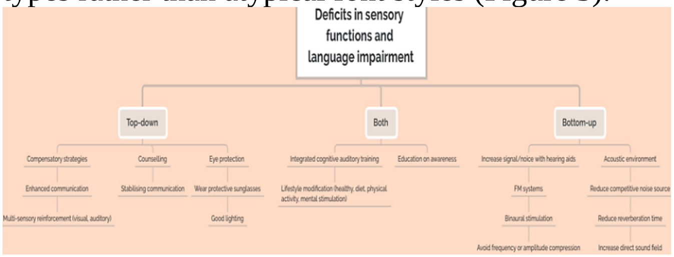

Figure 3: A diagram illustrating considerations and advice of sensory deficits and language impairment to the elderly. FM system is wireless assistive hearing devices that enhance the use of hearing aids, cochlear implants and also assist people who are hard to hear over distance and in noisy environments without having hearing aids.

1.1.3 Ageing and Language Cognition

Numerous studies have shown that older adults (between 60-80 years old) demonstrate language-related cognitive declines. For example, older adults tend to have a steady decline in mental processing speed, reasoning, spatial visualisation, and memory (Salthouse, 2010), which all contribute to a decline in language comprehension and word retrieval. However, vocabulary knowledge peaks around the age of 60, and then it slowly decreases due to a compensation of memory decline.

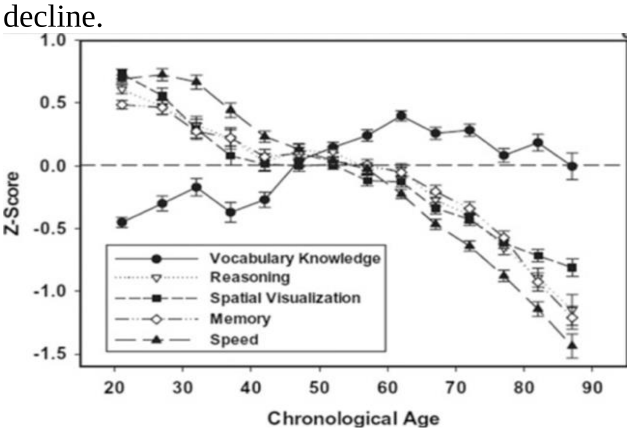

Figure 4: The effect of chronological age on Z-score, which is a combination of vocabulary, reasoning, spatial visualisation, memory, and

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processing speed values in arbitrary units. The sample sizes ranged from 2349 to 4149 are used. This figure is adapted from Salthouse (2010).

A general language processing pathway in older and younger adults exists (Figure 4). There is an association between age, perceptual speed and motor speed, which consequently, influence decision accuracy and decision time. As perceptual speed decreases over time, language processing should manifest a similar correlation as language is under the scope of cognition.

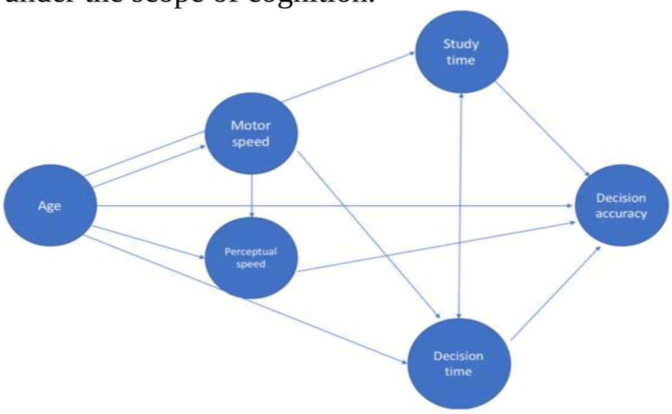

Figure 5: A path diagram demonstrating the interrelationships between different aspects of cognitive processing in ageing adults.

Other studies have demonstrated a decreased capacity in long-term memory in older than younger adults (Glisky, 2007). This phenomenon influences linguistic abilities of older adults as they might be unable to retrieve appropriate words whenever required, and this inability of recalling words immediately when there is a sense of familiarity of the words is referred as tip-of-tongue experience (TOT). TOTs occur more often in older adults than younger adults by related and unrelated priming, and known responses (correct retrieval) occur less often in the older population than younger (Burke and Shafto, 2004).

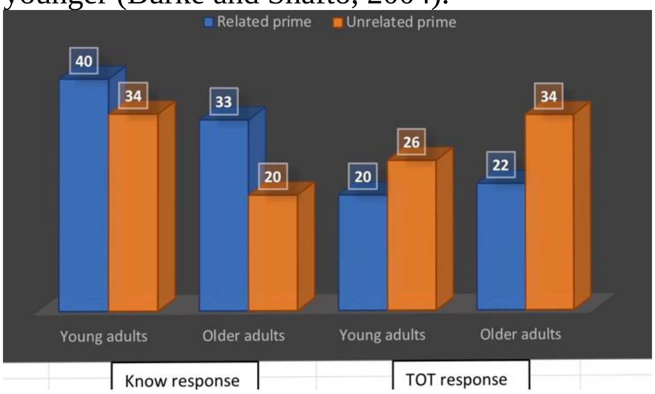

Figure 6: The proportion of trials with know and TOTs for young and older adults. The y-axis is the proportion of trials and the x-axis represents two groups of older and younger adults separated by the known response and TOTs.

In an experiment, participants were asked to recollect words from visual stimuli after the exposure of related and unrelated priming. If they could effectively retrieve the correct vocabulary, it was a 'know' response, and if not, it was a TOT response. Older adults had a lower likelihood of knowing the response by 7 trials and 14 trails in related and unrelated priming experiments, respectively (Figure 6). In addition, there is a higher likelihood that older adults have TOTs than younger adults by 2 trials and 8 trials in related and unrelated priming experiments, respectively (Figure 6).

1.1.4 Ageing and Language Production

In addition to language reception, language production can also be affected by ageing as experimental research has shown a negative correlation between ageing and effective word retrieval (as mentioned previously), correct spelling (a manifestation of written language production), and a change in vocal shift.

1.1.4.1 Anatomical Structures of Language Production

Human speech involves coordination of over 100 muscles ranging from those controlling the lungs to larynx and mouth, which are controlled by the motor cortex in the frontal lobe. Sounds are produced by vibrations in tightened vocal folds, and then it is modified in the vocal tract and the positions of the tongue, lips, and soft palate (Bear, Connors and Paradiso, 2016).

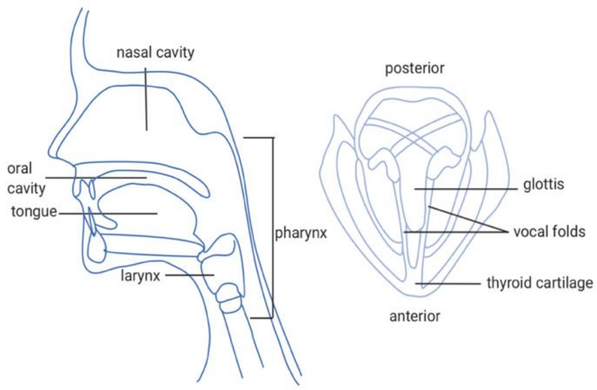

Figure 7: An anatomical drawing of the human vocal tract. A lateral view of the pharynx and a detailed cross section of the larynx.

Presbyphonia, or ageing voice, is a vocal change common in the elderly and have a significant influence on daily communication (Bruzzi et al., 2017). Changes in the vocal tract of the elderly occur as nose falls, teeth may be missing, weight gain and the accumulation of fat in the neck and parapharyngeal space which may lead to presbyphonia. Also, sex hormones influence the ageing voice as it is a secondary sexual characteristic (Bruzzi et al., 2017). In post-menopausal women, a drop in oestrogen and an increase in androgen levels lead to an increased thickness of vocal cords, which leads to a deeper tone of voice. Diadochokinesis, or slower speech, may also be associated with a decrease in oestrogen level (Meurer et al., 2004). In post-andropause men, a fall in androgen level leads to vocal folds thinning and acuteness of the vocal timbre which all lead to the feminisation of voice (Figure 8).

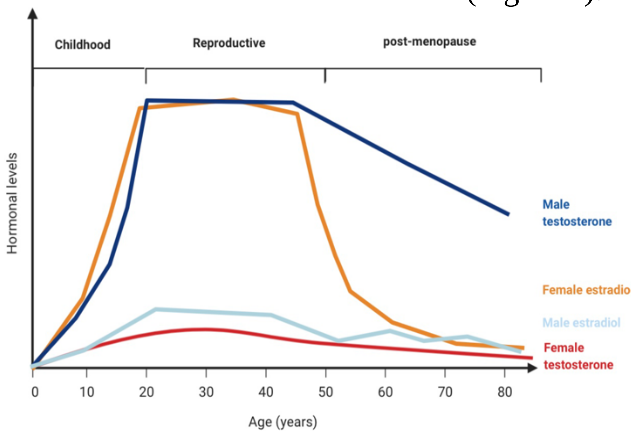

Figure 8: A change in levels of sex hormones in ageing male and female measured in blood.

Changes in the histological morphology of the vocal fold mainly induced by maculae flavae play a vital role in the advancement of presbyphonia (Sato, Hirano and Nakashima, 2003). The activity of the fibroblasts in the maculae flavae decreases and the production of HA reduces in ageing; the elastic fibres in the structure incline to atrophy gradually and collagens tend to increase in density (Bruzzi et al., 2017); the stiffness of vocal ligament increases and the concentration of collagen reduces the viscoelastic properties of the mucosa (Sato, Hirano and Nakashima, 2002). These functional and structural differences keep the vocal fold stretched and contribute to the normal muscular coordinations in language in elderly people (figure 9).

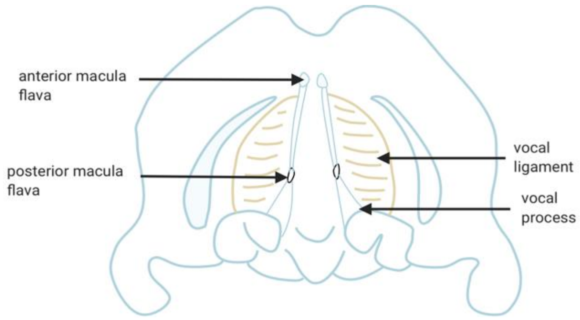

Figure 9: The anatomy of the larynx. Macula flavae are masses of cells, consisted of stellate cells and fibroblasts, and extracellular matrix, consisted of collagen fibres, glycoproteins and hyaluronic acid (HA), and they are located at the anterior and posterior commissures of the larynx (Bruzzi et al., 2017).

1.1.5 Genetics of Language

Language has a genetic basis. Several genes that are involved in language have been identified by tracing genetic mutations in dyslexics and patients of other language disabilities (Table 3).

Gene	Related functions	Impact of mutation/damage
FOXP2 (forkhead box P2)	1.Encodes for a transcription factor and regulates the expressions of other genes in neural development. It is expressed in the cortex, basal ganglia, thalamus and cerebellum (Kos et al., 2012). 2Its role in vocal motor function is also expressed in song-learning brain areas in birds (Bear et al, 2016) 3.Orofacial motor coordination of	1.Mutations cause severe deficits in language comprehension and expression (Bear et al., 2016). 2.Resembles apraxic speech and orofacial praxis deficits including simultaneous and sequential movements (Kos et al., 2012)

	tongue, lips, jaw and palate, which contributes to lingual articulation and non-lingual sound production (Oswald et al., 2017).	
CNTNAP2 (Contacten associated protein-like 2)	1.Encodes a neurexin protein that is involved in cell adhesion and is highly expressed in language-associated circuits in the brain (Kos et al., 2012). 2.Rs7794745 variant is associated with syntactic and semantic processing (Whalley et al., 2011). 3.It is a target of FOXP2 gene.	1.Related to impaired speech development in Pitt-Hopkins-like syndrome involving intellectual disability, to language regression and delay in acquisition (Gregor et al., 2011). 2.Delayed language development in autism (Alarcón et al., 2008).
KIAA0319	1.RD-associated haplotype is associated with reading skills and abilities (Scerri et al., 2011) 2.Involved in neuronal migration (Bear et al., 2016)	1.Susceptibility gene for dyslexia that increases the likelihood of difficulties in speaking and mathematics (Mascheretti et al., 2014).
CMIP	1.Associated with nonword repetition, which is related to phonological loop in short-term memory in language acquisition (Newbury et al., 2009).	1.Might be a risk factor of specific language impairment (SLI), such as developmental dyslexia that is related to difficulties in reading and spelling. (Newbury et al., 2009).

Table 3: A summary of language genes and their associated functions.

At the same time, increasing cell and DNA damage contributes to the dysfunction that characterises an ageing body (Rodriguez-Rodero et al., 2011). Oxidative damage caused by harmful free radicals produced as products by the metabolic reactions in mitochondria destroys fats, proteins, DNA, and neurones (Rodriguez-Rodero et al., 2011). DNA damage in ageing and neurodegenerative diseases like Alzheimer's caused by hydroxyl radicals can lead to break in DNA strands and protein structures, and this lead to increased mutations and compromised protein synthesis (Lovell and Markesbery, 2007).

2.Abnormal Ageing and Language Impairment

Alzheimer's Disease (AD) is a leading dementia syndrome that affects 50 million people worldwide (World Health Oragnization, 2019). Alzheimer's patients often have abnormal deterioration of language function that is much more severe than healthy ageing people and occur in the context of multiple cognitive impairments.

2.1 Impact of Dementia on Langauge

Patients with dementia demonstrate, among other signs, difficulty in word finding (anemia), sentence comprehension deficits, and lack of logic in speech (Table 4).

Language function	Normal ageing	Alzheimer's patient
Phonetics and phonology	1.Relatively lower speech tempo than younger adults, but the speed is normal. 2.Language fluency is	1.Lower speech rate in spontaneous speech and higher hesitation ratio when speaking (Jarrold et al., 2014)

	maintained. 3.Accurate phonetic paraphrase.	2.Language fluency is undermined (Werner et al., 2008) 3.Phonemic paraphasia (Jarrold et al., 2014)
Lexicons and semantics	1.Increased vocabulary level, the length of speech production is not noticeably changed. 2.No difficulty in speech comprehension 3.Might be slower naming and higher tip-of-tongue experience due to slower processing and memory decline respectively. 4.No difficulty in paraphrase.	1.Produces shorter texts (Taler and Philips, 2008) 2.Harder to associate vocabulary in the same semantic field (Duong, et al., 2006) 3.Difficulty in speech comprehension, naming , and object recognition (Kempler, 2004) 4.Semantic paraphasia (Jarrold et al., 2014)
Syntax	1.Less syntactic errors, and no agrammatism.	1.Reduced syntactic complexity in moderate and severe AD (Ullman, 2001) Agrammatisms in severe AD (Ullman, 2001)
Pragmatics	1.Able to relate to and not deviate from the topic of discourse. 2.Productive speech processing, able to respond speech quickly.	1.Reduction in productive and receptive discourse-level processing (Taler and Philips, 2008)

Table 4: A comparison between normal ageing and dementia in different aspects of language abilities.

In AD, language and memory functions are closely related since linguistic functioning requires memory functions. The initial aphasic presentation in AD patients can be related with primary progressive aphasia (PPA) syndrome, which is the functional language impairment with relative preservation of other cognitive functions (Mesulam et al., 2008). PPA patients usually preserve the memory of recent events, although memory scores obtained on verbally delivered tests may be abnormal. This selectivity of the language deficit is matched by asymmetric and selective atrophy of the language areas in the dominant (usually left) hemisphere (Mesulam et al., 2008). However, many autopsies from PPA patients have shown amyloid plaques and neurofibrillary tangles, which are the biomarkers for AD. Furthermore, hemispheric asymmetries of damage, similar to PPA, have also been reported in AD.

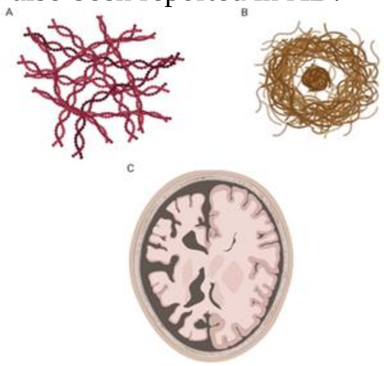

Figure 10: Biomarkers of Alzheimer's disease. A: neurofibrillary tangles (NFTs), misfolded tau proteins in the cytoskeleton of neurones which may be triggered by beta-amyloid plaque. B: dense Beta-amyloid plaques, insoluble protein clumps between neurones that cannot be broken down by alpha-secretase. C: A comparison between an AD brain (left) and a normal ageing brain (right).

Studies show that AD patients show markers of language deficits long before their diagnosis confirmation (Mesulam et al., 2008). This finding provides a potential for effective early-onset language training to delay language impairment when patients are waiting for a formal diagnosis, and a language assessment might be needed in annual health inspection to pay attention to changes in linguistics skills in older adults.

3.Factors Affecting Ageing And Language

Three main factors that promote healthy ageing and enhance cognitive functions are exercise, diet, and cognitive stimulation. Studies have shown that exercise may prevent age-related deterioration of cognitive and brain function and reduce age-related brain atrophy (Voss et al. 2013). In rodents, running also increases neurogenesis in the hippocampal dentate gyrus and induces angiogenesis in the cortex and other brain regions (Creer et al., 2010), thereby improving oxygen and glucose delivery to the brain. Higher cardiorespiratory fitness levels in cognitively normal adults are associated with better performance on a memory task and greater volume of the hippocampus (Erickson et al., 2009), which may help to reduce tip-of-tongue experiences due to memory decline, and more efficient recognition memory. As the hippocampal system is one of the first sites of attack by amyloid plaques and neurofibrillary tangles in AD, exercise may reduce the risks of AD and delay cognitive, especially language decline in older adults.

People with a healthy diet, such as the Mediterraneans who have a diet rich in fruits, vegetables, fish, nut and olive oil, have shown to have a lower incidence of AD (Lourida et al., 2013). Adult hippocampal neurogenesis can also be promoted by omega-3 intake in aged rodents with concurrent improvements in cognitive function (Cutuli et al., 2014), which can benefit memory and language processing.

Studies have also suggested that people who engage in more cognitively stimulating hobbies, social and job are at a lower risk of cognitive decline (Mitchell et al., 2012). Increased resilience of existing neural networks and higher availability of compensatory Networks are induced from life-long cognitive stimulation (Jackson et al., 2016). This means that the elderly can retain their semantic memory of vocabulary for a long time before it starts to decline, which may facilitate more effective communication with others.

3.1 The Effect of Bilingualism on Dementia

Bilingualism is one form of cognitive stimulation which has been shown to delay the onset of dementia symptoms in patients by 4-5 years relative to monolingual patients (Kim et al., 2019) due to its profound impact on the anatomy of the brain. Bilingual activity triggers the formation of neural connections to respond the demands of managing multiple elements of various language systems, such as phonology, semantics, syntax, and grammar (Costa and Sebastian-Galles, 2014), and preserves grey matters density. The utilisation of multiple languages also promotes synaptogenesis, the formation of new synapses, to strengthen the efficiency neural connections especially in Broca's and Wernicke's areas (Li et al., 2014),and this protects white matter integrity.

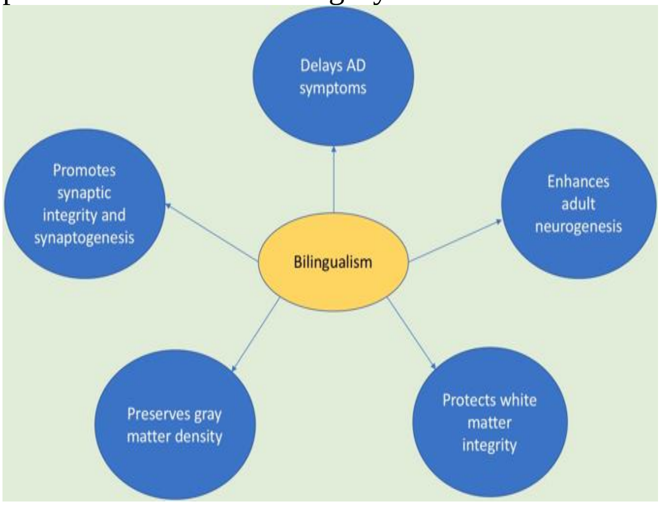

Figure 11: Benefits of bilingualism on synapses, neurones, white matter, and grey matters in the brain, which altogether contribute to a delay of AD symptoms.

III. CONCLUSION AND FUTURE PERSPECTIVES

Language is one of the quintessential aspects that render us as human beings. It allows us to communicate and collaborate with each other, so we can survive and thrive as a species. As ageing population increases gradually, the impact of ageing of language becomes increasingly important as these effects have shown to hinder communication among the elderly, as well as between elderly and younger people.

Overall, sensory, cognitive, and physiological changes in ageing do affect the efficacy of language communication in the elderly population. Lack of effective communication and mutual understanding of the language impairments in ageing may reduce the quality and happiness of life in older adults. Regarding to neurolinguistic studies previously mentioned, several implications in social policies can be made based on the decline in language

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processing and retrieval. For instance, more funding on hearing aids development and research is required to reduce the impact of poor communication in the elderly population because most hearing aids cannot block out background noise and cannot separate speech and noise in noisy environment. Also, presbyopia treatments apart from glasses should be developed, such as contact lens or surgical methods because glasses may be inconvenient; and alternative driving tests should be created and implemented to ensure that presbyopic people can drive safely. Furthermore, self-driving cars may be used to help elderly people with their sensory deficits. Moreover, charities and other non-profitable organisations should actively raise funds to support the local elderly population by establishing language courses in local communities to raise awareness for the sensory and language decline to older adults, and providing language counselling and training to delay the decline of language communication. Additionally, language therapy may be offered to the elderly in a monthly basis to train presbyphonia and ageing-related language impairments. Besides, cognitive tests should be conducted regularly in elderly inspection to track their cognitive conditions and to make diagnosis of potential abnormal ageing as early as possible. Lastly, physically and cognitively combined programs for retired elderly can be established in community centres, charities, or governmental institutes to promote overall cognitive well-being.

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