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The effect of Bilingualism on the aging brain

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Introduction

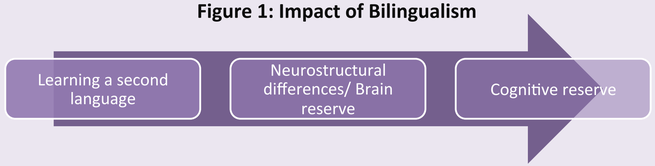
Research has shown many benefits of speaking more than one language. In fact, bilingualism has been reported to be linked with cognitive advantages during the aging process. The difference of the aging bilingual brain in comparison to the aging monolingual brain have been continuously studied and researchers have found that not only is the structure of the bilingual brain different than the monolingual brain, but the bilingual brain also performs greater in cognitive tasks.

As illustrated in Figure 1, many researchers (Abutalebi, Canini, Rosa, Green, & Weekes, 2014; Grant, Dennis & Ping, 2014) propose that bilingualism acts as a neuroprotective agent because the ability to speak two languages promotes brain plasticity and gray-matter preservation in lobes of the brain. Grant et al. (2014) defines this concept as brain reserve and further describes it as being quantitative (e.g. more neurons, more synapses), which then contributes to the concept of cognitive reserve.

Similarly to brain reserve, cognitive reserve is thought to be a protective mechanism that increases the brain's ability to cope with pathology. However, cognitive reserve also includes "differences in how people process tasks better than others with brain pathology" (Grant et al., 2014). The theory of cognitive reserve states that there are certain variables that contribute to the brain's ability to mitigate the effects of aging on cognitive functioning, such as bilingualism.

Evidence of cognitive reserve due to bilingualism can be seen in the structure and function of bilingual brains. Furthermore, cognitive reserve is seen by delayed age of onset and progression of Alzheimer's disease (AD) in bilingual patients.

Figure 1: Impact of Bilingualism



Onset and Progression of AD in Bilinguals

Craik, Bialystok, & Freedman (2010) collected data of monolingual and bilingual patients diagnosed with probable AD, including the participant's age of when cognitive impairment was first noticed and age of first clinical appointment. Results (Table 1) indicated that bilingual patients had reported onset of symptoms approximately 5 years later and had been diagnosed approximately 4 years later than the monolingual patients. The researchers concluded that bilingualism confers protection against the onset of AD, thus contributing to cognitive reserve and protection against the effects of AD.

Repeated studies (Bialystok, Craik, Binns, & Ossher, 2014) were found to be consistent with these reports. Specifically, the bilingual group began to show AD symptoms 4.7 years later and had their first clinic appointment 7.3 years later than the monolingual group.

Anatomical Differences

According to Li, Legault, & Litcofsky (2014), "grey matter and white matter are the most commonly identified anatomical changes" in the bilingual brain (p. 301). Grey matter consists of neuronal cell bodies; white matter consists of axons and allows for connectivity between different parts of the brain. Research has shown that there are differences grey matter volume (GMV) between aging monolingual and bilinguals. GMV in areas such as the anterior temporal lobe and the inferior parietal lobe have been researched due to their functions related to language (Figure 2).

Abutalebi, Canini, Rosa, Sheung, Green, & Weekes (2014) conducted a study focusing on GMV in the anterior temporal lobe of bilinguals and monolinguals. According to the researchers, this area is vulnerable to loss of GMV, especially in individuals affected by dementia or AD. Through the use of magnetic resonance imaging (MRI) and voxel based morphometry (VBM), researchers discovered that the bilingual's brains had an overall less decrease in GMV compared to monolingual's brains. Similarly, in a study by Abutalebi, Canini, Rosa, Green et al. (2014), GMV in the inferior parietal lobule of bilinguals and monolinguals was examined. VBM indicated that elderly bilinguals had greater GMV.

In addition, white matter connectivity between lobes of the brain is different for bilinguals and monolinguals. As seen in Figure 3, researchers believe there is a posterior-to-anterior shift in parts of the brain as individuals age and atrophy occurs, causing brain connectively to decline. The opposite is seen in aging bilinguals; connectivity seems to be preserved as activation is seen in more parts of the brain in order to maintain cognitive performance level. This is known as a compensatory mechanism of the bilingual brain, related to cognitive reserve (Grant et al., 2014; Wingfield & Grossman, 2006).

Other studies have discovered greater atrophy in bilingual's brains through computed tomography (CT) scans. According to Schweizer, Ware, Fischer, Craik, & Bialystok (2012), "bilingual patients with AD exhibited substantially greater amounts of brain atrophy than monolingual patients" in areas such as the temporal horn (p. 991).

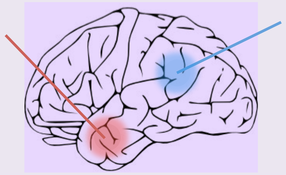
Table 1: Clinical Descriptors of Monolinguals and Bilinguals
(Adapted from Craik, Bialystok, & Freedman, 2010)

Language Group	No.	Age at onset	Age at first appointment
Monolingual	109	72.6	76.5
Men	49	73.3	77.3
Women	60	72.1	75.9
Bilingual	102	77.7	80.8
Men	42	77.6	80.4
Women	60	77.8	81.1

Anterior Temporal Lobe

- Processing
- Comprehension
- Storing
- Language retrieval

(Abutalebi , Canini, Rosa, & Sheung et al., 2014)



Source: www.bestclipart.com

Inferior Parietal Lobule

- Language
- Attention
- Short-term memory
- Sensory information

(Abutalebi , Canini, Rosa, & Green et al., 2014)

Figure 2: Areas of Neurostructural Changes

Functional Differences

After identifying neurostructural changes in the bilingual brain, researchers compared the function of the bilingual brain to the monolingual brain.

According to many studies, compared to monolinguals, bilinguals exhibited enhanced cognitive control through tasks involving "switching, inhibition, and conflict monitoring" (Grant et al., 2014, p. 1). Specific tests administered included the Attention Network Test (ANT), the Simon Task, and the Stroop Task.

Costa, Hernández, & Sebastián-Galléz (2009) conducted a study of alertness, orientation, and executive control in bilinguals compared to monolinguals using ANT. They discovered that bilinguals had an overall reduced reaction time while performing tasks and were more efficient in resolving conflicting information.

Similarly, during the Simon task, attention and executive functioning were tested. In a specific study by Bialystok, Craik, Klien, & Viswanathan (2004), bilinguals had a smaller Simon effect cost and a faster response time in "conditions that placed greater demands on working memory" compared to monolinguals (p. 290).

Results from the Stroop Task are consistent with the findings from ANT and the Simon task, where bilinguals performed better than their monolingual peers (Bialystok, 2011).

In a study by Schweizer et al. (2012), cognitive functioning of monolinguals and bilinguals diagnosed with probable AD were tested (e.g. memory, attention, language, naming, executive function). According to researchers, neuropathology in the brains of patients with AD positively correlates with the degree of atrophy. In other words, greater atrophy leads to greater cognitive decline. However, although greater brain atrophy in bilingual participants was discovered, the bilingual participants performed at the same cognitive level as the monolingual participants. This supported the researchers hypothesis that brains of bilinguals require a greater amount of atrophy in order to function at a lower cognitive level.

In total, these functional outcomes may be linked to the later onset of AD symptoms and clinical diagnosis. If bilinguals have higher cognitive functioning, symptoms will be noticed later by family members, friends , and one's self.

Conclusion

Bilingualism requires intricate cerebral activity, requiring the ability to process, comprehend, store, and retrieve two separate language systems in their appropriate contexts. Speaking two languages is a demanding effort, causing neurostructural and physiological differences compared to speaking one language. Evidence of the structural and functional changes in bilingual brains include:

- Later onset of symptoms of AD by approximately 5 years (Craik et al., 2010).
- Later diagnosis of AD by approximately 4 years (Craik et al., 2010).
- Greater GMV (Abutalebi, Canini, Rosa, Sheung, Green, & Weekes, 2014; Abutalebi, Canini, Rosa, Green et al. , 2014).
- Greater white matter connectivity (Grant et al., 2014).
- Same or higher level of performance of cognitive functioning tasks (Schweizer et al., 2012; Grant et al., 2014; Craik et al, 2004; Bialystok, 2011).

Figure 3: Posterior-to-Anterior Shift in Aging
(Source: Grant et al., 2014)

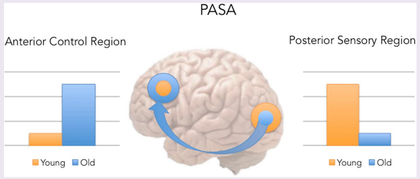


Figure 3 shows that with age comes a shift in the location of brain activity. Younger participants typically use posterior areas of the brain; older participants typically use anterior parts of the brain. Studies have shown that older bilingual participants use both posterior and anterior areas and have greater connectivity between the two. These findings support a compensatory mechanism of bilingualism related to cognitive reserve (Grant, et al., 2014; Wingfield & Grossman, 2006).

References available on separate sheet