Brain Organization in Bilinguals:

Impacting Factors and Differences with Monolingual Brains

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Abstract

This paper includes peer-reviewed articles that portray the brain organization in bilinguals. The paper will start with an introduction of the factors that impact the brain organization in bilingual brains: age of acquisition, language proficiency, and language exposure. Afterward, the paper will point out significant organizational differences across anatomy and activity in bilingual and monolingual brains. Lastly, this paper will examine how lesion studies using aphasic bilinguals help to show different language specific areas and patterns of activation across two acquired languages.

Keywords: Bilingual, brain, language, organization, anatomy, neural activity, aphasia

Introduction to Brain Organization in Bilinguals and its Affecting Factors

Do you speak more than one language? Are you bilingual? If you answered yes to both of those questions, then your brain organization is different compared to the brain organization of a monolingual. The holistic organization of the brain is composed of different structures, neural networks, connectivity, and more; all of which permit an individual to have cognitive states. Interestingly, the brain organization in bilinguals is affected by three language variables: age acquisition, language proficiency, and language exposure. Overall, the brain is a complex organ; thus, to understand the brain organization in bilinguals its affecting factors will be described.

To start, age acquisition signifies the age that a language is learned. According to age acquisition and bilingualism, there are two types of language learners, simultaneous bilinguals and sequential bilinguals. Simultaneous bilinguals learn a second language early on in life, sometimes even when learning their first. On the contrast, sequential bilinguals learn a second language later on in life, mainly after 3-5 years of age (Jasinska & Petitto, 2013). Age acquisition in bilinguals is vital to their brain's organization as it alters their brain's structure. For instance, Jasinska and Petitto (2013) identified that the earlier an individual learns a second language, the more impact does that language have on neural organization and language processing. Lastly, it is important to mention that different neural organizations cause differences in brain activity. Hence, age of acquisition matters as it can affect the brain's neural organization, language processing, and neural activity.

Furthermore, Klein, Zatorre, Chen et al. (2006) mentioned that language pattern activity in bilinguals is not solely affected by age acquisition but also language proficiency. Language proficiency is the level of ability to speak and write in a language across various situations.

Giussani, Roux, Lubrano, Gaini, and Bello (2007) concluded from converging studies using functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) techniques, that language proficiency matters, as bilinguals who had novice proficiency in their second language showed greater activation in cortical regions. The higher activation in the cortical areas can suggest that more electric potentials are occurring as it requires more internal processing to encode the second language. In all, language proficiency is relevant to bilinguals' brain organization as it can affect where and how much brain activity occurs in the brain.

A final variable that impacts the brain organization in bilinguals is language exposure. Language exposure signifies how much and how often a person uses a specific language. In Kovelman, Baker, and Petitto's (2008) study, they found that exposure to a second language early in life can modify a bilingual's language processing system. Moreover, Wei et al. (2015) noted that the amount of daily language exposure impacts the degree of brain activity, as less language exposure leads to more brain activity. Similarly, Tu et al. (2015) studied the effect of language exposure in bilingual brains using an fMRI; they determined that bilinguals who were exposed less to their second language required more brain activity in language control areas. Hence, just like age acquisition and language proficiency, the amount of exposure to a second language matters to brain activity.

In conclusion, the age of acquisition, language proficiency, and amount of exposure to a second language seem to influence the way that the brain organizes, processes, and activates language processing systems. On the contrast, it can be that a person's intrinsic brain, or a combination of both the inherent brain and variables, are the origin of the differences. Nevertheless, these variables show how there are differences between bilingual and monolingual brains, as there are variations within bilingual brains.

Differences in Brain Organization in Bilinguals Compared to Monolinguals

The brain organization in bilinguals compared to monolinguals is different. The difference in organization between bilinguals and monolinguals can be captured through brain anatomy, neural activity, and lesion studies. In all, to understand how the brain organization in bilinguals is different compared to monolingual brains, differences in brain structure, neural activity, and aphasias will be discussed.

To start, the brain anatomy of bilinguals is different from those of monolinguals. The thickness of the gray matter determines one of the differences. Mechelli et al. (as cited in Mohades et al., 2012) discovered that bilinguals compared to monolinguals had a greater gray matter density on their left inferior parietal cortex. The discovery of a greater gray matter density goes to show that bilinguals have more cell bodies compared to monolinguals in left the inferior parietal cortex. The significant amount of cell bodies can suggest that bilinguals need more cell bodies to apprehend spoken and written words.

Moreover, bilinguals compared to monolinguals have a higher amount of white matter. As evidence, Mohades et al. (2012) found that there was a higher percentage of myelination in the white matter tracts over the left inferior occipitofrontal fasciculus in simultaneous bilinguals. Hence, the finding concluded that simultaneous bilinguals might have faster processing by having more myelinated axons, which allows for a higher ability to carry and process neural impulses. In all, compared to monolinguals, simultaneous bilinguals tend to have a higher density of gray matter and myelinated axons in brain specific areas.

Furthermore, the brain activity in bilinguals is different than in those who are monolinguals. For example, in a study conducted by Hernandez, Martinez, and Kohnert (as cited in Fabbro, 2001) found that from a macro-anatomical view, there were no different brain activating areas across intensity and organization in six bilinguals with English and Spanish speaking and writing abilities. However, the results should be taken with caution as the study that led to these results were conducted in a small sample size. Additionally, in a study of word repetition with bilinguals, Klein, Zatorre, Milner, Meyer, and Evans (as cited in Abutalebi, Cappa & Perani, 2001) concluded that the first and second language of a sequential bilingual shared similar neural structures, however, what differed was the brain activity in the left putamen when individuals repeated words in their second language. In addition, Jasinska and Petitto (2013) detected that the prefrontal cortex was activated more in late-exposed bilinguals than in simultaneous bilinguals and monolinguals. In all, their finding helps to suggest that compared to monolinguals, sequential bilinguals have greater brain activity. Overall, results from converging studies indicate that the brain activity in late-exposed bilinguals is different across location and intensity compared to the brain activity in simultaneous bilinguals and monolinguals.

Lastly, lesion studies with aphasic bilinguals are relevant because they suggest that the two languages of bilinguals are organized differently in the brain. Also, there are different ways that aphasias manifest in bilinguals (Fabbro, 2001). Abutalebi, Cappa, and Perani (2001) described how some brain lesions in bilinguals could cause a language impairment in one language but not the other. For instance, some bilinguals with aphasia cannot translate words from their first language to the second, and vice versa. Also, a brain lesion called spontaneous translation, causes the need to translate everything from both of their languages. Further, other bilingual aphasics have the ability to translate words but lack comprehension. In other words, they cannot understand what they translate. Moreover, Abutalebi et al. (2001) suggested that bilingual aphasics' first and second language are organized differently according to their neural organizations, and that their differences may be dependent on how long after the second language was acquired from the first. Further, Minkowski (as cited in Fabbro, 2001) proposed that bilingual aphasias occur because the two languages activate different brain specific areas within a brain region. Overall, studies with bilingual aphasics indicate that the brains of monolinguals and bilinguals differ, as two languages are organized and activated differently in the brains of bilinguals.

Everything considered, the brain organization in bilinguals is both different and similar compared to those of monolinguals. Their differences are noted across anatomy and neural activity. Also, lesion studies help to capture how two languages manifest differently in the brain. Overall, it is clear to say that the brain organization in bilinguals is different, although not drastically, compared to monolingual brains.

Conclusion

In sum, the brain organization in bilinguals is different within bilinguals and across monolinguals. Although the differences in brain organization are not drastic, they are still important. The differences in organization help to capture what effects the brain's organization and activity in bilinguals across their two languages. Similarly, the brain organization of bilinguals suggests that bilingual brains process language differently compared to monolingual brains. Moving forward, there should be studies executed to clarify the long-term cognitive outcomes of variations across age acquisition, language proficiency, and language exposure in bilingual brains. In addition, there should be studies performed to note how different combinations of languages impact the brain organization in bilinguals. In all, the complex brain organization in bilinguals is suggested to be dependent on age acquisition, fluency, and the amount of language exposure. Hence, speaking and writing another language develops differences in brain anatomy and activity between bilingual and monolingual brains.

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