



Figure 1.

Anatomical and cytoarchitectonic details of the left hemisphere (adapted from Friederici, 2011).

Table 1 Core studies of functional brain variation related to language learning and processing

Functional imaging data			
Study	Behavioral task	Native language of learners - Target language to learn	Relationship to structure
Lexical level			
Wong et al. (2007)	Pitch-to-word learning until the training criterion was met ¹	English (L1) – Mandarin Chinese (L2)	Successful learners: left posterior superior temporal gyrus Less successful learners: right superior temporal gyrus and right inferior temporal gyrus.
Mei et al. (2008)	Passive listening task 2 - week training program	Chinese (L1) - Logographic artificial language (L2)	Training-induced changes in the left frontal areas, superior parietal lobule, right supplementary motor area, insula/putamen, cerebellum, and bilateral temporal lobe.
Breitenstein et al. (2005)	Pseudo-word sound-picture associations in a 50-min training session	German (L1) – Pseudowords issue from German words (L2)	Linear decrease in Blood Oxygen Level Dependent (BOLD) signal changes in the left hippocampus.
Phonological level			
Wang et al. (2003)	2 - week training program – tone identification	English (L1) – Chinese (L2)	Left superior temporal gyrus and adjacent areas (BA 22, BA 42), and right inferior frontal region homologous to Broca's area (BA 44).
Golestani and Zatorre (2004)	2 - week training with dental retroflex contrasts – sound identification	English (L1) – Hindi (L2)	Increased activations in the left superior temporal gyrus, insula-frontal operculum, and inferior frontal gyrus

Abbreviation: BA: Brodmann area

Table 2. Core studies of structural brain variation related to language learning and processing

Structural imaging data			
Study	Behavioral task	Native language of learners - Target language to learn	Relationship to structure
Zou et al. (2012)	Production task (overt spoken response given in spoken or sign language)	High-proficiency Chinese (L1) spoken- and sign-language (L2) bimodal bilinguals with normal hearing and unimodal bilingual (2 oral languages; L1 Chinese)	Greater GM volume in the left caudate nucleus for the bimodal bilinguals in comparison with the unimodal ones.
Mechelli et al. (2004)	No task	Bilinguals who learned a second European language early (AOA < 5 yrs) or late (AOA 10-15 yrs)	Increased GM volume in the left inferior parietal cortex – Positive correlation between L2 proficiency and GM

¹ Accuracy level in word identification of 95% or above for two consecutive sessions (“successful learning”), or 5% improvement or better for four consecutive sessions (“less successful learning”).

			volume – Negative correlation between the AOA and the GM volume.
Hosoda et al. (2013)	Learning of L2 vocabulary	Japanese (L1) – English (L2)	Increased volume of GM and WM in the right inferior gyrus – Correlation between changes in the right inferior frontal gyrus and an improvement in L2.
Xiang et al. (2012)	16-week training session of L2 English vocabulary learning	German or Dutch (L1) – English (L2)	Relationship between performance in rapid vocabulary learning and the pathway connecting the inferior frontal gyrus (BA 47) and the parietal lobe.
Klein et al. (2013)	No task	French (L1) – English (L2)	L2 AOA and cortical thickness (CT) correlated negatively in the right inferior frontal gyrus but positively in the left inferior frontal gyrus.
Garcia-Penton et al. (2014)	No task	2L1- Spanish – Basque	One left frontal and parietal/temporal sub-network and one parietal/temporal/right superior frontal gyrus sub-network more connected by white matter (WM) tracts in early bilinguals than in monolinguals.
Cummine and Boliek (2013)	Naming of regular and exception words	Chinese (L1) – English (L2)	Higher WM integrity for adult monolinguals over bilinguals in the right inferior fronto-occipital fasciculus and the anterior thalamic radiation.
Grogan et al. (2012)	Lexical decisions and number of words produced in a timed verbal fluency task	Bilinguals/Multilinguals – English (L2)	Positive correlation between GM volume in the left inferior frontal gyrus pars opercularis and performance levels in L2 lexical decision and verbal fluency tasks for young adult bilinguals.
Kwok et al. (2011)	Listening, naming, matching	Chinese	Changes in GM volume after only two hours' training.
Schlegel et al. (2012)	9-month language course to spoken and written Modern Standard Chinese	English – Chinese	Greater fractional anisotropy (FA) values for learners in comparison to control participants who did not learn Chinese within the same period.
Legault et al. (2019a)	Longitudinal 2 semesters of L2 Spanish classroom learning	English - Spanish	CT increase in the left anterior cingulate cortex (bilingual language control, conflict monitoring).
Grant et al. (2015)	Same as in Legault et al. (2019a)	English - Spanish	Changes in a functional network including the bilateral anterior cingulate cortex, caudate nucleus, inferior frontal gyrus, middle frontal

Mårtensson et al. (2012)	Intensive 10-month language training program for learning vocabulary and idioms in preparation for a career as a military interpreter	Swedish (L1) - Arabic, Dari, and Russian (L2)	gyrus and middle temporal gyrus. Increased CT in the left inferior frontal gyrus, left middle frontal gyrus, and left superior temporal gyrus, as well as increased right hippocampal volume in comparison with a control group matched for age and cognitive abilities.
Elmer et al. (2014)	Number of training years (3 to 22 years)	Multilingual simultaneous interpreters – Multilinguals	GM volume in the right inferior frontal gyrus pars opercularis, left inferior frontal gyrus pars triangularis, middle anterior cingulate cortex, and bilateral caudate nucleus negatively correlated with cumulative number of years interpreting.
Kwok et al. (2011)	Intensive 2-hour learning of four monosyllabic colour names	Chinese	Increased GM volume in the V 2/3 of the left visual cortex, a region known to mediate color vision.
Wong et al. (2008)	Word-pitch mapping task	American English	The performance on the word-pitch mapping task correlated positively with GM and WM volume in the left Heschl's Gyrus. Larger effect in "successful" than in "less successful" learners.
Luo et al. (2019)	No task	European / non European (L1) – English	Microstructural variations related to age of acquisition of the second language in the left inferior frontal region and the left fusiform gyrus.
Stein et al. (2012)	5 months learning German in immersion (Switzerland)	English – German	Increased GM volume in the left inferior frontal gyrus and the left anterior temporal lobe, two areas that are implicated in lexical access and semantic integration.
Legault et al. (2019b), Li et al. (2014)	Vocabulary learning	English – Chinese	GM volume increases in response to different modes of L2 learning (natural setting, formal instruction, or lab training) in various cortical and subcortical areas including the inferior frontal gyrus, the middle frontal gyrus, superior temporal gyrus, anterior temporal lobe, inferior parietal lobule, all in the left hemisphere, the cerebellum and the hippocampus in the right hemisphere, and the caudate nucleus mostly in the left hemisphere but in some cases bilaterally.

Abbreviations: L2: second language; GM: grey matter; WM: white matter; V: visual area; CT: Cortical thickness