Plasticity of Adult Human Brains

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Babies have the ability to learn quickly, and their growing brain structures are a testament to their acquired knowledge. Could the accumulation of knowledge in adult human brains also be related to structural brain changes? Scientists in previous cross-sectional and longitudinal studies observed motor behavior in children and adults and studied how their behaviors influenced brain development. In the paper “Acquiring ‘the Knowledge’ of London’s Layout Drives Structural Brain Changes,” Woollett and Maguire (2011) examined how structural brain changes in adult humans can be related to the spatial knowledge they obtain as London’s taxi drivers.

Based on their previous knowledge that hippocampal plasticity exists in humans, Katherine Woollett and Eleanor Maguire, neuroscientists at the University College London, conducted a longitudinal study observing 79 male trainee taxi drivers and 31 male controls who were non-taxi drivers (Woollett & Maguire, 2011). London taxi drivers serve as excellent models for studying the hippocampus and memory, as such drivers are required to learn more than 25,000 streets in order to obtain their operating license. Woollett and Maguire hypothesized that the taxi drivers would contribute to the nature versus nurture debate and help provide some insight on the plasticity of cognition. They observed taxi drivers' brain structures over a three to four year time period by using magnetic resonance imaging (MRI) and also assessed the individuals' performances through certain memory tasks.

From the original sample, only 39 participants passed the test and qualified as London taxi drivers. This allowed the researchers to divide the trainees into three groups: individuals who qualified (Q), individuals who went through training but did not pass (F), and the control group who did not undergo training (C). Woollett and Maguire examined participants' brain structures at the beginning of the study (T1) and did not identify any significant differences in the structures of the anterior or posterior hippocampus. All of the individuals performed relatively well on the memory tasks. It was crucial for them to identify and eliminate any confounding variables from the baseline measurements. At time two (T2), three to four years later, the researchers looked at the brain structures and assessed performance on memory tasks once again.

The researchers identified significant differences in the MRI scans and memory task performances by group. Specifically, they found that the volume of gray matter increased in the posterior hippocampus for the trainees who had qualified as London taxi drivers at T2 compared to their volume during T1. The researchers did not observe this brain structure change in the controls or individuals who failed to qualify. For the memory tasks, both the qualified and non-qualified trainees were significantly better at tasks involved with identifying London landmarks compared to the control group. Overall, individuals who went through training but did not pass were not significantly different than the control group. Thus, the researchers' hypothesis that structural brain changes can accompany improvement in memory in adults was largely supported.

Despite such promising results, several questions remain. For instance, it is unclear as to whether the trainees who were able to become taxi drivers had a biological advantage or genetic predisposition toward a more plastic brain compared to the trainees who did not qualify. Although the debate about nature versus nurture still exists, this unique study contributed to human brain research because it showed direct evidence for plasticity in the adult human brain as a function of memory and acquired knowledge. Woollett and Maguire proposed that this information has important implications for “lifelong learning and neurorehabilitation in the clinical context.” In the future, researchers can obtain more conclusive results by using other mechanisms of in vivo brain scanning in order to further explore how the hippocampus and other brain structures such as the amygdala (which is responsible for fear acquisition) play a role in memory and structural brain changes.

References