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PHYT 885 – Module 3 assignment
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Article summary and implications for practice

Hosseiny S, Pietri M, Petit-Paitel A, et al. Differential neuronal plasticity in mouse hippocampus associated with various periods of enriched environment during postnatal development. Brain Struct Funct. 2015. 220: 3435-48

The study by Hosseiny, et al explores the influence of environment on neuroplasticity. Previous research has validated that environmental factors influence brain anatomy, activity, function, and development – all of which are important for processes such as learning, memory, and cognitive function. The Hosseiny, et al study is more interested in examining the effect that duration of environmental exposure and the developmental age at exposure have on neuroplasticity.

The study included two sets of mice, each exposed to a different environment for different periods of time and at different ages. In one set, 12 mice were exposed to an enriched environment (EE), while the other set included 5 mice in a standard environment. An enriched environment is a standard for many studies, and in this case included 12 mice in a large container with a variety of objects (i.e. toys, tunnels, running wheel, hammock) that were changed twice per week. The idea is that the enriched environment will promote enhanced exploration, cognitive activity, social interaction, and physical exercise. The standard environment (SE) included 5 mice in a medium box kept at a comfortable temperature, on a regular light/dark cycle, and with access to food and water. Participants were either 4 or 8 weeks old, representing juvenile and young adult mice, and were kept in their respective environments for either 4, 6, or 8 weeks.

Hippocampal neurogenesis was measured through a series of compound injections and subsequent analysis of brain cross-sections. The researchers found that juvenile EE mice experienced a significant increase in hippocampal (dentate gyrus) neurogenesis – or at least synaptogenesis – while young adult EE mice did not. Furthermore, SE mice showed a significant decrease over time that was consistent with aging. Neurogenesis is important to support the constant reorganization the hippocampus undergoes in response to new stimuli, a foundational component of learning. This finding suggests that an enriched environment encourages learning by promoting reorganization of the hippocampus.

Brain slices were also imaged and magnified to allow observation of neurons and dendritic spines. Results showed that spine density and dendritic branching increased in all EE mice; whereas, SE mice displayed an age-related decrease. Increased spine density has been correlated to improved synaptic function through long-term potentiation (LTP). LTP, or increased synaptic strength in response to long-term (hours to days) neuronal activity, is an important mechanism of learning and memory. After first finding what could have been confounding results, the authors were able to further deduce that 4 weeks of EE in young adult mice increased LTP. These results indicate that an enriched environment serves to promote learning and memory through cellular change and improved synaptic plasticity. The hiccup the researchers came across helped to show that the brain responds differently to EE at different developmental ages.

The results of this study show that, generally, environment influences learning. By examining hippocampal neurogenesis and synaptogenesis, dendritic spine density and branches, and long-term potentiation (glutamatergic synapses), the study further suggests that environment affects brains differently depending on the participant age and duration of exposure. Young mice exposed to EE for extended periods have neural networks that are in better position to promote and enhance learning. Although the established synapses became increasingly silent after prolonged exposure to EE, indicating possible habituation, the neural network and synaptic connections largely remain in place and ready to become active again with new stimuli/learning.

Since previous studies have already examined the effects of EE on behavior and plasticity, this study helped to shine light on some of the other factors and morphological changes that occur, particularly at different ages and with different lengths of exposure. Environmental influence on learning is largely underrated, despite the strong evidence suggesting its importance. As this component of rehabilitation gathers attention, it's important to know that there's a time-sensitive element as well. Developmental age at exposure has obvious correlations to pediatric physical therapy and developmental interventions. Successful pediatric physical therapy should include, among other things, incorporation of an enriched environment that sponsors exploration, cognitive activity, social interaction, and physical exercise. This study indicates that the environment is most important at the earliest age.

But it will be interesting to see if some piece of this puzzle also applies to the adult brain following insult, like a stroke. Is there a window during rehabilitation in which an enriched environment can promote physical changes that would enhance the potential for learning and memory? Is it best to create this environment immediately, as with the youngest mice? One of the conclusions of this article that is easy to overlook is the evidence supporting the importance of continually introducing new learning and new stimuli to avoid habituation. This may be the critical element for the adult patient. It's very encouraging to know that the neural network is mostly maintained during habituation, just inactive. Therefore, it's important for therapists to continually and sufficiently challenge patients to promote active engagement and conscious learning.

At least one other question remains. We know that environmental factors have much less impact on older mice than young mice. We also know that the neural networks and synaptic connections built up during learning are mostly intact after the environmental influence has waned, such as in habituation. What, then, will it take to reactivate these dormant pathways? Is it still environment, just in some other dose or context – or something else entirely?

One of the limitations of this article is the use of abundant neurological jargon that bogs down reading the study. Similarly, the authors spend a great deal of words and effort explaining their methods, which are certainly important; however, in this case the reader may prefer to read more about the findings and their implications. Further studies are needed to replicate the procedure to see if the abnormal findings are duplicated, and to verify the authors' interpretations of those unexpected findings.

Resources

1. Hosseiny S, Pietri M, Petit-Paitel A, et al. Differential neuronal plasticity in mouse hippocampus associated with various periods of enriched environment during postnatal development. Brain Struct Funct. 2015. 220: 3435-48