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SPECIAL ARTICLE

Understanding adult neurogenesis beyond its role in learning and memory formation

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Abstract There has been a shift in the understanding of brain, neurons, and their functional role over the last two decades. Earlier it was believed that the brain was a static organ and was not subject to any change throughout life. An understanding was developed later that brain reorganizes its structure by a specific property called neuroplasticity. Recent research shows that the brain generates new neurons even in the adult stage, and this process is called adult neurogenesis. Although researchers still not have all the answers about the newborn neurons, and why and how they are generated, and what is their role, some have highlighted the importance of these in learning and memory formation, and even in memories of fear and spatial navigation. A wide range of environmental experience influences the generation of newborn neurons and their functional variability. There are questions about how different environmental experiences cause the differences in the generation of new neurons. Recently the field of optogenetics attempted to answer the questions on adult neurogenesis. However there are still questions about adult neurogenesis which needs a more naturalistic approach, for their better understanding.

PALABRAS CLAVE
Neurogénesis;
Cerebro;
Aprendizaje;
Memoria;
Neuroplasticidad

Comprendiendo la neurogénesis adulta más allá de su papel en la formación del aprendizaje y la memoria

Resumen No ha habido un cambio en la comprensión del cerebro, las neuronas y su papel funcional de las últimas 2 décadas. Anteriormente se creía que el cerebro es un órgano estático y no está sujeto a ningún cambio durante toda la vida. La comprensión se desarrolló más tarde, que el cerebro reorganiza su estructura por una propiedad específica llamada neuroplasticidad.

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Investigaciones recientes muestran que el cerebro genera nuevas neuronas, incluso en la etapa adulta, y este proceso se llama neurogénesis adulta. Aunque por ahora los investigadores no tienen todas las respuestas sobre las nuevas neuronas nacidas y por qué y cómo se generan, y cuál es su papel. Algunos han puesto de relieve la importancia de las neuronas recién nacidas en la formación del aprendizaje y la memoria, e incluso en los recuerdos de miedo y la navegación espacial. Una amplia gama de experiencia ambiental influye en la generación de neuronas recién nacidas y su variabilidad funcional. Hay preguntas acerca de cómo la variada experiencia ambiental ocasiona diferencias en la generación de nuevas neuronas. Recientemente, el campo de la optogenética intentó responder a las preguntas sobre la neurogénesis adulta. Sin embargo, todavía hay preguntas sobre la neurogénesis adulta que necesitan de un enfoque más naturalista para su mejor comprensión.

It was initially believed that brain is static organ, and is not subject to any change throughout life. This was followed by an understanding that brain can be reorganized by its special property called neuroplasticity, in which the brain is constantly organizing its structure by changing connections between neurons. Now most recent discoveries even show that there are newly born neurons in the brain which play an important role in the process of learning and memory formation. The discovery that human brain endures to produce neurons even in the adult brain confronts major dogma in the field of neuroscience, however the role of such newly born neurons in the behaviour and cognition is still not clear. The new born neurons in the hippocampus region of brain are critical for the formation and retrieval of memory. There has been a period of controversy regarding the functional role of adult born neurons, and some were of the view that they have no role in adult brain. However there came some breakthrough studies which help in understanding the role of adult neurogenesis. In a recent article the authors have extensively reviewed the literature and garnered evidences that silencing newborn neurons result in impairment of memory.[1] The article directly supports the idea that generation of neurons in the brain may be of grave importance in the overall process of learning and memory formation. Authors of the aforementioned article even suggest that new born neurons form connections with existing neurons in the adult brain. The authors have deeply analyzed vast amount of literature on environmental factors that influence the generation of new neurons in the hippocampus of adult brain, a region which plays an important role in learning and memory formation.[1] Such newly formed neurons may help organisms adapt changing environment and circumstances. There are number of studies which show that early environment affects the later development epigenetically primarily by DNA methylation and chromatin modification.[2–4]

The studies now are clear that environmental interaction could generate neurons in adult brain which has critical role in learning and memory formation. It is said that generation of newly neurons help fine tune the hippocampus to predicted environment. Depending upon the type of environmental experiences each individual is worked out to optimize the brain depending upon weather there is seeking out rewarding experiences or avoiding stressful experiences. However how the hippocampus and the formation of neurons function for the retrieval of adaptive memory still remain to understood and need more naturalistic environmental conditions, for better understanding. With recent research advances it is becoming increasingly clear that wide range of mammalian species have profound effect on adult brain due to environmental influences. It is also been clear through research that stressful experiences has the role to reduce the number of hippocampal neurons, and in contrary the rewarding experiences cause an increase in the number of new neurons in the hippocampus. A number of studies present evidences that stress induced experiences persuade the suppression of adult neurogenesis.[5–7] Significant changes in the hippocampal structure and synaptic plasticity of rats were observed in later life by receiving low maternal care during the early postnatal period.[8,9] As adult neurogenesis is also having role in behavioural and cognitive processes therefore stress has been associated with impairment of cognitive based hippocampal tasks for example spatial navigation learning and object memory. Stressful experiences are also shown arose an anxiety like behaviour, however in contrary a reduction in anxiety are associated with rewarding experiences and an improved performance on hippocampus based cognitive tasks.

Although it is not known, whether neurons produced in relation to any particular environmental experiences are geared towards the recognition of that experience in future or help to adapt other similar environmental condition. Recently it is proposed that stress related increase in anxiety and inhabiting exploration help improving the chances of survival.[1] In contrary to that reward modelled brain does the same by increasing chances of survival in low stress and high reward environment. It seems thus stress also play a role for increasing efficiency of an individual but when controlled at its earlier periods; however continued stress may impair the neuron information. It could be assumed that the outcome of complex interaction between environment and organism does influence the generation of newly formed neurons that help adapt modifications of environment. This may however help increase survival strategies by modulating behaviour, as the environmental interaction are the first step