Theta rhythm during passive whole body rotation is absent in phospholipaseβ1 knockout mice

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To clarify issues related to mechanisms underlying theta generation and functional significance, we investigated the interrelationship between behavioral states and theta rhythms in phospholipase C-β1 knockout mice. Here we show that: 1) theta rhythm from PLCβ1-/- mice was generated during wheel running but the power of theta rhythm was reduced compared to wild littermates; and 2) PLCβ1-/- mice did not show theta rhythm during passive whole body rotation while wild littermates generate theta rhythm during passive rotation. We will discuss how theta rhythm absent during passive whole body rotation in phospholipaseβ1 knockout mice can be related to spatial disorientation behavior.

Although theta rhythms have been investigated more than 40 years, numerous critical issues regarding both the generation of theta rhythms and their functional significance remain challenges for future research [1]. To clarify issues related to mechanisms underlying theta generation and functional significance, a new approach, which combines theta rhythms with three behavioral states: active wheel running, passive whole body rotation, and REM sleep, has been proposed based on a unifying theoretical framework on brain information processing [2]. On the other hand, Kim et al. produced a mouse strain harboring PLCβ1 null mutation [3] and the role of phospholipase C-β1 (PLCβ1) in the cholinergic modulation of hippocampal theta rhythm was demonstrated by using the phospholipaseβ1 knockout mice [4].

Here we have investigated the interrelationship between behavioral states and theta rhythms in PLC beta 1 knockout mice using the new approach combined three behavioral states. Firstly, we recorded hippocampal EEG during mice's wheel running to compare differences in theta rhythm generated during voluntary movement between PLCβ1-/- mice and wild littermates. To test EEG spectral characteristics in the theta band changed during wheel running and resting state, fast Fourier transforms were

performed on data collected during two 4 s intervals: immobility and wheel running. The relative power was averaged over these records for each of the respective 0.94 Hz bins. These analyses were performed on recordings from these intervals for 100 trials from both PLCβ1-/- mice (N=6) and wild littermates (N=7). Our results demonstrate that theta rhythm from PLCβ1-/- mice was generated during wheel running but the amplitude (or power) of theta rhythm was reduced compared to wild littermates.

In a second behavioral test, theta rhythm from PLCβ1-/- mice and wild littermates was compared when mice were rotated passively on a turntable. To test EEG spectral characteristics in the theta band changed during passive rotations, fast Fourier transforms were performed on data collected during two 4 s intervals: resting state before rotation and resting state during passive whole body rotation. The relative power was averaged over these records for each of the respective 0.94 Hz bins. These analyses were performed on recordings from these intervals for 100 trials from both PLCβ1-/- mice (N=6) and wild littermates (N=7). As expected from a theoretical model [2], PLCβ1-/- mice did not show theta rhythm during passive whole body rotation on a turntable while wild littermates generate theta rhythm during passive rotation. No differences were found for clockwise versus counterclock-wise rotations.

To characterize theta rhythm during paradoxical sleep from PLCβ1-/- mice, here we recorded and analyzed EEG during paradoxical sleep from PLCβ1-/- mice and wild littermates. Theta rhythm has been found from PLCβ1-/- mice during paradoxical sleep. But, power spectral density of theta rhythm from PLCβ1-/- mice is smaller than wild-type littermates. This result is comparable with similar characteristics of theta rhythm recorded during wheel running in both mutant and wild mice.

In addition, our results demonstrate that PLCβ1-/- mice show increased power (or amplitude) in large irregular activity (LIA) during resting state compared to wild littermate.

In the 2004 CNS meeting, we will discuss how theta rhythm absent during passive whole body rotation in phospholipaseβ1 knockout mice can be related to spatial disorientation behavior.

Reference

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