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Research Report

The influences of dark rearing on the transmission characteristics of layer II/III pyramidal cells during the critical period

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ARTICLE INFO

Article history:
Accepted 27 March 2012
Available online 2 April 2012

Keywords:
Short-term synaptic plasticity
Long-term synaptic plasticity
Dark-rearing
Visual cortex

ABSTRACT

The characteristics of synaptic plasticity on layer II/III pyramidal cells in different ages of rats have been studied extensively, and dark rearing is one of the important impact factors. To systematically analyze the influence of dark rearing on synaptic plasticity during the critical period of visual development, we studied the characteristics of short-term and long-term synaptic plasticities of layer II/III pyramidal cells of rats in three rearing conditions during P14 to P37. The paired-pulse ratio (PPR) of inhibitory postsynaptic currents (IPSCs) of layer II/III pyramidal cells was effected by both ages and rearing conditions, but the PPR of excitatory postsynaptic currents (EPSCs) did not change obviously. Moreover, long-term synaptic plasticity of rats in the dark rearing condition did not significantly change with age, while it was elevated during P16 and P21 for rats in the normal rearing condition. These results suggest that visual experience can affect the characteristics of short-term and long-term synaptic plasticities. The IPSC/EPSC ratio increased gradually with aging for NR rats, but the ratio slightly decreased for DR rats, which indicates the relative increase of inhibitory components during the critical period of visual development. The characteristics during P35 and P37 of the 30-day dark-reared (30 D×N) group had similar trends with the normal-reared rats during P16 and P21, which emphasizes that dark rearing can postpone the timing of the critical period.

1. Introduction

The visual experience is easily manipulated, and the resulting neural changes are conveniently measured, leading the visual cortex as one of the most intensively studied models of the cortex. And these intense studies have allowed important conclusions to be made. For example, the subunit composition of NMDA receptors is affected by visual experience and may form a major aspect which affects neuronal plasticity in the visual cortex (Bear, 1996; Liu and Chen, 2008; Murphy et al., 2005; Philpot et al., 2001; Tongiorgi et al., 2003; Yoshimura et al., 2003). AMPA receptors and their subunit composition change with age and visual experience (Choquet, 2010; Goel et al., 2006; Liu and Chen, 2008; Rumpel et al., 1998, 2004). Maturation of GABAergic inhibition is thought to be involved in the onset and termination of visual cortical plasticity

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doi:10.1016/j.brainres.2012.03.062

(Fagiolini and Hensch, 2000; Ferster, 2004; Heinen et al., 2004; Jiang et al., 2005, 2010a, 2010b; Ramoa and Sur, 1996; Rozas et al., 2001).

Dark rearing can change the transmission characteristics of the visual cortex and alter the timing of the critical period of visual development. These findings indicate that the critical period of visual cortex can be postponed or even activated, (Jiang et al., 2005, 2010a, 2010b; Maffei et al., 2006), which has clinical significance for dealing with amblyopia. However, during the critical period of visual development, the transmission characteristics of layer II/III pyramidal cells have not been systematically studied. Here, we focus on the influence of aging and visual experience on the transmission characteristics of layer II/III pyramidal cells by analyzing the features of short-term and long-term synaptic plasticities of normal-reared (NR) and dark-reared (DR) rats. Furthermore, we studied the corresponding characteristics of partial dark-reared rats, which were in normal environments for 5–7 days after 30-day dark rearing (30 D×N), and attempted to investigate the characteristics of the critical period that is delayed by dark rearing.

The visual transmission pathways are specific when receiving visual stimulation (Majewska and Sur, 2006; Watanabe et al., 2005; Reyes et al., 1998). In this pathway, both excitatory and inhibitory afferents were involved, and the stimulation was specific. We used equal size but not the maximum stimulation to evoke EPSCs and IPSCs. The results show that the PPR of evoked EPSCs and IPSCs in normal-reared rats mainly decreased from P16 and P21, and long-term synaptic plasticity also increased during these ages. Dark rearing can delay the above-mentioned phenomenon, and 30 D×N rats can exhibit the same changing trends as P21–P23 NR rats. These results suggested that visual experience but not age is the major influence factor and that dark rearing can postpone the onset of the critical period of visual development. The IPSC/EPSC ratio increased gradually with aging in NR rats but not in DR rats, indicating the relative increase of inhibitory components during the critical period of visual development.

2. Results

To investigate the impacts of visual experience on the transmission characteristics of layer II/III pyramidal cells during the critical period of visual development, we examined the characteristics of short-term and long-term synaptic plasticities of layer II/III pyramidal cells of three rearing conditions. The results are described below.

2.1. *Dark rearing altered the short-term synaptic plasticity characteristics of visual cortical layer II/III pyramidal cells*

To determine the developing characteristics of short-term synaptic plasticity on layer II/III pyramidal cells, we studied the PPR of EPSCs and IPSCs of NR and DR rats in different ages, and 30 D×N rats, PPR is defined as the peak amplitude of

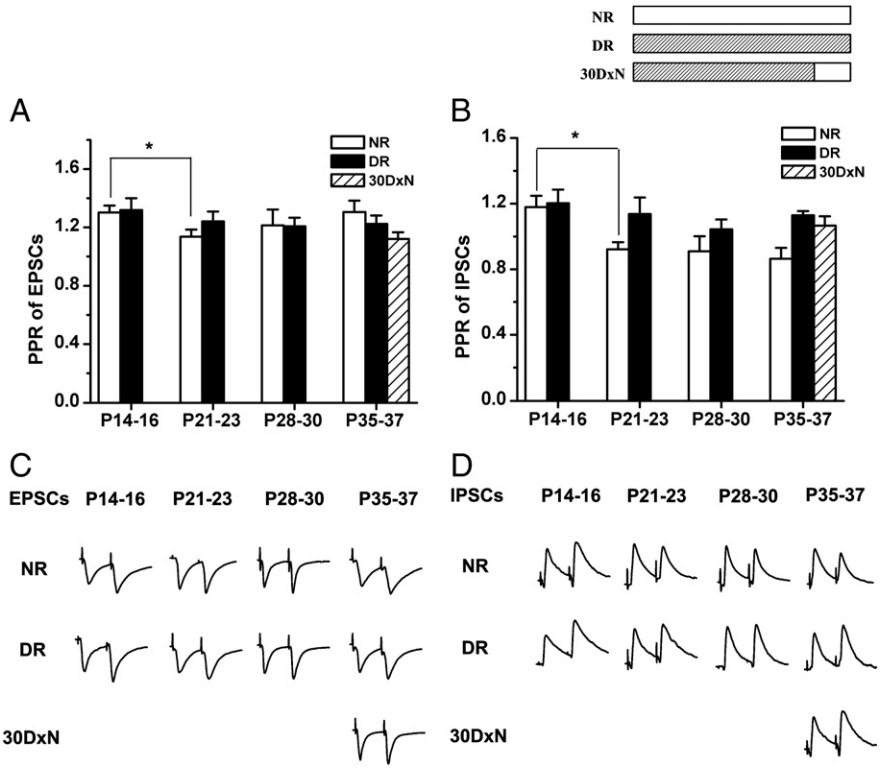

Fig. 1 – The results of short-term synaptic plasticity in different ages and rearing conditions. A: comparison of the PPR of EPSCs in different age groups of NR, DR and 30 D×N rats. B: statistical results of the PPR of IPSCs in different age groups and rearing conditions. C: examples of paired-pulse changes of EPSCs present in various groups. D: examples of paired-pulse changes of IPSCs present in various groups. The upper-right corner of the graph shows the three different rearing conditions that were mentioned in our study. '*', the results have statistically significant difference at the level of 0.05.