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Research report

Electroencephalographic coupling in the amygdala and prefrontal cortex in relation to the estrous cycle and duration of vaginocervical stimulation in the rat

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ABSTRACT

The influence of the duration of vaginocervical stimulation (VCS) on the electroencephalographic activity (EEG) of medial amygdala (MeA) and prefrontal cortex (PFC) in rats during proestrus-estrus (P-E) and diestrus (D) was examined. Using a glass syringe plunger, a constant force of 300 g was exerted against the cervix during 60 s. Relative power (RP) and correlation of three EEG band frequencies were compared between the first and last 30 s intervals of VCS. A higher RP of the 4–7 Hz band and a lower RP of the fast frequencies were observed in the MeA and PFC in P-E females during the first 30 s of VCS as compared to the last 30 s. Only during P-E, a higher interamygdaline correlation in the 8–12 Hz band and a lower correlation in the 13–21 Hz band during the first 30 s were observed. Similarly, a higher interamygdaline correlation in the 8–12 Hz band was observed during the first 30 s of VCS during P-E as compared to D. During the last 30 s of VCS there was no difference between phases. The VCS evoked EEG changes in the MeA that varied between phases of the estrous cycle and depended on the duration of the stimulation. These effects could be associated with the quantification processes of VCS that has been proposed to occur in the amygdala. These findings show differential responsiveness of the MeA and PFC according to the amount of VCS received, and that the response varies according to the estrous cycle.

1. Introduction

Female sexual behavior is influenced not only by gonadal hormones but also by the sensory stimulation that the female receives during mating. In female rats, the somatosensory stimulation generated by vaginocervical stimulation (VCS) produces neuroendocrine changes that contribute to mating-induced potentiation of sexual receptivity (Rodriguez-Sierra et al., 1975), temporary analgesia (Catelli et al., 1987; Gómora et al., 1994), tonic immobilization (Komisaruk et al., 1976), and pseudopregnancy (Berkley et al., 1993; Erskine, 1985; Erskine et al., 1989, 2004; Lehmann and Erskine, 2005). The amount and timing of VCS also contribute to estrus termination (Reading and Blaustein, 1984), and may enhance rejection behavior during mating (Pfaus et al., 2000). Moreover, artificial VCS produces conditioned place preference (Meerts and Clark, 2009a) and has, consequently, rewarding properties.

In addition to the effects of VCS described in the preceding paragraph, this kind of stimulation has short-lived aversive consequences. In tests for copulatory behavior, the female will withdraw from the male for a time determined by the intensity of the VCS received. After an intromission, the female withdraws for a shorter time than after an ejaculation, for example (Coopersmith et al., 1996). This difference disappears after section of the pelvic nerve (Erskine, 1992), the main sensory nerve relaying information from the vaginocervical area to the spinal cord. Thus, while VCS has rewarding properties as shown in the place preference studies already mentioned, it also has aversive consequences. It could, of course, be argued that the avoidance of the male after intromission or ejaculation is caused by reduced motivation to engage in sexual activities rather than by aversive consequences of VCS. The short-lived reduction of sexual motivation

Abbreviations: VCS, vaginocervical stimulation; EEG, electroencephalographic activity; MeA, medial amígdala; PFC, prefrontal cortex; P-E, proestrus-estrus; D, diestrus; RP, Relative power

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would be a consequence of the rewarding effects of sexual interaction. However, section of the pelvic nerve does not reduce the reward value of mating stimuli (Meerts and Clark, 2009b), making the previous argument untenable. It may be more reasonable to propose that VCS is aversive and rewarding at the same time, the former effect causing withdrawal from the male and the latter effect underlying continued copulation. The dual effect of VCS could perhaps be explained by proposing that the aversive effects are transmitted by the pelvic nerve whereas the rewarding effects depend on the vagus nerve. There are some data supporting this proposal (Komisaruk and Whipple, 2000; Komisaruk and Sansone, 2003).

It is most likely that the diffuse central nervous processing of VCS underlies the many, sometimes contradictory, effects of it. In fact, VCS is processed at different levels in the central nervous system. For example, VCS produces an increase in brain glucose utilization (Allen et al., 1981), activation of the immediate early gene c-fos in several

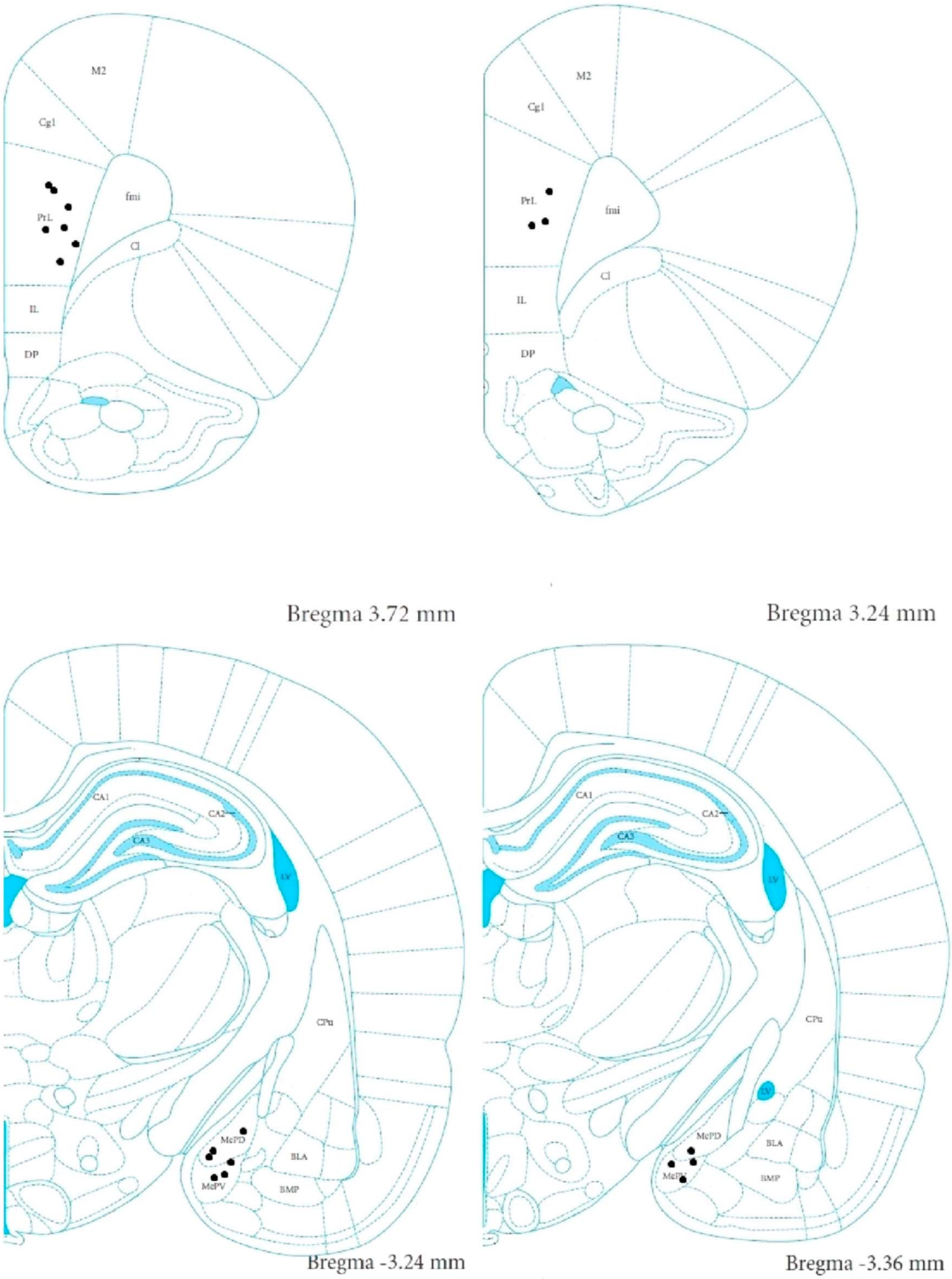

Fig. 1. Schematic representation of electrode tips placements in PFC (A) and MeA (B) (n=10). Anterior-posterior coordinates are given with respect to Bregma.