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# Food competition and social experience effects on $V_{1a}$ receptor binding in the forebrain of male Long–Evans hooded rats

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**Abstract**

The present study investigated the effect of social status in Long–Evans hooded rats established during food competition on $V_{1a}$ vasopressin receptor ($V_{1a}$R) binding in the lateral septum (LS), medial preoptic area (MPOA), bed nucleus of the stria terminalis (BNST), anterior hypothalamus (AH), and central/basolateral amygdala (CeB). Serum concentration of testosterone (T) and corticosterone (CORT) was also measured. In Experiment 1, thirty-two lever-trained weight-matched rat pairs were placed in operant chambers where a single bar press provided access to milk reinforcement. A dominant–subordinate relationship, determined by the duration of drinking, was evident in 88% of the pairs. Sixteen rats were lever-trained but did not interact and served as no-treatment (NT) controls. In the LS, $V_{1a}$R binding in the subordinate (SUB) group was significantly higher than in the dominant (DOM) group. $V_{1a}$R binding was significantly higher in the LS, BNST, CeB, and AH in the NT group than in the other groups. The levels of CORT and T were not affected significantly by group membership. Experiment 2 investigated whether the binding effect in the LS was related to differences in fluid consumption. The results did not indicate a significant effect of fluid consumption. In the rat, $V_{1a}$R binding in several forebrain areas seems to be affected by brief periods of social interactions, and, in the LS, it also appears to be related to dominance status.

*Keywords:* $V_{1a}$ receptor; Vasopressin; Social interaction; Food competition; Lateral septum

## Introduction

Researchers define dominance in terms of the results of competitive tasks involving access to territory, mates, food, or water. In newly formed pairs or groups of animals, agonistic encounters generally bring about a social ranking that reduces conflict, enabling one animal to gain priority access to limited survival and reproductive assets. The resident–intruder (R–I) and colony models are commonly used for social conflict studies with rodents. These models take advantage of rodents' predisposition to defend their territory, mate or litter from intrusions by conspecifics. In both models, social conflict generally yields a winner of agonistic encounters (dominant) and one or more defeated (subordinate) subjects that have little control over the shared environment (see review by Martinez et al., 1998a). Another model involves competition for access to a limited food or water source (Baenninger, 1970; Lanctot and Best, 2000; Lucion and Vogel, 1994). In this food competition model, the definition of dominance is based on the extent of control exerted by an animal over the limited resource, with the animal gaining priority access to the resource being categorized as dominant.

The R–I and colony models have been used to investigate the neurobiological substrates of agonistic behavior and the physiological consequences/correlates of social rank (Martinez et al., 1998a). Data from R–I studies

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indicate that many rodent forebrain areas including the lateral septum (LS), central and basolateral nuclei of the amygdala (CeB), medial preoptic area (MPOA), anterior hypothalamus (AH), and bed nucleus of the stria terminalis (BNST) play a role in social behavior (Kollack-Walker et al., 1999; Kollack-Walker et al., 1997; Martinez et al., 1998a,b). In rodents, many of these brain areas are either sources of vasopressin (VP; De Vries et al., 1985) or are targets of VP fibers (Caffé et al., 1987; De Vries et al., 1985; Ferris and Potegal, 1988; Szot et al., 1994). Centrally released AVP is involved in many social behaviors including affiliation (Young et al., 1999), pair bonding (Winslow et al., 1993), and paternal behavior (Bamshad et al., 1994) in voles; flank-marking (Bamshad and Albers, 1996) and aggression (Ferris et al., 1997) in hamsters; and social recognition (Englemann and Landgraf, 1994; Everts and Koolhaas, 1997) and aggression (Koolhaas et al., 1991) in rats. Of the three subtypes of AVP receptors, the peripheral $V_{1a}$ receptor ($V_{1a}R$) is pharmacologically the most similar to central AVP receptors (Phillips et al., 1988) and the most frequently linked to behavioral effects (Albers et al., 1986; Ferris and Potegal, 1988; Landgraf et al., 2003; Winslow et al., 1993).

There is an extensive literature implicating the septal area in the regulation of various aspects of agonistic behavior in rodents, including aggression and dominant–subordinate relationships (Sheehan and Numan, 2000). For example, electrolytic lesions of the septum of Long–Evans rats reversed dominant status in a food competition setting 1 week and 3 weeks following lesion placement; no status change was seen in septal-lesioned subordinate rats (Costanzo et al., 1977). AVP in the LS appears to be involved in the display of aggression and/or dominance status in rats. Compared to non-aggressive mice, aggressive mice show a higher density of AVP neurons in the BNST (a major source of AVP input into the LS) and of AVP innervation in the LS (Compaan et al., 1993). Similarly, Everts et al. (1997) report a negative correlation between LS AVP content and AVP fiber density and intermale aggression in wild-type rats.

Social defeat and subordination in laboratory rodents have been associated with an increase in circulating levels of glucocorticoids (Huhman et al., 1990, 1991; Pich et al., 1993). Defeat and subordination have also been associated with a decrease in hypothalamic–gonadal axis (HPG) activity that is evidenced by a decrease in leutenizing hormone, follicle-stimulating hormone, and testosterone (Blanchard et al., 1993; Bronson, 1973; Huhman et al., 1991; Schuurman, 1980). In the rat, adrenal steroids may play a role in the regulation of $V_{1a}R$ in several forebrain areas (Watters et al., 1996).

In this study, we used a food competition model to establish a dominant–subordinate relationship in pairs of rats contending for access to a liquid reinforcer. The rat in the pair that gained priority access as determined by the higher duration of drinking (s) was labeled “dominant.” This definition of dominance was used to investigate the relationship between social status and $V_{1a}R$ binding in several areas of the rat brain (AH, BNST, MPOA, LS, and CeB) that have been shown to regulate agonistic behaviors in rodents. Previous literature suggests involvement of septal AVP in the regulation of aggression and/or dominance status, thus, we anticipated differences in $V_{1a}R$ binding between dominant and subordinate rats in the LS. We also explored the relationship between social status and serum concentration of testosterone and corticosterone.

## Materials and methods

### Animals

The subjects were 64 male Long–Evans hooded rats obtained from Charles Rivers Laboratories. They were approximately 90 days old and weighed 300–400 g at the beginning of the study. Subjects were individually housed in hanging cages (17.8 × 24 × 17.8 cm) in the animal facility at Morris Brown College. A 12:12 light–dark cycle with lights off at 19:00 h was in effect in the colony room. The rats were maintained at 95% ± 3% of ad libitum food weight-corrected for growth. Rat chow was given daily between 15:30 and 17:00 h. Water was available ad libitum. The Atlanta University Center Institutional Animal Care and Use Committee approved all procedures and protocols.

### Apparatus

The food competition procedure was carried out in four computer-controlled modular operant conditioning chambers (MED Associates, Inc, ENV-007). Each chamber (interior dimensions: 24.1 × 30.5 × 30.5 cm) was placed inside a ventilated, sound-attenuating box (61 × 61 × 91.5 cm). A dipper was installed on the front wall of the operant chambers to dispense 0.02 ml of the liquid reinforcement (RNF), which was a 3:1 solution of $H_2O$ and sweetened condensed milk. A response lever was located 2.5 cm to the right of the dipper opening. A minimum downward force of approximately 0.2 N operated the lever. Three small stimulus lamps were installed in a row 3 cm above the lever. A house lamp was located on the back wall of the chamber, 1.5 cm below the top of the chamber. The chambers were modified to permit rapid placement and removal of a wire mesh partition. This partition was placed parallel to and 17 cm from the front wall (13.5 cm from the back wall). Separate Plexiglas doors (10 × 20 cm), hinged at the top, were located on one side of the chamber. Rats were inserted into and removed from the chamber through these doors. The opening through which the partition was slid into the chamber was located between the two doors. Programming and data recording equipment were run by MED/PC software (Med Associates, Inc., Version 1.20). Logitech QuickCam Pro 3000 cameras were mounted on the