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Evidence for the Involvement of Two Areas of the Zebra Finch Forebrain in Sexual Imprinting

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Sexual imprinting in male zebra finches is a two-step process, including an acquisition period early in life and a stabilization process normally occuring during the first courtship attempts of the male. During the acquisition period, a young male learns about its social environment. During stabilization, which can be delayed experimentally until day 100, it develops a preference for the appropriate object for courtship behavior on the basis of its previous and acute experience. Thereafter, this preference cannot be altered again. Exploring the physiological basis for imprinting, we have previously shown that the neurons of two forebrain areas (ANC and HAD) increase their spine density in the course of the stabilization process, while in two other areas (MNH and LNH) a decrease of spine density can be observed. With the present experiments, we tested the idea that the spine density decrease in MNH and LNH is the anatomical manifestation of the imprinting process. Previous behavioral experiments have shown that exposure to a nestbox after 100 days of age stabilizes the sexual preference of a zebra finch male as well as does exposure to a female. The present study shows that nestbox exposure also reduces the spine density in MNH and LNH, but has no effect on ANC and HAD. It has also been shown previously that treating males with an antiandrogen between days 40 and 100 affects the final preference of a male. The present experiment indicates that the same treatment affects spine growth during development in MNH and LNH and prevents the increase of spine density within HAD and ANC normally induced by exposure to a female. The results are interpreted as strong evidence for the involvement of MNH and LNH in sexual imprinting. © 2000 Academic Press

Key Words: Golgi; spine density; arousal; cyproterone acetate; testosterone; birds; avian brain; learning.

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INTRODUCTION

Sexual imprinting has been defined as an early learning process by which a young bird learns the characteristics of its prospective sexual partner (Immelmann & Suomi, 1982). We have recently shown in foster raised zebra finches (Bischof & Clayton, 1991; Immelmann, Pröve, Lassek, & Bischof, 1991; Bischof, 1994) that sexual imprinting, like song learning, consists of two different events: During a sensitive period from about days 10 to 35 or 40, a young male bird stores information about its social environment (acquisition period). When the male becomes sexually mature, it starts courting objects which resemble these previously acquired features. This means that there is a preference for courting females of its foster species, but courtship to other species, which are not too different from the foster parents in appearance, is also possible. During the first courtship events, the previously acquired preference is stabilized (it cannot be altered again), if these first courtship bouts are directed to the foster parent species. If the first courtship is directed to females of the bird's own species, the initial preference for the foster species can be modified, such that the bird finally may prefer females of its own species instead of the foster species. (Immelmann et al., 1991; Kruijt & Meeuwissen, 1991, Bischof & Clayton, 1991). In any case, however, the preference of a given bird cannot be altered again after the first exposure to a female. We have shown that this process of stabilization of the previously acquired preference is independent from the acquisition process (Oetting, Pröve, & Bischof, 1995).

In the lab, the stabilization process can be delayed and controlled by isolating birds after they reach independence (at day 40) and by exposing them to a female at day 100. It is therefore possible to examine the effects of the exposure to a female (which leads to stabilization) on the wiring of brain areas which may be involved in the imprinting process. Because the first exposure to a female after isolation from independence is also the first occasion for a young male to show directed courtship behavior, we call this behavioral situation the "first courtship."

Studies with 14C-2-deoxyglucose (Bischof & Herrmann, 1986, 1988) have shown that four areas of the forebrain are strongly activated in the first courtship situation. All of these are not restricted to one morphologically definable region or nucleus (see Fig. 1). HAD (hyperstriatum accessorium/dorsale) is the telencephalic target of the thalamofugal visual projection. While the input layer of this area, IHA (n. intercalatus hyperstriati accessorii), is permanently active (Rollenhagen & Bischof 1996), HA and HD are active only in arousing situations. MNH (medial neo/hyperstriatum) has been shown to receive acoustic information (Bredenkötter and Braun, 1997) and to be involved in acoustic imprinting (Scheich et al., 1991). The song system nucleus mMAN (medial part of n. magnocellularis anterioris neostriatalis) is located in the center of the neostriatal part of this area. It has been shown to undergo changes during song learning similar to those we describe here for sexual imprinting (Nixdorf-Bergweiler et al., 1995; Wallhäusser-Franke et al., 1995). LNH is located dorsolateral to the ectostriatal complex and receives visual information from the ectostriatal belt (Engelage & Bischof, 1996; Sadananda, 1997). It projects to a variety of areas, including the archistriatum. ANC (archi-neostriatum caudale) receives information from many different sources, including the tectofugal visual pathway, and projects, besides other targets, to the optic tectum and motor areas of the brainstem (Zeier & Karten, 1971).

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