HUMAN HYPOTHALAMUS SHOWS DIFFERENTIAL RESPONSES TO BASIC MOTIVATIONAL STIMULI—AN INVASIVE ELECTROPHYSIOLOGY STUDY


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Abstract—The hypothalamus supports basic motivational behaviours such as mating and feeding. Recording directly from the posterior inferior hypothalamus in a male patient receiving a deep brain stimulation (DBS) electrode for the alleviation of cluster headache, we tested the hypothalamic response to different classes of motivational stimuli (sexually relevant: pictures of dressed and undressed women; pictures of food) and pictures of common objects as control. Averaged local field potentials (LFP) to sexually relevant stimuli were characterized by a biphasic response (relative to objects; bootstrapping statistics) with a first phase starting at around 200 ms and a second phase peaking at around 600 ms. Sexually relevant stimuli also showed a greatly enhanced positivity relative to other stimulus classes in surface event-related potentials in a group of 11 male control participants. It is suggested that the hypothalamus is involved in the recruitment of attentional resources by sexually relevant stimuli reflected in this surface positivity. In a second session, the response to food stimuli relative to objects was tested in two states: after fasting for 14 h, LFPs to food and object stimuli showed significant differences in between 300 and 850 ms, which disappeared after a full high-calorie meal, thus replicating classic studies in monkeys [Rolls et al., Brain Res (1976) 111:53–66]. The current data are the first to demonstrate hypothalamic responses to the sight of motivational stimuli in man and thus shows that recording from DBS electrodes might provide important information about the cognitive functions of subcortical structures. © 2011 IBRO. Published by Elsevier Ltd. All rights reserved.

Key words: hypothalamus, local field potentials, invasive recordings, motivational stimuli.

Our brain contains multiple systems that are devoted to basic motivational behaviors, such as mating, ingestion of fluids and food, and defense. In a widely accepted framework Swanson (2000) proposes that interconnected sets of nuclei in the hypothalamus and its brainstem extensions support the elaboration and control of such behaviors. Correspondingly, animals with lesions sparing the hypothalamus eat, drink, reproduce, and show defensive behaviors, while transections below the hypothalamus severally impair these behaviors. The hypothalamus projects widely and indirectly to neocortex and forebrain limbic structures on the one hand and to brainstem motor pattern generators on the other hand (Kelley, 2004; Risold et al., 1997). The former projections may impact higher order behaviors, whereas the latter are responsible for automatic motor actions.

In the human, neuroimaging studies have shown the hypothalamus (together with other structures, such as the periaqueductal gray, and the insula) to be activated by sexually motivating pictures in healthy subjects (Karama et al., 2002; Mouras et al., 2003). Other work has demonstrated a hypothalamic response to food-related stimuli (Cornier et al., 2007; Killgore et al., 2003). For example, in normal volunteers, the hypothalamus showed marked activation to pictures of high calorie compared to low calorie foods suggesting that it is involved in the coding of motivational salience of food stimuli (Killgore et al., 2003).

Thus, there is evidence for an involvement of the hypothalamus in the regulation of reproductive and ingestive behaviors in the human, but owing to the low temporal resolution of imaging techniques the temporal dynamics of its neural responses remain largely unknown. In the present investigation we address these dynamics by recording electrophysiological activity from an electrode located in the posterior inferior hypothalamus (PIH) in an awake human, while he viewed stimuli of motivational content. We took advantage of the fact that deep brain stimulation (DBS) of the PIH has been used in clinical studies for the treatment of chronic cluster headache (CH, (Bussone et al., 2007; Leone, 2006)). CH is defined by severe unilateral headache of acute onset, accompanied by trigeminal autonomic dysfunction such as ipsilateral lacrimation (Headache Classification Committee of the International Headache Society, 2004; May, 2005). It shows striking seasonal variation and a relapsing-remitting course. Positron emission tomography (PET) studies have shown activation of the ipsilateral PIH during attacks (Sprenger et al., 2004; May et al., 1998) and increased grey matter density of the ipsilateral PIH has been described using voxel-based mor-
Mungamdee SS, Baldwin BA, Chindadoungratana C, Kotchabhakdi N (2002) Hypothalamic and zona incerta neurons in sheep, initially only responding to the sight of food, also respond to the sight of water after intracerebroventricular injection of hypertonic saline or angiotensin II. Brain Res 925:204–212.