Please cite this article in press as: Yasoshima Y et al. The basolateral nucleus of the amygdala mediates caloric sugar preference over a non-caloric sweetener in mice. Neuroscience (2015), http://dx.doi.org/10.1016/j.neuroscience.2015.02.009

Neuroscience xxx (2015) xxx–xxx

THE BASOLATERAL NUCLEUS OF THE AMYGDALA MEDIATES CALORIC SUGAR PREFERENCE OVER A NON-CALORIC SWEETENER IN MICE

Y. YASOSHIMA,[a]* H. YOSHIZAWA,[b] T. SHIMURA[a] AND T. MIYAMOTO[b,c]

[a] *Division of Behavioral Physiology, Department of Behavioral Sciences, Graduate School of Human Sciences, Osaka University, 1-2 Yamadaoka, Suita 565-0871, Japan*

[b] *Division of Material and Biological Sciences, Graduate School of Science, Japan Women's University, 2-8-1 Mejirodai, Bunkyo-ku, Tokyo 112-8681, Japan*

[c] *Laboratory of Behavioral Neuroscience, Department of Chemical and Biological Sciences, Faculty of Science, Japan Women's University, 2-8-1 Mejirodai, Bunkyo-ku, Tokyo 112-8681, Japan*

Abstract—Neurobiological and genetic mechanisms underlying increased intake of and preference for nutritive sugars over non-nutritive sweeteners are not fully understood. We examined the roles of subnuclei of the amygdala in the shift in preference for a nutritive sugar. Food-deprived mice alternately received caloric sucrose (1.0 M) on odd-numbered training days and a non-caloric artificial sweetener (2.5 mM saccharin) on even-numbered training days. During training, mice with sham lesions of the basolateral (BLA) or central (CeA) nucleus of the amygdala increased their intake of 1.0 M sucrose, but not saccharin. Trained mice with sham lesions showed a significant shift in preference toward less concentrated sucrose (0.075 M) over the saccharin in a two-bottle choice test, although the mice showed an equivalent preference for these sweeteners before training. No increased intake of or preference for sucrose before and after the alternating training was observed in non-food-deprived mice. Excitotoxic lesions centered in the BLA impaired the increase in 1.0 M sucrose intake and shift in preference toward 0.075 M sucrose over saccharin. Microlesions with iontophoretic excitotoxin injections into the CeA did not block the training-dependent changes. These results suggest that food-deprived animals selectively shift their preference for a caloric sugar over a non-caloric sweetener through the alternate consumption of caloric and non-caloric sweet substances. The present data also suggest that the BLA, but not CeA, plays a role in the selective shift in sweetener preference. © 2015 Published by Elsevier Ltd. on behalf of IBRO.

Key words: amygdala, calorie, food restriction, microlesion, preference shift, sweetener, taste.

INTRODUCTION

Caloric intake from sugar-sweetened foods and liquids in humans has increased for several decades (Saris, 2003; Bellisle and Drewnowski, 2007) despite the development and wide use of non-caloric artificial sweeteners. Increased intake of sweetened foods/fluids can disturb appetite control (Erlanson-Albertsson, 2005; Malik et al., 2006; Malik and Hu, 2012). Consumption of caloric sugar-sweetened beverages has been suggested to be a key factor for increased body weight (Ludwig et al., 2001; Hu, 2013). Moreover, an increased preference for caloric sugars over non-caloric sweeteners may contribute to increased caloric intake derived from caloric sugars in humans. Increased preference for caloric sucrose has been reported in rat studies with experimental manipulations such as stress loading, adrenalectomy, Roux-en-Y gastric bypass, and taste–nutrient learning (Dess, 1992; Sclafani, 1995, 2004; Laugero et al., 2001; Mathes and Spector, 2012; Mathes et al., 2012). However, the neural and behavioral mechanisms underlying shifts in preference for caloric sugars over non-caloric sweeteners remain unclear.

Although many brain areas that regulate taste-processing and feeding behavior may be involved in the sweetener preference shift, we assumed that the amygdala would be critical because of the following reasons: (1) The amygdala plays a role in the association between sensory cues and reinforcers (Balleine and Killcross, 2006; Dwyer and Iordanova, 2010; Mahler and Berridge, 2012) and (2) in the encoding of the reward value of food (Kenny, 2011); (3) the amygdala response to caloric sucrose is altered by habitual consumption of non-caloric sweeteners (Green and Murphy, 2012; Rudenga and Small, 2012). However, in rats, lesions of the whole amygdala fail to disrupt nutrient-conditioned preferences for taste mixture stimuli that are clearly different from each other ('bitter-sweet' versus 'salty-sweet') (Touzani and Sclafani, 2005). In this previous study, the salience of the taste mixtures may be strong

*Corresponding author. Tel: +81-6-6879-8047; fax: +81-6-6879-8049.
E-mail addresses: yasosima@hus.osaka-u.ac.jp (Y. Yasoshima), rukafuku@yahoo.co.jp (H. Yoshizawa), shimura@hus.osaka-u.ac.jp (T. Shimura), tmiyamoto@fc.jwu.ac.jp (T. Miyamoto).

Abbreviations: ANCOVA, analysis of covariance; ANOVA, analyses of variance; AP, anteroposterior; BLA, basolateral nucleus of the amygdala; CeA, central nucleus of the amygdala; DV, dorsoventral; ML, mediolateral; NeuN, neuronal nuclei; PB, phosphate buffer; PBS, phosphate-buffered saline.

http://dx.doi.org/10.1016/j.neuroscience.2015.02.009
0306-4522/© 2015 Published by Elsevier Ltd. on behalf of IBRO.

UNCORRECTED PROOF

enough to be associated with postingestive influences in the absence of amygdala function. It remains unclear whether the amygdala plays a role in the preference shift for a 'simple' oral caloric sucrose cue over that of an equally sweet-tasting non-caloric saccharin cue. The amygdala consists of subnuclei that have different roles. Thus, the question of which subnucleus was dominantly involved in the sweetener preference shift arose. We explored the role of the basolateral nucleus of the amygdala (BLA), because the BLA plays roles in learned preference changes for flavor through flavor–nutrient (Touzani and Sclafani, 2005; Dwyer and Iordanova, 2010) or flavor–taste (Gilbert et al., 2003; Dwyer, 2011) associations. The central nucleus of the amygdala (CeA) plays a role in feeding behavior including unconditioned feeding control (Hajnal et al., 1992; Bovetto and Richard, 1995) and an unconditioned preference–aversion shift toward a highly concentrated sodium solution in sodium-depleted animals (Galaverna et al., 1993). The CeA also has a relatively weaker contribution to flavor–nutrient learning (Touzani et al., 2009). To evaluate the roles of these subnuclei, we compared the effects of selective lesions of the BLA and CeA on the sweetener preference shift. For selective lesions of the CeA, we used a well-controlled microlesioning technique (Hernadi et al., 2000) to minimize and localize the lesioned area while preserving the BLA.

To examine the roles of the BLA and CeA, we used a novel behavioral model of the sweetener preference shift in mice. To develop the sweetener preference shift in the model, we selected an oral-simultaneous training method, i.e., alternating oral delivery of caloric sucrose and non-caloric saccharin (cf. Sclafani, 1995; Dwyer and Iordanova, 2010). During training, mice received both oral (e.g., sweet taste) and post-oral (postingestive consequences) cues that normally occur after the intake of each sweetener. To evaluate the effect of energetic state on the intake of and preference for the sweeteners (Sclafani, 1991; Sclafani and Ackroff, 1993), we first compared sweetener preferences between the two groups of mice in the presence or absence of food access prior to sweetener access.

We used the well-studied sweet-sensitive C57BL/6J (B6) mouse strain (Bachmanov et al., 2001; Sclafani and Glendinning, 2003; Glendinning et al., 2005; Pinhas et al., 2012). Since B6 mice are widely used as a control strain in transgenic mouse studies (e.g., de Araujo et al., 2008; Stratford and Finger, 2011), the behavioral model used herein is applicable to transgenic strains for the investigation of neurobiological and genetic mechanisms.

EXPERIMENTAL PROCEDURES

Animals

C57BL/6J male mice (10–12 weeks-old, weighing 18–20 g at the start of the study; $n = 50$) were obtained from CREA Japan (Osaka, Japan). Mice were divided into two groups: those receiving chow for only 4 h per day (Chow4h) ($n = 41$) or 20 h per day (Chow20h) ($n = 9$). A pellet diet (MF; Oriental Yeast, Japan) was delivered as normal chow. Seven days after arrival at our laboratory, mice were subjected to the experimental procedures described below. All behavioral procedures were conducted in their home cages. Mice were individually housed in transparent plastic cages at 23 °C (60% humidity) under a 12-h-light/dark cycle, with lights on at 07:00 h. Water and food were available *ad libitum* unless otherwise indicated. Behavioral manipulations were performed during the light cycle after at least 7 days of acclimation to the laboratory environment. Mice were treated in accordance with the Guidelines for the Care and Use of Laboratory Animals (National Institute of Health, 1985) and the Guiding Principles for the Care and Use of Animals in the Field of Physiological Sciences (Physiological Science of Japan, 2003). All procedures were approved by the Animal Experiment Committees of Japan Women's University and Graduate School of Human Sciences, Osaka University. All efforts were made to minimize the number of animals used and their discomfort.

Training with an alternating oral delivery method

All procedures were conducted in the animal's home cage. All animals were first placed on a water-restricted schedule with *ad libitum* food access (bottle habituation). To adjust the motivation to consume a given sweetener solution at the time of access (09:00), all mice were placed on a water restricted schedule and habituated to scheduled liquid consumption before oral-simultaneous training.

Fig. 1 summarizes an outline of the behavioral procedures. All mice underwent a habituation period (4–7 days) for the 10-min access to water delivered via two bottles at 09:00 under water-deprivation conditions (14:00–09:00 the next day) with *ad libitum* chow access. To avoid dehydration, mice received additional exposure to water for 1 h from 13:00 to 14:00. The left/right positions of these bottles during habituation periods were alternated every 2 min. After habituation, mice were divided into two groups named according to length of food availability (4 h and 20 h) as Chow4h and Chow20h groups. To maximize the effect of postingestive influences after sucrose intake, mice in the Chow4h group ($n = 10$) received only 4 h (13:00–17:00) of access to normal chow after sucrose access under the 20-h food-deprivation schedule (17:00–13:00 the next day). To minimize the effects of sucrose-induced postingestive influences, mice in Chow20h group ($n = 9$) received nocturnal chow access prior to sucrose access with 4-h food deprivation (09:00–13:00). In Chow4h groups, mice were placed on the food- and water-deprivation schedule for 5 days (pretraining) to adapt to the food-deprivation regimen. Basal water intake before the oral-simultaneous training was calculated by monitoring water intake over the last 3 days of the pretraining period.

After all mice in the Chow4h and Chow20h groups demonstrated a stable water intake during the 10-min period, they received a brief (10 min) two-bottle choice preference test (pre-test) with 0.075 M sucrose versus 2.5 mM saccharin. Intake of each solution was measured. To determine equivalent unconditioned

UNCORRECTED PROOF

Please cite this article in press as: Yasoshima Y et al. The basolateral nucleus of the amygdala mediates caloric sugar preference over a non-caloric sweetener in mice. Neuroscience (2015), http://dx.doi.org/10.1016/j.neuroscience.2015.02.009

Download English Version:

https://daneshyari.com/en/article/6272759

Download Persian Version:

https://daneshyari.com/article/6272759

Daneshyari.com