Feeding behavior

Taste/odor sensat

Proceedings of the International Symposium on Neuroscience in Orofacial sensory–motor functions 2015

May 10th–11th, 2015,
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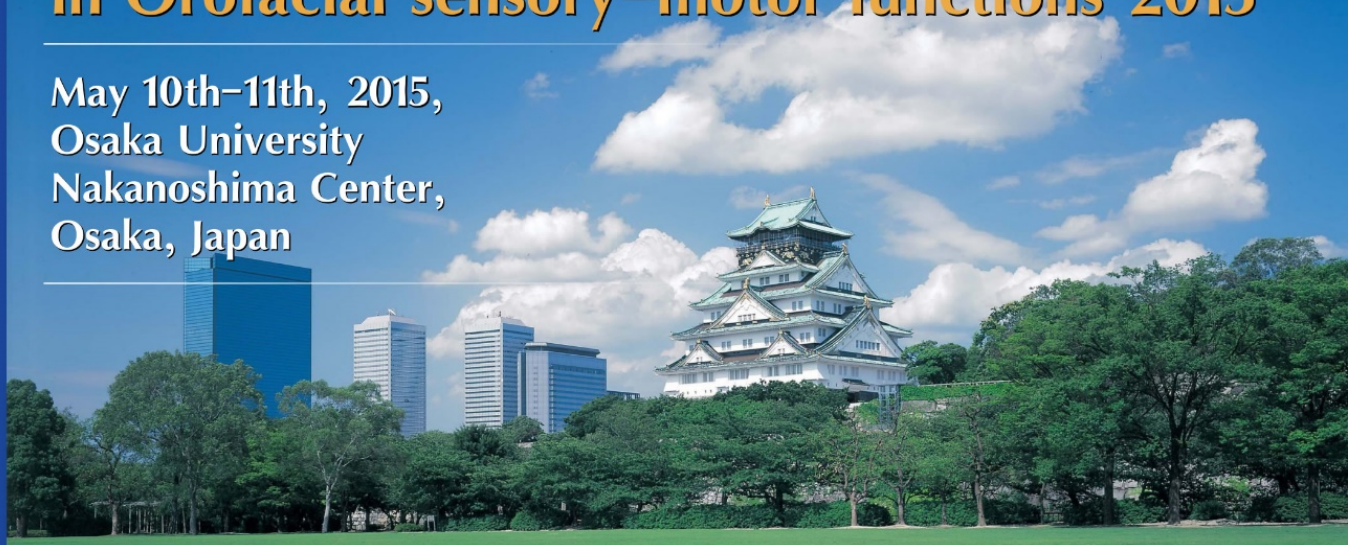

Mikihiko Kogo, Ph.D., D.D.S. and Youngnam Kang, Ph.D., D.D.S.
Co-presidents of the Organizing Committee of
the International Symposium on Neuroscience in Orofacial sensory–motor functions 2015

Mastication

Orofacial pain

Program: Sunday, May 10th

Symposium at Saji Keizo Hall (10F) / Poster presentations at Salon de l'Amical (9F)

Time	Title & Speaker
08:30– 08:45	(Poster posting)
08:45– 08:50	**Opening remarks** Youngnam Kang, Co-president of the Organizing Committee of the ISNO2015
Session 1	Chair person: Youngnam Kang, Professor, Osaka Univ. Grad. Sch. Dent.
08:50– 09:30	**1S-1: Cerebral cortical descending pathways modulating orofacial sensory processing in the rat trigeminal sensory nuclear complex** Atsushi Yoshida, Professor, Osaka Univ. Grad. Sch. Dent.
09:30– 10:10	**1S-2: Premotoneuronal inputs and dendritic responses in trigeminal motoneurons** Tomio Inoue, Professor, Showa Univ. Sch. Dent.
Session 2	Chair person: Mikihiko Kogo, Professor, Osaka Univ. Grad. Sch. Dent.
10:15– 10:55	**1S-3: Ionic mechanisms for switching the firing mode between a train of single spikes and bursting in mesencephalic trigeminal sensory neurons** Youngnam Kang, Professor, Osaka Univ. Grad. Sch. Dent.
10:55– 12:10	**1S-4: Ion channels: The little engines for mastication** Scott H. Chandler, Professor, David Geffen Sch. Med., UCLA
12:10– 13:20	Buffet lunch (free) & Poster discussion
Session 3	Chair person: Koichi Iwata, Professor, Nihon Univ. Sch. Dent.
13:20– 14:10	**1S-5: Targeting trigeminal neuropathic pain and tooth pain: From mechanisms to therapeutics** Seog Bae Oh, Professor, Dent. Res. Inst., Seoul National Univ.
14:10– 15:00	**1S-6: Chronic pain in dentistry: Can it be predicted or prevented?** Dong-Kuk Ahn, Professor, Sch. Dent., Kyungpook National Univ.
Session 4	Chair person: Tomio Inoue, Professor, Showa Univ. Sch. Dent.
15:05– 15:55	**1S-7: T1r-independent mechanisms may function in taste cell to detect sugars** Yuzo Ninomiya, Professor, Grad. Sch. Dent. Scis., Kyushu Univ.
15:55– 16:35	**1S-8: Behavior of non-neuronal cells in the trigeminal ganglion following peripheral nerve injury** Satoshi Wakisaka, Professor, Osaka Univ. Grad. Sch. Dent.
16:35– 17:55	Poster discussion

Program: Monday, May 11th

Symposium at Room 703 (7F) / Poster presentations at Salon de l'Amical (9F)

Time	Title & Speaker
Session 5	Chair person: Yoshinori Sahara, Professor, Sch. Dent., Iwate Med. Univ.
08:45–09:25	**2S-1: PRIP regulates feeding behavior and energy metabolism** Takashi Kanematsu, Professor, Inst. Biomed. Health Scis., Hiroshima Univ.
09:25–10:05	**2S-2: Prenatal drug exposure and brain pathology in developmental disorders** Kazuhiro Takuma, Professor, Osaka Univ. Grad. Sch. Dent.
Session 6	Chair person: Yuzo Ninomiya, Professor, Grad. Sch. Dent. Scis., Kyushu Univ.
10:10–10:50	**2S-3: Convergence of gustatory and olfactory information in the endopiriform nucleus of rats** Hiroshi Yoshimura, Professor, Univ. Tokushima Grad. Sch.
10:50–11:30	**2S-4: Exploration of human brain region relevant to odor stimulus by using ultra-high (7 Tesla) MRI** Yoshinori Sahara, Professor, Sch. Dent., Iwate Med. Univ.
11:30–12:40	Buffet lunch (free) & Poster discussion
Session 7	Chair person: Hiroshi Yoshimura, Professor, Univ. Tokushima Grad. Sch.
12:40–13:20	**2S-5: Electrophysiological properties of P-type Ca^{2+} channel in Purkinje cells dissociated from three types of tottering mice** Minoru Wakamori, Professor, Grad. Sch. Dent., Tohoku Univ.
13:20–14:00	**2S-6: Alveolar nerve injury changes topographical organization in the insular cortex in rats** Masayuki Kobayashi, Associate Professor, Nihon Univ. Sch. Dent.
Session 8	Chair person: Minoru Wakamori, Professor, Grad. Sch. Dent., Tohoku Univ.
14:05–14:45	**2S-7: The orexigenic neuropeptides modulate the masticatory muscle activities and trigeminal sensorimotor neuronal excitabilities** Susumu Tanaka, Assistant Professor, Osaka Univ. Grad. Sch. Dent.
14:45–15:25	**2S-8: Morphological and electrophysiological properties of trigeminal α- and γ-motoneurons** Mitsuru Saito, Assistant Professor, Osaka Univ. Grad. Sch. Dent.
Session 9	Chair person: Atsushi Yoshida, Professor, Osaka Univ. Grad. Sch. Dent.
15:30–16:10	**2S-9: The role of TASK channels in rank-ordered recruitment of trigeminal jaw-closing motoneurons** Hiroki Toyoda, Associate Professor, Osaka Univ. Grad. Sch. Dent.
16:10–16:50	**2S-10: Subthreshold and resurgent sodium currents in burst generation in mesencephalic V neurons** Akifumi Enomoto, Assistant Professor, Kinki Univ. Sch. Med.
16:50–16:55	**Closing remarks** Atsushi Yoshida, Professor, Osaka Univ. Grad. Sch. Dent.
16:55–17:00	(Poster removal)

Poster presentations (Only the first author is indicated.)

Feeding behavior

P-1: Postprandial feeding cessation system mediated by peptide YY is blunted in mice showing binge-like overconsumption. Erina Yamaguchi (Grad. Sch. Human Scis., Osaka Univ.)

P-2: Distinct involvements of the rostral and caudal parts of rat basolateral amygdala in the retrieval of conditioned taste aversion.
Tadashi Inui (Grad. Sch. Human Scis., Osaka Univ.)

P-3: Lesions of the insular cortex, but not gustatory thalamus, enhance binge-like sugar overconsumption in mice. Yasunobu Yasoshima (Grad. Sch. Human Scis., Osaka Univ.)

P-4: The olfactory stimulus of *Osmanthus fragrans* changes the masticatory pattern.
Tadataka Tsuji (Osaka Univ. Grad. Sch. Dent.)

P-5: Anandamide-induced network oscillation in the insular cortex implicated in taste-driven feeding.
Hajime Sato (Osaka Univ. Grad. Sch. Dent.)

Mastication (1)

P-6: Glutamatergic responses in rat developing jaw-closing motoneuron dendrites.
Shiro Nakamura (Showa Univ. Sch. Dent.)

P-7: Projection from lateral habenula to trigeminal mesencephalic nucleus and its function.
Haruka Ohara (Osaka Univ. Grad. Sch. Dent.)

P-8: Locus coeruleus modulates proprioceptive trigeminal neuron activity by inhibiting hyperpolarization-activated current.
Jonghwa Won (Seoul National Univ.)

P-9: The cryo-preserved nerve graft on inferior alveolar nerve. Akira Ito (Osaka Univ. Grad. Sch. Dent.)

Taste/odor sensation

P-10: The neural mechanisms underlying the perception of burning taste of capsaicin and subsequent autonomic responses.
Shinpei Kawakami (Osaka Univ. Grad. Sch. Dent.; Morinaga & Co., Ltd.)

Orofacial pain

P-11: Involvement of endothelin in tongue-cancer pain relief at early stage in rats.
Akihiko Furukawa (Nihon Univ. Sch. Dent.)

Mastication (2)

P-12: Modulation of TASK Currents by the activity of cGMP-dependent protein kinase.
Chie Tanaka (Osaka Univ. Grad. Sch. Dent.)

P-13: Central processing of masticatory muscle sensation.
Takashi Fujio (Osaka Univ. Grad. Sch. Dent.)

P-14: Neuropeptide Y modulates the spike discharge characteristics in mesencephalic trigeminal neurons.
Soju Seki (Osaka Univ. Grad. Sch. Dent.)

P-15: Reduced mastication impairs spatial memory in young zinc-deficient mice.
Kumiko Kida (Osaka Univ. Grad. Sch. Dent.)

P-16: PSD-95 protein expression in rat oro-maxillofacial motoneurons during postnatal development. Akira Tanaka (Osaka Univ. Grad. Sch. Dent.; Yukoukai General Hospital)

Others

P-17: Behavior of glial cells in trigeminal motor nucleus following peripheral axotomy of the masseteric nerve of the rat.
Hide Ogura (Osaka Univ. Grad. Sch. Dent.)

P-18: Enhanced SOCE in layer 3 pyramidal cells in the barrel cortex of PRIP-1/2 double KO mice.
Tsutomu Kawano (Osaka Univ. Grad. Sch. Dent.)

P-19: The synchronous oscillations in the rat barrel cortex mediated by kainic acid.
Dong Xu Yin (Osaka Univ. Grad. Sch. Dent.)

Symposium, 1S-1 (08:50–09:30, May 10th; Saji Keizo Hall)

Cerebral cortical descending pathways modulating orofacial sensory processing in the rat trigeminal sensory nuclear complex

Atsushi Yoshida, Fumihiko Sato and Takafumi Kato

Department of Oral Anatomy and Neurobiology, Osaka University Graduate School of Dentistry, Suita, Osaka, Japan

Orofacial sensations are conveyed to the trigeminal sensory nuclear complex (TSNC). Subsequently, in lateral system, they are conveyed to the lateral thalamus and then to the somatosensory cortex which is involved in the sensory discrimination, but, in medial system, they are conveyed to the medial thalamus and then to the prefrontal cortex which is involved in the sensory-related emotion and autonomic function. However, little is known about the corticofugal descending projections to the TSNC. To address this issue, we employed neuronal tract tracings in rats. The orofacial areas of the primary and secondary somatosensory cortex (S1 and S2) which were electrophysiologically identified projected to almost all rostrocaudal levels of TSNC. However, the projections from the S2 orofacial area to the trigeminal interpolar subnucleus were weaker. Whereas, the orofacial areas of the prefrontal cortex were identified as the areas projecting to the TSNC. The granular and dysgranular insular cortex projected to superficial layers of the trigeminal caudal subnucleus (Vc) and trigeminal oral subnucleus. The dorsal peduncular cortex projected only to the rostro-dorsomedial part of superficial layers of the Vc. Our findings suggest that the somatosensory cortex and prefrontal cortex modulate orofacial sensory processing in the TSNC in distinct neuronal mechanisms.

Symposium, 1S-2 (9:30–10:10, May 10th; Saji Keizo Hall)

Premotoneuronal inputs and dendritic responses in trigeminal motoneurons

Tomio Inoue

Department of Oral Physiology, Showa University School of Dentistry, Tokyo, Japan

Feeding is one of the most important survival functions for mammals. To understand neural mechanisms underlying jaw motor function during feeding, we examined electrophysiological and morphological properties of premotor neurons targeting jaw-muscle motoneurons, and postsynaptic responses in jaw-muscle motoneurons in brainstem slice preparations obtained from P1–12 neonatal rats using whole-cell recordings and laser photolysis of caged glutamate. Premotor neurons were detected on the basis of antidromic responses to stimulation of the trigeminal motor nucleus (MoV) using Ca^{2+} imaging, which were divided into 2 groups: those firing at higher (HF neurons) or lower (LF neurons) frequency. Intracellular labeling revealed that the morphologies of axons and dendrites were different between HL and LF neurons. Laser uncaging of glutamate in the area where the premotor neurons were located induced postsynaptic responses in the motoneurons. Focal uncaging of glutamate in the dendrite of a jaw-closing motoneuron evoked a dendritic NMDA spike P2–5 rats. These results suggest that the premotor neurons targeting the MoV with different firing properties have different dendritic and axonal morphologies, and dendritic NMDA spikes may contribute to boosting of postsynaptic responses. These premotor neuron classes and dendritic properties of motoneurons may play distinctive roles in suckling and chewing.

Symposium, 1S-3 (10:15–10:55, May 10th; Saji Keizo Hall)

Ionic mechanisms for switching the firing mode between a train of single spikes and bursting in mesencephalic trigeminal sensory neurons

Youngnam Kang[1], Mitsuru Saito[1], Gehoon Chung[1,3], Yasuhiro Kawasaki[1,2], Mikihiko Kogo[2], Seog Bae Oh[3] and Yong Chul Bae[4]

[1]Department of Neuroscience and Oral Physiology, Osaka University Graduate School of Dentistry, Suita, Osaka, Japan; [2]First Department of Oral and Maxillofacial Surgery, Osaka University Graduate School of Dentistry, Suita, Osaka, Japan; [3]Pain Cognitive Function Research Center, Dental Research Institute and Department of Neurobiology and Physiology, School of Dentistry, Seoul National University, Seoul, Republic of Korea; [4]Department of Oral Anatomy, School of Dentistry, Kyungpook National University, Daegu, Republic of Korea

The primary sensory neurons in the mesencephalic trigeminal nucleus (MTN) display bursting upon activation of glutamatergic synaptic inputs while they faithfully relay respective spikes arising from peripheral sensory organs. Such bursts were found to be generated by the persistent sodium current (I_{NaP}). However, the ionic mechanisms for switching the firing mode between a train of single spikes and bursting are not well understood. We have been studying this question for a decade. First, we demonstrated that the spike-initiation occurred in the stem axon through activation of I_{NaP}. 4-AP-sensitive K^+ current expressed in the soma suppressed the spike generation by synaptic inputs whereas it facilitated axonal spike invasion at higher frequencies by decreasing the spike duration. Next, we found that mGluR1/5 and Nav1.6 are co-localized in the stem axon on which glutamatergic synapses are made, and the enhancement of resonance-dependent oscillation through the upregulation of INaP by mGluR1/5 activation switches single spiking to bursting. Finally, we found that AMPA-receptor current is attenuated by activation of HCN channels through the interaction between AMPA-receptors and HCN channels in the Na^+ microdomain created in the microvilli which cover all the soma of MTN neurons. These mechanisms underlie the firing mode switching in MTN neurons.

Symposium, 1S-4 (10:55–12:10, May 10th; Saji Keizo Hall)

Ion channels: The little engines for mastication

Scott H. Chandler

Departments of Integrative Biology and Physiology, University of California at Los Angeles, Los Angeles, California, USA

Ion channels are essential proteins for cellular processes and life as we know it. In neurons they are what drive all chemical and electrical signaling. They are responsible for detecting the sound of a loud drum during a concert, and the taste of sweet candy. They guide the pianist hand to the proper keys and allow for the effortless movement of our jaws during eating fine food. We are now beginning to understand the varied types of ion channels and how they are used to produce numerous discharge patterns in neurons that underlie particular behaviors. A hallmark signature of smooth oral-motor activity is rhythmical burst discharge in certain trigeminal sensory neurons, and motoneurons, as well as interneurons. Although our knowledge of the precise synaptic connectivity within the pattern generating circuits for mastication is not known, we are starting to understand the cellular processes responsible for burst pattern generation. In this presentation, I will discuss the cellular mechanisms underlying burst discharge in motoneurons, Mesencephalic V and trigeminal interneurons involved in oral-motor function. Finally, we will present some new data on changes in discharge and membrane properties that occur in a devastating, terminal disease, Amyotrophic Lateral Sclerosis using a transgenic mouse model.

Symposium, 1S-5 (13:20–14:10, May 10th; Saji Keizo Hall)

Targeting trigeminal neuropathic pain and tooth pain: From mechanisms to therapeutics

Seog Bae Oh

Pain Cognitive Function Research Center, Dental Research Institute and Department of Neurobiology and Physiology, School of Dentistry, Seoul National University, Seoul, Republic of Korea

Neuropathic pain and tooth pain are two main types of pain frequently observed in the trigeminal system. However, their underlying molecular and cellular mechanisms are not fully understood yet. In this talk, I will discuss roles of glial cells in trigeminal neuropathic pain, and TRP channels in dental pain. We employed inferior alveolar nerve transection or infraorbital nerve-chronic construction injury in adult rats for trigeminal neuropathic pain models, and investigated how microglial activation in medullary dorsal horn contributes to development of neuropathic pain. For dental pain, temperature-sensitive and/or mechano-sensitive TRP channels expressed on dental primary afferent fibers might play a critical role, and it is possible that dental pain could be controlled by targeting TRP channels with the combination of an appropriate TRP agonist and QX-314, a permanently charged membrane impermeant sodium channel blocker. With this combination approach, we found that TRPV1-expressing nociceptive fibers were selectively silenced by QX-314 delivered into the cells through TRPV1, which may provide an effective local anesthetic option for dental patients in the clinic. Currently, we are studying electrophysiological properties of medullary dorsal horn microglia and also trying to identify low-threshold mechanoreceptors expressed by dental primary afferent fibers.

Symposium, 1S-6 (14:10–15:00, May 10th; Saji Keizo Hall)

Chronic pain in dentistry: Can it be predicted or prevented?

Dong-Kuk Ahn

Department of Oral Physiology, School of Dentistry, Kyungpook National University, Daegu, Republic of Korea

It has been well known that acute post-operative pain is strongly correlated with chronic post-operative pain in the previous clinical studies. The present study demonstrated that central transitional mechanisms from acute to chronic pain. Especially the present data showed important roles of glia cells involved in the development of chronic pain conditions. Previous pain experience produced a glia cell activation resulted in the central sensitization. Moreover, a glial cell activation plays a role of key factor in the transition to chronic pain condition. QX314-induced long lasting preemptive analgesia produces inhibition of development of neuropathic pain through a regulation of the satellite glial cells and neuronal p-p38 expression in the trigeminal ganglion. Importantly, these results provide a potential preemptive therapeutic strategy for the treatment of neuropathic pain following nerve injury. In the further experiment, we investigated the antinociceptive effects of botulinum toxin type A (BoNT-A) in a rat model of trigeminal inflammatory and neuropathic pain. The present data provide possible mechanisms involved in BoNT-A-induced anti-nociception. These results suggest a potential new therapeutic strategy for treatment of chronic trigeminal pain.

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Symposium, 1S-7 (15:05–15:55, May 10th; Saji Keizo Hall)

T1r-independent mechanisms may function in taste cell to detect sugars

Yuzo Ninomiya[1,2,3], Shusuke Iwata[1], Keiko Yasumatsu[2], Ryusuke Yoshida[1], Robert F. Margolskee[3] and Noriatsu Shigemura[1]

[1]Section of Oral Neuroscience, Graduate School of Dental Sciences, Kyushu University, Fukuoka, Japan; [2]Division of Sensory Physiology, Research and Development Center for Taste and Odor Sensing, Kyushu University, Fukuoka, Japan; [3]Monell Chemical Senses Center, Philadelphia, Pennsylvania, USA

The major sweet receptor in mammalian taste cells for sugars and non-caloric sweeteners is the heteromeric combination of type 1 taste receptors 2 and 3 (T1r2+T1r3). Yet, in the absence of T1r2+T1r3, T1r-independent mechanisms may function in taste cells to detect sugars. Recently, several glucose transporters (GLUTs), sodium-glucose cotransporter 1 (SGLT1) and the ATP-gated K^+ metabolic sensor are reported to be preferentially expressed in taste cells with T1r3, suggesting existence of two sweet-sensing pathways: T1r-dependent and -independent mechanisms. However, the T1r-independent pathway would only explain responses to monosaccharides such as glucose, fructose and galactose, but not to disaccharide sugars (e.g., sucrose and maltose) that are not substrates for GLUTs or SGLT1. So, we tested if multiple carbohydrate-hydrolyzing enzymes known to be present in the intestinal "brush border" and to function during digestion would be expressed also in taste cells. Then, our RT-PCR and histochemical studies showed expression of neutral alpha-glucosidase C, maltase-glucoamylase and sucrase-isomaltase in taste cells. Our electrophysiological study demonstrated that treating the tongue with inhibitors of disaccharidases specifically decreased gustatory nerve responses to disaccharides but not to monosaccharides or to non-caloric sweeteners. This suggests that taste-expressed enzymes may locally produce monosaccharides to serve as substrates for the T1r-independent sugar sensing pathway.

Symposium, 1S-8 (15:55–16:35, May 10th; Saji Keizo Hall)

Behavior of non-neuronal cells in the trigeminal ganglion following peripheral nerve injury

Satoshi Wakisaka[1], Kohki Kadono[1], Akiyo Kawano[1] and Shiho Honma[1,2]

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Recent studies suggest that neuron-glia interaction is one of the important factors for abnormal sensations evoked by nerve injury. In the peripheral nervous system, there are two types of glial cells, namely satellite cells (SC) and Schwann cells. Based on the functional and biochemical similarities, SC and Schwann cells resemble astrocytes and oligodendrocytes, respectively. It is unknown, however, whether cells similar to microglia are present in the peripheral nervous system. Thus we investigated the behavior of SG and cells immunoreactive for Iba1 (Iba1-IR), a marker for microglia, in the trigeminal ganglion (TG). In the normal TG, neurons were surrounded with SC closely and smoothly. Iba1-IR cells were ovoid in shape having short processes, and localized along the SC. Following mental nerve injury, membrane of TG neurons became irregular, and the space between SC and TG neurons was expanded. Iba1-IR cells increased in number in the mandibular portion of TG, and extended thin process along the SC. When injury was severe, Iba1-IR cells invaded the expanded space between SC and injured neurons. The present results suggest that Iba1-IR cells in TG have phagocytotic function following nerve injury similar to microglia.

Symposium, 2S-1 (08:45–09:25, May 11th; Room 703)

PRIP regulates feeding behavior and energy metabolism

Takashi Kanematsu and Kana Oue

Department of Cellular and Molecular Pharmacology, Institute of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan

Feeding behavior is regulated by hypothalamic AgRP neurons that release gamma-aminobutyric acid (GABA) in the parabrachial nucleus and paraventricular hypothalamus. It is known that the activation of AgRP neurons increases feeding. We reported that phospholipase C-related catalytically inactive protein (PRIP) is a modulator for $GABA_A$ receptor signaling, and PRIP knockout (*Prip*-KO) mice show the upregulation of $GABA_A$ receptor activity and food intake. However, *Prip*-KO mice displayed a lean phenotype. Therefore, we examined total energy expenditure to explain the phenotype using high-fat diet (HFD)-fed mice. The *Prip*-KO mice showed resistance to HFD-induced obesity in spite of more food intake. Energy expenditure and body temperature were significantly increased in the *Prip*-KO mice compared with wild-type mice. Expression and activity of uncoupling protein 1, a thermogenic protein, was upregulated in *Prip*-KO brown adipocytes, which was triggered by the promotion of β-adrenergic receptor-mediated lipolysis. The results indicate that PRIP is a modulator for fat lipolysis and thermogenesis in adipocytes, and thus PRIP silencing may be an anti-obesity therapy. Further comprehensive studies regarding PRIP signaling will help a better understanding of the etiopathology of obesity and feeding behavior, contributing to the potential development of new therapeutic targets aimed at tackling excess body fat accumulation.

Symposium, 2S-2 (09:25–10:05, May 11th; Room 703)

Prenatal drug exposure and brain pathology in developmental disorders

Kazuhiro Takuma[1,2,3], Shigeru Hasebe[1,2], Yukio Ago[2] and Toshio Matsuda[2,3]

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Clinical studies over the past 40 years have shown that prenatal exposure to drugs is associated with birth defects, cognitive deficits, and increased risk of autism spectrum disorders (ASD), which are classified as neurodevelopmental disorders. We have recently demonstrated that prenatal exposure to valproic acid (VPA), a major antiepileptic drug, caused ASD-like behavioral abnormalities, such as impaired social interaction and anxiety, in mice (*Int. J. Neuropsychopharmacol.* 2013). We have also found an increase in apoptotic cell death in the neocortex and a decrease in cell proliferation in the ganglionic eminence within 24 h after VPA exposure, and the Nissl-positive cell loss in the cortical cell layers at young-adult age in the prenatal VPA-induced ASD mouse model. The present review summarizes the roles of brain pathology in the pathogenesis of developmental disorders, focused on our recent *in vivo* findings on prefrontal cortical dopaminergic dysfunction and dendrite spine loss in the hippocampus of ASD mouse model. Furthermore, we present our recent *in vitro* findings suggesting the involvement of disrupted neuronal maturation in prenatal VPA-mediated ASD pathology.

Symposium, 2S-3 (10:10–10:50, May 11th; Room 703)

Convergence of gustatory and olfactory information in the endopiriform nucleus of rats

Hiroshi Yoshimura

Department of Molecular Oral Physiology, Institute of Biomedical sciences, Tokushima University Graduate School, Tokushima, Japan

The integration mechanism of gustatory and olfactory information is not well understood. The region around the middle cerebral artery in the insular cortex (IC) is primary cortical site devoted to gustatory information processing. The piriform cortex (PC) is the largest cortical area involved in olfactory perception. The endopiriform nucleus (EPN) located in the depth of the PC is one of the candidate sites where gustatory and olfactory information converge, since the EPN is anatomically connected with the gustatory and olfactory cortices. Recently, we reported that the EPN neurons receive voltage signal from the gustatory IC, and also receive signal from the PC of rat brain slices. Optical recording methods with voltage sensitive dye enabled us to observe these neural activities. Furthermore, unit recordings from anesthetized rats reveled that many neurons in the EPN respond to both gustatory and odor stimulation. These results suggest that gustatory information from the IC is transmitted to the EPN, and integrated with olfactory information transmitted from the PC. Since the EPN is connected with the limbic system, the cortical integration of gustatory and olfactory information may modulate mechanisms involved in emotional reactions relating to the chemical senses.

Symposium, 2S-4 (10:50–11:30, May 11th; Room 703)

Exploration of human brain region relevant to odor stimulus by using ultra-high (7 Tesla) MRI

Yoshinori Sahara, Hideyuki Fukami, Sawa Horie, Satomi Higuchi and Makoto Sasaki

Department of Physiology, School of Dentistry and Division of Ultrahigh Field MRI, Institute for Biomedical Sciences, Iwate Medical University, Morioka, Iwate, Japan

Functional magnetic resonance imaging (fMRI) makes considerable advances in understanding the central neural mechanism of olfaction in human; fMRI experiments have shown that 1) odor coding is functionally dissociable in the piriform subregions; and 2) odorant identity, the composite sum of an odorant's molecular and chemical constituents, is encoded in the anterior piriform cortex, where signal fidelity of the original stimulus can be preserved. In most olfactory fMRI studies, however, piriform cortex showed inconsistent activation in response to odor. Echo-planar imaging (EPI), the most commonly used fast imaging sequence to measure BOLD signal, has inevitably associated with geometric distortion and signal loss due to susceptibility artifacts (*i.e.*, in areas of the brain near interfaces between air and tissue). To clarify the processing mechanism of odors, we utilized ultrahigh-field (7 Tesla)-MRI (GE Discovery MR950 system), the principal advantages of which lie in its relatively high spatiotemporal resolution, and its capacity to demonstrate the entire network of brain areas engaged when subjects undertake particular tasks. EPI was optimized to minimize high field related susceptibility artifacts. Odorants (isovaleric acid, peppermint and coffee odor) and odorless air (mechanical) stimulation were applied to nose by air pressure. Activation by odor and mechanical stimuli were detected in piriform cortex, amygdala, hippocampus, thalamus, cingulated cortex, insula, orbitofrontal cortex and somatosensory cortex. In the piriform cortex, odor stimuli activated at anterior and mechanical stimuli at posterior. In the insula, olfactory stimuli evoked activation in the anteroventral portion and mechanical stimuli in the posterodorsal portion. Mechanical stimuli induced strong activation in thalamus. These results suggested that odor and mechanical systems are primarily specialized to detect each sensory modality, and send the information from olfactory epithelial cells to different brain areas in parallel.

Symposium, 2S-5 (12:40–13:20, May 11th; Room 703)

Electrophysiological properties of P-type Ca^{2+} channel in Purkinje cells dissociated from three types of *tottering* mice

Minoru Wakamori

Department of Oral Biology, Graduate School of Dentistry, Tohoku University, Sendai, Miyagi, Japan

Recent genetic and molecular biological analyses have revealed that mutations of the gene encoding the $Ca_v2.1$ channel α_{1A} subunit cause cerebellar ataxia and other forms of neurological disorders. Spinocerebellar ataxia type 6 (SCA6) is a neurodegenerative disease caused by the expansion of a polyglutamine tract in the α_{1A} subunit, and characterized by a loss of motor coordination and balance including dysphagia. To elucidate etiology of the human genetic channelopathies and to develop methods for treatments, the spontaneous mutants of the mouse α_{1A} subunit gene are useful models.

We made comprehensive comparison of the mutant $Ca_v2.1$ channel properties, excitability, and synaptic inputs in native Purkinje cells of *tottering tg*, *leaner* (tg^{la}), and *rolling Nagoya* (tg^{rol}) mice using the patch-clamp methods. The tottering mutations are directly responsible for reduction in current density and deviations in gating behavior, which lead to attenuation of Ca^{2+} spikes and parallel fiber synaptic inputs. Severity of neural symptoms exactly corresponds to defects in the electrophysiological properties of $Ca_v2.1$ channel. We propose that 3 types of *tottering* mice are useful models to study how $Ca_v2.1$ channel and cerebellum control oral functions such as swallowing.

Symposium, 2S-6 (13:20–14:00, May 11th; Room 703)

Alveolar nerve injury changes topographical organization in the insular cortex in rats

Masayuki Kobayashi

Department of Pharmacology, Nihon University School of Dentistry, Tokyo, Japan

Nociception is processed in the several regions in the cerebral cortex including the somatosensory, cingulate, and insular cortices. We have elucidated the roles of the cerebral cortex in dental pain, however, it is still an open issue how nerve injury modulates neural activities in the higher brain including the insular cortex. In the present study, we focused on the plastic changes of excitation in the insular cortex in the inferior alveolar nerve injury (IAI) model. To evaluate the spatiotemporal profiles of excitation in the insular cortex, the precise regions responding to the electrical stimulation of the maxillary and mandibular molar tooth pulps were detected by the optical imaging technique with a voltage sensitive dye. We found that excitatory propagation in the insular cortex was expanded 1–2 weeks after IAI, and the expanded excitatory propagation did not recovered in a month. *In vitro* whole-cell recording from layers II/III pyramidal neurons revealed an increment of excitatory inputs from layer IV in IAN models. These results suggest that IAI may induce unrecovered changes in the higher brain, and therefore, the treatment to repair injured nerves is necessary to suppress the neuroplastic changes in the cerebral cortex.

Symposium, 2S-7 (14:05–14:45, May 11th; Room 703)

The orexigenic neuropeptides modulate the masticatory muscle activities and trigeminal sensorimotor neuronal excitabilities

Susumu Tanaka

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The energy homeostasis and appetite are regulated by neuropeptides released from several nuclei in the hypothalamus, thus coordinating the feeding behavior. While the intracerebroventricular (ICV) administration of orexigenic neuropeptides have shown the increase of food intake, little is known about its influence on the characteristics of chewing pattern. These neuropeptides are known to project to extra-hypothalamic regions involving lower brainstem, and play a key role on other neuronal systems related to arousal, autonomic regulation and neuroendocrine homeostasis as well. Therefore, it is crucially important to verify the direct modulatory effects of neuropeptides on the trigeminal sensorimotor circuits underlying the jaw movements.

To this end, we firstly investigated the features of chewing pattern under ICV administration of orexin or Neuropeptide-Y (NPY) in rats using video analysis and electromyography (EMG) recordings. In the following experiments, whole-cell patch clamp recordings from trigeminal motoneurons or mesencephalic trigeminal neurons were performed to reveal the possible effects of those two neuropeptides on the characteristics of membrane excitability in these neurons.

Our data showed the magnitude of muscle activities were increased by orexin or NPY, reflecting the facilitation of feeding behavior. Furthermore, these neuropeptides induced inward currents and enhanced the membrane excitability in both trigeminal neurons.

Symposium, 2S-8 (14:45–15:25, May 11th; Room 703)

Morphological and electrophysiological properties of trigeminal α- and γ-motoneurons

Mitsuru Saito, Yukako Isogai-Morita, Kayo Nishimura, Masahiro Ota, Hiroki Toyoda, Hajime Sato, Tsutomu Kawano and Youngnam Kang

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The muscle contraction during voluntary movement is regulated by the activities of α- and γ-motoneurons (αMN and γMN, respectively). The tension of jaw-closing muscles can be finely tuned over a wide range. This excellent feature is thought to be established by the specific population of αMN and γMN innervating the jaw-closing muscles. Since the orderly recruitment of motor units depends on the soma size of αMNs, we first examined the size distribution of jaw-closer MNs in the rat after identifying αMN and γMN by the expressions of orphan nuclear hormone receptor Err3 and neuronal DNA binding protein NeuN (Friese et al., *PNAS*, 2009). In contrast to the unimodal size distribution of the spinal αMN reported in the mice, the size distribution of jaw-closer αMNs was bimodal or skewed to the left, revealing the presence of many αMNs as small as γMNs. Such wide-ranged size distribution of αMNs might contribute to the precise regulation of muscle tension. Next, the electrophysiological properties of jaw-closer MNs were investigated under the current-clamp condition. We found that the jaw-closing αMNs were divided into two subclasses and that the jaw-closing γMNs displayed a characteristic pulse afterdepolarization mediated by flufenamate-sensitive Ca^{2+}-dependent cation current.

Symposium, 2S-9 (15:30–16:10, May 11th; Room 703)

The role of TASK channels in rank-ordered recruitment of trigeminal jaw-closing motoneurons

Hiroki Toyoda[1], Keiko Hirao[1], Norihito Emura[1], Mitsuru Saito[1], Hajime Sato[1], Tsutomu Kawano[1], Eriko Kuramoto[2], Takeshi Kaneko[3] and Youngnam Kang[1]

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The trigeminal jaw-closing motoneurons (TJMNs) abundantly express TWIK-related acid-sensitive-K^+ channel 1 (TASK1) and TASK3, which are determinants of input resistance (IR) and resting membrane potential. TJMNs are recruited depending on the order of their sizes during isometric contraction, known as the size principle. Because IR reflects the size of MNs, TASK channels play important roles in the rank-ordered recruitment of TJMNs. Here, we demonstrate using real-time PCR that TASK1 mRNA is 2 times more abundant than TASK3 mRNA in large (> 35 μm) TJMNs while the former is 20 times more abundant than the latter in small (< 20 μm) TJMNs. Considering the difference in GAPDH content between the different-sized TJMNs, TASK1 mRNA is estimated to be 2 times more abundant in large TJMNs compared to small TJMNs. We next demonstrate using immunohistochemical method that TASK1 and TASK3 channels are complementary distributed in soma and dendrites of TJMNs, respectively. Furthermore, we show using simultaneous whole-cell current-clamp recordings from a smaller and larger TJMNs that stimulation of the presumed Ia inputs invariably recruit TJMNs depending on their soma size or IR. These results suggest that the rank-ordered recruitment of TJMNs is dependent on the resting activities of TASK1 and TASK3 channels.

Symposium, 2S-10 (16:10–16:50, May 11th; Room 703)

Subthreshold and resurgent sodium currents in burst generation in mesencephalic V neurons

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Subthreshold sodium currents are important in sculpting neuronal discharge and have been implicated in production and/or maintenance of subthreshold membrane oscillations and burst generation in mesencephalic trigeminal neurons (Mes V). Moreover, resurgent sodium currents contribute to production of high-frequency burst discharge.

In the presentation, we showed the direct participation of these currents during Mes V electrogenesis using the action potential-clamp method. We found that TTX-sensitive sodium current is the main inward current flowing during the interspike interval, compared with the h-current (I_h) and calcium currents. Furthermore, in addition to the transient sodium current that flows during the upstroke of action potential, we show that resurgent sodium current flows at the peak of afterhyperpolarization and persistent sodium current flows in the middle of the interspike interval to drive high-frequency firing. Additionally, transient, resurgent, and persistent sodium current components showed voltage- and time-dependent slow inactivation, suggesting that slow inactivation of these currents can contribute to burst termination.

Our study suggests that high frequency burst discharge (>100 Hz) in Mes V neurons is regulated by TTX-sensitive persistent current, and a fast dynamic resurgent current. Slow inactivation of the I_{NaP} contributes, but is not solely responsible for, burst termination during rhythmic burst activity.

Poster presentation, P-1 (May 10th–11th; Salon de l'Amical)

Theme: Feeding behavior

Postprandial feeding cessation system mediated by peptide YY is blunted in mice showing binge-like overconsumption

Erina Yamaguchi, Yasunobu Yasoshima and Tsuyoshi Shimura

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Overconsumption may be due to the following two factors, "enhancement of motivation to eat" and "dysfunction of postprandial feeding cessation to avoid excessive eating". Since few studies examine the latter factor, we investigated the mechanism of postprandial feeding cessation using a mouse model for binge-like overconsumption of sucrose. In the present study, we focused on the role of the anorexigenic gut hormone, peptide YY (PYY) for overconsumption. First, we compared neural responses of feeding-related brainstem nuclei between control and bingeing mice to an intraperitoneal injection of PYY using c-fos immunoreactivity as neural activation marker. The number of c-fos-immunopositive cell in mice bingeing on sucrose was significantly smaller than that in control mice. Second, we assessed plasma PYY levels after intragastric infusion of the sucrose solution. Mice bingeing on sucrose showed lowered plasma PYY levels compared to control mice. These results suggest that binge-like overconsumption is associated with blunted central neural response to peripheral PYY and decreased postprandial PYY secretion.

Poster presentation, P-2 (May 10th–11th; Salon de l'Amical)

Theme: Feeding behavior

Distinct involvements of the rostral and caudal parts of rat basolateral amygdala in the retrieval of conditioned taste aversion

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Previous studies have shown the involvement of the basolateral amygdala (BLA) in conditioned taste aversion (CTA). However, the role of the BLA on the retrieval of CTA has not been fully understood. Therefore, we aimed to clarify the effects of temporal inactivation of the BLA on animal's behaviors during the CTA retrieval. Rats implanted with guide cannulae into the BLA were trained to drink water for 30 min in an experimental chamber for measuring approach to and intake of a conditioned stimulus (CS). On the conditioning day, they received a pairing of 5 mM saccharin solution as the CS with an i.p. injection of 0.15 M lithium chloride. On the test day, they were presented with the CS just after the microinjection of GABAA receptors agonist muscimol or saline. The muscimol into the caudal BLA significantly elevated the approach to and intake of the CS. On the other hand, muscimol injections into the rostral BLA had smaller effects on the impairment of the CTA retrieval than the caudal part. These results suggest that the caudal BLA is more deeply involved in both approach and consumption behaviors on the CTA retrieval than the rostral part.

Poster presentation, P-3 (May 10th–11th; Salon de l'Amical)

Theme: Feeding behavior

Lesions of the insular cortex, but not gustatory thalamus, enhance binge-like sugar overconsumption in mice

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Food-deprived mice with limited access to a sweetened solution show its overconsumption as binge-like behavior. It remains unclear whether the binge-like sugar overconsumption requires higher gustatory processing. To address the issue, we assessed the effects of lesions of the cortical gustatory area in the insular cortex (IC) and of the thalamic gustatory area on binge-like sucrose overconsumption in mice. Under 20-h food restriction, all mice received daily 4-h access to both sucrose and chow for 10 days. Daily intake of 0.5 M sucrose solution gradually increased in trained mice with sham lesions of the IC and reached to about 3–4-fold of the sugar intake during pre-training phase. IC-lesioned mice increased the sugar intake more rapidly than sham-lesioned mice. Lesions of the gustatory thalamic area did not affect the binge-like behavior without any facilitation. The present findings indicate that the binge-like sugar overconsumption does not require the cortical and thalamic gustatory processing. In addition, our data suggest that the IC, but not the thalamic gustatory area, has an inhibitory role in development of binge-like overconsumption of palatable sweet substances.

Poster presentation, P-4 (May 10th–11th; Salon de l'Amical)

Theme: Feeding behavior

The olfactory stimulus of *Osmanthus fragrans* changes the masticatory pattern

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Odors have been shown to exert an influence on various physiological and behavioral activities. However, little is known whether or not odor stimulation directly affects feeding-related neuropeptides and feeding behavior involving masticatory muscle activities. We selected the essential oils of milk and *Osmanthus fragrans* (OSM) as olfactory stimuli, and examined the effect of odors on the expression of orexigenic neuropeptides in the hypothalamus including AgRP, MCH, NPY and prepro-orexin as well as anorexigenic neuropeptides including CART and POMC. To analyze the changes in the feeding pattern, we recorded the electromyographic activities of the masticatory muscles during eating foods in rats. The neural transmission by OSM decreased the mRNA expression of orexigenic neuropeptides as AgRP, NPY, MCH and prepro-orexin, while increased anorexigenic neuropeptides as CART and POMC in rats. During the OSM odor exposure, the magnitude of the bursts became smaller in gnawing phase in both masseter and digastric muscles, the burst duration became longer in both phases in masseter muscle, and the intra-burst interval became longer in gnawing phase in masseter muscle. This study suggests that the OSM odor decreases food intake, accompanied by changing eating pattern, which contrasts markedly with the facilitatory feeding pattern in rat intracerebroventricularly-injected with orexins.

Poster presentation, P-5 (May 10th–11th; Salon de l'Amical)

Theme: Feeding behavior

Anandamide-induced network oscillation in the insular cortex implicated in taste-driven feeding

Hajime Sato[1], Mitsuru Saito[1], Dong Xu Yin[1], Tsutomu Kawano[1], Sook Kyung Park[2], Yong Chul Bae[2], Hiroki Toyoda[1] and Youngnam Kang[1]

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Anandamide (AEA) and *N*-oleoylethanolamine (OEA) are produced or increased in the intestine and brain during fasting and satiety, respectively. Subsequently, the former facilitates food intake via activation of cannabinoid type 1 receptors (CB1Rs) while the latter decreases food intake via activation of peroxisome proliferator-activated receptor-α (PPAR-α) and/or G-protein-coupled receptor 119 (GPR119). Neuronal activity in the gastrointestinal region of the autonomic insula (GI-Au-I) that rostrally adjoins the gustatory insula (Gu-I) increases during fasting, causing appetite sensation while umami and sweet taste sensations in the Gu-I enhances appetite sensation in the GI-Au-I. Given that AEA induces neural coordination between the Gu-I and GI-Au-I, such coordination would be critically involved in inducing the taste-driven feeding. However, these possibilities have not been addressed. Here, we demonstrate with live imaging that application of AEA induces theta-rhythm oscillatory coordination between the Gu-I and GI-Au-I. This neural coordination was modulated by $GABA_B$ receptor-mediated feed-forward inhibition and was abolished by AM251, a CB1R antagonist and OEA, a GPR119 agonist and rolipram, a phosphodiesterase 4 inhibitor. We propose a novel brain mechanism in which taste-driven feeding is regulated by the neural coordination between the Gu-I and GI-Au-I through the opposing activities between the CB1R and GPR119.

Poster presentation, P-6 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (1)

Glutamatergic responses in rat developing jaw-closing motoneuron dendrites

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The dendrites of trigeminal motoneurons (TMNs) are well developed and ramify extensively in the trigeminal motor nucleus and surrounding reticular formation. It is possible that the dendrites of jaw-closing motoneurons have active properties, which are altered with development of the orofacial musculoskeletal system during the early postnatal period. Thus, we examined the developmental changes of somatic voltage responses evoked by focal dendritic photostimulation using laser photolysis of caged glutamate and somatic whole-cell recordings in the retrogradely-labeled masseter motoneurons (MMNs) obtained from postnatal day (P) 2–5 (n = 22) and 9–12 (n = 18) rats. We stimulated 39 spots arranged around the recorded neurons in a concave shape array for each neuron with a laser power of 13.1 μJ, and found that laser photostimulation of 9.7 spots per neuron induced membrane depolarization in the presence of tetrodotoxin (TTX) in all P2–5 MMNs tested. These photostimulation-evoked responses were reduced by the application of N-methyl-D-aspartate (NMDA) receptor antagonist D(−)-2-amino-5-phosphonovaleric acid (APV). With increasing photostimulation intensity, the responses grew in amplitude up to a certain threshold, where a step-like increase in the somatic voltage amplitude, known as the NMDA spikes/plateau potentials, occurred in 75% (6/8) of P2–5 MMNs. Application of 20 μM APV completely abolished the step-like depolarization increase. The photostimulation-evoked responses became significantly smaller in amplitude and shorter in duration at P9–12 than at P2–5. Furthermore, only a few P9–12 MMNs tested showed NMDA spikes compared to P2–5 MMNs. These results suggest that the properties of responses evoked by photostimulation of the MMN dendrites change during the first 2 postnatal weeks, and such changes in the dendritic processing of the synaptic inputs to the MMNs are involved in the transition from sucking to chewing and biting during early postnatal development.

Poster presentation, P-7 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (1)

Projection from lateral habenula to trigeminal mesencephalic nucleus and its function

Haruka Ohara, Fumihiko Sato, Hiroyuki Yano, Etsuko Ikenoue, Takafumi Kato and Atsushi Yoshida

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The lateral habenula (LHb) is implicated in disappointment and expectation of negative conditions such as stressful conditions, suggesting that it is also involved in motor control of food intake. The trigeminal mesencephalic nucleus (Vmes) neurons convey deep sensations from masticatory muscles and periodontal ligaments, and function in orofacial movements, especially jaw movements. Therefore, we examined whether LHb neurons activated by stress to the animals directly project to Vmes neurons in rats. After a retrograde tracer, Fluorogold (FG), was injected into Vmes, many neurons were labeled bilaterally in both the lateral part (LHbL) and medial part (LHbM) of LHb. After injections of an anterograde tracer, biotinylated dextranamine (BDA) into LHb, axon fibers and terminals were labeled bilaterally in Vmes. Some BDA-labeled terminals contacted the cell bodies of Nissl-stained Vmes neurons bilaterally. After FG injections into Vmes and subsequent application of restraint stress, many c-Fos immunoreactive (ir) cells were observed bilaterally in LHb; the number of c-Fos-ir cells in LHbM was higher than that in LHbL bilaterally. A small number of FG/c-Fos double labeled neurons were found bilaterally in LHb; the number of double labeled neurons in LHbM was slightly higher than that in LHbL. The percentage of double labeled neurons to FG labeled neurons in LHb was higher than that obtained in control cases with FG injections into Vmes but no restraint stress. This study suggested that LHb neurons activated by stress directly project to Vmes neurons.

Poster presentation, P-8 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (1)

Locus coeruleus modulates proprioceptive trigeminal neuron activity by inhibiting hyperpolarization-activated current

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Locus coeruleus (LC) is a small population of noradrenergic neurons located in the rostral pons with projections widely distributed in the central nervous system, thereby involved in many brain functions such as arousal, attention and stress. The proprioceptive sensory neurons innervating jaw-closing muscles are exceptionally located in the mesencephalic trigeminal nucleus (MTN), which medially adjoins or intermingles with the LC nucleus. MTN neurons can display two distinct firing patterns by either relaying spike trains arising from muscle spindles or generating bursts in response to synaptic inputs. MTN neurons express hyperpolarization-activated current (I_h), which can decrease glutamate receptor current, thereby suppressing bursts. We aimed to investigate whether I_h in MTN neurons would be affected by the activity of LC neurons.

Dual or single whole-cell patch-clamp recordings were obtained from MTN and LC neurons or MTN neurons alone. LC neurons were activated by injection of current pulses or microstimulation while I_h was induced in MTN neurons. Recorded neurons were labeled by injection of Lucifer yellow, and tyrosine hydroxylase immuno-staining was carried out to identify LC neurons. I_h was either reduced (n = 7/10) or showed no change (n = 3/10) during LC stimulation. In the presence of α2 adrenoceptor antagonist, I_h reduction was significantly suppressed (n = 4). Immuno-staining results showed that I_h reduction was seen in MTN neurons when tyrosine hydroxylase positive LC neurons were activated (dual recording, n = 4/4).

Poster presentation, P-9 (May 10th–11th; Salon de l'Amical)
Theme: Mastication (1)

The cryo-preserved nerve graft on inferior alveolar nerve

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When peripheral nerve is severely damaged, various treatments such as nerve suture, nerve cross-anastomosis and/or nerve graft are employed. The previous study demonstrated that periodontal Ruffini endings of lower incisor can regenerate after immediate nerve graft of facial nerve (FN) to inferior alveolar nerve (IAN). In this study, we examine whether periodontal nerve fibers, particularly mechanoreceptive Ruffini endings are able to regenerate following nerve graft after cryo-preservation. The small segment of the FN was cut from adult rat, and kept in situ. Transected FN was removed, and preserved using programmed freezer, and kept at −196°C for 7 days. Small segment of IAN was removed and cryo-preserved FN was grafted to the same animal. Regenerating nerve fibers were recognized at 7 days following nerve graft. Terminal Schwann cells began to migrate to the tooth-related areas where no neural elements are detected in the normal animals. They gradually increased in number, and terminal morphology became expanding. Around 42–56 days after nerve graft, the terminal morphology of regenerated Ruffini endings returned almost normal. The present results indicate periodontal nerve fibers are able to regenerate following the cryo-preserved nerve graft.

Poster presentation, P-10 (May 10th–11th; Salon de l'Amical)

Theme: Taste/odor sensation

The neural mechanisms underlying the perception of burning taste of capsaicin and subsequent autonomic responses

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When we taste spicy foods containing capsaicin, we experience various physiological responses such as perspiration from face, salivation and facilitation of cardiovascular activity. Such autonomic responses may be induced through viscero-visceral autonomic reflexes. However, this does not necessarily preclude the involvement of higher-order sensory-motor integration between the gustatory insular (Gu-I) and autonomic insular (Au-I) cortices. A human fMRI study demonstrated that the tasting and swallowing of capsaicin cause excitation in Gu-I, suggesting that Gu-I processes the information of spicy taste of capsaicin. Using fMRI, we addressed whether neural activity in Gu-I caused by capsaicin is coordinated with that in Au-I. Group analysis revealed that significant increases in BOLD signals were caused in the bilateral anterior and middle short insular gyri (ASG and MSG, respectively) following capsaicin application to the subject's mouth. The BOLD signals were significantly higher in ASG than in MSG. The fingertip temperature measured after repeating capsaicin application twice was significantly higher than that before the first capsaicin application. Right ASG only showed a significant positive correlation between fingertip temperatures and BOLD signals. These results suggest that the neural coordination between Gu-I and Au-I induced by capsaicin is responsible for autonomic responses as reflected in fingertip temperature increases.

Poster presentation, P-11 (May 10th–11th; Salon de l'Amical)

Theme: Orofacial pain

Involvement of endothelin in tongue-cancer pain relief at early stage in rats

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In many clinical cases, oral cancer patients do not complain of obvious pain at early stage. Due to the lack of pain at early stage, detection of oral cancer is sometimes delayed. It is necessary to detect oral cancer at early stage in order to treat cancer patients appropriately. To evaluate the mechanisms underlying tongue-cancer pain, we studied the involvement of endothelin in tongue pain associated with tongue cancer in rats. Squamous carcinoma (SCC) cells were inoculated into the tongue. PBS was used as a control. After SCC inoculation, tumor growth progressed over time. Head-withdrawal reflex threshold (HWRT) to mechanical but not heat stimulation of the tongue was significantly decreased on day 11 after SCC inoculation. HWRT to mechanical and heat stimulation of the tongue was not changed in control group. After SCC inoculation, the amount of β-endorphin and endothelin-1 in tongue tissue is significantly increased in SCC-inoculated rats compared with PBS-inoculated rats on day 6. We also observed endothelin A receptor expression in SCC-158 cells *in vitro*. The decrement of HWRT is significantly recovered in SCC-inoculated rats following ET-A receptor antagonist or μ-opioid receptor antagonist into the tongue. β-endorphin released from SCC cells by endothelin-1 signaling may be involved in depress of tongue cancer-pain at early stage.

Poster presentation, P-12 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (2)

Modulation of TASK currents by the activity of cGMP-dependent protein kinase

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Leak K^+ conductances generated by TASK1 and TASK3 channels are crucial for determining the resting membrane potential (V_r) and input resistance (IR) in neurons. Both *m*RNAs of the TASK1 and TASK3 channels are abundantly expressed in the trigeminal motor nucleus of the rats (Karschin et al., 2001). Therefore, modulation of TASK1 and TASK3 conductances is thought to play important roles in regulating the rank-ordered recruitment of trigeminal motoneurons observed during isometric contraction of jaw-closing muscles. We previously demonstrated that an activation of cGMP-dependent protein kinase (PKG) upregulates TASK1 channels heterologously expressed in PKG-loaded HEK293 cells (Toyoda et al., *J. Neurosci.*, 2010). PKG activation by application of 8-Br-cGMP hyperpolarized V_r and reduced IR in the rat trigeminal motoneurons with small somata where TASK1 but not TASK3 is predominantly expressed. In contrast, 8-Br-cGMP application did not necessarily cause such changes in V_r and IR in the large trigeminal motoneurons that express TASK1 in their somata and TASK3 in their dendrites, suggesting that TASK3 is downregulated by PKG activation at least at physiological pH. In the present study, we examined this possibility in the heterologous expression systems of *Xenopus laevis* oocytes injected with TASK3 *c*RNA, and found that 8-Br-cGMP application suppressed TASK3 conductances.

Poster presentation, P-13 (May 10th–11th; Salon de l'Amical)
Theme: Mastication (2)

Central processing of masticatory muscle sensation

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The masticatory muscle sensation is involved in the orofacial movements. This sensation is conveyed to the supratrigeminal nucleus (Vsup) by the trigeminal mesencephalic nucleus neurons in cats. However, little is known about ho w to identify the Vsup and about the central processing of the sensation through the Vsup. To address these issues, we used neuronal tract tracing and electrophysiological recording techniques in the rat. After application of cholera toxin subunit B to the masseter nerve (MN), we found anterogradely labeled axon terminals in almost entire area of the Vsup, which was cytoarchitectonically identified. The Vsup was also identified electrophysiologically by recording responses to electrical stimulation of the MN and the passive jaw-jerk; no fast responses were recorded after electrical stimulation of the lingual nerve. After injections of biotinylated dextranamine into the Vsup, anterogradely labeled axon terminals were found contralaterally in the caudo-ventromedial part of the ventral posteromedial nucleus (VPMcvm) and bilaterally in the paracentral nucleus in the thalamus. The VPMcvm was also identified electrophysiologically by recording responses to electrical stimulation of the MN and the passive jaw-jerk. After Fluorogold injections into the VPMcvm, retrogradely labeled cells were found contralaterally in the Vsup and i n the dorsomedial margin of the trigeminal principal nucleus adjacent to the Vsup. These findings have for the first time demonstrated features of the central processing of muscle sensation.

Poster presentation, P-14 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (2)

Neuropeptide Y modulates the spike discharge characteristics in mesencephalic trigeminal neurons

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Neuropeptide Y (NPY) is one of neuropeptides with powerful orexigenic effect. Recent study has demonstrated that intracerebroventricular administration of NPY induced increase of food intake in a dose-dependent manner, while feeding rate was decreased in a higher concentration. In addition to a role on the feeding behavior, NPY also has integral effects on neuronal systems related to other spontaneous behaviors such as rearing, grooming. Therefore, in the present study, we focused on the direct effects of NYP on the trigeminal neurons underlying jaw movements. Coronal brain-slices were prepared from Sprague-Dawley rats (P10–19) and whole-cell patch-clamp recordings were obtained from mesencephalic trigeminal neurons (MTN). Patch-electrodes with 3–4 MΩ resistance were filled with K-gluconic acid-containing normal solution. Bath application of NPY depolarized the membrane potential and induced inward current in MTN, which was persisted in the presence of TTX and dependent on external Na^+ and Ca^{2+}. The duration of AHP following an action potential was significantly shortened and the mean spike frequency in the repetitive firing activity was consistently increased. Intrinsic bursting activities induced by maintained current injection showed significant increase of bursting frequency. Further experiments revealed an involvement of both Y1 and Y5 receptor activations in the modulatory effects of NPY.

Poster presentation, P-15 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (2)

Reduced mastication impairs spatial memory in young zinc-deficient mice

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Sufficient oral microelements such as zinc and fully chewing of foods are required to maintain cognitive function despite aging. No knowledge exists about the relationship between factors such as zinc deficiency and reduced mastication on learning and memory. Here we show that the impaired spatial performance in the zinc-deficient groups coincided well with the increase in the density of glial fibrillary acidic protein-labeled astrocytes in the hippocampal CA1 region, but not body weight. After switching both zinc-deficient groups to the normal diet with sufficient zinc, spatial memory recovered, with more spent time in mice with tooth extraction followed by zinc deprivation compared to the zinc-deficient mice. Our data suggest that the effect of zinc deficiency on spatial memory is reversible and stronger than that of reduced mastication, and that additive effects of these two factors but not body weight may inhibit recovery of impaired spatial learning despite a young age.

Poster presentation, P-16 (May 10th–11th; Salon de l'Amical)

Theme: Mastication (2)

PSD-95 protein expression in rat oro-maxillofacial motoneurons during postnatal development

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Chemical synapses contain a number of diverse proteins, which form the postsynaptic density (PSD), and these are involved in synaptic structure, neurotransmission and signal transduction. PSD-95 is implicated in the formation and maturation of excitatory synapses. PSD-95 regulates the localization of NMDA receptors by means of binding with NMDA receptor subunit 2 (NR2). Rhythmical oro-maxillofacial activities, such as suckling and chewing, are generated in the brainstem, and we showed that NMDA receptors play a critical role in the rhythm and pattern generation and signal transmission around the trigeminal motor nucleus during prenatal and early postnatal development. Here, we immunohistochemically examined the temporal distribution of PSD-95 protein in developing rat brainstem from suckling to the mature chewing stage. There was early emergence of PSD-95 expression in the interneurons located in the medial region of the trigeminal motor nucleus. This observation supports the notion that the central pattern generator for rhythmical jaw movements is located peritrigeminal area.

Poster presentation, P-17 (May 10th–11th; Salon de l'Amical)

Theme: Others

Behavior of glial cells in trigeminal motor nucleus following peripheral axotomy of the masseteric nerve of the rat

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It is known that peripheral nerve injury due to surgical operation causes abnormal sensation such as paresthesia. Recent studies indicate that peripheral nerve injury evoked morphological and biochemical alterations not only in neurons but also in surrounding glial cells, and neuron-glial interactions play important roles for pathogenesis of abnormal sensation. In the present study, we examined the behavior of glial cells in the trigeminal motor nucleus following peripheral axotomy to the masseteric nerve in the rat. Unilateral peripheral axotomy of the masseteric nerve was applied to 6-week-old Sprague-Dawley rats, and immunohistochemistry for Iba1, a marker for microglia, and GFAP, a marker for astrocyte, was performed. Iba1-immunoreactive (-IR) microglia were evenly distributed in the normal animals, and accumulated near the injured neurons. They changed their morphology from ramified type to ameboid type, and increased in number, reaching the maximal level at 3–5 days following injury. GFAP-IR astrocytes were found sparsely in the normal animals, and their number increased after axotomy with a maximal level around 5–7 days. GFAP-IR astrocytes around the injured neurons extended their processes. The present results indicate that peripheral injury evoked the morphological changes in both microglia and astrocytes under different time course.

Poster presentation, P-18 (May 10th–11th; Salon de l'Amical)

Theme: Others

Enhanced SOCE in layer 3 pyramidal cells in the barrel cortex of PRIP-1/2 double KO mice

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The two subtypes of phospholipase C-related but catalytically inactive protein (PRIP-1/2) are IP_3-binding proteins. IP_3-induced Ca^{2+} release was impaired in cultured PRIP-1 KO cortical neurons while store-operated Ca^{2+} entry (SOCE) was enhanced in PRIP-2 KO B cells. Here we aimed to clarify the differences in Ca^{2+}-induced Ca^{2+}-release (CICR) and SOCE between layer 3 pyramidal cells (PCs) in the barrel cortex of WT and PRIP-1/2 double KO (DKO) mice. Application of the bath solution containing high K^+ and caffeine induced CICR, which decayed to a plateau level. The mean peak and plateau amplitudes of CICR and the mean half-decay time from the peak CICR were larger in DKO PCs than in WT. We next examined in DKO PCs whether SOCE occurred following CICR or not. The CICR was induced twice with an interval of 35–40 min by the same way. When $[Ca^{2+}]_o$ was decreased from 2 to 0 mM after the first CICRs, the first Ca^{2+} transient decayed more rapidly compared to the second one, and the Ca^{2+} transient increased in amplitude after $[Ca^{2+}]_o$ was returned to 2 mM. These results indicate that CICR was followed by SOCE, suggesting that SOCE is more potent in DKO PCs compared to WT.

Poster presentation, P-19 (May 10th–11th; Salon de l'Amical)

Theme: Others

The synchronous oscillations in the rat barrel cortex mediated by kainic acid

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How functional columns are synchronized or desynchronized is an important question to understand inter-columnar integration. It is reported that synchronous network oscillations at 1–5 Hz were induced by acute application of kainic acid (KA) in layer 2/3 of the rat barrel cortex. We have recently reported that $GABA_B$ receptor-mediated presynaptic inhibition ($GABA_B$-Pre-I) of intracortical inputs serves as a basis for the inter-columnar desynchronization most prominently seen at 5 Hz in the barrel cortex, using dual whole-cell patch-clamp recordings from two layer 3 pyramidal cells in the mutually adjacent columns. In the present study, we investigated whether and how synchronous network oscillations induced by KA in the rat barrel cortex are modulated by the $GABA_B$ action using a voltage-sensitive dye imaging method. Bath application of KA caused synchronous oscillations across multiple columns in the barrel cortex. Power spectral analysis revealed that the synchronous oscillations were mainly composed of theta and delta frequency components. Following application of CGP55845, a $GABA_B$ receptor antagonist, the delta waves were largely abolished while the theta waves were slightly enhanced. These results suggest that the delta waves observed following KA application are primarily generated by the activity of presynaptic $GABA_B$ receptors expressed in the glutamatergic axon terminals.

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