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Research report

Cerebral processing of gustatory stimuli in patients with taste loss

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Abstract

Aim was to investigate differences in the central-nervous processing of gustatory stimuli between normogeusic subjects and patients with taste disorders. Twelve subjects with normal gustatory function and eight patients suffering from hypo- to ageusia underwent one fMRI run each in a 1.5 T scanner where they received liquid gustatory stimuli. fMRI analyses were performed by means of SPM2. Across all participants clusters of activated voxels were mainly found in orbitofrontal and insular regions of interest. Even those patients who did not perceive any stimuli showed some activation of gustatory centers. Group comparisons revealed higher activation of the insular and orbitofrontal cortices in patients compared to the group of healthy subjects. While further studies are needed, this finding may be interpreted in terms of enhanced neuronal recruitment due to functional impairment in patients with gustatory loss. It may ultimately prove useful in terms of the prognostic evaluation of individual patients.

Keywords: Taste; Ageusia; Gustation; Medico-legal; Chemosensory

1. Introduction

As compared with motor or other sensory systems, to date, relatively few publications used functional MRI (fMRI) for detailed investigations dealing with the processing of gustatory stimuli (e.g., [1–8]). Although the complexity of taste processing is frequently considered [9], in general, the studies agree on the insular cortex representing the primary site of gustatory processing [10,11]. The orbitofrontal cortex (OFC) is found to be involved secondarily in the gustatory system [11], as has been suggested in anatomical studies in monkeys [12,13].

Studies exploring the use of taste-related fMRI in a clinical environment are not yet available. Thus, in the present study, fMRI was chosen to compare cerebral representations of gustatory processing between patients suffering from taste disorders and healthy subjects with normal taste functions. The perspective was to study the potential value of fMRI in the clinical evaluation of patients with gustatory loss.

2. Subjects and procedures

2.1. Subjects

The study was designed to compare two groups: eight patients with taste disorders and twelve normogeusic subjects. The patient group consisted of two males and six females with ages ranging from 38 to 73 years (mean age: 58 years). All patients suffered from impairment of the sense of taste, with onsets between 6 and 86 months (mean 26 months) prior to participation in the present study, having presented with taste complaints at the Dresden Smell & Taste Clinic. In three patients, the disorder had been brought about by trauma (one accident, two surgeries), two suffered from postinfectious dysfunction, and in the remaining two no specific cause could be identified (for details see Table 1). Structural MR scans in any of the patients with gustatory dysfunction did not show any lesions that could be related to the loss of the sense of taste. While the cause of the taste loss was unexplained in the investigated patients none of these patients exhibited dysgeusia in the from of, for example metallic or bitter tastes.

The control group included six men and women each, with an age range between 21 and 51 years (mean age 30 years), all of whom were normogeusic. Prior to the scans all subjects

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Table 1
Patients and clinical status

Patient no.	Sex	Age (years)	Gustatory function	Onset (months) prior to fMRI	Etiology
1	Female	60	Hypogeusia	6	Idiopathic
2	Female	73	Hypogeusia	6	Postinfectious
3	Female	52	Hypogeusia	17	Posttraumatic
4	Male	50	Ageusia	54	Postinfectious
5	Female	38	Hypogeusia	86	Idiopathic
6	Male	64	Hypogeusia	8	Posttraumatic
7	Female	57	Ageusia	16	Postinfectious
8	Female	59	Ageusia	12	Posttraumatic

had received psychophysical taste testing using a standardised, validated taste test kit, the "taste strips" [14].

2.2. Gustatory stimulation

Two gustatory qualities were used for stimulation: sweet and sour. Stimulants were administered in liquid form. The sweet stimulant was represented by a 2.92 mol/l sucrose in water solution, the sour one by 0.21 mol/l citric acid in water (Evian®, Danone Waters, Wiesbaden, Germany). Taste solutions were freshly prepared prior to each investigation. In order to use the same solvent, tasteless water (Evian®, Danone Waters, Wiesbaden, Germany) was used as control.

Stimulants were delivered into the subject's mouth via dedicated Teflon® tubing fed through a small outlet in the wall of the scanner room. Three separate tubes for the respective stimulants were connected to one common mouth piece which could easily be held in place by the subject's lips and teeth. The outer diameter of the tubes was 3 mm, their inner diameter was 2 mm, and their length approximately 5 m. Immediately before imaging sessions, the tubes were filled with the respective stimulants by means of syringes. These remained connected to the tubing via three-way valves, enabling replenishment of the syringes, blockage of flow from either ends, and controlled delivery of the liquids. Stimulation was performed by releasing 0.1 ml liquid onto the subject's tongue. Stimuli were presented at room temperature. In between stimulations, the subjects' mouth was rinsed with 2 ml of water. Subjects were instructed only to swallow during the "rinse" condition.

2.3. Experimental design

Each functional imaging investigation ("run") consisted of four sessions, two with each tastant which were applied in alternating fashion. Among runs, the two resulting sequences, starting with either sweet or sour sessions, were randomly distributed.

Three experimental conditions were used: In addition to the "active" tastant condition (sweet or sour, respectively) and the "inactive" control condition (water), a rinse condition was established in order to prevent smearing effects on the tongue and enhance distinction of the taste/no-taste sensations. Rinsing – effected with water – was performed after each of the two main conditions, resulting in a basic sequential module of four conditions: water (control), water (rinse),and taste water (rinse). This sequence of four conditions was repeated three times within each session, yielding a succession of 12 conditions, with repeated application of water between taste stimulations proper. These sequences of experimental conditions were uniform within and between sessions.

During each condition, 10 functional imaging scans were performed. With a repetition time of 3 s (see below), the total scanning time of one complete run was 24 min (see Table 2 for a schematic illustration).

Table 2
Experimental design

Experimental condition	Scans#			
	Session 1, tastant 1	Session 2, tastant 2	Session 3, tastant 1	Session 4, tastant 2
Water	0–9	120–129	240–249	360–369
Rinse	10–19	130–139	250–259	370–379
Taste	20–29	140–149	260–269	380–389
Rinse	30–39	150–159	270–279	390–399
Water	40–49	160–169	280–289	400–409
Rinse	50–59	170–179	290–299	410–419
Taste	60–69	180–189	300–309	420–429
Rinse	70–79	190–199	310–319	430–439
Water	80–89	200–209	320–329	440–449
Rinse	90–99	210–219	330–339	450–459
Taste	100–109	220–229	340–349	460–469
Rinse	110–119	230–239	350–359	470–479

Tastants "sweet" and "sour" were randomly distributed as "taste condition 1" and "taste condition 2" among runs. Water was applied as both control stimulus and rinse fluid.