Facial Reactions in Response to Gustatory and Olfactory Stimuli in Healthy Adults, Patients with Eating Disorders and Patients with Attention-Deficit Hyperactivity Disorder

(Mimische Reaktionen auf Geschmacks- und Geruchsreize
bei gesunden Erwachsenen, Patientinnen mit Essstörungen und
Patientinnen mit Aufmerksamkeitsdefizit/Hyperaktivitätsstörung)

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Table of contents

	Summary			1
	Zusammenfassung			3
I.	Introduction			5
	1.	Importance of the senses of taste and smell		7
	2.	Influences on facial reactions in response to tastes and odors		10
		2.1.	Biological mechanisms	11
		2.2.	Individual moderators	15
			2.2.1. Age	16
			2.2.2. Food preferences and food aversions	20
			2.2.3. Eating Disorders	22
			2.2.4. Personality variables	25
			2.2.5. Sensory characteristics	28
		2.3.	Cultural and social moderators	31
II.	Experiments			36
	1.	Study 1 – "*Facial reactions in response to tastes and odors in healthy adults*"		36
		1.1.	Aims, specific research questions, and hypotheses	36
		1.2.	Methods	37
			1.2.1 Participants	37
			1.2.2. Taste and odor stimuli	38
			1.2.3. Dependent variables – Subjective and facial reactions	39
			1.2.4. Procedure	40
			1.2.5. Statistical analyses	42
			1.3. Results	42
			1.3.1. Subjective reactions	42
			1.3.2. Specific facial activity	45
			1.3.3. Overall facial activity	50
			1.3.4. Gender differences	52
		1.4.	Discussion	53
	2.	Study 2 – "*Facial reactions in response to tastes and odors in Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder*"		60
		2.1.	Aims, specific research questions, and hypotheses	60

2.2. Methods 62

2.2.1 Participants 62

2.2.2. Eating pathology 64

2.2.3. Taste and odor stimuli 65

2.2.4. Dependent variables – Subjective and facial reactions 66

2.2.5. Taste and odor sensitivity 68

2.2.6. Personality aspects 70

2.2.7. Procedure 72

2.2.8. Statistical analyses 73

2.3. Results 74

2.3.1. Subjective reactions 74

2.3.2. Overall facial activity 78

2.3.3. Specific facial activity 81

2.3.4. Electromyographic activity 88

2.3.5. Taste and odor sensitivity, and personality aspects 93

2.4. Discussion 95

3. Study 3 – "*Facial reactions in response to tastes, odors, and cartoons in Bulimia Nervosa and Attention-Deficit Hyperactivity Disorder*" 104

3.1. Aims, specific research questions, and hypotheses 104

3.2. Methods 107

3.2.1 Participants 107

3.2.2. Eating and Attention-Deficit Hyperactivity pathology 108

3.2.3. Taste stimuli, odor stimuli, and cartoons 109

3.2.4. Dependent variables – Subjective and facial reactions 110

3.2.5. Taste and odor sensitivity 112

3.2.6. Personality aspects 112

3.2.7. Procedure 113

3.2.8. Statistical analyses 115

3.3. Results 116

3.3.1. Subjective reactions 116

3.3.2. Overall facial activity 120

3.3.3. Specific facial activity 123

3.3.4. Electromyographic activity 126

3.3.5. Taste and odor sensitivity, and personality aspects 131

3.3.6. Influence of ADHD medication on facial activity 133
3.4. Discussion 133
III. General Discussion 141
Appendix A: FACS and EMG, further results, preparation of taste stimuli 148
Appendix B: Instructions and rating scales 161
Appendix C: Tables and Figures 176
References 270

Summary

Background: The aim of this project was to investigate whether reflex-like innate facial reactions to tastes and odors are altered in patients with eating disorders. Qualitatively different tastes and odors have been found to elicit specific facial expressions in newborns. This specificity in newborns is characterized by positive facial reactions in response to pleasant stimuli and by negative facial reactions in response to unpleasant stimuli. It is, however, unclear, whether these specific facial displays remain stable during ontogeny. Despite the fact that several studies had shown that taste-and odor-elicited facial reactions remain quite stable across a human's life-span, the specificity of research questions, as well as different research methods, allow only limited comparisons between studies. Moreover, the gustofacial response patterns might be altered in pathological eating behavior. To date, however, the question of whether dysfunctional eating behavior might alter facial activity in response to tastes and odors has not been addressed. Furthermore, changes in facial activity might be linked to deficient inhibitory facial control. To investigate these questions, facial reactions in response to tastes and odors were assessed. Facial reactions were analyzed using the Facial Action Coding System (FACS, Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002) and electromyography.

Study 1: The aim of the first study was to evaluate whether qualitatively different tastes and odors elicit facial reactions in healthy adults which are comparable to those facial reactions observed in newborns. Moreover, it was to be explored whether taste concentration increases the percentage of adults displaying facial reactions. Twenty-eight healthy non-smokers tried different taste solutions differing in concentration and smelled different odors while facial reactions were recorded. The results indicated that adults' facial reactions elicited by tastes and odors mostly correspond to those found in newborns, with unpleasant stimuli eliciting negative displays and the sweet taste – but not pleasant odors – eliciting positive displays. Moreover, an increase of taste concentration revealed a higher frequency of adults' displaying facial reactions. In contrast to newborns, adults smiled in the case of higher concentrations of some unpleasant tastes, which can be regarded as serving communicative functions, and they expressed negative displays with higher levels of sweetness. In conclusion, adults' facial reactions to tastes and odors appear to remain stable in their basic displays; however, they are also altered by display rules, i.e. "social" smile in response to unpleasant tastes.

Study 2: The second study explored whether eating pathologies are associated with quantitative and qualitative changes in facial activity elicited by different tastes and odors due

to their dysfunctional eating-related symptoms associated with food intake. In particular, bulimics and binge eaters were expected to show more and anorexics less facial reactions than controls. In response to the sweet taste, anorexics and bulimics might show negative facial reactions and binge eaters positive facial reactions compared to controls. Seventy-four women (Anorexia, *n* = 20; Bulimia, *n* = 19; Binge-Eating, *n* = 15, healthy controls, *n* = 20) tried different taste solutions differing in concentration and smelled different odors while facial reactions were recorded by camera and EMG. The results obtained by FACS indicated that bulimics and binge eaters displayed a higher taste-elicited facial activity than did anorexic patients and/or controls which might be due to their greater food reactivity. Moreover, the gustofacial pattern in response to the tastes is altered in patients with binges. Bulimics and binge eaters showed ambivalent displays in response to the low sweet taste and negative displays in response to the high sweet taste. Unexpectedly, anorexics showed negative displays as frequently as controls in response to the sweet taste. The groups did not differ in their quantitative and qualitative facial reactions to odors, since odors reflect no threat to shape and weight of eating-disordered patients. No substantial group differences were found in EMG activity, thus EMG might be less sensitive.

Study 3: The aim of the third study was to investigate whether inhibitory deficits are associated with a heightened taste-elicited facial activity in patients with Bulimia Nervosa (BN) and Attention-Deficit Hyperactivity Disorder (ADHD). Thirty-six women (Bulimia, *n* = 12; ADHD, *n* = 12; healthy controls, *n* = 12) tasted different solutions, smelled different odors, and rated the funniness of cartoons. Their spontaneous and suppressed facial reactions in response to these stimuli were recorded by camera and EMG. In response to tastes, bulimic and ADHD patients produced more spontaneous facial reactions than controls. When participants were asked to suppress facial reactions, ADHD patients – but not bulimic patients – displayed more facial reactions than controls. Thus bulimic patients are able to reduce their facial responses on verbal command, unlike ADHD patients. In response to odors, the groups did not differ in the frequency of their spontaneous and suppressed facial reactions. In response to cartoons, ADHD and bulimic patients displayed more facial reactions during facial suppression, but not during spontaneous reactions. In bulimics, this result seems to be confounded by funniness. In sum, ADHD patients' greater expressiveness might be due to their deficient inhibitory control, whereas bulimics' greater expressiveness is associated with greater reactivity to food cues. ADHD patients have more problems in voluntary control of emotional expression than Bulimia Nervosa patients.

Zusammenfassung

Hintergrund: Ziel dieses Projektes war es zu untersuchen, ob spezifische, mimische Reaktionen auf Geschmacks- und Geruchsreize bei Patientinnen mit Essstörungen verändert sind. Bei Neugeborenen rufen qualitativ verschiedene Geschmacksreize und Geruchsreize spezifische mimische Reaktionsmuster hervor. Diese Spezifität zeichnet sich infolge angenehmer Reize durch positive mimische Reaktionen und infolge unangenemher Reize durch negative mimische Reaktionen aus. Es ist jedoch unklar, ob diese spezifischen Reaktionsmuster während der ontogentischen Entwicklung stabil bleiben. Trotz der Befunde, dass geschmacks- und geruchsinduzierte mimische Reaktionen bei Erwachsenen relativ stabil bleiben, erlauben spezifische Forschungsfragen und verschiedene Methoden nur einen begrenzten Vergleich zwischen den Studien. Darüber hinaus könnten die gustofazialen Reaktionsmuster bei Patientinnen mit Essstörungen verändert sein. Diese Frage wurde jedoch bisher nicht untersucht. Weiterhin könnten Veränderungen in den mimischen Reaktionen bei essgestörten Patientinnen mit einer defizitären Hemmungskontrolle bedingt sein. Zur Klärung dieser Fragestellungen wurden mimische Reaktionen auf Geschmacks- und Geruchsreize erfasst. Die Mimikanalyse erfolgte mit Hilfe des Facial Action Coding Systems (FACS, Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002) und des Elektromyogramms.
Studie 1: Die erste Studie untersuchte, ob qualitativ verschiedene Geschmacks- und Geruchsreize spezifische mimische Reaktionen bei Erwachsenen hervorrufen, die denen Neugeborener ähneln. Darüber hinaus wurde erforscht, ob die Geschmackskonzentration einen Einfluss auf die mimischen Reaktionen hat. Achtundzwanzig gesunde Nichtraucher kosteten verschiedene Geschmacksproben mit unterschiedlicher Konzentration und rochen verschiedene Gerüche während ihre Reaktionen mit Kamera aufgezeichnet wurden. Die Ergebnisse sprechen dafür, dass die geschmacks- und geruchsinduzierten mimischen Reaktionen Erwachsener mit den Reaktionen Neugeborener vergleichbar sind. Erwartungsgemäß stieg die Zahl mimischer Reaktionen mit steigender Geschmackskonzentration. Im Gegensatz zu Neugeborenen, lachten Erwachsene mit steigender Konzentration unangenehmer Geschmäcker und zeigten negative Ausdrücke mit steigender Süße. Zusammenfassend, scheinen spezifische mimische Reaktionen auf Geschmacks- und Geruchsreize bei Erwachsenen relativ stabil zu bleiben, jedoch sind sie außerdem durch bestimmte Darstellungsregeln, wie das soziale Lächeln bei unangenehmen Geschmäckern, verändert.
Studie 2: Die zweite Studie erforschte den Zusammenhang zwischen der Esspathologie und der geschmacks- und geruchsinduzierten mimischen Aktivität. Es wurde erwartet, dass

Bulimiker und Binge eater mehr, Anoretiker jedoch weniger mimische Reaktionen zeigen als gesunde Personen. Insbesondere der süße Geschmack sollte bei anorektischen und bulimischen Personen negative Ausdrücke, hingegen bei Binge eatern positive Ausdrücke hervorrufen. Vierundsiebzig Frauen (Anorexie, *n* = 20; Bulimie, *n* = 19; Binge-Eating Störung, *n* = 15, gesunde Kontrollen, *n* = 20) kosteten verschiedene Geschmacksproben in unterschiedlicher Konzentration und rochen verschiedene Gerüche während ihre Reaktionen mittels Kamera und EMG aufgezeichnet wurden. Bulimiker und Binge-eater wiesen eine erhöhte geschmacksinduzierte mimische Aktivität auf als Anorektiker und/oder gesunde Frauen, möglicherweise bedingt durch eine erhöhte Nahrungsreaktivität. Die mimischen Reaktionsmuster auf die Geschmäcker waren bei Personen mit Essanfällen verändert. So zeigten Bulimiker und Binge eater ambivalente Ausdrücke auf den niedrig süßen Geschmack, jedoch negative Ausdrücke auf den äußerst süßen Geschmack. Unerwarteterweise unterschieden sich die Anorektiker nicht von den Kontrollpersonen in ihren spezifischen Reaktionen auf den süßen Geschmack. Die mimischen Reaktionen auf Gerüche waren in ihrer Anzahl und Art zwischen den Gruppen vergleichbar. Vermutlich bedeuten Gerüche keine Bedrohung für Figur und Gewicht. Da die EMG Aktivität zwischen den Gruppen vergleichbar war, scheint FACS für die Erfassung spezifischer Reaktionen sensitiver zu sein als das EMG.

Studie 3: Ziel der dritten Studie war die Untersuchung, ob es einen Zusammenhang zwischen der gesteigerten geschmacks-induzierten mimischen Aktivität und einer defizitären Impuls-kontrolle bei Bulimie und Aufmerksamkeitsdefizit/Hyperaktivitätsstörung (ADHS) gibt. Sechsunddreißig Frauen (Bulimie, *n* = 12; ADHS, *n* = 12; gesunde Kontrollen, *n* = 12) kosteten verschiedene Geschmacksproben, rochen verschiedene Gerüche, und bewerteten die Witzigkeit von Bilderwitzen. Die spontanen und unterdrückten mimischen Reaktionen auf diese Reize wurden mittels Kamera und EMG erfasst. Bei den Geschmäckern zeigten Frauen mit Bulimie oder ADHS mehr spontane Reaktionen als gesunde Frauen. Bei der mimischen Unterdrückungsaufgabe zeigten ADHS Patientinnen mehr mimische Reaktionen als gesunde Frauen. Die Gruppen unterschieden sich nicht in ihrer Anzahl spontaner und unterdrückter Reaktionen auf Gerüche. Jedoch zeigten ADHS und Bulimie Patientinnen mehr mimische Reaktionen als gesunde Frauen auf die Bilderwitze während der Unterdrückungsaufgabe. Bei Bulimikern scheint dies mit einer höheren Witzigkeit zusammenzuhängen. Insgesamt, ist die stärkere mimische Aktivität bei ADHS Patientinnen vermutlich durch eine defizitäre Impulskontrolle bedingt, wohingegen die stärkere mimische Aktivität bei Bulimikern mit einer erhöhten Nahrungsreaktivität assoziiert zu sein scheint. ADHS Patientinnen haben größere Probleme bei der willkürlichen Kontrolle mimischer Reaktionen als Bulimiker.

I. Introduction

The sensations provided by the senses of taste and smell are manifold – the sweetness of a piece of chocolate, the bitterness of tonic water, the saltiness of salted sticks, the sourness of a lemon, the sweet-spicy scent of cinnamon, the earthier scent of coffee, the pungent smell of ammonia and the fishy smell of tuna. Tasting and smelling of a given food is often accompanied by emotions and facial reactions which indicate whether the food is liked and tastes delicious or whether the food is disliked and tastes terrible. Therefore facial reactions elicited by tastes and odors may signal food acceptance or food rejection through positive or negative facial displays. If a person ingests something disagreeable, e.g. sour milk or rotten meat, he/she will display a grimace including upper lip raise, nose wrinkle and frown. In contrast, after ingestion of something delightful, e.g. a cake, the person might display a relaxed face or might even lick his/her lips and smile.

In general, humans have a preference for sweet tastes and an aversion against bitter tastes. This innate preference for sweets and aversion to bitter substances is important for survival, since it signals either nutritious or potentially harmful substances, respectively. Immediately after birth, newborns display differential facial reactions to qualitatively different taste and odor stimuli, corresponding to the hedonic valence of the stimuli. More specifically, pleasant tastes and odors are accompanied by positive facial displays indicating pleasure, whereas unpleasant tastes and odors are accompanied by negative facial displays indicating displeasure.

Throughout life people acquire various food preferences and food aversions which may even shift over time. The small number of studies which explored facial displays in response to tastes and odors in healthy adults indicated that adults' facial reactions are quite comparable to those of newborns. Thus it might be argued that taste-and odor-specific facial displays remain stable over a human's life-span, but a verification of these results is still necessary. Moreover, individual eating habits and food attitudes may alter facial reactions elicited by tastes and odors. Patients with eating disorders who have dysfunctional eating habits and an extreme anxiety to gain weight may exhibit other facial reactions indicating the aversive nature of ingestion in general. Eating disorders are severe behavioral disorders with a dysregulated balance of energy. A recent survey with more than 17.000 participants aged from 11 to 17 years indicated that 30% of these girls suffer from an eating disorder such as Anorexia Nervosa, Bulimia Nervosa, or obesity (Robert-Koch-Institute Berlin, 2003-2006). Life time prevalence of Anorexia Nervosa has been estimated at about 0.3%-1.0% and

Bulimia Nervosa at about 0.8%-3.0% (Fichter, 2008). The prevalence of the Binge-Eating Disorder is highest with 1.6%-3.5% of the population being affected. To date, the question of whether disturbed eating behavior may alter facial activity in response to tastes and odors has not been addressed. Therefore it is unclear whether patients with eating disorders show different taste- and odor-elicited facial displays. Another factor which might affect facial reactions in response to tastes and odors refers to deficient inhibitory control present in patients with Bulimia Nervosa and patients with Attention-Deficit Hyperactivity Disorder. It might be argued that facial motor control is disinhibited in these patients resulting in a higher frequency of facial reactions in response to tastes and odors. To date, facial reactions have never been linked with inhibitory deficits. Overall, the investigation of facial behavior in this dissertation aims to contribute to the clarification of the following three questions with each question being independently addressed in one study.

1. Do adults' facial reactions in response to tastes and odors correspond to those facial reactions observed in newborns?
2. Are gustofacial and olfactofacial responses altered in patients with eating disorders?
3. Are facial reactions in response to tastes and odors and inhibitory deficits related to each other?

In the first study, facial reactions in response to qualitatively different tastes and odors in healthy adults were investigated and compared to those facial reactions observed in newborns. Moreover, the suitability of tastes and odors regarding intensity and pleasantness, as well as methodological issues were explored in order to apply well-established stimuli in the second and third study. The main aim of this project was to investigate the relationship between pathological eating behavior and facial reactions elicited by gustatory and olfactory stimuli in order to extend the previous knowledge about affectivity and food intake in various eating disorders. It is expected that eating pathology affects facial expressions elicited by tastes and odors. Therefore, the second study explored whether taste-and odor-elicited facial reactions are altered in patients with eating disorders, i.e. Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder. In the third study the role of deficient inhibitory control was explored as a moderator of facial activity in Attention-Deficit Hyperactivity Disorder and eating pathology. Consequently, facial reactions were assessed in patients with Attention-Deficit Hyperactivity Disorder and patients with Bulimia Nervosa since inhibitory control deficits had been shown to affect behavior in both disorders. In each study, video recordings of facial reactions were analyzed using the Facial Action Coding System (FACS, Ekman &

Friesen, 1978; Ekman, Friesen, & Hager, 2002), an anatomically based system which classifies every conceivable human facial expression regarding facial movements. Additionally, in study 2 and 3, electromyographic activity over the corrugator, levator, and zygomaticus muscle was recorded.

The general outline of the chapters will be as follows. The introductory part is divided into two chapters. In chapter 1 the importance of the senses of taste and smell is described. In chapter 2, a model which includes mediating and moderating factors of facial reactions elicited by tastes and odors is established and discussed. The experimental part is divided into three chapters in which each study will be described including research questions and hypotheses, methods, results, and discussion. The general discussion part integrates the results of each study and discusses its implications.

1. Importance of the senses of taste and smell

Both taste and smell are chemical senses which belong to the phylogentically oldest senses. Taste is an immediate sense, whereas smell is a more distant sense (Birbaumer & Schmidt, 1999). In common usage, taste refers to the global taste and odor feeling, including tactile, trigeminal (irritation from strong acid or chilli), and thermal perception. Taste sensations provide information about the acceptability of food and other substances, such as minerals and poisons, before they enter the body. The experience of taste, or gustation, occurs when the taste buds in the mouth respond to substances dissolved in saliva. The sense of taste gives important information about the nutritional qualities of the food to be eaten: sweet signalizes ripe fruit and carbohydrates, sour signalizes unripe fruit, acidity and vitamin C, salty signalizes salt, electrolytes and other minerals, bitter signalizes poisonous plants and toxic substances, and umami signalizes protein. Food potentially useful for the body such as sugar is likely to taste good, whereas food potentially harmful for the body such as poison is likely to taste bad. Humans, as any other living organisms, have a strong need to eat and to provide energy and nutrients for the body in order to maintain the physiological homeostasis by keeping body functions constant. Interoceptive signals such as stomach rumbling or blood glucose reduction initiate physiologically based ingestion. Moreover, the affective value, i.e. food likes or dislikes, can lead to ingestion. Eating can be triggered by environmental cues even in the absence of hunger through anticipation of reward.

Taste is a sensory function of the central nervous system. The receptor cells for taste in humans are found on the surface of the tongue, along the soft palate, and in the epithelium of the pharynx and epiglottis. Taste receptors on the tongue recognize sweetness, bitterness, saltiness, and sourness which are referred to as the basic tastes. In addition, savoriness which is called umami (glutamate) has been recognized as the fifth basic taste. Umami comes from the Japanese word umai meaning delicious and is contained in protein-heavy food such as soy sauce, fish, and cheese (Ikeda, 2002). The taste umami was first developed in 1908 by Ikeda and is a well established palatability enhancer. Research on palatability effects of monosodium-glutamate (MSG) indicates that the optimal concentration is within the range of 0.4%-0.6% in healthy young European adults when MSG is added to food (Bellisle, 1989; Bellisle et al., 1991). More recently, researchers have suggested other taste categories such as fatty acid taste and metallic taste. Different taste receptors are sensitive to different tastes. Taste receptors for sour and salty are ion channels. Taste receptors for sweet, bitter and umami belong to the class of G protein coupled receptors (Bachmanov & Beauchamp, 2007). The detection thresholds vary among taste qualities, with lower thresholds for bitter and sour tastes than for salty, sweet (Birbaumer & Schmidt, 1999), and umami tastes (Lugaz, Pillias, & Faurion, 2002). Bitter substances are potentially harmful for the body and thus low bitter thresholds are adaptive to prevent toxicity. All of the taste sensations can be described as a combination of the five basic tastes. Taste sensations arise from all regions of the oral cavity. The common view that specific areas of the tongue are sensitive to different tastes (Hänig, 1901) had been disproven. Taste stimulus information is transmitted from the medulla oblongata to the thalamus and cortical representations (insula, orbitofrontal cortex), as well as to the hypothalamus and the amygdala.

Taste intensity depends on taste concentration, temperature and temporal influence/ the duration of the effect. In general, higher taste concentrations are perceived as more intense when compared to low concentrations. However, low concentrations of NaCl are perceived as sweet. Melted ice-cream tastes much sweeter than frozen ice-cream and cold coffee tastes much bitterer than hot coffee. Taste experience is also subject to effects of adaptation with a reduction in sensation due to long term taste stimulation. Affective valence, i.e. pleasantness, is also influenced by taste concentration. Usually, high taste concentrations of sweet tastes are perceived as pleasant, whereas high taste concentrations of bitter, salty, sour, and umami tastes are perceived as unpleasant (Pfaffmann, 1960; Schandry, 2006; Wundt, 1911; Yamaguchi, 1987). Moreover, subjective pleasantness and taste concentration follow an inverse relationship (Pfaffmann, 1960). The pleasantness of sucrose is heightened with increasing concentration, while the pleasantness of quinine is reduced with increasing concentration. The pleasantness of sour and salty solutions increases at low concentrations, but decreases at high concentrations. Later, Moskowitz, Kluter, Westerling, and Jacobs (1974) postulated an inverted U-shape function between sugar concentration and pleasantness as indicated by an increased liking with sweetness at a medium level, and a reduced liking for high sweetness in most people. The affective value associated with a food stimuli, can be considered as sensory reward (Pfaffmann, 1960), which might involve the release of opioid substances (Fantino, Hosotte, & Apfelbaum, 1986). It appears that especially tasty food elicits brain responses similar to those elicited by drugs such as cocaine and nicotine, pointing to a general involvement of the brain's "reward" system (Berridge, 1996; Robinson & Berridge, 1993). Dopamine-based reward circuitry appears to play a role in encoding reward from eating and incentive sensitization (Stice & Dagher, 2010). Food consumption has been found to increase dopamine release in the neural reward circuits and to increase motivated behavior in rats and humans (Hoebel, Hernandez, Schwartz, Mark, & Hunter, 1989; Volkow et al., 2002). In addition, sweet tastes have been shown to reduce pain reactivity in infants accompanied with a calming effect, diminished crying rate and heart rate (see Blass & Watt, 1999, for review).

Smell sensations allow the detection of small concentrations of airborne substances. The sense of smell therefore provides information about the chemical composition of these substances in order to prevent more direct contact when they are potentially harmful. The perception of a smell, or olfaction, occurs when substances in the air pass through the nose stimulating the olfactory nerve or when molecules reach the olfactory receptors by passing from the oral cavity through the nasal pharynx. Thus, there are two routes of smelling either via the nose while sniffing (orthonasal olfaction), or via the mouth while eating or drinking (retronasal olfaction) (Ganchrow & Menella, 2003; Hummel, 2008; Rozin, 1982). Taste and smell (via retronasal olfaction) are both defined as the term "flavor". Taste is only one component that contributes to the sensation of food in the mouth. Much of the flavor of food is contributed by smell. The taste of a meal depends on the interplay of both chemical systems: a palatable meal loses its typical taste (flavor) without its odors which is present when being unable to smell during a cold. The olfactory receptors in the nasal passages are fine-tuned and highly discriminating. Humans can tell the difference between 10.000 different odors (Birbaumer & Schmidt, 1999), which are difficult to name. Odor experience is subject to effects of adaptation with a reduction in sensation due to long term odor stimulation. Odor stimulus information is transmitted from the bulbus olfactorius to the telencephalon and neocortex as well as to the limbic system, the hypothalamus and formatio reticularis. The sense of smell has a strong connection to the limbic system (Cain, 1974). Thus the smell of food is closely linked with affective reactions and may elicit associations and memories. Odors have been often used to manipulate emotions (Aggleton & Mishkin, 1986) and pleasant smells are used in supermarkets to encourage customers.

Although smell is not as important for humans as for many animals, smell possesses the ability to guide behavior. Through the sense of smell, newborns can recognize their mother's breast and are able to differentiate between the odor of their mother and an unfamiliar woman (Schaal, 1986, 1988). The smell of the mother's breast facilitates breast-feeding and calming of the infant (Schaal, 1986; Sullivan & Toubas, 1998). Moreover, the sense of smell signalizes the edibility of food, danger in given situations, e.g. the escape of gas, hygiene properties, sexual reproduction via pheromones; and, especially in animals, smell is important for the search for food and communication.

Taste and smell experiences depend on the internal or motivational state. If hungry, people are more prone to smell food or to seek food. In contrast, when people are satiated, they stop eating. There is a strong link between pleasantness of a given food and its physiological need. For instance people have an aversion against sweets and craving for something savory after repeated sugar intake. A lack of salt induces a craving for salt. 16-week-old infants of mothers with morning sickness, or vomiting during pregnancy, ingested larger volumes of NaCl when compared to control infants of mothers without these symptoms (Crystal & Bernstein, 1998). Both the sense of taste and smell are linked to affective reactions. The culture, cultural norms, given food availabilities as well as food appropriateness determines ingestion. For instance in the rain forest, eating plant leaves or insects is appropriate, whereas in Western culture it is not appropriate.

All in all, the senses of taste and smell are important for survival as they provide information about the chemical composition of food and its harmfulness. Sensory and affective evaluation of tastes and odors depends strongly on the concentration which therefore was carefully controlled in the three studies. Moreover, taste and smell are accompanied by emotions indicating whether the given food is liked or disliked. In the next chapter it will be shown that these affective responses elicited by tastes and odors also include specific facial reactions indicating the pleasure or displeasure of a taste or smell.

2. Influences on facial reactions in response to tastes and odors

In this section, variables that influence facial reactions in response to tastes and odors will be reviewed. The starting point will describe gustofacial and olfactofacial reactions in response to tastes and odors in newborns, which are mediated by the biological mechanisms, i.e. the preference for pleasant stimuli and the aversion against unpleasant stimuli. A mediator is a quantitative variable that occurs in a causal pathway from an independent to a dependent variable (Baron & Kenny, 1986). Moderators that have been evidenced or that are expected to affect facial reactions in response to tastes and odors will be explained. According to Baron and Kenny (1986), a moderator is a qualitative or quantitative variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable. The distinction between mediator and moderators is illustrated within the model in Figure 1. The biological mechanism, i.e. the mediator variable, is indicated by an oblong. The model highlights that different moderators from the individual or the culture are expected to affect facial responsiveness elicited by tastes and odors. Tastes and odors are the stimuli, i.e. the independent variable, that elicit differential facial reactions, i.e. the outcome, mediated by innate preferences and aversions. Individual and cultural moderators that are expected to influence facial reactions in response to tastes and odors are indicated by circles. Age, acquired food likes and dislikes, eating disorders, personality aspects, and sensory characteristics belong to individual moderators. Social context and display rules belong to cultural moderators. Moderators which are related to the general research questions will be explained in the model. The model thus does not cover all influencing factors on taste- and odor-elicited facial expressiveness. Rozin (2000) argued that ingestion is influenced by biological/genetical, individual, and cultural factors. These factors can be adapted to the model presented here, postulating that facial reactions in response to tastes and odors are affected by biological (mediating variable), individual and cultural (moderating) variables. In the following sections each variable will be explained.

2.1. Biological mechanisms

The following section deals with the question whether newborns display specific facial reaction patterns in response to different tastes and odors. Therefore studies in newborns are critically reviewed in order to compare specific facial reactions across these studies. Once the relevant facial displays have been identified, a direct comparison between newborn and adult facial displays can be drawn, which is important since this dissertation project explored facial reactions in adults.

In general, newborns have an innate preference for pleasant tastes (and odors) and an innate aversion to unpleasant tastes (and odors) which are accompanied by facial reactions indicating

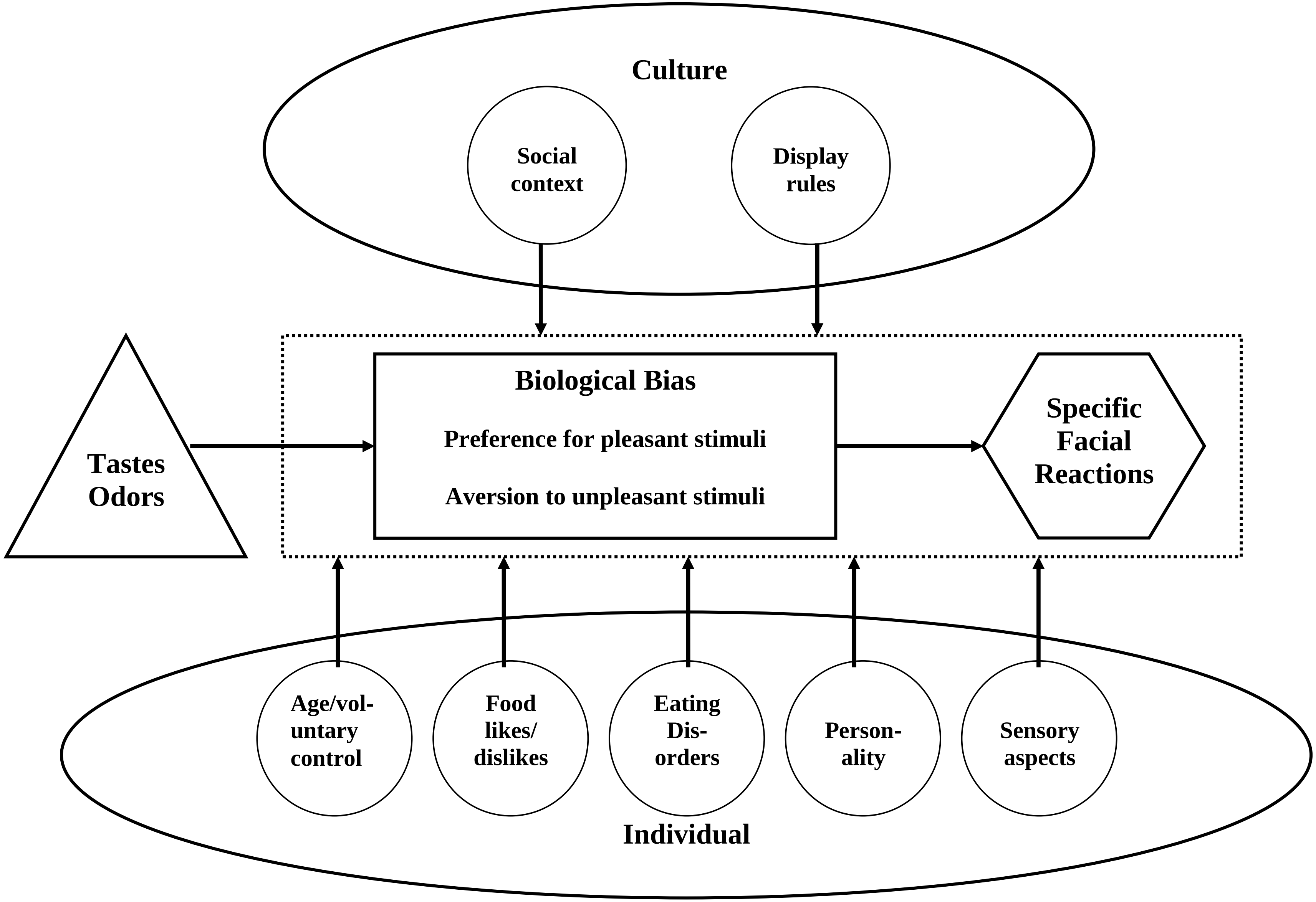


Figure 1: Model of facial reactions in response to tastes and odors.

pleasure and displeasure. Tastes and odors have been found to elicit different facial reactions which underline newborns' ability to discriminate among different taste and odor stimuli (Rosenstein & Oster 1988, 1997; Schaal, Marlier, & Soussignan, 2000; Schaal, Soussignan, & Marlier, 2002; Soussignan, Schaal, Marlier, & Jiang, 1997; Steiner, 1973, 1977, 1979; Steiner, Glaser, Hawilo, & Berridge, 2001) and among different taste concentrations (Ganchrow, Steiner, & Daher, 1983). Newborns' preference for sweet tastes and aversion to bitter tastes have been indicated through positive and negative facial reactions, which are interpreted as indicating attraction and aversion, respectively. Likewise, pleasant and unpleasant odors had been found to elicit positive and negative facial reactions in newborns, respectively; however, the findings for pleasant odors are equivocal (Schaal et al., 2000, 2002; Soussignan et al., 1997; Steiner, 1974, 1977, 1979).

Studies on taste-elicited facial reactions have consistently demonstrated that newborns show expressions indicating pleasure in response to sweet tastes and expressions indicating displeasure in response to sour and bitter tastes (see reviews by Cowart, 1981; Ganchrow et al., 1983; Peiper, 1963; Rosenstein & Oster, 1988, 1997; Steiner, 1973, 1977; Steiner et al., 2001). Salty tastes elicited facial reactions ranging from indifferent to nonspecific negative expressions, which are less clearly indicative for displeasure (Peiper, 1963; Rosenstein & Oster, 1988). Despite this consistent view regarding facial hedonics to tastes in general, researchers do not completely agree on the specific facial components elicited by the taste qualities observed in newborns. In response to the sweet taste, Steiner (1973, 1977, 1979) and colleagues (2001) reported expressions of facial relaxation, smiling, lip wiping, and lip sucking. With increasing sweetness, more infants displayed these positive facial reactions (Ganchrow et al., 1983). Rosenstein and Oster (1988) confirmed facial relaxation elicited by the sweet taste but did not observe more smiling, lip sucking, and lip wiping. Umami tastes (monosodium glutamate) added to a soup produced the same – albeit less intense – positive lower-face components as did sweet tastes (Steiner, 1987). Consistent facial responses to the bitter tastes included mouth opening/gaping, upper lip raising, and nose wrinkling (Rosenstein & Oster 1988; Steiner, 1973, 1977, 1979). Likewise, Steiner (1973, 1977, 1979) observed lip corner depression, and Rosenstein and Oster (1988) reported activity of upper face components such as brow and cheek raising and brow lowering as most frequent additional responses to the bitter taste. With increasing bitterness, the percentage of infants displaying negative facial reactions (repetitive lip pursing, lowering mouth corners, mouth opening, head turning, and nose wrinkling) increased (Ganchrow et al., 1983). The sour taste has been shown to consistently elicit lip pursing and nose wrinkling (Rosenstein & Oster, 1988; Steiner

1973, 1977, 1979). In addition, Rosenstein and Oster (1988) reported similar upper face reactions to the bitter taste such as brow raising, cheek raising, brow lowering, and upper lip raising in response to the sour taste. The salty taste elicited facial responses with diffuse mouth and lip movements and occasionally negative upper- and mid-face actions, mouth gaping, and lip pursing (Rosenstein & Oster, 1988). Photos of newborns' facial reactions are depicted elsewhere (e.g. Ganchrow & Mennella, 2003; Steiner, 1977). In sum, newborns' facial reactions responded differentially to sweet (vs. non-sweet stimuli, Rosenstein & Oster, 1988), bitter, and sour tastes.

Studies on olfactofacial responses have demonstrated inconsistent evidence that newborns display differential facial reactions according to the hedonic odor valence appraised by adults (Soussignan et al., 1997; Steiner, 1979). Observers (blind to stimuli) judged photographs of newborns displaying positive facial expressions such as smiling and sucking in response to pleasant odors (banana, butter, and vanilla) as indicating attraction/indifference, and negative facial expressions such as lip corner depression and lip pursing in response to unpleasant odors (fish and rotten eggs) as indicating rejection (Steiner, 1974, 1977, 1979). In contrast, Soussignan et al. (1997) who reinvestigated olfactofacial responses in three-day-old infants, found no evidence that odors classified by adults in terms of hedonic valence as pleasant (vanilla) or unpleasant (butyric acid) elicit facial reactions reflecting attraction or aversion. Butyric acid, however, elicited more facial reactions indicating disgust (nose wrinkling and upper lip raising) than vanillin, whereas vanillin did not elicit more smiling (lip corner pull) than butyric acid. Moreover, newborns did not respond differentially to the four different concentrations of butyric acid and vanillin. In sum, inconsistent olfactofacial evidence suggests that facial reactions in response to pleasant and unpleasant odors do not seem to be highly stereotyped (Schaal et al., 2000, 2002) and that newborns' hedonic experience to odors may be different from that of adults. However, the evidence suggests that some odorants experienced during the latter stages of gestation can have a hedonic quality or at the very least can be perceived at birth.

Newborns' discriminative facial reactions elicited by tastes and odors were regarded as low-level, reflex-like responses in the reflexive-hedonic model by Steiner (1977). According to this model humans are biologically hardwired to react with stimulus-dependent behaviors reflecting the hedonic evaluation of tastes and odors in a reflexive way (olfactofacial and gustofacial responses). Therefore, Steiner's model postulates a direct relationship among chemosensory stimuli, hedonic experience, and facial expression. The discriminative facial reactions in newborns reflect a universal and innate behavior present at birth and thus independent from learning. This implies that differential taste- and odor-elicited facial reactions are quite robust and consequently also present in adults. The subcortical origin of facial reactions to tastes and odors was evidenced in anencephalic and hydranencephalic newborns (Peiper, 1963; Steiner, 1973, 1977, 1979), who displayed specific facial reactions a few hours after birth without prior postnatal ingestion before stimulus application (Steiner, 1973, 1977, 1979). Newborns' facial reactions convey communication signals about the hedonic value of stimuli (Rosenstein & Oster, 1997; Steiner, 1977; Steiner et al., 2001). These responses are based on biologically adaptive functions that might facilitate ingestion of nutritious stimuli or block ingestion of harmful substances (Oster, 2004; Rosenstein & Oster, 1997). Some researchers (Rosenstein & Oster, 1988; Soussignan et al., 1997) have criticized methodological aspects in the newborn studies by Steiner (1974, 1977, 1979). More specifically, they argued that Steiners' data are inconclusive, there are no specified criteria for coding, the inter-rater reliability is missing, and only frequencies but not facial configurations are reported. Nevertheless, at least the unpleasant tastes and odors evoke a robust pattern of negative facial displays indicating displeasure (Rosenstein & Oster, 1988; Soussignan et al., 1997). In contrast, pleasant tastes and odors did not evoke positive facial displays indicating pleasure, which is in contrast to the findings by Steiner.

In sum, studies in newborns indicated the facial reactions of interest when investigating facial reactions in response to tastes and odors. The findings indicated differential taste- and odor-elicited facial reactions in newborns that are particularly pronounced for unpleasant stimuli. In contrast, there is conflicting evidence for pleasant tastes and odors, since positive displays were not consistently found across studies. Thus, the stereotyped innate reflex-like facial responses to pleasant stimuli in newborns do not seem to be as stable as previously had been proposed by Steiner. The results give reason to question whether adults' facial reactions are comparable to those displayed by newborns. In contrast to newborns, adults have been exposed to food many times, which might determine changes in food preferences and aversions as well as eating habits. The studies that investigated adults' facial reactions will be described within the next section, wherein age is introduced as an influencing moderator.

2.2. Individual moderators

Individual variables might moderate facial expressiveness in response to tastes and odors. Variables relating to this category are age, acquired food preferences and food aversions, eating disorders, personality aspects, and sensory characteristics of the individual. Within the next sections each variable will be described on the basis how it has been found to affect taste- and odor-elicited facial reactions.

2.2.1. Age

According to Steiner (1977) newborns' discriminative facial reactions elicited by tastes and odors should remain stable during adulthood. However, as children grow up, voluntary facial control becomes more and more present during development (Doty & Shah 2008; Ekman, 1972; Ganchrow & Mennella, 2003; Houstis & Kiliardis, 2009; Izard, 1991; Kraut, 1982; Rinn, 1991) which might affect facial expressiveness in response to tastes and odors. In this section, studies will be referred to in light of the question of whether adults show similar differential facial reactions regarding tastes and odors or whether an increased facial voluntary control alters facial reactions. Moreover, this section will shed light on the different methods with which facial reactions have been studied in children and adults and whether they yielded similar results.

Several studies which investigated facial reactions in response to tastes and odors using observational systems demonstrated that taste- and odor-elicited facial reactions in healthy children (Zeinstra, Koelen, Colindres, Kok, & de Graaf, 2009), developmentally disordered children (Soussignan, Schaal, Schmit, & Nadel, 1995), healthy adults, demented elderly adults, and Parkinson patients (Greimel, Macht, Krumhuber, & Ellgring, 2006; Perl, Shay, Hamburger, & Steiner, 1992; Saku & Ellgring, 1992; Steiner, Lidar-Lifschitz, & Perl, 1993) are mostly comparable to those facial displays observed in newborns. Some of these studies (Greimel et al., 2006; Saku & Ellgring, 1992; Soussignan et al., 1995; Zeinstra et al., 2009) used the Facial Action Coding System (FACS, Ekman & Friesen, 1978), which is an objective, standardized, and descriptive system to classify every conceivable human facial expression. Based upon a notational system of the anatomy of facial movements by the Swedish anatomist Hjortsjö (1970), FACS was developed by Paul Ekman and Wallace Friesen in 1978 and was slightly revised in 2002 (Ekman et al.). FACS consists of 44 different facial displays, i.e. Action Units (AUs), which relate to a specific number. According to the FACS criteria in the manual, each facial action is precisely described on the basis of anatomical appearance changes. Findings obtained by FACS, demonstrated that children and adults express newborn-like facial displays with pleasant tastes and odors eliciting positive facial reactions and the unpleasant tastes and odors eliciting negative facial reactions. In children, Zeinstra et al. (2009) found positive facial reactions such as smiling, including cheek raise (AU 6) and lip corner pull (AU 12), in response to the pleasant tastes (sweet taste, apple juice) and negative facial reactions such as brow lower (AU 4), upper lip raise (AU 10), lip press (AU 24), lips part (AU 25), and head shake (AU 84) in response to the unpleasant tastes (sour and bitter). Correspondingly to newborns, adults showed positive displays such as lip corner pull (AU 12), lip suck (AU 28), lip wipe (AU 37), and lip press (AU 24) in response to the sweet taste, whereas they showed negative displays such as brow lower (AU 4), upper lip raise (AU 10), and jaw drop (AU 26) in response to the bitter taste (Greimel et al., 2006). Another study (Steiner et al., 1993) indicated that healthy adults showed the negative facial displays of furrowing of the forehead, pulling down the outer lip corners (AU 15) as well as the middle of the lower lip (AU 16) in response to the bitter taste, and the positive facial displays of smiling (AU 12) and lip licking (AU 37) in response to the sweet taste.

Facial reactions in response to odors in adults correspond to the facial displays observed in newborns. Adult controls and patients with Parkinson disease (Saku & Ellgring, 1992) displayed facial reactions similar to those of newborns, with pleasant odors eliciting smiling (AU 12) and inner and outer brow raising (AU 1 + 2) and negative odors eliciting brow lower (AU 4), nose wrinkle (AU 9), upper lip raise (AU 10), and chin raise (AU 17). Odor-elicited facial reactions in developmentally disordered children – but not in healthy children – differentiated across odor stimuli as has been observed in newborns due to deficits in facial control (Soussignan et al., 1995). Developmentally disordered children displayed negative reactions, such as nose wrinkle (AU 9), upper lip raise (AU 10) and mouth opening (AU 25, 26, 27), in response to unpleasant odors and positive facial displays, such as lip corner pull (AU 12), in response to pleasant odors. In general, the findings presented so far indicate that discriminative facial reactions in response to tastes and odors seem to remain quite stable across adulthood, according to Steiner (1977), when facial reactions are assessed using observational systems.

Likewise, studies that used electromyography to assess facial reactions in response to tastes and odors are in accordance with findings in observational systems. Electromyography (EMG) is a method to record muscular contraction with the electromyograph detecting the electrical activity generated by stimulated muscle cells. If a muscle is stimulated, the electrical events of the muscle action potential cause a brief reversal (depolarization) of the resting membrane potential which is recorded as the EMG response (see Goldstein, 1972). Studies that assessed facial activity in response to tastes and odors by EMG indicated that the activity of corrugator supercilii, levator labii, and zygomaticus major in children (Armstrong, Hutchinson, Laing, & Jinks, 2007) and adults (Chapman, Kim, Susskind, & Anderson, 2009; Horio, 2003; Hu et al., 1999; Jäncke & Kaufman, 1994) correspond to facial displays in newborns. In particular, four studies revealed that the levator labii muscle, i.e. upper lip raise (AU 10), is indicative for taste unpleasantness (Armstrong et al., 2007; Chapman et al., 2009; Hu et al., 1999) and for odor unpleasantness (Armstrong et al., 2007; Jäncke & Kaufman, 1994). Unpleasant tastes and odors elicit a higher levator labii activity, whereas pleasant tastes and odors elicit a lower levator labii activity. Increased activity in the levator labii muscle might have evolved as a functional necessity to protect the body from contamination, poisoning, or illness due to oral consumption or smelling (Fox & Davidson, 1986; Rozin & Fallon, 1987; Vrana, 1993, 1994). Levator labii activity has often been described as the prototypical disgust response (Darwin, 1872; Ekman, 1971; Ekman & Friesen, 1975; Izard, 1971; Rozin, Haidt, & McCauley, 2000; Rozin, Lowery, & Ebert, 1994; Vrana, 1993, 1994).

Moreover, Horio (2003) found that unpleasant tastes elicited higher activities of the corrugator supercilii, i.e. brow lowering (AU 4), as well as of other muscles in response to unpleasant tastes compared to more pleasant tastes in adults. In contrast, the zygomaticus major, indicative for smiling (AU 12), did not differentiate between the four basic tastes (bitter, salty, sour, and sweet) and different odors in children (Armstrong et al., 2007). At least pleasant and unpleasant stimuli elicited a greater zygomaticus activity compared to neutral stimuli. In an adult sample, however, greater zygomaticus activity was found in response to the pleasant tastes (Jäncke & Kaufman, 1994). To sum up, electromyographic studies have consistently found a greater corrugator and levator activity associated with taste unpleasantness, whereas conflicting results have been reported for the zygomaticus major activity.

Despite this evidence regarding relatively stable facial reactions in response to tastes and odors, children and adults also displayed facial reactions which were not observed in newborns. Two studies that used an observational system, i.e. the Facial Action Coding System (Ekman & Friesen, 1978, Ekman et al., 2002), reported distinct facial displays in children and adults in response to unpleasant stimuli, which indicate the role of facial voluntary control as a moderator of taste- and odor-elicited facial expressiveness (Greimel et al., 2006, Soussignan et al., 1995). In contrast to newborns, adults displayed positive reactions such as smiling (lip corner pull, AU 12) in response to the bitter taste (Greimel et al., 2006). The authors argued that the social context may have activated a socially-accepted reaction, a display rule such as smiling, to mask the experienced unpleasant emotion. Whether other unpleasant tastes would also elicit positive facial displays is not clear, since Greimel et al.

(2006) did not apply salty, sour, and umami tastes. A similar finding has been reported by Soussignan et al. (1995), who found healthy children displaying more smiles (AU 6 + 12) in response to unpleasant odors, which was interpreted as attempt to mask the internal state due to a greater facial voluntary control. Thus unpleasant tastes and odors are not only accompanied by negative facial displays but also by positive facial displays. This was not observed in newborns since facial voluntary control and the acquisition of display rules evolves during socialization.

Theoretical background which underlines the role of facial voluntary control provides the neurocultural model of facial expressions of emotion (Ekman, 1972). This model postulates first that there is a close correlation between subjective emotion and facial activity, which signals the individual feelings, and second, that the display of facial expressions driven by innate central affect programs is gradually altered by the volitional control over facial behavior due to social learning (Izard, 1994; Izard & Malatesta, 1987). Therefore, the model differentiates between involuntary and voluntary expressions, arguing that certain facial movements are spontaneous and expressive of an emotional state, while others are deliberate and serve social-communicative purposes. In contrast, voluntary expressions are regulated by learned display rules, which can be defined as the social or cultural norms acquired during development that indicate who can show what facial behavior to whom in which situation (Ekman, 1972; Ekman & Friesen, 1969). According to Ekman (1978), display rules are "social norms regarding facial appearance, probably learned early in life and functioning on a habitual basis. They specify which one of the four management techniques is to be applied by whom to which emotion in a given circumstance" (p. 111). The four management techniques refer to (1) exaggerating, (2) attenuating, (3) neutralizing, or (4) masking (with another emotional expression) a facial expression. Facial motor programs are mediated by culture-specific display rules (Ekman, Friesen, & Ancoli, 1980; Gosselin, Kirouac, & Doré, 1995).

Despite the evidence accounting for relatively stable taste-and odor-elicited facial reactions across the life-span (except for the display rules observed in response to unpleasant tastes), the specificity of research questions and different research methods allow only limited comparisons between studies. Few studies used the fine-gain Facial Action Coding System (Ekman & Friesen, 1978; Ekman et al., 2002) for the analysis of facial reactions (Greimel et al., 2006; Saku & Ellgring, 1992; Soussignan et al., 1995; Zeinstra et al., 2009), whereas other studies used self-developed notational systems (Perl et al., 1992; Steiner et al., 1993). The studies, moreover, differed in applied stimuli. Greimel et al. (2006) used real foods rather than pure taste solutions that, however, did not cover the range of the basic tastes, and thus a direct comparison to the newborn studies is not given. Facial expressions in newborns were paid much attention to. In contrast, it has rarely been explored whether facial displays in healthy adults correspond to the facial displays observed in newborns (except the study by Greimel et al., 2006). Therefore, the first study of this project aimed to investigate healthy adults' facial reactions in response to qualitatively different tastes and odors by using the whole range of basic tastes, i.e. bitter, salty, sour, sweet, and umami, and odors differing in valence. Since in adults, unlike in newborns (Ganchrow et al., 1983), the influence of taste concentration has never been investigated, the question of whether an increase of taste concentration is associated with an increase of facial reactions displayed was also addressed in the first study. Facial voluntary control, i.e. display rules, has been found to alter facial reactions in response to the bitter taste in adults and unpleasant odors in children. Thus, another aim of the first study was to explore whether other tastes and odors may also elicit distinct facial displays in adults.

In each of the three studies facial reactions will be assessed before and after swallowing – a method which was developed by Greimel et al. (2006). Despite not being directly addressed by the authors, the separation into two observation periods seems to be very advantageous in order to exclude the facial activity associated with swallowing (often accompanied by lip press, inward pulling of the mouth corners, sometimes brow lower). Moreover, it allows comparing facial reactions on a number of indices during both periods which probably represent different appraisal processes (Scherer, 2001, 2004, 2007; Scherer & Ellgring, 2007). Moreover, it has been shown that studies either used observational or electromyographic systems to study facial expressiveness in response to tastes and odors. Facial reactions in the first study were assessed by the Facial Action Coding System (Ekman, & Friesen, 1978). In the second and third study, both the Facial Action Coding System (Ekman et al., 2002) and electromyography were used in order to explore their sensitivity to detect facial reactions in patients with eating disorders and patients with Attention-Deficit Hyperactivity Disorder.

2.2.2. Food preferences and food aversions

This section deals with the question whether food preferences and food aversions are flexibly changed over time. These hedonic shifts from preference to aversion or vice versa might be accompanied by facial reactions corresponding to the actual hedonic valence of a given food. Studies contributing to this question are referred to.

Throughout life humans acquire food preferences and food aversions by individual food experiences and food exposures. Once these food preferences and aversions have been acquired, they are not fixed but may even shift during ongoing life. For instance, a person might learn to prefer and like previously aversive food stimuli such as chilli or olives, or a person might learn to avoid recently liked food stimuli (via classical conditioning) when the eaten food, e.g. sweet taste, was paired with visceral illness (Garcia, Lasiter, Bermudez-Rattoni, & Deems, 1985; Reilly & Schachtman, 2009; Rozin, 2000). Overall, food preferences and food aversions might determine which facial reactions are elicited by a given food. Individuals accept or reject a given food with respect to its sensory features such as taste, color, texture, and form of a food stimulus (see sensory affective component, Rozin, 2000). If a food stimulus tastes delicious, it is preferred, and thus humans are likely to ingest it (Drewnowski & Hann, 1999), which is followed by positive facial displays. If a food stimulus tastes bad, it will be rejected, which is accompanied by negative facial displays and thus humans are likely to refuse to eat it. It is argued that the acquisition of food preferences and food aversions, which develop after birth dependent on food exposure, may alter innate food preferences and food aversions. Bitter tastes which are rejected at birth in general might be liked during adulthood, e.g. learned acceptance for coffee. Moreover, the sugar solution, which is preferred at birth, might be perceived as less pleasant in adulthood due to more delightful food experiences (candy, cakes) or due to the intention to eat healthy foods.

Developmental differences in taste preferences have been indicated over the life-span. A recent study indicated that the acceptance of the basic tastes changes over the first year of life (Schwartz, Issanchou, & Nicklaus, 2009). The study assessed facial mimics as well as ingested volume. According to the facial data, infants (facially) preferred the sweet taste over water at the ages of 3, 6, but not at 12 months. Infants were indifferent to the salty taste over water at the age of 3 months, but preferred the salty taste over water at the age of 6 and 12 months. Bitter and sour tastes were rejected over water at all ages. Infants were indifferent to the umami taste at all ages. The ingestion data were similar to the facial data; however, both measures became more congruent when infants grew up. Moreover, the data revealed a high within-subject variability, which led the authors to the conclusion that the acceptance of the basic tastes does not seem to be as stereotyped as it has often been described in the literature.

Further evidence for ontogenic changes in taste preferences over time comes from studies using acceptance measures such as ingested taste volume or sucking rates. Preference for the sweet taste remain heightened during infancy, i.e. from the ages of 1-3 days to 20-28 weeks (Desor, Maller, & Turner, 1973), and childhood; however, it decreased during late adolescence to levels similar in adulthood (Beauchamp & Cowart, 1987; Desor & Beauchamp, 1987). Indifferences to the salty taste in human newborns at birth shift to a preference for salt at around 3-6 months of age, remains heightened throughout childhood and adolescence, and then decreases from late adolescence to levels similar in adults (Beauchamp, Cowart, Mennella, & Marsh, 1994; Beauchamp, Cowart, & Moran, 1986; Desor, Greene, & Maller, 1975; Schwartz et al., 2009). Sour taste aversions, which are present at birth in human infants, shift to heightened sour taste preferences during infancy (Blossfeld et al., 2007) and childhood (Liem & Mennella, 2003), and then decrease in adulthood.

Overall, food preferences underlie flexible changes, which depend on food exposure and its perceived affective valence. Adults have greater food experiences than newborns which might be associated with changes of innate food preferences and aversions that are in turn accompanied with different facial displays. Dysfunctional hedonic shifts might be expected in patients with eating disorders since food is perceived as strongly aversive. It is expected that this hedonic shift is expressed through patients' facial reactions to a given food.

2.2.3. Eating disorders

This section addresses the question on the relationship between patients with eating disorders and food stimuli. The psychological mechanism behind food aversion and/or food attraction will be described for each eating disorder. Studies are presented which focused on eating disordered patients' hedonic and sensory perception of the sweet taste. Both the psychological mechanism and the studies contribute to the hypothesis that affective reactions in response to tastes and odors, including subjective as well as facial reactions, might be altered in patients with eating disorders.

Patients with eating disorders suffer from a disturbed eating rhythm and dysfunctional food-related cognitions (see appendix C for characteristic symptoms). Anorexics restrict their food intake below a certain minimum. Bulimics have intermitted phases of fasting and binges accompanied by engaging in methods to counteract weight gain. Binge eaters often suffer from weight gain as a consequence of regular binges without counteracting behaviors. Patients with eating disorders, in particular anorexics and bulimics, anticipate negative consequences with ingestion. According to Rozin (2000), anticipatory consequences contribute to whether individuals accept or reject food stimuli. Patients with eating disorders anticipate negative effects such as gaining weight, and thus they restrict their food intake. They anticipate positive effects with the ingestion of low calorie foods such as a thin shape and higher self-esteem and thus are more likely to prefer these foods. Therefore, food selection and ingestion underlies a high cognitive control, which is determined by food attitudes and evaluations about the type, quantity, and content of food as well as frequency and time of ingestion. As has been previously mentioned, cognitive control of food selection is characterized in eating-disordered patients by an avoidance of high calorie foods, and a preference for low calorie foods. Anorexics successfully restrict their food intake to low calorie foods, whereas bulimics and binge eaters fail to maintain to eat low calorie foods during their regular binges in which high calorie foods are consumed.

Patients with eating disorders might have an ambivalent affect-laden link to food stimuli (Berridge, 2007, 2009; Drobes et al., 2001). In particular bulimics and binge eaters are overwhelmed by their strong food cravings and emotions during a binge and thus fail to maintain dieting or fasting from time to time, and consume a large amount of food. Prior to a binge, bulimics and binge eaters experience a strong desire or craving for food stimuli they usually avoid leading to a binge. Negative emotions often induce food intake in order to cope with negative affect (Ganley, 1989; Macht, 1999), which is a phenomenon called emotional eating (Bruch, 1973; Kaplan & Kaplan, 1957). Negative affect was found to precede binges in patients with bulimia nervosa (Alpers & Tuschen-Caffier, 2001; Davis, Freeman, & Garner, 1988; Johnson & Larson, 1982; Lingswiler, Crowther, & Stephens, 1989; Hilbert & Tuschen-Caffier, 2007) and binge-eating disorder (Cattanach, Malley, & Rodin, 1988; Deaver, Miltenberger, Smyth, & Crosby, 2003; Greeno, Wing, & Shiffman, 2000; Hilbert & Tuschen-Caffier, 2007; Johnson, Schlundt, Barclay, Carr-Nangle, & Engler, 1995; Stein et al., 2007; Stice, Akutagawa, Gaggar, & Agras, 2000; Telch & Agras, 1996). During and after a binge, mood declines and patients experience negative emotions such as shame and guilt about having overeaten (Eversmann, Schöttke, & Wiedl, 2007; Schöttke, Eversmann, & Wiedl, 2006) which in turn leads to purging in bulimic patients – but not in binge eaters – in order to prevent weight gain. Ingestion is therefore linked to ambivalent affect in both patients. Eating-disorders often co-occur with affective disorders (Braun, Sunday, & Halmi, 1994; Laessle, Tuschl, Kotthaus, & Pirke, 1989; Yanovski, Nelson, Dubbert, & Spitzer, 1993), contributing to the necessity to evaluate severity of depression in this project.

In general, patients with Anorexia Nervosa avoid food with high carbohydrate content (Crisp, 1967; Russell, 1967; van Binsbergen, Hulshof, Wedel, Odink, & Coelingh Bennink, 1988) and/or fat content (Drewnowski, Halmi, Pierce, Gibbs, & Smith, 1987; Drewnowski, Pierce, & Halmi, 1988; Pierce, Halmi, & Sunday, 1989; Sunday & Halmi, 1990; van Binsbergen et al., 1988). In contrast, bulimics prefer high carbohydrate and high fat food during their binges (Drewnowski, 1989), but avoid fat during non-binge times (Drewnowski et al., 1987, 1988). Patients with eating disorders anticipate gaining weight by ingestion, and especially high fat and carbohydrate food imply a threat for body weight. Studies have investigated hedonic and sensory perception of tastes in patients with eating disorders. There are conflicting results concerning the pleasantness of the sweet taste. Garfinkel (1974) and Garfinkel, Moldofsky, and Garner (1979) found a heightened preference for sweet in women with anorexia. In contrast, Simon, Bellisle, Monneuse, Samuel-Lajeunesse, and Drewnowski (1993) found no difference between anorexics and healthy controls. Bulimic women preferred high sweet stimuli to a greater degree than controls (Drewnowski et al., 1987). Franko, Wolfe, and Jimerson (1993) reported that those bulimics who suffered from anorexia in the past rated the sweet taste as more unpleasant, whereas bulimics who did not suffer from anorexia in the past rated it as more pleasant than did controls. Neither weight gain nor weight loss had an influence on hedonic rating of the sweet taste (Drewnowski, 1989; Drewnowski et al., 1987; Garfinkel et al., 1979; Rodin, Moskowitz, & Bray, 1976). However, body weight appears to be linked with the pleasantness of the sweet taste. Lower body weight was associated with a heightened preference for sweet, whereas higher body weight (BMI) was associated with a heightened preference for fat (Drewnowski et al., 1987). Eiber, Berlin, de Brettes, Foulon, and Guelfi (2002) who applied a “sip and spit” or “sip and swallow” procedure found that hedonic reactions in patients with eating disorders (bulimia, anorexia both types) were lower when the patients swallowed the sugar solutions compared to when they spit them out. The anxiety to swallow and thus to gain weight moderated the pleasantness of sweet tastes. Despite the differences in pleasantness in response to sweet tastes, sensory taste perception for sweet taste (Drewnowski et al., 1987; Franko et al., 1993; Simon et al., 1993; Sunday & Halmi, 1990) did not differ between patients with eating disorders and controls.

In sum, several studies have indicated that patients with eating disorders like the sweet taste more or less than controls, but perceived it as equally intense as controls. The inconsistent results regarding the pleasantness of the sweet taste might be due to subjective ratings, which are faced with several problems such as answering biases. Thus, there is need for a more objective measure such as facial reactions. Facial reactions may provide a clearer read-out of emotion and thus may be a more reliable measure of the affective value of tastes and odors in patients with eating disorders. Up to now, facial reactions in response to food stimuli have never been investigated in patients with eating disorders. There is one unpublished study (Saku, Ellgring, Bossert, Meiller, & Pirke), that found bulimics displaying more negative and more intense facial reactions in response to the unpleasant odor ammonia compared to anorexics and controls. It is unclear whether taste-elicited facial responses are altered in eating disorders and whether facial reactions in response to all basic tastes (not only the sweet taste) are changed. Therefore, the second and the third study addressed whether patients with eating disorders show altered facial reactions in response to tastes and odors.

2.2.4. Personality variables

Personality aspects such as deficient inhibitory control and expressivity are expected to serve as a moderator influencing facial reactions elicited by tastes and odors. This section will present empirical findings linking deficient inhibitory control with eating disorders. It will also shed light on Attention-Deficit Hyperactivity Disorder, which involves deficient inhibitory control as a key symptom. Moreover, motoric inhibition may not be limited to behavioral reactions already described but also to facial behavior. The great interindividual variety in facial expressiveness will be shown with respect to gender.

Eating-disorders, in particular Bulimia Nervosa, have often been related to impulsivity and behavioral disinhibition (Claes, Vandereycken, & Vertommen, 2002; Fahy & Eisler, 1993; Kaye, Bastiani, & Moss, 1995; Kaye, Strober, & Jimerson, 2004; Lacey & Evans, 1986; Steiger, 2004; Vitousek & Manke, 1994; Westen & Harnden-Fischer, 2001). Recurrent binges of patients with Bulimia Nervosa and Binge-Eating Disorder, in which they consume an amount of food in a fixed period of time that is definitely larger than most people would eat under similar circumstances followed by a lack of control over eating (APA, 1994), might characterize a form of impulsive behavior (Nederkoorn, Van Eijs, & Jansen, 2004). Additionally, bulimic individuals are prone to other kinds of impulsive behaviors, like substance abuse, self-harm or theft (Dykens & Gerrad, 1986; Holderness, Brooks Gunn, & Warren, 1994; Nagata, Kawarada, Kiriike, & Iketani, 2000). They scored higher on self-reports that measure impulsive actions in daily life, sensation seeking, risk taking, and reward sensitivity (Claes et al., 2002; Claes, Vandereycken, Vertommen, 2005; Fahy & Eisler, 1993; Loxton & Dawe, 2001, 2004; Newton, Freeman, & Munro, 1993; Rossier, Bolognini, Plancherel, & Halfon, 2000; Rosval et al., 2006; Steiger et al., 2001; Wonderlich, Connolly, & Stice, 2004). Therefore, impulsive behaviors might not be limited to bulimic eating behavior per se, but rather indicate general deficits in their impulse control (Nederkoorn et al., 2004).

Impulsivity is a multidimensional construct, including cognitive and attentional impulsivity, i.e. the inability to maintain directed attention, and behavioral/motor impulsivity, i.e. the proneness to rash actions (Fischer, Smith, & Anderson, 2003; Helmers, Young, & Pihl, 1997; Whiteside & Lynam, 2001). An impulsive response refers to a behavior characterized by rashness, insufficient forethought, planning, or control, and lack of reflection. Impulsive actions reflect a continuum of a personality trait, with some people acting on impulse from time to time and some people acting on impulse very frequently, which is maladaptive, like in patients with Attention-Deficit Hyperactivity Disorder (ADHD) (Levy, Hay, McStephen, Wood, & Waldman, 1997). Barkley (1997) has argued that impulsivity is the consequence of deficient inhibitory control. If someone has insufficient inhibitory control, impulses and immediate reward will rule over secondary considerations and long-term consequences. Eating behavior might be influenced by the vulnerability for immediate gratification. The sight, smell, or thought of tasty food induces appetite in most people. Eating inhibition will fail in an individual with deficient inhibitory control, leading him/her to overeat or a heightened facial activity in response to foods. Increased vulnerability to binge eating also may involve heightened reward sensitivity/drive. Reward sensitivity may play a role in the initiation of binge cravings and desire to binge, and the component of rash spontaneous impulsiveness contributes to disinhibited behavior and loss of control during a binge-episode, and/or the inability to resist binge cravings (Fischer et al., 2003).

Bulimic eating behavior is linked to worse performance on various executive function tasks (Jones, Duncan, Brouwers, & Mirsky, 1991; Lauer, Gorzewski, Gerlinghoff, Backmund, & Zihl, 1999; McKay, Humphries, Allen, & Clawson, 1986) with deficits in cognitive/attention impulsivity, motor impulsivity, and heightened reward sensitivity. Several studies found a poor inhibitory performance from disorder-salient words on modified Stroop tasks in patients with bulimia (Cooper & Fairburn, 1994; Cooper & Todd, 1997; Cooper, Anastasiades, & Fairburn, 1992; Jones-Chesters, Monsell, & Cooper, 1998; Lovell, Williams, & Hill, 1997; Mobbs, Van der Linden, d'Acremont, & Perroud, 2008) which reflect their attentional bias toward food, weight, and body shape. In addition, bulimic patients also tend to make more inhibitory failures than controls on tasks related to motoric forms of impulsivity (Marsh et al., 2009; Mobbs et al., 2008; Rosval et al., 2006). Rosval et al. (2006) found that bulimics and purging anorexics made more errors of commission in a go/no-go task compared to the restrictive anorexics and control groups. Moreover, bulimics tended to react faster than controls in an adaptation of the go/no-go affective shifting task (Mobbs et al., 2008). Marsh et al. (2009) argued that bulimics’ failure to engage frontostriatal circuits appropriately lead to a more impulsively responding and a higher error rate on the Simon Spatial Incompatibility task compared to controls.

Likewise in patients with Attention-Deficit Hyperactivity Disorder, inhibitory deficits are discussed as precursor underpinning general executive dysfunction in ADHD (Barkley, 1997; Barkley, Murphy, & Fischer, 2008; Sonuga-Barke, 2003). Attention-Deficit Hyperactivity Disorder (ADHD) is a neurobehavioral developmental disorder (Zwi, Ramchandani, & Joughin, 2000) which is primarily characterized by inattention, hyperactivity, and impulsivity (see appendix C for DSM-IV criteria in children and adults). The DSM-IV defines three types of ADHD: an inattentive type, a hyperactive/impulsive type, and a combined type. ADHD is a common chronic disorder in children (Van Cleave & Leslie, 2008) with 30% to 50% of those individuals diagnosed in childhood continuing to have symptoms into adulthood (Bálint, Czobor, Mészáros, Simon, & Bitter, 2008; Elia, Ambrosini, & Rapoport, 1999; Stern & Stern, 2002). Adolescents and adults with ADHD tend to develop coping mechanisms to compensate for some or all of their impairments. The signs and symptoms may differ from those during childhood and adolescence due to the adaptive processes and avoidance mechanisms learned during the process of socialisation. Treatment for adult ADHD combines medication, behavioral, and cognitive interventions. Stimulant medications are often the first line treatment (Kolar et al., 2008) such as with methylphenidate. In a double-blind, randomized, placebo-controlled study, the efficacy and safety of methylphenidate has been recently demonstrated (Medori et al., 2008). The treatment with three dosages of methylphenidate over five weeks versus placebo revealed a symptom reduction, which was most pronounced for the highest dosage. Recent reviews of the literature have indicated that not deficient inhibitory control per se but rather deficient inhibitory motor control, i.e. problems in the suppression of prepotent motor responses, is the core deficit of ADHD (Lijffijt et al., 2004; Lijffijt, Kenemans, Verbaten, & Van Engeland, 2005; Nigg, 2001; Oosterlaan, Logan, & Sergeant, 1998; Sergeant, Geurts, & Oosterlaan, 2002).

Overall, patients with Bulimia Nervosa suffer from inhibitory deficits. Deficits in motor impulsivity have been indicated by reaction times or error rates. To date, however, a greater facial expressiveness as a means of facial motor impulsivity has never been linked to deficient inhibitory control either in patients or healthy controls. Therefore, the second study addresses the question of whether the quantity of facial reactions in response to tastes and odors is altered in patients with various eating disorders. In contrast to bulimics, inhibitory deficits have never been shown in binge eaters who also report regular binges (due to the fact that is has never been investigated). Once facial reactions have been established as indices of motoric disinhibition in eating disorders, the finding needs to be verified in a sample of patients with Attention-Deficit Hyperactivity Disorder, who clearly exhibit executive function deficits. Therefore the third study will address whether both bulimics as well as ADHD patients exhibit a greater facial expressiveness in response to tastes and odors during spontaneous facial reactions and during facial suppression.

Individuals vary strongly in their emotional expressiveness. Some persons are highly expressive, enabling observers to infer emotional states, whereas other persons are straight-faced, making it difficult to infer emotional states (Manstead, 1991). Facial expressiveness can be assessed by judgement measures, by electromyography, or by observational systems. Facial expressiveness can be explained by factors such as gender, extroversion, and temperament. It has been shown that women are more facially expressive (except for anger) than men in naturalistic and posed situations (Biehl et al., 1997; Dimberg & Lundquist, 1990; Hall, Carter, & Horgan, 2000). Females exhibit a greater facial EMG activity than males do (Schwartz, Ahern, & Brown, 1979; Schwartz, Brown, & Ahern, 1980; Schwartz, Fair, Salt, Mandel, & Klerman, 1976a, b; Schwartz et al., 1978). They have higher corrugator activity levels (indicative for sadness or concern) during posed facial expressions. Judgement measures confirm this gender effect since females' spontaneous facial responses to emotional stimuli are more accurately decoded by observers compared with males' facial responses (e.g. Buck, Savin, Miller, & Caul, 1972; Gallagher & Shuntich, 1981). Gender differences in facial expressiveness elicited by tastes and odors have never been investigated yet. Therefore the first study compares facial reactions in men and women. The second and third study will investigate facial reactions exclusively in women since their percentage of an eating disorder diagnosis is higher than in men. Women's differences in facial expressiveness will be assessed by questionnaire.

2.2.5. Sensory characteristics

Within this section the question will be addressed how sensory characteristics such as bitter sensitivity and taste and odor thresholds contribute to the inter-individual variety of food preferences and food aversions. Different assessment methods of bitter sensitivity will be explained in order to answer which is the best method. Empirical findings contribute to the question of whether patients with eating disorders have impaired taste and odor thresholds.

Taste is a hereditary trait and affects eating and dietary behavior. In particular, bitter sensitivity had been of special interest in research (Bartoshuk, Duffy, Reed, & Williams, 1996; Bartoshuk, Fast, Snyder, & Duffy, 2004; Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006; Macht & Müller, 2007). In 1931, Fox discovered the phenomenon of taste blindness during the synthesis of the bitter substance phenylthiocarbamid (PTC). After PTC had been volatilized, one of Fox' colleagues perceived the substance as bitter, whereas Fox did not taste anything (from Bartoshuk et al., 2004). Nowadays, 6-n-propylthiouracil (PROP) instead of PTC is used in research, since PROP is odorless and less toxic.

Approximately 25%–30% Caucasians in Europe and North America perceive PTC/PROP as less intense and are referred to as non-tasters (Tepper, 1998). 70%–75% of the Caucasians are tasters, who perceive PTC/PROP as more intense. The early dichotomous classification into non-tasters and tasters was broadened by a differentiation of tasters into medium-tasters and super-tasters (Bartoshuk, Duffy, & Miller, 1994). Approximately 25% of tasters perceive PTC/PROP as very intense and thus are referred to as super-tasters (Bartoshuk et al., 1994; Tepper, 1998). Women are more likely to belong to the taster group (Bartoshuk et al., 1994). Bitter sensitivity is inherited with PTC/PROP tasting as a dominant trait (Bartoshuk et al., 1994). Non-tasters have two homozygous recessive alleles, medium-tasters two heterozygous alleles, and super-tasters two homozygous dominant alleles. Although most of the variation in bitter sensitivity can be explained by a single bitter receptor gene on chromosome 7q (TAS2R38) (Drayna et al., 2003; Kim et al., 2003), anatomical data suggests that PROP sensitivity also varies as a function of fungiform papillae density (Bartoshuk et al., 1994; Drewnowski, Henderson, Shore, & Barratt-Fornell, 1997; Essick, Chopra, Guest, & McGlone, 2003; Tepper & Nurse, 1997).

Certain foods contain higher levels of bitter constituents such as broccoli, green cabbage, Brussels sprouts, radishes, spinach, grapefruit, green tea, and coffee, which are perceived as more intense by super-tasters. From an evolutionary perspective, the perception of bitter tastes has a protective mechanism, preventing people from excessive consumption of goitrogen substances present in bitter tasting plants. The sensitivity for PTC/PROP is accompanied by a heightened sensitivity for some bitter constituents and correspondingly a dislike of bitter tasting foods (Drewnowski, Henderson, & Barratt-Fornell, 2001; Drewnowski et al., 1997; Drewnowski & Rock, 1995; Drewnowski, Henderson, Hann, Berg, & Ruffin, 2000; Duffy & Bartoshuk, 2000; Gent & Bartoshuk, 1983) which was however not shown in two studies (Jerzsa-Latta, Krondl, & Coleman, 1990; Mattes & Labov, 1989). There is evidence that tasters have a higher sensitivity for many oral stimuli such as sugars (Bartoshuk et al., 1994; Gent & Bartoshuk, 1983; Looy & Weingarten, 1992; Yeomans, Tepper, Rietzschel, & Prescott**,** 2007) and thus tend to reject sweet foods. Looy and Weingarten (1992) found that the liking for sweet correlated strongly with the genetically determined bitter sensitivity: PROP non-tasters were almost always sweet likers, whereas PROP tasters were almost always sweet dislikers. This varying sweet preference was also expressed via facial reactions. More specifically, naive raters correctly classified “sweet dislikers” in 86% of the cases upon their (negative) facial expressions (frown, grimace, eyes rolled, tongue show). “Sweet likers”, however, were less correctly classified (brow raise, lip wipe) via their (positive) facial expressions (40%), which was attributed to a lower complexity of facial reactions to positive taste stimuli (Looy & Weingarten, 1992). In another study, super-tasters showed more frequently the negative facial display of brow lower compared to non- and medium-tasters (Macht, Weiland, Wegmann, & Ellgring, unpublished data). However, there are also studies that found no relationship between sensory reactions to sweet tastes and bitter sensitivity (Drewnowski, Henderson, & Barratt-Fornell, 1998; Drewnowski et al., 1997; Drewnowski, Henderson, Levine, & Hann, 1999; Ly & Drewnowski, 2001).

Several methods to determine bitter sensitivity have been identified. Today suprathreshold scaling methods have replaced threshold methods. Suprathreshold scaling methods use different intensity scales, e.g. Labeled Magnitude Scale (LMS), which is a quasilogarithmic scale with label descriptors that is equivalent to magnitude estimation (Green, Shaffer, & Gilmore, 1993). This scale enables participants to rate intensity of a stimulus relative to the strongest imaginable taste or oral stimulus they have ever experienced in everyday life. Researchers differ in the number of applied PROP concentrations which range from 5 to 3 to 1 solution. NaCl is often used as a reference standard since it is not expected to be systematically associated with bitter sensitivity. Limitations on NaCl have been reported (Bartoshuk, 2000) leading to the use of sounds and weights as standards. Later these limitations were ruled out (Bartoshuk et al., 2004) and thus there is no substantial argument against the use of NaCl as reference. PROP status classification can be assessed by different methods. Rankin, Godinot, Christensen, Tepper, and Kirkmeyer (2004) described methods such as the distribution method (25% non-tasters - 50% medium-tasters - 25% super-tasters), 1.2 PROP ratio defined by the formula [(3.2mM PROP/ 1M NaCl) + (0.32mM PROP/ 0.1M NaCl)/2)], K-means non-hierarchical cluster analysis on PROP ratings with a three cluster solution, a combination of K-means and PROP ratio, and visual classification (non-taster: PROP ratings are much lower than for NaCl, medium-taster: comparable PROP and NaCl ratings, super-taster: higher PROP than NaCl ratings). Moreover, test-retest reliability of different methods for the assessment of taster status varied among the number of applied solutions. The one-solution test, first validated by Tepper, Christensen, and Cao (2001), revealed higher test-retest reliabilities (range from 78%-83%) than the three-solution test (range from 54%-72%). The highest test-retest reliability for the one-solution test was obtained by K-means, followed by K-means/ratio, visual classification, distribution, and PROP ratio (Rankin et al., 2004). Moreover, the one-solution test requires the shortest administration. Due to the advantages of the one-solution test, it was used to assess bitter sensitivity in the second and third study.

Taste and odor thresholds are also important for gustatory and olfactory perception and influence affective experience. A complete loss of the ability to detect tastes and odors (ageusia, anosmia) or even the reduced ability to taste and smell (hypogeusia, hyposmia) are accompanied by a decreased subjective quality of life. Studies on taste perception in eating disorders indicated that the majority of anorexic and bulimic patients had a hypogeusia (Jirik-Babb & Katz, 1988; Nakai, Kinoshita, Koh, Tsuji, & Tsukada, 1987; Nozoe et al., 1996) for the four basic tastes. Hypogeusia was impaired the strongest for the sour taste (Jirik-Babb & Katz, 1988). Rodin, Bartoshuk, Peterson, and Schank (1990) argued that chronic purging might have caused the loss of sour receptors. Casper, Kirschner, Sandstead, Jacob, and Davis (1980) found a hypogeusia for sour and bitter tastes. Nozoe et al. (1996) reported a recovery of sensitivity for sour and bitter tastes when a daily calorie intake of 1600 kcal was consumed. Anorexics had a heightened odor threshold compared to controls (Roessner, Bleich, Banaschewski, & Rothenberger, 2005).

In sum, bitter sensitivity and taste and odor thresholds have been shown to affect food preferences and aversions in healthy people and might also play a role in patients with eating disorders. Therefore, these variables will be assessed in the second and third study.

2.3. Cultural and social moderators

This section will address the question of how social context and culture influence facial reactions. Studies that manipulated the social context are reviewed which have been shown to facilitate or inhibit facial reactions in response to tastes and odors. Important implications for the project will be drawn.

One critical aspect of the context affecting emotional expressiveness is the presence of others. The intimacy of the interactants, their given task (coaction vs. observation), their power and status with respect to each other influence emotion expression. Usually, coaction (with a friend or a familiar person) facilitates facial expression and being observed (by an experimenter or a stranger) inhibits facial expression (Buck, Losow, Murphy, & Costanzo, 1992; Wagner & Smith, 1991). Thus, different social contexts might produce qualitatively different facial behaviors.

Studies that investigated the effect of social context on facial reactions in response to tastes and odors in newborns and adults have indicated conflicting results. These studies assessed facial behavior in face-to-face situations with the presence of the experimenter and/or in situations when participants' facial reactions were recorded on video (Armstrong et al., 2007; Chapman et al., 2009; Greimel et al., 2006; Horio, 2003; Hu et al., 1999; Perl et al., 1992; Rosenstein & Oster, 1988; Saku & Ellgring, 1992; Soussignan et al., 1995; Steiner, 1974, 1977, 1979; Steiner et al., 2001; Steiner et al., 1993; Zeinstra et al., 2009). The knowledge that they are being recorded on video might also characterize a form of social context since participants anticipate that the video will be watched afterwards. Four studies directly tested the effect of social presence on taste-elicited facial responses (Brightman, Segal, Werther, & Steiner, 1975, 1977) and odor-elicited facial responses (Jäncke & Kaufman, 1994; Kraut, 1982; Soussignan & Schaal, 1996). The studies supported either the emotional expression view with more facial reactions being displayed when alone compared to when others are present (Kraut, 1982; Soussignan & Schaal, 1996) or the behavioral ecology view (Brightman et al., 1975; Jäncke & Kaufman, 1994) with more facial reactions being displayed when others are present compared to when alone. For example, Kraut (1982) found that adult facial expressions were more valid cues to the hedonic assessment of odors when the adults were alone than when they were in the presence of another person. Brightman et al. (1975) provided adults with either highly sweet or highly salty margarine sandwiches. When eating in the presence of others, adults displayed facial responses similar to newborns, whereas when eating alone, adults inhibited their facial responses. Jäncke & Kaufman (1994) found that when adults were confronted with an experimenter they exhibited a greater facial EMG activity over the periocular and cheek region (indicative for smile) in response to pleasant odors than those adults who smelled these odors in private. In response to unpleasant odors adults confronted with an experimenter showed stronger nasalis activity (indicative for disgust) than those who smelled it in private.

Other studies (Gilbert, Fridlund, & Sabini, 1987; Greimel et al., 2006; Perl et al., 1992; Saku & Ellgring, 1992; Rosenstein & Oster, 1988; Steiner, 1974, 1977, 1979; Steiner et al., 1993; Tassinary, 1985) did not examine whether facial responsiveness to tastes and odors varied as a function of social context. In sum, the higher facial responsiveness in the presence of others may serve at least in part as a socially communicative function and may selectively activate display rules (Ekman, 1972; Ekman & Friesen, 1982; Greimel et al., 2006; Soussignan et al., 1995).

Opponents of the behavioral-ecology view (Fridlund, 1991a, 1992, 1994) postulate that human facial reactions reflect social motives rather than emotional states. Facial behavior signals intentions of a person, which increases their chance of survival. Therefore, facial displays are social signals which serve to communicate social motives and they are driven by social intents. Fridlund (1991a, 1992, 1994) argued that there is no direct relationship between emotion and facial expression. Moreover, facial displays depend on the intent and context in which they occur rather than on the underlying emotional state of the individual. Smiles do not indicate expressions of happiness but are signals that serve a variety of functions in different social contexts, e.g. readiness to affiliate, to continue the current interaction, or to display empathy with another person. Crying is not expression of sadness, but rather to display one's need for comfort or one's sense of ultimate helplessness. Whether a particular face co-occurs with a particular emotion depends on the nature of the social interaction and not on the intensity of the felt emotion. The sociality of the situation gives rise to certain social motives that determine the type of facial activity that is displayed. This argument has received some empirical support (Chovil, 1991; Fernández-Dols & Ruiz-Belda, 1995; Fridlund, 1991; Kraut & Johnston, 1979; Wagner & Lee, 1999). In contrast, opponents of the emotional expression view argued that involuntary or spontaneous facial displays in solitary situations are "the biologically based, evolved, universal facial expressions of emotion" (Ekman, 1984, p. 321) and thus have been denoted as the purest "read-out" of emotion (Buck, 1984; Ekman, 1984). They underestimate the sociality of the experimental situation.

It has been shown that even when people are alone, they display facial reactions. Moreover, studies indicated that short interactions with a stranger or experimenter are sufficient to reduce the effect that facial reactions are inhibited in the presence of unfamiliar persons (Hess, Banse, & Kappas, 1995; Wagner, Gee, & Quine, 1993). This demonstrates the importance of the interaction not only during the experiment but also before the experiment. Fridlund (1991) claimed that facial reactions are shown even in solitary situations due to the presence of an implicit companion, such as a friend. This means that even when people are physically alone, they are never mentally so. Individuals treat themselves as interactants, they act as if other persons are present, they imagine that others are present, they anticipate interaction, or they treat objects as interactants. Fridlund (1991) tested his predictions in a study with four experimental conditions differing in sociality (1. participant came alone to the lab and viewed film alone; 2. participant came to the lab with a friend and viewed film together; 3. participant came to the lab with a friend and they were then separated to view the film each alone; or 4. participant came to the lab with a friend and the friend completed a different task in another room) in which participants watched an amusing film while zgyomaticus major muscle activity was recorded. Participants who believed their friend was viewing the same film in another room smiled as much as participants whose friend was physically present, and both of these groups smiled more than those who came alone. There were no differences in self-reported happiness. Thus smiling was just equally enhanced by an implicit friend and by a physical present friend. Fridlund found evidence for his predictions in other studies (Fridlund et al., 1990; Fridlund, Kenworthy, & Jaffey, 1992).

To sum up, social context is an important variable when studying facial behavior. This project will not manipulate social context, since facial reactions are not supposed to differ in the presence of others or alone. In all studies, facial reactions in response to tastes and odors will be investigated obtrusively. Thus, the participants know that they will be recorded on video, while the experimenter is present but not visible for them during the experiment. Uncertainty about the role of the experimenter will be reduced prior to the experiment due to several interactions (introductory session, questionnaire session) and special attention is paid to create a warm atmosphere.

Culture and acquired cultural-specific display rules are also expected to moderate facial expressiveness. According to Ekman (1978), display rules are social norms that determine which facial expression can be shown to whom in what situation. Display rules are characterized through (1) exaggerating, (2) attenuating, (3) neutralizing, or (4) masking (with another emotional expression) a facial expression. In a cross-cultural study, Japanese and American students watched neutral and stressful films while their facial reactions were covertly recorded (Ekman, 1972; Friesen, 1972). Facial behavior was similar when seeing the film alone. However, when the participants watched the film again in the presence of a scientist of the same ethnicity, Japanese students masked their facial expressions of negative emotions by “social” smiles to a greater extent than did American students. Moreover other studies provided empirical evidence that facial expressiveness depends on culture or nationality (Lambert, Hamers, & Fraser-Smith, 1979; Sommers, 1984; Wallbott, Ricci Bitti, & Bänninger-Huber, 1986). Each culture has its culture-specific food rules which are acquired through social learning within a family or later within a peer-group. In the Mexican culture children are acquainted with the taste of chilli at the age of 3 years. The children grow up in an environment in which chilli is regularly consumed. Due to social pressure, the children learn to prefer chilli, for which all people have an innate aversion. The empirical evidence on the influence of food preferences in children by parents is rather small (r = 0.2, r = 0.3) (Birch, Zimmerman, & Hind, 1980; Birch & Marlin, 1982). Social learning within a family and the culture play an important role for the acquisition of food preferences (Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2007; Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007). The effect of culture and social learning will not be directly tested within this project.

II. Experiments

1. Study 1 – "*Facial reactions in response to tastes and odors in healthy adults*"

1.1. Aims, specific research questions, and hypotheses

General aim of the first study was to examine whether adults' facial reactions in response to qualitatively different tastes and odors are comparable to those facial reactions observed in newborns. This study aimed to specifically explore

(1) … adults' facial reactions in response to the five basic tastes (bitter, salty, sour, sweet, and umami) and adults' facial reactions in response to different odors (banana, cinnamon, clove, coffee, fish, and garlic)
(2) … the influence of taste concentration on the number of adults showing facial reactions using low, medium, and high concentrations of the tastes
(3) … the overall facial activity in response to tastes and odors
(4) … gender differences in facial reactions in response to tastes and odors.

The following questions were addressed to explore the issues mentioned above.

(1) Do qualitatively different tastes and odors elicit specific facial reactions in adults that correspond to those facial reactions observed in newborns?

It was expected that adults display specific facial reactions in response to tastes and odors that correspond to those observed in newborns (Ganchrow et al., 1983; Rosenstein & Oster, 1988, 1997; Soussignan et al., 1997; Steiner, 1973, 1977, 1979, 1987; Steiner et al., 2001).

Tastes: The pleasant tastes (sweet and umami) were expected to elicit positive facial displays such as lip suck, lip wipe, and smiling. The unpleasant tastes (bitter, salty, and sour) were expected to elicit negative facial reactions such as upper lip raise, mouth opening, nose wrinkle, brow lower, and lip corner depress. Moreover, it was expected that adults smile in response to the unpleasant tastes correspondingly to the finding by Greimel et al. (2006), which was not observed in newborns.

Odors: Unpleasant odors were expected to elicit negative facial displays (e.g. mouth corner depression, lip pursing, nose wrinkle, and upper lip raise) and pleasant odors were expected to elicit positive facial displays (e.g. smiling and sucking).

(2) Does the frequency of adults showing facial reactions increase with increasing taste concentration?

It was expected that more adults display positive facial reactions (e.g. lip suck, lip wipe, and smiling) with increasing sweetness level and negative facial reactions (e.g. brow lower, upper lip raise, mouth opening, and lip corner depress) with increasing bitterness, saltiness, sourness, and savoriness level (Ganchrow et al., 1983; Macht et al., unpublished data).

(3) Do pleasant and unpleasant tastes and odors differ in the overall facial activity?

It was expected that unpleasant tastes elicit a higher overall facial activity than pleasant tastes (Greimel et al., 2006; Looy & Weingarten, 1992). Likewise, unpleasant odors were expected to elicit a higher overall facial activity than pleasant odors.

(4) Do men and women differ in the overall facial activity to tastes and odors?

It was expected that women exhibit a greater overall facial activity than men in response to tastes and odor since women are more facially expressive than men in general (Biehl et al., 1997; Brody & Hall, 2000; Dimberg & Lundquist, 1990; Hall et al., 2000). Likewise, women were expected to show more specific facial reactions than men.

1.2. Methods

1.2.1. Participants

Thirty-two healthy participants (16 female, 16 male) were recruited at the University of Würzburg to voluntarily take part in the study. Data of four participants were not included in the analysis since these participants did not follow the instructions exactly (swallowed too early, rinse too early, rinse immediately after swallowing, face was sometimes out of the camera focus, active joking in front of the camera). Thus, data of twenty-eight participants were analyzed. Participants were mostly students (90%) with a mean age of 25 years (SD = 3.4), ranging from 18 to 32 years. Participants had normal weight with a mean Body Mass Index (BMI, body weight divided by squared height, kg/m^2) of 21.80 (SD = 3.1) for female participants and 22.89 (SD = 2.4) for male participants. Participants were native German speakers, non-smokers, free from medications, colds, food allergies, nasal allergies, and olfactory or gustatory disorders at the moment of the test. They abstained from eating and drinking for at least 1.5 hours prior to the experiment. Please see the appendix C Table 06 for further sample characteristics.

1.2.2. Taste and odor stimuli

Taste stimuli were solutions of PROP (6-*n*-Propylthiouracil) for bitter taste (Merck-VWR, Darmstadt, Germany), NaCl for salty taste, citric acid for sour taste, sucrose for sweet taste (Adler Apotheke, Dinkelsbühl, Germany), and MSG (monosodium glutamate) for umami taste (Ajinomoto Foods, Germany). Each taste quality was applied in three different concentrations, i.e. low, medium, and high. Taste concentration were solutions of 0.032mM, 0.32mM and 3.20M PROP, 0.01M, 0.1M and 1.0M NaCl, 0.01M, 0.03M and 0.05M citric acid, 0.10M, 0.42M and 0.83M sucrose and 0.001M, 0.05M, and 0.1M glutamate. The choice of concentrations was determined according to criteria set up by Looy and Weingarten (1991, 1992), Bartoshuk et al. (1994), Hodson and Linden (2006), Robin, Rousmans, Dittmar, and Vernet-Maury (2003), and Rousmans, Robin, Dittmar, and Vernet-Maury (2000). Taste concentrations used in this study were all above the detection threshold, i.e. citric acid 0.0023M, NaCl 0.01M, sucrose 0.01M (Birbaumer & Schmidt, 1999), PROP (non-tasters $>1.8 \times 10^{-4}$mol/l PROP, super-tasters $<3.2 \times 10^{-5}$mol/l PROP; Drewnowski et al., 1997), and MSG 0.009M (Lugaz et al., 2002). Evian mineral water (ph 7.2) served as the control taste (neutral taste). All solutions were dispensed in 5ml distilled water and were administered at room temperature (20-22°). Before and after testing, taste solutions were stored in the refrigerator. Taste solutions were removed from the refrigerator at least 3 hours prior to testing to ensure an up-to-room-temperature, which was measured by a thermometer immediately before testing. Each stimulus was presented once in a disposable cup of 20ml maximum content. The stimuli were colorless to avoid that participants guessed the taste quality in the cups before actually tasting the stimulus. Taste solutions were freshly prepared a few days prior to the experiment (see the appendix A for the preparation of the tastes).

Odor stimuli were pen-like odor dispensing devices of the “Sniffin’ Sticks” test (Kobal et al., 1996). “Sniffin’ Sticks” is a test of nasal chemosensory performance which consists of three tests of olfactory functions, i.e. odor threshold, odor discrimination, and odor identification. In this study, only the odor identification test was used. It contains 16 common odors, which are presented in a randomized order by the use of felt-tip pens. Video recordings of only 6 of these 16 odors, i.e. banana, cinnamon, clove, coffee, fish, and garlic, were analyzed due to the high time costs of facial expression analysis by observational systems. These 6 odors were selected according to their perceived pleasantness, with banana, cinnamon, and coffee representing the pleasant pole and with fish, garlic, and clove representing the unpleasant pole.

1.2.3. Dependent variables – Subjective and facial reactions

Subjective reactions: Participants were instructed to rate intensity, pleasantness, and perceived quality for each taste and odor stimulus. Intensity and pleasantness in response to each stimulus were rated on verbally anchored scales from 1 to 25, using a method of category scaling developed by Heller (1985): Five numerical subdivisions are assigned to each of the five verbal categories (with endpoints “very low intensity” and “very high intensity”, “very unpleasant” and “very pleasant”). Participants were asked to first decide on a verbal category and then on the numerical gradation within the category. This scaling method allows participants to make a rough categorization in the first step and then fine-grade their decision in the second step. For the identification of taste quality, participants had to decide for one of six possible tastes in a multiple choice task (bitter, salty, sour, sweet, neutral, and miscellaneous). To identify odors, participants had to choose one out of four odor descriptors in a multiple choice task (see Kobal et al., 1996).

Facial reactions: Facial expressions were analyzed from video recordings using the Facial Action Coding System (Ekman & Friesen, 1978), an objective, standardized, and descriptive system for coding facial expressions based on the anatomy of facial movements. A visible facial movement is assigned to a single Action Unit (AU). Specific facial reactions refer to the frequency of an Action Unit. A parameter of overall facial activity was defined as the total number of AUs shown (multi-occurrence of AUs from 1-40; cf. Ellgring, 1989).

Two trained FACS coders – blind to stimulus condition – independently analyzed the videos in slow motion and frame by frame and coded the apex (moment of the most intense facial expression) of each facial expression. Facial reactions in response to tastes were separately assessed during two observation periods, i.e. before swallowing (a) and after swallowing (b), to exclude facial activity due to swallowing. The observation period before swallowing (a) began when the cup was put down to chin level to ensure visibility of participants’ entire face. This observation period ended when the participants had swallowed the liquid. The second observation period began after the participants had swallowed the liquid (b). The observation period for facial odor reactions began when the participant had placed the pen’s tip 2cm in front of both nostrils. Each observation period lasted up to a maximum of 4s.

Inter-rater reliability (IR) of FACS coding was assessed by a second coder who independently scored the expressions of 7 randomly chosen participants. IR was determined by dividing the number of AUs agreed upon by the two coders by the total sum of AUs scored by each (cf. Ekman & Friesen, 1978). Inter-rater reliabilities of IR = .82 and IR = .86 were achieved for reactions to taste stimuli and odor stimuli respectively and are regarded as good (see appendix C Tables 13 and 14).

1.2.4. Procedure

Participants were individually tested and seated in a comfortable chair in a room with a constant temperature (22°) and received identical written and spoken instructions. They were told that the study examines taste and odor perception. No other details about the aims of the study were given. Participants were informed that the experiment would be continuously video-recorded. They were, however, not told that their facial expressions would be analyzed specifically, in order to avoid exaggerated or moderated facial expressions. The video camera was placed in front of the participants at a distance of 2.5m. The experimenter who was present in the room during the entire experiment was not visible to the participants but could watch their behavior online via closed circuit TV. Please note that 4 different experimenters (2 female, 2 male) ran the study. All participants gave informed consent, including agreement to be recorded on video.

Taste presentation: For each of the 16 liquid solutions, participants were asked to rinse their mouth with mineral water prior to each liquid sample. Participants were requested to give the experimenter the verbal signal "Ready" each time when they had finished rinsing. Immediately after this signal, the experimenter measured 45s with a stopwatch. Within this time period, participants were asked to relax. After this 45s rest period, participants were told to taste the liquid, to keep it in the mouth for 5s and then to swallow it. Immediately after swallowing, participants rated intensity, pleasantness, mood, and perceived taste quality. Participants then rinsed their mouth with mineral water and were asked again to give the experimenter the signal ("Ready"). This experimental procedure of tasting was repeated identically with the 15 solutions (see Figure 2).

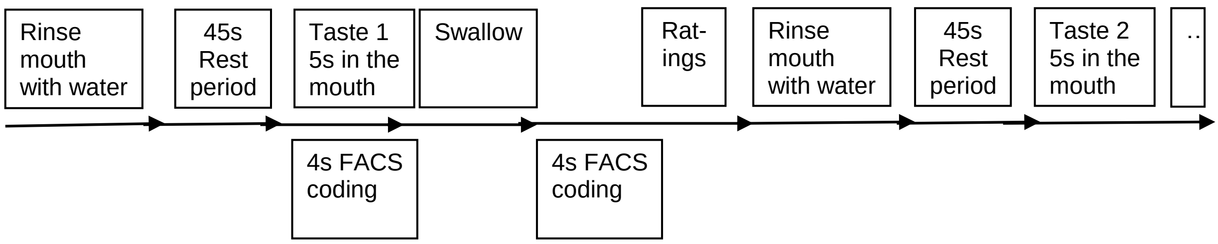


Figure 2: Experimental procedure of tasting.

Taste solutions were placed on a table in front of the participants in small cups numbered from 0 to 15. Mineral water (no. 0) was always presented as the first stimulus to make the participant familiar with the tasting procedure and to suppress some surprise effect. The initial water stimulus was not taken into account in the data analysis. Next, sweet, sour, salty, and umami solutions (no. 1 to 12) were presented in a pseudo-randomized order. 4 different pseudo-randomized taste orders were used, with 7 participants each receiving one taste order. Participants received the bitter taste (no. 13, 14, 15) at the end due to its masking effect (Dallenbach & Dallenbach, 1943; Leach & Noble, 1986). For each taste quality, the concentration was applied in ascending order, first low, then medium, and lastly high concentration (see appendix C Table 02).

Odor presentation: The odors were placed on a table in front of the participants numbered from 1 to 16. They were presented in a pseudo-randomized order (see appendix C Table 03). For each of the 16 odors, participants were asked to give the experimenter the verbal signal “Ready”. Immediately after this signal, the experimenter measured 30s with a stopwatch. After this 30s rest period, the experimenter told the participants to smell the odor (no. 1). Participants took the stick from the pen holder, removed the cap, placed it about 2cm in front of both nostrils and smelled it for at least 5s.

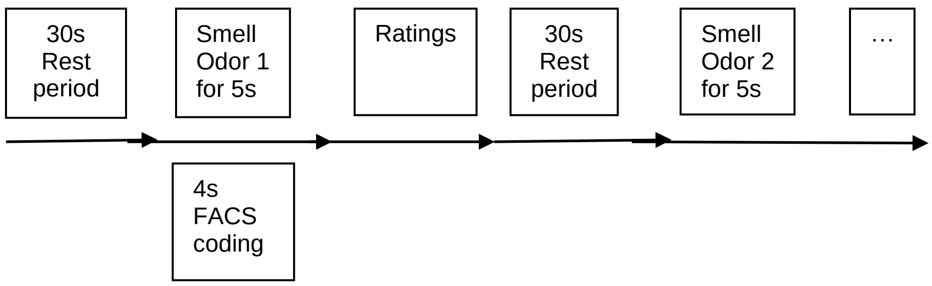


Figure 3: Experimental procedure of smelling.

After smelling, the participants put the stick back into the pen holder. Participants rated intensity, pleasantness and mood, and identified the odor using a multiple choice task with four odor descriptors. After the ratings, participants gave the experimenter the verbal signal “Ready”. This experimental procedure of smelling was repeated identically with the 15 odors (see Figure 3). The entire experiment lasted approximately 45 minutes.

1.2.5. Statistical analysis

Repeated measures ANOVAs were conducted for taste ratings (changes from water) and odor ratings for intensity, pleasantness, and mood separately.

To explore whether various tastes and odors elicited specific facial reactions, the frequencies of single facial reactions, i.e. Action Units, in response to the tastes vs. odors were compared by Cochran's *Q*-tests for differences among proportions. McNemar-tests were carried out to explore differences of specific facial activity between tastes and between odors.

To test whether taste concentration affected the number of adults showing specific facial reactions, the frequencies of single facial reactions, i.e. Action Units, in response to each taste concentration were compared by Cochran's *Q*-tests for difference among proportions. McNemar-tests were carried out to explore differences between tastes with respect to frequencies of Action Units.

To test taste-elicited and odor-elicited overall facial activity, i.e. the total number of facial reactions (AU 1-40), repeated measures ANOVAs were carried out.
To explore whether men and women differed in overall facial activity in response to tastes vs. odors repeated measures ANOVAs (tastes: 5 × 2 factors, odors: 6 × 2 factors) were carried out. For all ANOVAs, a Bonferroni correction was applied for single comparisons in case of significant main effects or significant interaction effects. To explore whether men and women differed in specific facial reactions in response to tastes and odors, the frequencies of single facial reactions, i.e. Action Units, were compared by Mann-Whitney U-Tests for differences among proportions.

1.3. Results

1.3.1. Subjective reactions

Tastes: In Figure 4 the taste ratings are presented. Perceived **taste intensity** of each taste quality significantly increased across concentrations, i.e. from low to medium, from low to high, and from medium to high (main effects of taste quality, $F(4, 104) = 27.57$, $p < .001$, taste concentration, $F(2, 52) = 280.86$, $p < .001$, significant taste quality × taste concentration interaction, $F(8, 208) = 14.69$, $p < .001$). This finding demonstrates that concentrations were successfully chosen within each taste quality. However, within each concentration, some tastes were not matched in perceived intensity (low concentrations: sour more intense than the other tastes, *ps* < .001; sweet more intense than bitter, salty, umami, *ps* < .05; medium concentrations: sour more intense than bitter, salty, umami, *ps* < .05; sweet more intense than umami, *p* = .009; high concentrations: umami less intense than the other tastes, *p* ≤ .002; sweet less intense than salty, *p* = .005).

Taste pleasantness of bitter, salty, sour, and umami tastes, but not the pleasantness of sweet tastes, was reduced with increasing concentration (main effects of taste quality, *F*(4, 104) = 27.07, *p* < .001, taste concentration, *F*(2, 52) = 41.29, *p* < .001, significant taste quality × taste concentration interaction, *F*(8, 208) = 9.18, *p* < .001). Taste pleasantness declined across each concentration of the bitter and the salty taste, i.e. from low to medium, from low to high, and from medium to high concentration (*ps* ≤ .05). In response to the umami taste, participants rated the medium and the high concentration as less pleasant compared with the low concentration (*ps* ≤ .001). The pleasantness of the sour taste significantly declined from medium to high concentration (*p* = .042).

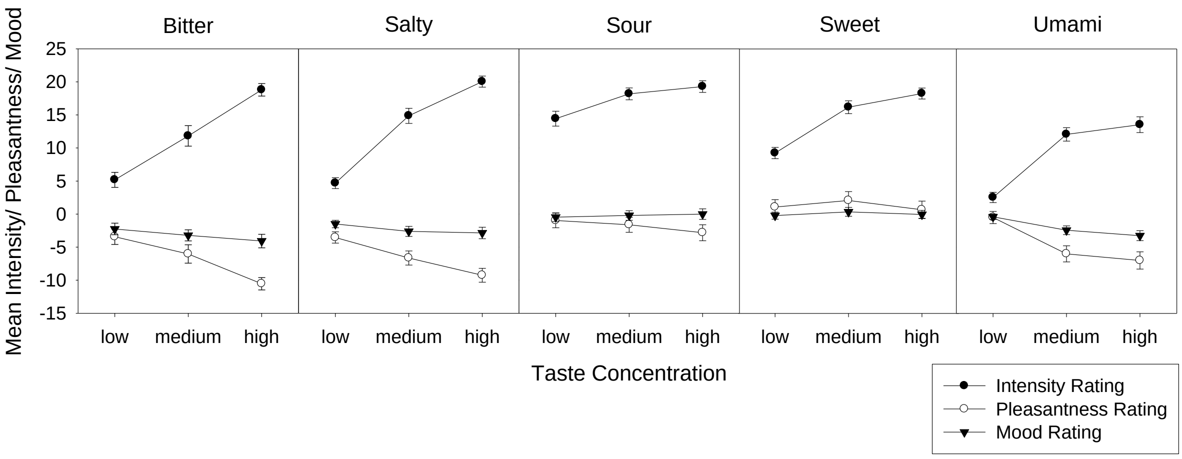


Figure 4: Intensity, pleasantness, and mood ratings for bitter, salty, sour, sweet, and umami tastes – average deviations (Means ± *SEM*) from ratings for mineral water (*N* = 28).

Mood after tasting declined with increasing concentration of bitter, salty, and umami tastes, whereas mood remained stable in response to sour and sweet tastes (main effects of taste quality, *F*(4, 104) = 9.74, *p* < .001, taste concentration, *F*(2, 52) = 12.26, *p* = .001, significant taste quality × taste concentration interaction, *F*(8, 208) = 7.07, *p* < .001). In response to the umami taste, mood declined across each concentration, i.e. from low to medium, from low to high, and from medium to high concentration (*ps* ≤ .05). Participants also reported significantly lower mood for the medium concentrated than for the low concentrated salty taste (*p* = .024), as well as for the high concentrated than for the low concentrated bitter taste (*p* = .006).

Taste identification rates were significantly different among the 15 taste solutions ($Chi^2 = 1280.24$, $p < .001$). They were high for mineral water (100%) and for the medium and the high concentration of PROP (75%, 96%), NaCl (82%, 100%), citric acid (100%, 96%), and sucrose (96%, 96%). Low sour (89%) and low sweet (86%) concentrated solutions were also clearly recognized. Low bitter was recognized as bitter in 54% of the cases. Low salty was mostly perceived as bitter (39%) and as neutral (29%) rather than as salty (18%). The umami taste showed mixed perceived gustatory sensations for each concentration, mostly perceived as neutral in the low concentration (68%) or as salty in the medium (71%) and high concentration (50%). No gender differences were found for taste intensity, $F(1, 26) = .332$, $p = .569$, taste pleasantness, $F(1, 26) = .003$, $p = .958$, mood, $F(1, 26) = .125$, $p = .727$, and taste identification rates (*ps* > .05).

Moreover, it was explored whether the four different **taste orders** yielded different taste ratings (t-tests, Bonferroni correction $\alpha/6 = 0.008$). In general, intensity, pleasantness and mood did not differ dependent on taste order. However, umami was rated as more intense by participants who received the second taste order when compared to participants who received the third taste order ($p < .008$).

Odors: Figure 5 depicts the odor ratings. Perceived **odor intensity** differed across odors, $F(5, 130) = 4.94$, $p = .001$. Garlic was rated as more intense than cinnamon and coffee (*ps* ≤ .005). There was no significant odor × gender interaction, $F(5, 130) = 1.91$, $p = .115$.

Odor pleasantness differed across odors, $F(5, 130) = 33.08$, $p < .001$. Banana, cinnamon and coffee were rated as more pleasant than garlic, fish and clove (*ps* ≤ .001). There was no significant odor × gender interaction, $F(5, 130) = .943$, $p = .447$.

Mood differed **after smelling** the odor stimuli, $F(5, 130) = 6.65$, $p = .001$. Mood declined in response to clove and garlic compared to banana (*ps* < .05). There was no significant odor × gender interaction, $F(5, 130) = .404$, $p = .704$.

Odor identification rates were similar among the 6 odors ($Chi^2 = 8.13$, $p > .05$). Participants correctly identified cinnamon, clove and garlic in 89% of the cases. Coffee and fish were correctly identified by 93% of the participants and banana by 96% of the participants.

No gender differences were found for odor intensity, $F(1, 26) = .002$, $p = .968$, odor pleasantness, $F(1, 26) = .225$, $p = .639$, mood, $F(1, 26) = .269$, $p = .608$, and odor identification rates (*ps* > .05).

It was explored whether **modality order** (first tastes or first odors) affected taste and odor ratings. Participants who smelled the odors first, rated the sweet (low concentration), sour (low, medium, high) and umami taste (high) as more intense and the sour taste (medium, high) as less pleasant compared to participants who tested taste solutions first (*ps* $\leq$ .05). by Participants who tasted first rated umami (low) as more pleasant (*p* = .042) than participants who smelled first. Participants who smelled the odors first rated the smell of shoe leather as more pleasant (*p* = .017) and clove as more intense (*p* = .006) than those participants who tasted first.

1.3.2. Specific facial activity

Taste quality: Tastes elicited significantly different facial reactions dependent on taste quality (Cochran's *Q*-tests). Table 1 lists the numbers of facial reactions, i.e. AUs, to each taste quality regardless of taste concentration and observation period.

The sweet taste elicited lip suck (AU 28) more frequently than the salty taste (*p* = .002) and the sour taste (*p* = .031). Unexpectedly, lip wipe (AU 37) and lip corner pull (AU 12), i.e. an indicator of smiling, were displayed equally among taste qualities and thus were not frequent responses to the sweet taste.

The bitter, salty, and sour taste shared the same negative and positive facial reactions, as well as the typical surprise reaction. In response to the bitter, salty, and sour taste, adults displayed brow lower (AU 4, *p* = .004, *p* = .039, *ns* for sour), upper lip raise (AU 10, *p* = .002, *p* < .001, *p* = .001), and lip corner depress (AU 15, *p* = .012, *p* = .001, *p* = .039) more frequently when compared to the sweet taste. Furthermore, the bitter, salty, and sour taste elicited cheek raise (AU 6) more frequently than the sweet taste, (*p* = .065, *p* = .002, *p* = .003). The higher frequency of cheek raise occurring together with lip corner pull (AU 12) indicated that adults smiled more often in response to these taste qualities when compared with the sweet taste. However, lip corner pull (AU 12) was equally displayed among these tastes. In addition, the bitter, salty, and sour taste elicited inner and outer brow raise (AU 1 + 2) more frequently than the sweet taste (AU 1, *p* = .004, *p* = .001, *p* < .001; AU 2, *p* = .031, *p* = .001, *p* < .001), which reflects a surprise expression.

The sour taste elicited the most manifold facial pattern when compared to the other tastes. In response to the sour taste, adults displayed lip tight (AU 23) more frequently than to the bitter (*p* = .004), salty (*p* = .021), sweet (*p* = .004), and umami taste (*p* = .002). Additionally, the sour taste tended to elicit lip pucker (AU 18) more frequently than the salty taste and the sweet taste (*ps* = .070). Lip press (AU 24) was more often elicited by the sour taste than by the salty taste (*p* = .031). The sour taste elicited outer brow raise (AU 2) and lip corner pull (AU 12) more frequently when compared to the umami taste (*p* = .013, *p* = .016).

Table 1: Frequencies of single facial reactions in response to the bitter, salty, sour, sweet, and umami taste.

	Taste stimuli					
Action Unit	bitter	salty	sour	sweet	umami	*Q*-tests
AU 1 Inner Brow Raise	13	15	16	4	12	***
AU 2 Outer Brow Raise	10	15	16	4	6	***
AU 4 Brow Lower	28	26	24	19	25	*
AU 6 Cheek Raise	13	16	17	6	10	*
AU 7 Lids Tight	10	13	15	9	12	*ns*
AU 9 Nose Wrinkle	2	6	5	2	5	*ns*
AU 10 Upper Lip Raise	24	26	24	11	19	***
AU 12 Lip Corner Pull	17	19	23	21	16	*
AU 13 Sharp Lip Pull	1	1	5	2	1	*
AU 14 Dimpler	24	23	22	25	25	*ns*
AU 15 Lip Corner Depress	15	19	14	6	12	***
AU 16 Lower Lip Depress	10	8	8	4	8	*ns*
AU 17 Chin Raise	12	13	12	11	14	*ns*
AU 18 Lip Pucker	4	2	8	2	3	(*)
AU 19 Tongue Show	4	3	0	1	4	(*)
AU 20 Lip Stretch	2	5	2	1	1	(*)
AU 23 Lip Tight	3	4	12	3	2	***
AU 24 Lip Press	16	15	21	18	20	*ns*
AU 25 Lips Part	20	19	24	23	22	*ns*
AU 26 Jaw Drop	22	20	24	21	23	*ns*
AU 28 Lip Suck	6	0	4	10	6	(*)
AU 37 Lip Wipe	1	0	2	4	3	*ns*

Note: The data represent the number of participants (maximum N = 28) who showed Action Units (AUs). AUs were only included if shown by ≥ 4 participants.
(*)$p \leq 0.10$,*$p < 0.05$, ***$p \leq 0.001$.
Cochran's *Q*-tests comparing reactions to each of the five stimuli.

The umami taste elicited more facial displays indicating a lower pleasantness than the sweet taste and more facial displays indicating a higher pleasantness than the salty taste. Compared with the sweet taste, the umami taste more often elicited inner brow raise (AU 1, *p* = .021) and tended to elicit upper lip raise (AU 10, *p* = .057) more frequently. In response to the umami taste, adults displayed outer brow raise (AU 2, *p* = .022) and upper lip raise (AU 10, *p* = .016) less frequently, lip corner depress (AU 15, *p* = .065) marginally less frequent, and lip suck (AU 28, *p* = .031) more frequently when compared to the salty taste.

Overall, the sweet taste elicited positive facial reactions (lip suck, AU 28), whereas the bitter and salty taste elicited both negative facial reactions (brow lower, AU 4; upper lip raise, AU 10; lip corner depress, AU 15) but also positive facial reactions, i.e. smiling (cheek raise, AU 6; lip corner pull, AU 12). The sour taste elicited similar negative and positive facial reactions as the bitter and salty taste but also other distinctive facial reactions in the mouth region (lip tight, AU 23; lip pucker, AU 18) when compared to the other tastes. Facial reactions to the umami taste differed from the sweet taste by the presence of the negative facial display of upper lip raise (AU 10).

Odors: Different odors elicited different facial reactions (Cochran's *Q*-tests). Odor unpleasantness was associated with negative facial displays with unpleasant odors, i.e. fish, garlic and clove, eliciting brow lower (AU 4), lids tight (AU 7), and upper lip raise (AU 10) more frequently than pleasant odors, i.e. banana, cinnamon and coffee. Table 2 displays the numbers of facial reactions, i.e. AUs, to each odor.

In response to fish and garlic, adults displayed brow lower (AU 4), lids tight (AU 7), upper lip raise (AU 10), and lip corner depress (AU 15) more frequently when compared to banana and cinnamon (*ps* < .05). Fish and garlic more often elicited brow lower (AU 4) and upper lip raise (AU 10) when compared to coffee (*ps* < .05). Clove elicited brow lower (AU 4), lids tight (AU 7), and upper lip raise (AU 10) more frequently than banana and cinnamon.

Table 2: Frequencies of single facial reactions in response to banana, cinnamon, clove, coffee, fish, and garlic odors.

	Odor stimuli						
Action Unit	banana	cinnamon	clove	coffee	fish	garlic	*Q*-tests
AU 1 Inner Brow Raise	1	0	4	2	5	1	*
AU 2 Outer Brow Raise	1	0	3	2	3	1	*ns*
AU 4 Brow Lower	3	2	13	6	16	14	***
AU 5 Lid Raise	3	2	0	1	3	0	*ns*
AU 6 Cheek Raise	0	0	2	0	2	2	*ns*
AU 7 Lids Tight	8	10	17	16	19	17	*
AU 9 Nose Wrinkle	1	1	2	0	4	3	*ns*
AU 10 Upper Lip Raise	5	6	13	8	18	17	***
AU 12 Lip Corner Pull	2	2	3	3	3	3	*ns*
AU 14 Dimpler	3	2	2	6	3	6	*ns*
AU 15 Lip Corner Depress	0	1	2	3	6	6	*
AU 17 Chin Raise	1	1	2	2	5	5	*ns*
AU 25 Lips Part	2	1	2	3	3	4	*ns*

Note: The data represent the number of participants (maximum $N = 28$) who showed Action Units (AUs). Total occurrence of AU 13, 16, 18 = 0; AU 19, 24 = 1; AU 23 = 2; AU 20, 26, 38 = 5; AU 43 = 6.
*$p < 0.05$, ***$p \leq 0.001$.
Cochran's *Q*-tests comparing reactions to each of the six stimuli.

Also, adults displayed brow lower (AU 4) in response to clove more often than in response to coffee ($p < .05$). Coffee elicited lids tight (AU 7, $p = .039$) more often than banana. In conclusion, adults' facial reactions differentiated unpleasant from pleasant odors. The negative facial displays to the most unpleasant odors (garlic, fish) were all characterized by brow lower (AU 4), lids tight (AU 7), upper lip raise (AU 10), and lip corner depress (AU 15) when compared to the most pleasant odors (banana, cinnamon).

Taste concentration: In general, with increasing concentration of the bitter, salty, sweet, and umami taste, the frequency of participants showing specific facial reactions increased significantly (Cochran's *Q*-tests). In contrast, an increased concentration of the sour taste had no impact on the frequency of participants displaying facial reactions. This is mainly due to a high proportion of participants showing facial reactions already to the low sour concentration. Table 3 displays the number of participants displaying specific facial reactions, i.e. AUs, to each of the taste qualities and its concentration.

With increasing concentration of the bitter, salty, sweet, and umami taste more participants showed negative facial reactions indicating displeasure, i.e. brow lower (AU 4) and upper lip raise (AU 10). Specifically, more participants displayed brow lower in response to the high concentration when compared to the low concentration of the bitter ($p = .007$), salty ($p = .021$), sweet ($p = .001$), and umami taste ($p = .002$). Moreover, the frequency of participants showing brow lower increased from low to medium umami concentration ($p = .002$). In response to the sweet taste, more participants displayed brow lower to the high concentration when compared to the medium concentration ($p = .021$). Upper lip raise increased with increasing bitterness, i.e. from low to medium ($p < .001$), medium to high ($p = .070$), and low to high ($p < .001$). In response to the salty and umami taste, more participants expressed upper lip raise in response to the medium ($p < .001$, $p = .002$) and high concentration ($p < .001$, $p = .002$) when compared to the low concentration. Also, in response to the sweet taste, more participants tended to show upper lip raise to the high concentration when compared to the low concentration ($p = .070$).

With increasing concentration of the bitter and the salty taste further negative facial reactions were elicited. In particular, more adults displayed lip corner depress (AU 15) with increasing bitterness, i.e. from low to high ($p = .012$) and medium to high ($p = .039$), and with increasing saltiness, i.e. from low to medium ($p = .057$) and low to high ($p = .022$). Moreover, the frequency of adults showing chin raise (AU 17) and nose wrinkle (AU 9) increased from the low to the high concentration ($p = .039$, $p = .031$) of the salty taste. In addition, with increasing concentration of the bitter and the salty taste, more participants smiled.

Table 3: Single facial reactions in response to low, medium, and high concentrations of the bitter, salty, sour, sweet, and umami taste.

	bitter				salty				sour				sweet				umami			
	l	m	h	*Q*-tests	l	m	h	*Q*-tests	l	m	h	*Q*-tests	l	m	h	*Q*-tests	l	m	h	*Q*-tests
AU 1	1	6	8	*	2	7	14	***	9	13	11		1	2	4		1	5	8	*
AU 2	1	4	7	(*)	2	5	14	***	8	11	10		1	1	3		1	2	5	(*)
AU 4	11	19	22	*	12	17	22	*	16	18	17		5	10	18	***	7	20	20	***
AU 6	1	4	13	***	1	6	15	***	11	9	12		1	4	4		4	5	4	
AU 9	1	1	1		0	3	6	*	3	1	2		0	0	2		0	3	5	*
AU 10	5	17	23	***	5	19	24	***	17	20	20		2	6	8	(*)	3	16	15	*
AU 12	2	6	16	***	3	9	18	***	15	12	17		15	13	13		10	7	7	
AU 13	1	1	0		1	0	0		4	3	1	(*)	0	2	1		1	1	1	
AU 14	19	16	11	*	20	12	14	*	16	16	15		20	20	20		21	17	14	(*)
AU 15	4	6	13	*	4	12	13	*	9	9	8		2	3	5		3	6	8	
AU 16	1	5	6	(*)	2	4	5		3	3	6		2	1	3		3	4	5	
AU 17	3	7	8		3	4	10	*	7	7	7		8	2	6	(*)	6	7	7	
AU 19	1	1	3		0	1	3	(*)	0	0	0		0	0	1		0	2	4	*
AU 23	0	1	2		0	2	4	*	5	5	10	(*)	0	0	3		0	2	0	
AU 24	9	11	9		9	11	11		13	18	13	(*)	14	12	15		11	16	10	(*)
AU 25	14	13	12		16	9	12	(*)	18	16	17		16	16	15		14	14	10	
AU 26	13	12	18	(*)	10	15	16	(*)	18	20	19		12	15	14		10	11	18	*
AU 28	2	2	3		0	0	0		3	3	2		4	4	5		3	1	3	*
AU 37	0	1	0		1	1	0		0	1	2		2	1	2		1	0	2	*

Note: The data represent the number of participants (maximum $N = 28$) who showed Action Units (AUs). AUs were only included if shown by ≥ 4 participants.
(*)$p \leq 0.10$,*$p < 0.05$, ***$p \leq 0.001$.
Cochran's *Q*-tests comparing reactions among taste concentrations within each taste quality.

In particular, more participants displayed cheek raise (AU 6) and lip corner pull (AU 12) in response to the high concentration when compared to the low and medium concentration of the bitter taste (AU 6, $p < .001$, $p = .004$, AU 12, $p < .001$, $p = .006$)and salty taste (AU 6, $p < .001$, $p = .012$, AU 12, $p < .001$, $p = .012$). Here, display rules may have played a role (cf. discussion).

Moreover, surprise reactions (AU 1 + 2) increased with increasing concentration of the bitter, salty, and umami taste. In response to the salty taste, more participants displayed brow raise (AU 1 + 2) to the high concentration when compared to the low (*ps* < .001) and medium concentration ($p = .039$, $p = .012$). The bitter and the umami taste also elicited inner brow raise more frequently when comparing high with low concentration (AU 1, *ps* = .039).

In contrast to the increase of many facial reactions, there were two facial reactions, i.e. dimpler (AU 14, pulling of the lip corners inwards) and chin raise (AU 17, upward movement of the lower lip), whose frequency decreased with increasing concentration of some tastes. Less participants displayed the dimpler in response to the bitter taste to the high concentration when compared to the low and medium concentration ($p = .039$, $p = .063$). In response to the salty taste, the number of participants showing the dimpler also decreased from low to medium concentration ($p = .008$). Thus, a lower frequency of the dimpler appears to be associated with a higher unpleasantness. Chin raise decreased from low to medium concentration of the sweet taste ($p = .039$) and thus less chin raise appears to be associated with higher pleasantness, since chin raise decreased for the sweet taste but increased for the salty taste. Both Action Units seem incompatible on a functional muscular basis with those increasing with negative tastes.

To sum up, with increased taste concentration the number of participants showing many specific facial reactions increased as well. With increasing concentration more negative facial reactions, i.e. brow lower and upper lip raise, occurred in response to the bitter, salty, sweet, and umami taste. The bitter and the salty taste elicited smiling with increasing concentration. In contrast, an increase of concentration of the sour taste had no impact on the frequency of facial reactions as a low concentration already yielded high frequencies.

1.3.3. Overall facial activity

Tastes: Overall facial activity increased with increasing concentration of bitter, salty, and umami tastes, but not of sour and sweet tastes (Figure 5). The sour taste elicited the highest overall facial activity than all other tastes (*ps* ≤ .001). ANOVA revealed main effects of taste quality, $F(4, 104) = 13.42$, $p < .001$, taste concentration, $F(2, 52) = 32.08$, $p < .001$, and a significant taste quality × taste concentration interaction, $F(8, 208) = 3.59$, $p < .01$. In response to the bitter and the umami taste, overall facial activity significantly increased from low to medium concentration ($p = .004$, $p = .009$) and from low to high concentration ($p = .001$, $p = .036$). In response to the salty taste, overall facial activity significantly increased across each concentration, i.e. from low to medium ($p < .001$), from medium to high ($p < .001$), and from low to high ($p = .002$). An increase of taste concentration of sour and sweet tastes did not affect overall facial activity (*ps* >.05).

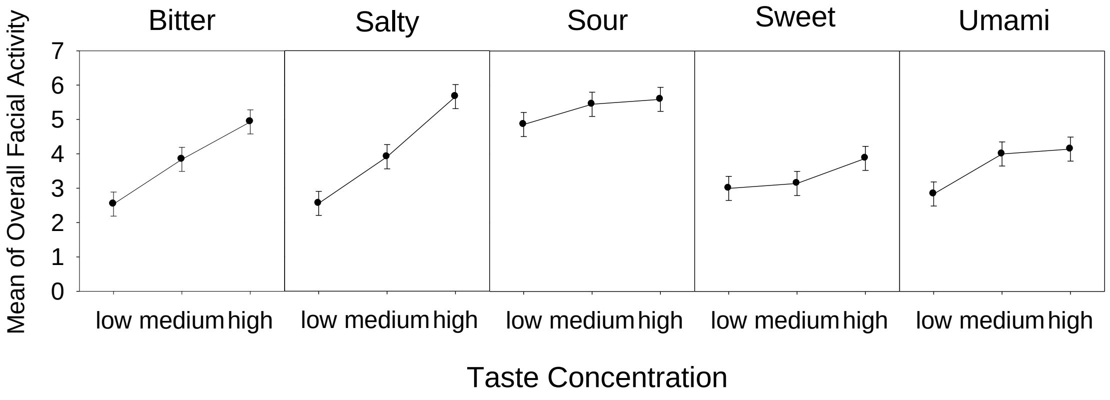


Figure 5: Overall facial activity (Means ± *SEM*) for salty, bitter, umami, sweet, and sour tastes differing in concentration (low, medium, high) in the total sample ($N = 28$).

In addition, the observation period affected overall facial activity, $F(1, 27) = 79.17$, $p < .001$, and indicated that more facial reactions were displayed after swallowing ($M = 5.38$, $SEM = .13$) than before swallowing ($M = 2.67$, $SEM = .13$).

Odors: Figure 6 depicts overall facial activity in response to different odors.

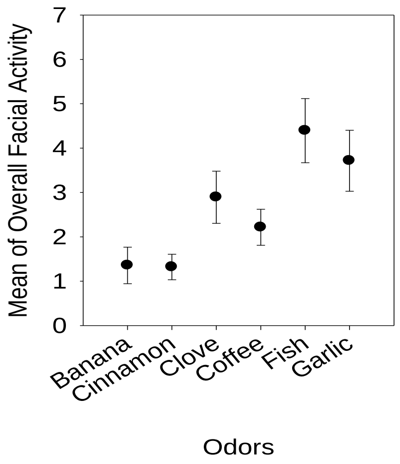


Figure 6: Overall facial activity (Means ± *SEM*) for banana, cinnamon, clove, coffee, fish, and garlic odors ($N = 28$).

Overall facial activity differed across odors (main effect of odor $F(5, 130) = 7.30$, $p < .001$) with adults displaying more facial reactions in response to unpleasant odors, i.e. garlic and fish, than to pleasant odors, i.e. banana and cinnamon.

Post-hoc tests indicated that fish and garlic elicited a higher overall facial activity when compared to banana ($p = .003$, $p = .020$) and cinnamon ($p = .001$, $p = .011$). Fish also elicited a higher overall facial activity than coffee ($p < .05$).

1.3.4. Gender differences

Tastes: There was a significant main effect of gender, $F(1, 26) = 14.83$, $p = .001$, indicating a higher overall facial activity in response to tastes in men than in women. Unexpectedly, women did not show more facial reactions than men.

In addition, there were significant differences in the frequency of single Action Units between men and women. Men displayed more frequently lip press (AU 24) in response to the salty ($p = .024$) and sour taste ($p = .012$), smiles in response to the salty (AU 6 + 12, $ps = .035$) and sour taste (AU 12, $p = .044$), mouth opening (AU 26) in response to the salty taste ($p = .044$), and brow lower (AU 4) in response to the umami taste ($p = .027$).

Odors: Although the effect of gender reached no statistical significance, $F(1, 26) = 3.72$, $p = .065$, it indicated a tendency of a higher overall facial activity in men than in women. Men and women did not differ in single facial reactions in response to odors except that men tended to display more often upper lip raise (AU 10) in response to coffee than women ($p = .050$).

The matching of the sex of experimenter and participant might have contributed to these effects. In general, women self-disclosed more to female partners, but not more to male partners, than males do (see meta-analysis; Dindia & Allen, 1992). A one-factorial ANOVA was conducted to explore the impact of sex matching of experimenter and participant (female/female, $n = 9$, female/male, $n = 7$, male/male, $n = 7$, male/female, $n = 5$) on overall facial activity. Sex matching significantly affected facial reactions in response to tastes in women and men, $F(3, 27) = 6.66$, $p = .002$, with men displaying more facial reactions than women, irrespective of whether a male or a female experimenter guided the study. Men displayed more facial reactions in the presence of a female and male experimenter in response to the bitter ($p = .003$, $p = .029$), salty ($p = .008$, $p = .016$), sour ($p = .005$, $p = .023$), sweet ($p = .016$, $p = .031$), and umami taste ($ps = .042$). Likewise for odors, there was a tendency of a significant effect for sex matching, $F(3, 27) = 2.52$, $p = .082$, with men displaying marginally more facial reactions in response to odors than women, irrespective of whether a male or a female experimenter guided the study.

1.3. Discussion

The present experiment examined (1) whether qualitatively different tastes and odors elicit specific facial reactions in adults that correspond to those facial reactions observed in newborns. Moreover, it was investigated (2) whether taste concentration increases the frequency of adults showing specific facial reactions as it does in newborns. The experiment further examined (3) whether the overall facial activity differs between unpleasant and pleasant tastes and odors. Lastly, it was explored (4) whether men and women differ in overall facial activity in response to tastes and odors.

Specific facial activity: The results confirmed the hypotheses regarding taste- and odor-elicited specific facial reactions in adults (1). As expected, many specific facial displays elicited by tastes and odors are comparable to those observed in newborns (Mennella & Beauchamp, 1997; Rosenstein & Oster, 1988; Soussignan et al., 1997; Steiner, 1973, 1974, 1977, 1979, 1987; Steiner et al., 2001) and adults (Greimel et al., 2006; Perl et al., 1992; Saku & Ellgring, 1992; Steiner et al., 1993). Moreover, it was expected that adults, in contrast to newborns, display positive facial reactions to unpleasant tastes, presumably serving communicative functions. The results indicate that the gustofacial and olfactofacial responses remain quite stable over the life-span, but that a higher voluntary facial control does also affect facial displays of adults.

Adults' facial reactions to unpleasant tastes, i.e. bitter, salty, and sour, and unpleasant odors, i.e. fish, garlic, and clove, were differentiated from the reactions to pleasant tastes and odors by the presence of negative facial displays of brow lower (AU 4), upper lip raise (AU 10) and lip corner depress (AU 15) indicating displeasure. Corresponding with this adult sample, upper lip raise and brow lower have been found to be frequent reactions to unpleasant tastes and odors in newborns (Rosenstein & Oster, 1988; Soussignan et al., 1997; Steiner, 1973) and in adults (Greimel et al., 2006; Saku & Ellgring, 1992; Steiner et al., 1993). Upper lip raise has often been associated with the prototypical disgust reaction (Darwin, 1872; Ekman & Friesen, 1975; Hu et al., 1999; Izard, 1971; Rozin et al., 2000; Vrana, 1993). The umami taste has been found to be less accepted than the sweet taste in adults as indicated by more upper lip raises which is in contrast to newborns' positive facial displays elicited by the umami taste (Steiner, 1987). However, this result is not surprising since the data represent the composite facial pattern of three umami concentrations and are in accordance with adults reporting MSG solutions at 0.094%-6% concentrations as neutral or unpleasant when compared to water (Yamaguchi, 1987).

Brow lower may characterize disgust expressions to unpleasant stimuli as well (Horio, 2003); it is, however, also associated with other negative emotions, e.g. anger, or with cognitively demanding tasks. Lip corner depress (AU 15), which has been related to disgust by Darwin (1872) could distinguish unpleasant tastes and odors from pleasant tastes and odors in adults, respectively. This study is the first that links lip corner depress with taste and odor unpleasantness in adults. In newborns, there are conflicting results, which either have observed lip corner depress as a frequent reaction (Steiner, 1973) or not (Rosenstein & Oster, 1988). Although the evidence is inconsistent, lower face actions, which are more prone to learning (Rinn, 1991), may occur in adults more frequently than in newborns that have not learned voluntary facial control yet. In response to unpleasant odors, adults have shown an additional facial display, i.e. lids tight (AU 7), which has not been reported as frequent reaction yet. Lids tight (AU 7) might reflect a defensive response to aversive odor stimulation in order to protect the eye from harmful substances. It has also been observed as frequent reaction to tastes, but lids tight occurred equally among unpleasant and pleasant tastes. In sum, the negative facial reactions observed in response to unpleasant tastes and odors in adults can be regarded as avoidance reactions which correspond to their perceived unpleasantness. However, facial reactions and pleasantness are dissociated for the sour taste, being rated as more pleasant than the bitter and salty taste and equally pleasant as the sweet taste but which nevertheless elicited negative facial displays. These negative reactions may be associated with the high sourness rather than with the perceived pleasantness.

In addition to adults' negative facial responsiveness to unpleasant tastes, adults have displayed positive facial reactions, i.e. Duchenne smiles including cheek raise (AU 6) and lip corner pull (AU 12), to the bitter, salty, and sour taste. Smiling has been reported as frequent facial reaction elicited by the sweet taste in newborns (Mennella & Beauchamp, 1997; Steiner, 1987; Steiner et al., 2001) and adults (Greimel et al., 2006; Steiner et al., 1993). However, smiling has also been observed in adults in response to the bitter taste (Greimel et al., 2006). The facial display of smiling which seems incompatible with the unpleasant subjective taste experience might serve social communicative functions (Ekman & Friesen, 1982). The unpleasant tastes may have activated display rules, i.e. smiling to mask the experienced negative emotions, in the presence of the (here invisible) experimenter but visible video camera. Moreover, smiling may serve as a self-regulatory coping strategy which enables individuals to distract themselves from threat. This was recently discussed as explanation of smiles during painful stimulation (Kunz, Prkachin, & Lautenbacher, 2009) and during negative emotional events (Ansfield, 2007; Keltner & Bonanno, 1997). Unexpectedly, unpleasant odors have not elicited more smiles, presumably due to the less invasive and less aversive nature of odors when compared to tastes.

Adults' facial reactions elicited by the unpleasant tastes are further characterized by brow raise (AU 1 + 2), which reflects a typical surprise expression. According to Scherer's component process model, brow raise may characterize an early appraisal sequence in which the stimulus relevance, i.e. its novelty and importance, is evaluated before stimulus pleasantness and other appraisal steps are expressed via facial reactions (Scherer & Ellgring, 2007). Corresponding to newborns, brow raise has been reported as a frequent reaction to unpleasant tastes which reflects a defensive response to aversive stimulation (Rosenstein & Oster, 1988). The sour taste has been found to induce the most manifold facial pattern since adults' facial reactions are further characterized by lip tight (AU 23) and lip pucker (AU 18) which are inconsistent reactions when compared to the sensory-based reflex through lip pursing observed in newborns (Rosenstein & Oster, 1988; Steiner et al., 2001). Lip tight and lip pucker in response to the sour taste in adults may be considered as a sensory reflex rather than as reflecting affective reactions.

Unexpectedly, the pleasant sweet taste and pleasant odors (banana, cinnamon, coffee) evoked less positive facial displays despite being rated as more pleasant overall compared to the other tastes and odors. The sweet taste elicited lip suck (AU 28), which corresponds to findings in newborns (Ganchrow et al., 1983; Steiner, 1973, 1977, 1979) and in adults (Greimel et al., 2006). In this study, adults did not display further positive facial reactions such as lip wipe (AU 37) or smiling (AU 12) more frequently in response to the sweet taste which corresponds to findings in newborns (Rosenstein & Oster, 1988). However, lip wipe and smiling have been found to be frequent reactions to the sweet taste in other studies in newborns (Ganchrow et al., 1983; Steiner, 1973, 1977, 1979; Steiner et al., 1993, 2001) as well as in adults (Greimel et al., 2006). The low positive facial responsiveness to the sweet taste might be due to the fact that sugar diluted in water is simply not as pleasant as sugar containing foods for adults. Likewise, adults have expressed few smiles to pleasant odors, which is consistent to findings in newborns (Soussignan et al., 1997). It might also be argued that the pleasantness of tastes and odors is more likely to be expressed through a general facial relaxation that indicates satisfaction rather than through various positive facial displays.

In sum, adults' taste- and odor-elicited facial reactions mainly correspond to those observed in newborns in particular for the unpleasant stimuli. Unpleasant tastes and odors are clearly differentiated from pleasant tastes and odors by the presence of negative facial displays. Pleasant tastes and odors, however, have been found to evoke less positive facial displays in adults which is not the case for newborns. In addition, smiling is exclusively displayed by adults in response to unpleasant tastes accounting for a stronger facial control in adults.

Taste concentration: The results of the present study confirmed the hypothesis regarding taste-concentration-related increases of adults displaying negative reactions to unpleasant tastes but could not confirm adults displaying positive reactions with increasing concentration of pleasant tastes (2). Adults displayed negative reactions (brow lower, upper lip raise) and positive reactions (smiling) with increasing bitterness which have not been observed in newborns (Ganchrow et al., 1983). Moreover, adults displayed negative (brow lower) instead of positive facial reactions observed in newborns with increasing sweetness. This study provides the first evidence that the bitter and the salty taste share many specific facial reactions in adults with increasing concentration ranging from negative, to neutral, and positive displays but also share some specific reactions with the umami taste.

With increasing concentration of unpleasant tastes (bitter, salty, and umami) more adults have displayed negative facial reactions indicating displeasure, i.e. upper lip raise (AU 10) and brow lower (AU 4). Both displays were not observed in newborns in response to the bitter taste and in response to the other tastes since they were not applied (Ganchrow et al., 1983). With increasing bitterness and saltiness, more adults have displayed lip corner depress (AU 15) which is the only negative facial display in adults which was also observed in newborns with increasing bitterness (Ganchrow et al., 1983). The higher presence of upper lip raise (AU 10), i.e. the prototypical disgust reaction (Darwin, 1872; Ekman & Friesen, 1975; Hu et al., 1999; Izard, 1971; Rozin et al., 2000; Rozin et al., 1994; Vrana, 1993), brow lower (AU 4) and lip corner depress (AU 15) indicate that these tastes become more unpleasant with increasing concentration. Indeed, pleasantness is decreased with increasing concentration of the bitter, salty, and umami taste. The frequency of brow raise (AU 1 + 2) which reflects a surprise expression is also increased with higher concentrations of the bitter, salty, and umami tastes. High concentrations may signal a greater relevance of the stimulus (Scherer & Ellgring, 2007) and thus brow raise may reflect a defensive response to aversive stimulation (Rosenstein & Oster, 1988). In addition, more adults have expressed positive facial reactions, i.e. smiling (AU 6 + 12), with increasing concentration of bitter and salty tastes. As has been already stated above, smiling in response to unpleasant tastes might serve social communicative functions (Ekman & Friesen, 1982) and may characterize a display rule.

Unexpectedly, with increasing sweetness adults displayed the negative facial reaction of brow lower (AU 4) instead of positive facial reactions. This finding is in contrast to newborns, who displayed more positive facial displays (lip wipe, lip suck, smiling) with increasing sweetness (Ganchrow et al., 1983). Since pleasantness of the sweet taste remains stable with increasing concentration, brow lower may indicate a negative display associated with the high taste concentration rather than with taste pleasantness.

In contrast to the other tastes, the frequencies of adults showing specific facial reactions are unaffected by increasing sourness. As indicated by intensity ratings, sour tastes are rated as more intense with increasing concentration and thus subjects are able to differentiate between the different sour concentrations. However, differences in sourness intensity are not reflected by an increase of facial reactions in adults which might be due to the fact that the sour concentrations were too high to induce concentration related differences in facial reactions. Another explanation may be that the sour taste elicits reflex-like facial responses based on its sensory properties which may be independent of taste concentration.

In summary, with increasing concentration of unpleasant tastes (bitter, salty, umami) more adults expressed negative and neutral facial reactions. In contrast to newborns, with increasing bitterness and saltiness, more adults displayed positive reactions (smiling). Higher sweetness elicited negative facial reactions in adults which is not the case for newborns, where positive reactions have been observed. Higher sourness did not increase any specific facial display in adults. Moreover, adults displayed distinctive negative reactions when compared to newborns.

Overall facial activity: The results of the present study confirmed the hypotheses regarding overall facial activity in response to odors with unpleasant odors eliciting more facial reactions than pleasant odors. However, the results did not confirm that unpleasant tastes elicit a higher overall facial activity than pleasant tastes (3).

Unlike newborns (Soussignan et al., 1997), adults are more expressive in response to unpleasant odors, i.e. fish and garlic, when compared to pleasant odors, i.e. banana and cinnamon. In the case of tastes, the sour taste has been found to elicit more facial reactions than the other tastes, which is in inconsistent to the finding by Zeinstra et al. (2009). The taste results are strongly influenced by taste concentration since the sour taste concentrations were clearly too high as indicated by subjective ratings. Furthermore, even when comparing taste qualities within each taste concentration, unpleasant tastes (except for the sour taste) did not elicit more facial reactions than pleasant tastes. Therefore, it can be concluded that overall facial activity in response to tastes seems to be not affected by valence, whereas overall facial activity in response to odors is affected by valence.

Moreover, adults' overall facial activity increased with increasing concentration of bitter, salty, and umami tastes. This reflects the subjective increase in experienced intensity and unpleasantness with increasing concentration of theses tastes. It is, however, not clear, whether more intense and more pleasant tastes may also elicit more facial reactions in adults. In newborns, with increasing sweetness, more positive facial reactions were observed (Ganchrow et al., 1983), whereas positive facial reactions were not associated with higher subjective pleasantness in 5-13 year-old children (Zeinstra et al., 2009). Due to a general lower complexity of facial reactions to positive stimuli, we would expect no greater facial activity (Greimel et al., 2006; Looy & Weingarten, 1992). Adults' overall facial activity is not enhanced with increasing concentration of sour and sweet tastes despite being rated as more intense but as equally pleasant with increasing sourness and sweetness. Thus overall facial activity seems to be affected by experienced pleasantness but not by intensity of tastes. Sour and sweet tastes were not matched in perceived intensity within low and medium concentrations with the other tastes. Whether even lower concentrations of sour and sweet tastes would yield different results, especially with regard to subjective pleasantness, remains unclear.

Despite not being directly addressed, this study has demonstrated that odor stimuli elicit a lower overall facial activity than taste stimuli which corresponds to Perl et al. (1992). Since humans are always surrounded by odors, they might consequently be more able to control facial reactions to odors than to tastes. In addition, tastes produce an aftertaste which might last longer and be more aversive than an 'aftersmell'. Also, the tastes had to be swallowed which is more invasive than to smell odors.

Gender differences: The results of the present study did not confirm the hypotheses regarding a heightened overall facial activity in women compared to men (4). Indeed, men showed more facial reactions than women, and this effect is present irrespective of the sex of the experimenter. This result is inconsistent to the findings in the literature (Biehl et al., 1997; Brody & Hall, 2000; Dimberg & Lundquist, 1990; Hall et al., 2000) that found women to be more facially expressive than men. Only tentative conclusion from this finding can be drawn. Since more women than men were psychology students (n = 7, n = 4) or were doing a PhD (n = 4, n = 1), this might have reduced womens' facial reactions relative to mens' facial reactions. These persons might be more familiar with scientific research in general and might have taken this study more seriously, and thus might have engaged less in “facial” contact. Another explanation might be that conformity effects to public standards or norms are higher in women than in men. Thus, conformity will lead women to produce more conventional expressions or to disguise reactions to emotional stimuli even if they are highly aversive such as the tastes in this study. The results indicate that it is important to study facial reactions either in women or men, and to have one experimenter who runs the study in orer to maximize emotional expression (Dindia & Allen, 1992). With regard to the further studies, this means that facial reactions in response to tastes and odors only in women due to the high prevalence of eating disorders in women) are investigated and that a female experimenter runs the experiment.

In conclusion, this study demonstrates that taste- and odor-elicited facial reactions in adults mostly correspond to those observed in newborns supporting the hypothesis that taste- and odor-elicited facial reactions remain quite stable over the life-span. Due to prior experiences the reactions to sweet tastes may have been shifted from positive displays to rather neutral displays. The finding that adults smiled to unpleasant tastes can be explained by voluntary facial control and the acquisition of display rules during socialization. Taste concentration increases the number of adults showing facial reactions as it does in newborns. However, adults have shown distinctive reactions in response to unpleasant and pleasant tastes. Due to the fact that some taste concentrations are not comparable in subjective intensity, future studies should aim to use equi-intense concentrations to examine the role of taste concentration on differential taste-elicited facial reactions.

2. Study 2 – "*Facial reactions in response to tastes and odors in Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder*"

2.1. Aims, specific research questions, and hypotheses

The general aim of the second study was to explore whether taste- and odor-elicited facial reactions are altered in patients with eating disorders. Therefore, facial, physiological, as well as subjective reactions in patients with various eating disorders, were investigated. To date, it had never been investigated, whether patients with eating disorders differ in their facial reactions from controls in quantitative and qualitative terms. Patients with eating disorders have an extreme anxiety to gain weight, negative food-related cognitions, and a greater impulsivity related to food and non-food, which may lead to changes in facial reactions in response to tastes and odors (see sections 2.2.3. and 2.2.4.). Thus, it is expected that patients with eating disorders display different facial reactions to tastes and odors, quantitatively and qualitatively. To test this, facial reactions in response to different tastes (bitter, salty, sour, sweet, umami) differing in concentration (low, high), and water, as well as different odors (banana, clove, cinnamon, fish, garlic, licorice, neutral odor) were recorded from women with Anorexia Nervosa, Bulimia Nervosa, Binge-Eating Disorder, and healthy controls, using electromyography and a camera. Videos were analyzed using the Facial Action Coding System (FACS, Ekman et al., 2002). More specifically, this study aimed to investigate

(1) … taste-elicited overall facial activity in patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder
(2) … odor-elicited overall facial activity in patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder
(3) … whether patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder differ in their specific facial reactions, i.e. Action Units, from controls in response to tastes
(4) … whether patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder differ in their specific facial reactions, i.e. Action Units, from controls in response to odors
(5) … whether electromyographic activity in response to tastes and odors differs between patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder form controls.

The following questions were addressed to explore the issues mentioned above.

(1) **Do patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder differ from healthy controls in their overall facial activity in response to tastes?**
It was expected that patients with Bulimia and Binge-Eating Disorder show a higher overall facial activity than controls due to their affect-laden link to food stimuli and their greater reactivity to food. In contrast, patients with Anorexia were expected to display a lower overall facial activity when compared to controls. Anorexic patients have difficulties in recognizing, describing, and expressing emotions towards others and appear to avoid the expression of negative and positive emotions in their families (Bruch, 1962, 1991). Based on personal observations, anorexic patients might be less amenable to contact and are more controlled in their nonverbal behavior, especially facial behavior, than bulimic patients.

(2) **Do patients with various eating disorders differ from controls in their overall facial activity in response to odors?**
No group differences in overall facial activity in response to odors were expected between eating-disordered patients and controls, since odors represent no threat for shape and weight.

(3) **Do patients with Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder display specific facial reactions, i.e. Action Units, differently than do controls in response to tastes?**
Patients with Anorexia and Bulimia were expected to express more negative facial reactions, such as brow lower (AU 4) and upper lip raise (AU 10) in response to the sweet tastes, than controls. For these patients, sweet tastes signal carbohydrates and potential energy and therefore a threat to weight loss. Patients with Binge-Eating Disorder were expected to display more positive facial reactions such as smiling (cheek raise, AU 6, and lip corner pull, AU 12), lip suck (AU 28), and lip wipe (AU 37) in response to the sweet taste when compared to controls. Binge eaters might be attracted by the sweet taste and thus savor it. In response to the other tastes, no specific hypotheses had been formulated.

(4) **Do patients with various eating disorders differ from controls in their specific facial reactions in response to odors?**
No group differences in specific facial reactions in response to odors were expected between patients with eating-disorders and controls.

(5) Do patients with eating disorders differ from controls in their electromyographic activity in response to tastes and odors?

It was expected that patients with Anorexia and Bulimia, who might display more negative facial reactions (brow lower, upper lip raise) in response to the sweet tastes, correspondingly show increased amplitudes of the corrugator and levator, i.e. muscles which characterize negative facial reactions when activated. Patients with Binge-Eating Disorder were expected to show an increased zygomaticus activity, which relates to the positive facial display of smiling, since they might be attracted by the sweet tastes. In response to the other tastes, no specific hypotheses had been formulated. No group differences for corrugator, levator, and zygomaticus activity were expected in response to odors.

2.2. Methods

2.2.1. Participants

Female patients (*n* = 62) were either recruited in clinics („Klinik am Korso in Bad Oeynhausen", „Seepark Klinik in Bad Bodenteich", „Helios Klinik in Bad Grönenbach", „Burg-Klinik in Stadtlengsfeld", „Klinik und Poliklinik für Psychiatrie und Psychotherapie in Würzburg", „Krankenhaus für Psychiatrie, Psychotherapie, und Psychosomatische Medizin in Lohr am Main") specialized in psychosomatic and/or eating disorders (*n* = 56) or were recruited through internet advertisement (*n* = 6). Healthy female controls (*n* = 23) were also recruited through internet advertisement to voluntarily take part in the study. The data of 11 women had to be excluded from the analysis due to several problems (2 bulimic women were too old, 2 anorexic women and 2 bulimic women caught a cold between the two sessions, 1 anorexic and 1 bulimic woman due to technical problems with the video, 3 controls due to a poor video quality). Therefore, the total sample consisted of 74 women. Those patients who had been recruited in clinics were tested in a local room. Their actual body weight was taken from the patients' chart. Participants that were recruited through the internet were tested in the laboratory in Würzburg. They were weighed and this body weight was taken for the calculation of BMI (body weight divided by squared height, kg/m²).

Using the criteria from the International Classification of Mental Disorders (ICD-10, Dilling, Mombour, & Schmidt, 2005) and the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, Saß, Wittchen, & Zaudig, 2003), experienced clinical psychologists diagnosed 20 women with Anorexia Nervosa (ICD-10, F50.0) and 19 women with Bulimia

Nervosa (ICD-10, F50.2). 15 women met DSM-IV criteria for Binge-Eating Disorder (307.50). Participants were native speakers of German, free from colds, food allergies, nasal allergies and olfactory or gustatory disorders at the moment of the tests. They abstained from eating and drinking at least 1.5 hours prior to the experiment and received € 20 for their 3-hour participation. The ethics commission of the German Psychological Association (DGPs) had approved the study (2007).

The mean age of the sample was 24.1 years (*SD* = 6.4) and ranged from 14 to 52 years. The groups were comparable in their age despite the significant age effect, $F(3, 73) = 4.0$, $p = .011$, due to inhomogenic variances (Table 4).

Table 4: Sample characteristics.

	Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age*	22.6	2.3	22.7	6.5	23.5	5.5	28.9	8.9
BMI (kg/m²)***	23.1	2.3	16.8	1.9	22.6	6.0	40.5	10.3
Weight (in kg)***	64.3	7.7	46.4	6.3	62.2	18.8	114.8	30.1
Height (in cm)	168.9	6.5	166.2	5.9	165.8	6.4	168.9	6.9
Hospitalization (in days)*			44.2	19.3	31.0	20.3	22.9	16.5

*$p < .05$, ***$p < .001$.

As expected, the groups differed in their body weight, $F(3, 73) = 47.89$, $p < .001$, and also in their Body Mass Index (BMI), $F(3, 73) = 52.39$, $p < .001$. Patients with Binge-Eating Disorder had the highest weight and BMI when compared to the other groups (*ps* < .001), whereas patients with Anorexia Nervosa had the lowest weight (*ps* < .001) and lowest BMI (*ps* < .005), compared to the other groups.

During the study, 48 women with an eating disorder were currently undergoing treatment at a hospital, whereas 6 female patients (5 with Binge-Eating Disorder, 1 with Anorexia Nervosa) were not hospitalized. The patients who were hospitalized differed in the length of their hospitalization, $F(2, 47) = 4.57$, $p = .016$, with anorexic patients being hospitalized for a longer time than binge eaters ($p = .020$).

47 participants were non-smokers and 27 participants were smokers (AN, BED, C, *n* = 7 each, BN, *n* = 6). The frequency of smokers did not differ across the groups. Please see the appendix C (Table 19) for further sample characteristics.

2.2.2. Eating pathology

All participants were characterized by the Structured Inventory for Anorectic and Bulimic Eating Disorders (SIAB-S, Fichter & Quadflieg, 1999). The SIAB-S, a self-report measure with 87 items, measures eating disorder symptoms in accordance with the DSM-IV and ICD-10 as well as pathological eating-related symptoms. Participants are asked to answer questions on their symptoms mostly using 5-point scales ranging from 0 (“symptom/ problem not present”) to 4 (“symptom/ problem very severely present”) with regard to two states: symptoms within the last 3 months (present state) and symptoms in the past (past state). The present state part includes 6 subscales, i.e. general psychopathology and social integration; bulimic symptoms; body image and slimness ideal; sexuality and body weight; inappropriate compensatory behaviors to counteract weight gain, fasting and substance abuse, and atypical binges. The past state part includes 7 subscales, i.e. bulimic symptoms; general psychopathology; slimness ideal; sexuality and social integration; body image; inappropriate compensatory behaviors to counteract weight gain, substance abuse, fasting and autoaggression; and atypical binges.

The SIAB-S revealed satisfactory psychometric criteria, with Cronbach’s α between 0.74 and 0.92 for the present state (expect factor inappropriate compensatory behaviors to counteract weight gain, fasting and substance abuse with coefficient alpha = 0.34). Cronbach’s alpha for the present state in this sample were .93, .91, .90, .82, .61, and .74, respectively. The internal consistency for scales of the past state ranged from 0.69 to 0.94. Moreover, the SIAB-S revealed a satisfactory convergent validity (Fichter & Quadflieg, 2001). Cronbach’s alpha for the past state in this sample were .96, .94, .91, .77, .74, .78, and .74, respectively.

The SIAB-S was used in order to exclude the presence of any eating disorder or pathological eating-related symptoms in the control group (n = 20) and to verify the diagnosis of an eating disorder in patients who were recruited via internet advertisement ((n = 6; when no diagnosis by a clinical psychologist was available). According to the SIAB-S, none of the healthy controls had a past or a current eating disorder. From 6 patients, who were recruited via internet, 5 were diagnosed with Binge-Eating Disorder and 1 was diagnosed with Anorexia Nervosa by the SIAB-S. The diagnosis of clinical psychologists for hospitalized patients with eating disorders, rather than the SIAB-S diagnosis, was utilized for the classification into the following groups: Anorexia Nervosa, Bulimia Nervosa, and Binge-Eating Disorder. This was necessary since not all diagnostic criteria were fulfilled in some patients due to the length of their hospitalization and already achieved therapeutic steps, e.g. increased body weight above 17.5 kg/m² in anorexic patients by which the first criteria of Anorexia Nervosa is no longer fulfilled. The completion of the SIAB-S takes approximately 45 to 60 minutes. Participants completed the SIAB-S before the main experiment.

2.2.3. Taste and odor stimuli

Taste stimuli were solutions of PROP (6-*n*-Propylthiouracil) for bitter taste (Merck-VWR, Darmstadt, Germany), NaCl for salty taste, citric acid for sour taste, sucrose for sweet taste (Adler Apotheke, Dinkelsbühl, Germany), and MSG (monosodium glutamate) for umami taste (Ajinomoto Foods, Germany). Each taste quality was applied in two different concentrations, i.e. low and high. Taste concentration were solutions of 0.032mM and 3.20M PROP, 0.02M and 1.0M NaCl, 0.005M and 0.05M citric acid, 0.10M and 0.83M sucrose and 0.01M and 0.2M glutamate. The choice of concentrations was determined according to criteria set up in the first study. According to the subjective data from the first study, low concentrations of the sour and sweet taste were reduced (sour 0.01M to 0.005M, sweet 0.10M to 0.05M). Also, the low concentration of the salty and umami taste (salty 0.01M to 0.02M, umami 0.001M to 0.01M) and the high concentration of the umami taste (0.1M to 0.2M) were increased.

Taste concentrations used in this study were all above the detection threshold, i.e. citric acid 0.0023M, NaCl 0.01M, sucrose 0.01M (Birbaumer & Schmidt, 1999), PROP (non-tasters >1.8 x 10^{-4}mol/l PROP, super-tasters <3.2 x 10^{-5}mol/l PROP; Drewnowski et al., 1997), and MSG 0.009M (Lugaz et al., 2002). Evian mineral water (ph 7.2) served as the control taste (neutral taste). All solutions were dispensed in 5ml distilled water and were administered at room temperature (20-22°). Before and after testing, taste solutions were stored in the refrigerator. Taste solutions were removed from the refrigerator at least 3 hours prior to testing to ensure an up-to-room-temperature, which was measured by a thermometer immediately before testing. Each stimulus was presented once in a disposable cup of 20ml maximum content. The stimuli were colorless to avoid that participants guessed the taste quality in the cups before actually tasting the stimulus. Taste solutions were freshly prepared a few days prior to the experiment (see the appendix A for the preparation of the taste solutions).

Odor stimuli were pen-like odor dispensing devices of the “Sniffin’ Sticks” test (Kobal et al., 1996; see section 1.2.2.). In this study, 6 of the 16 common odors from the odor identification test, i.e. banana, clove, cinnamon, fish, garlic, and licorice, were used. These odors were selected according to their perceived pleasantness with banana and cinnamon representing the pleasant pole, and fish and garlic representing the unpleasant pole. Licorice and clove were rated as being in-between, and as thus representing the neutral pole. Moreover, a neutral odor was administered as a probe (which was a stick that originally contained the odor rose, but which had been rinsed carefully).

2.2.4. Dependent variables – Subjective and facial reactions

Subjective reactions: Participants were instructed to rate intensity, pleasantness, mood, and perceived quality for each taste and odor stimulus. Intensity, pleasantness and mood in response to each stimulus were rated on verbally anchored scales from 1 to 25, using a method of category scaling developed by Heller (1985) (see section 1.2.3. for explanation). For the identification of a taste quality, participants had to decide on 5-point scales ranging from 1 (“not at all”) to 5 (extreme”) how bitter, salty, sour, sweet, savory, and neutral the taste was. To identify odors, participants had to decide on the same scale how acid-like, fishy, menthol-like, sweetish, artificial, and pungent the odor smelled.

Facial reactions: Facial expressions were analyzed from video recordings using the **Facial Action Coding System** (Ekman et al., 2002), an objective, standardized, and descriptive system for coding facial expressions based on the anatomy of facial movements (see section 1.2.4.and appendix A). A visible facial movement is assigned to a single Action Unit (AU). Specific facial reactions refer to the frequency of each single Action Unit. A parameter of overall facial activity was defined as the total number of AUs shown (multi-occurrence of AUs from 1-40; cf. Ellgring, 1989).

Two trained FACS coders, blind to stimulus condition, independently analyzed the videos in slow motion and frame by frame and coded the apex (moment of the most intense facial expression) of each facial expression. Facial reactions in response to tastes were separately assessed during two observation periods, i.e. before swallowing (a) and after swallowing (b), to exclude facial activity due to swallowing. The observation periods in response to tastes and odors were similar to those used in study 1 (see section 1.2.3.).

Inter-rater reliability (IR) of FACS coding was assessed by a second coder who independently scored the expressions of 7 randomly chosen participants. IR was determined by dividing the number of AUs agreed upon by the two coders by the total sum of AUs scored by each (cf. Ekman & Friesen, 1978). Inter-rater reliabilities of IR = .82 and IR = .84 were achieved for reactions to taste stimuli and odor stimuli respectively and are regarded as good.

Facial muscular activity was recorded using bipolar placements of Ag-AgCl surface electrodes on the left side of the face in accordance with the guidelines of Fridlund and Cacioppo (1986). Before the electrodes were attached, the participants' skin was cleaned and slightly rubbed with a peeling paste (Every). The electrodes were filled with electrolyte gel (abralyth) and were placed in pairs over the target facial muscles with an electrode distance of about 1cm. Target facial muscles were zygomaticus major to record smiling, corrugator supercilii to record brow lowering, levator labii to record upper lip raising (disgust), and thyrohyoideus to record swallowing. In addition, an earth electrode was placed behind the left ear and in the middle of the forehead. The electrode impedance was less than 10kΩ.

The EMG raw signal was measured with a NeuroscanSyncAmps amplifier, digitalized by a 16-bit analog-to-digital converter, and stored on a personal computer with a sampling rate of 1.000Hz. Raw data were rectified offline and filtered with a 30Hz low cut off filter, a 500Hz high cut off filter, a 50Hz notch filter, and a 125ms moving average filter. Facial EMG responses were averaged over intervals of 500ms during 4 seconds for each muscle group (corrugator, levator, zygomaticus). This resulted in 8 different periods. The responses were expressed as a change in activity from the prestimulus level, which was defined as the mean activity during the last second before stimulus onset.

The aim of this study was to compare identical sequences in EMG and video recording. Therefore triggers were sent to both EMG recording and the video simultaneously. These triggers were pressed manually by the experimenter. When a stimulus-dependent trigger button was pressed, which was defined beforehand in the program Presentation, a trigger appeared immediately in the EMG recordings and simultaneously a light bulb flashed for approximately 2s in the video recording. This light bulb was attached to the chair behind the participant and could not be seen by the participant, but was clearly visible in the video. The number of the triggers and thus the type of stimuli was presented only in the EMG recording, thus the video did not indicate which stimulus was presented. This was important in order to achieve that the coders would be blind to the stimuli when coding facial reactions. The trigger buttons were manually pressed by the experimenter when the participant had the taste solution in the mouth (i.e. before swallowing), when the participant had swallowed the solution (i.e. after swallowing), and when the participant was going to smell the odor. This trigger presentation by the experimenter sometimes happened too early and sometimes too late. At times it was difficult to indicate the swallowing of the participants. Therefore, triggers were later corrected for time in the EMG and video recordings, which was achieved by using the timeline in the video (time deviation was calculated).

2.2.5. Taste and odor sensitivity

Taste sensitivity: To assess gustatory function, taste strips (Müller et al., 2003), which are papers impregnated with taste solutions were used. The length of a taste strip is 8 cm and an area of 2cm² is impregnated with a taste solution. Taste strip concentrations were 0.006, 0.0024, 0.0009, 0.0004g/ml quininehydrochloride for bitter taste, 0.25, 0.1, 0.04, 0.016g/ml sodium chloride for salty taste, 0.3, 0.165, 0.09, 0.05g/ml citric acid for sour taste, and 0.4, 0.2, 0.1, 0.05g/ml sucrose for sweet taste.

Four concentrations were used for each taste quality resulting in a maximum score of 16, and 4 for each taste quality. 2 blank strips without taste were also used. Taste strips were presented in increasing concentrations in a randomized order. The strips were placed at the middle of the participants tongue at a distance of approximately 1.5cm from the tip. Participants were then asked to close their mouth and to indicate the taste quality by choosing one of five possible answers on a form (sweet, sour, salty, bitter, no taste). Before assessment of each taste strip the mouth was rinsed with water. 1.5 hours prior to testing, participants were asked not to eat or drink anything except water, not to smoke, and not to brush their teeth.

Bitter sensitivity: The genetically determined bitter sensitivity was assessed by the 1-solution test (Prescott, Ripandelli, & Wakeling, 2001; Prescott & Swain-Campbell, 2000; Tepper et al., 2001). According to Tepper et al. (2001) taste sensitivity to 6-*n*-Propylthiouracil (PROP) can be reliably assessed by the three-solution test as well as by the one-solution test. The one-solution test has the advantage that it requires less time than the three-solution test since one solution of NaCl (10ml of 0.1mol/l) and PROP (10ml of 0.32mmol/l) rather than three concentrations of PROP and of NaCl are used. Moreover, test-retest reliability obtained by the one-solution method is higher than by the three-solution method (Rankin et al., 2004). Participants were asked to rinse their mouth with water before they began the test and between the taste solutions. They were required to place the 10ml NaCl solution which was presented first, in their mouth for 5s, expectorate it, and rate its intensity on the Labeled Magnitude Scale (LMS). After rinsing and a 45s pause, this procedure was repeated with the 10ml PROP solution. The Labeled Magnitude scale, a quasilogarithmic scale with label descriptors that is equivalent to magnitude estimation, was used to assess perceived taste intensity (Green et al., 1993). The scale ranges from 0 ("barely detectable") to 100 ("strongest imaginable"). The LMS enables the participant to rate the intensity of a stimulus relative to the strongest imaginable taste or oral stimulus they have ever experienced in everyday life.

Odor sensitivity: Odor threshold for n-butanol was assessed using a single-staircase, three alternative forced choice procedure of the Sniffin' Sticks test (Kobal et al., 1996). Sniffin' Sticks are felt-tip pens filled with an odorant. The odor threshold test contains 16 dilutions prepared in a geometric series starting from a 4% n-butanol solution (dilution ratio 1:2 in deionized aqua conservata as solvent). Pens are labeled with numbers from 1-16. Pens with red caps contain the odorant at a certain dilution with number 1 containing the highest concentration (lowest dilution step) and number 16 containing the lowest concentration (highest dilution step). Pens with green caps and blue caps contain the solvent.

In each trial, three pens are presented in a randomized order, with two pens containing the solvent and the third pen containing the odorant. The order of the presentation of the pens varies from triplet to triplet as follows: Red Green Blue, Blue Red Green, Green Blue Red, Red Green Blue etc. Triplets of pens are presented at intervals of 20-30s.

Before beginning with threshold measurements, participants are familiarized with the odor of butanol using pen number 1 which contains the highest concentration. The experimenter who wears odorless gloves removes the cap and places the pen's tip at approximately 2cm in front of both nostrils of the blindfolded participant wearing a sleeping mask. Using a verbal command the participant is asked to take a sniff. The participants are instructed to identify the odor-containing pen. At the beginning of the test, the participants are presented triplets in dilution steps 16, 14, 12 etc. or 15, 13, 11 etc., respectively, until the participant correctly identified the butanol-containing pen in two successful trials at the same dilution. This dilution is the starting point of the threshold measurements. After the starting point has been found, the next higher dilution step is offered. The next turning point is the odor concentration which is not correctly identified. Now the participant receives the next higher concentration, until a certain dilution step is identified correctly twice in a row. This will be turning point number 3. This procedure is continued until 7 turning points have been established. The threshold is defined as the mean of the last 4 turning points (turning points 4-7). The participants' scores ranged between 1 and 16. The participant was asked not to eat, drink, smoke, or consume drops or chewing gum 15 minutes prior to the measurements.

2.2.6. Personality aspects

Different personality aspects such as participants' level of depression, eating behavior, personality traits, and subjective expressivity were assessed by questionnaires which are described in the following.

Depressivity: The original Beck Depression Inventory (BDI, Beck, Erbaugh, Ward, Mock, & Mendelsohn, 1961, German version by Hautzinger, Bailer, Worall, & Keller, 1995) is a self-report questionnaire for the assessment of the severity of depression. BDI items relate to symptoms of depression (mood deterioration, pessimism, failure, dissatisfaction, guilt, self-punishment, self-dislike, self-accusations, suicidality, crying, irritability, social withdrawal, indecisiveness, change in body image, difficulties at work, insomnia, fatigue, appetite swings, weight loss, somatic preoccupation, and loss of libido). The BDI is widely used as an assessment tool by health care professionals and researchers in a variety of settings. The original BDI consists of 21 items about how the participant has been feeling in the week before. Each question has a set of at least four possible answers, varying in intensity. A score of 0 ("not present") to 3 ("strongly present") is assigned for each answer and then the total score is compared to a key to determine the depression's severity. The standard cut-offs are as follows: 0–9 indicates that a person is not depressed, 10–18 indicates mild-moderate depression, 19–29 indicates moderate-severe depression, and 30–63 indicates severe depression. Higher total scores indicate more severe depressive symptoms. Cronbach's alpha of the BDI are very good (.92) in this sample.

Eating behavior: The Dutch Eating Behavior Questionnaire (DEBQ, German version by Grunert, 1989; Dutch version by van Strien, Frijters, Bergers, & Defares, 1986) assesses eating behaviors. The DEBQ is based on assumptions regarding psychosomatic theory (Bruch, 1973; Kaplan & Kaplan, 1957), externality theory (Schachter, Goldman, & Gordon, 1986), and restraint theory (Herman & Polivy, 1980). According to these theories, the DEBQ has 3 subscales for emotional, external, and restrained eating behavior. Emotional eating behavior refers to a tendency to eat in response to emotionally aroused states such as fear, anger or anxiety. External eating behavior characterizes a tendency to eat in response to external food cues such as the seeing and smelling of food. Restraint eating behavior indicates a tendency to overeat after a period of slimming when the cognitive determination to diet is abandoned.

The DEBQ consists of 33 items. The German version of the DEBQ includes 30 items (3 items of the emotional eating subscale were excluded) with 10 items for each of the 3 subscales. Participants are asked to what extent each eating-related behavior occurs using a 5 point Likert scale from 1 (“never”) to 5 (“very frequently”). The DEBQ is a reliable instrument with satisfactory concurrent and discriminative validity as well as excellent factorial validity (Grunert, 1989). Cronbach’s alpha for emotional, external, and restraint eating behavior are very good in this sample (.96, .90, .94) and are comparable to those of Grunert (1989, .82, .91, .91).

Personality traits: In order to assess the participants’ personality, the German version of the NEO Five-Factor Inventory (NEO-FFI, Costa & McCrae, 1992) by Borkenau & Ostendorf (1993) was used. The NEO-FFI is a 60-item inventory designed to reliably and validly assess the Big Five domains of adult personality. Each of these five subscales consists of 12 items referring to the subscales neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. Participants are asked to rate on a 5-point Likert-scale from 0 (“strongly disagree”) to 4 (“strongly agree”) to what extent they agree on a statement. High neuroticism levels characterize emotional instability, which refers to the tendency to experience unpleasant emotions easily and to be less reactive to stress. People with high extraversion levels are gregarious, assertive, and interested in seeking out excitement in the presence of others. High levels regarding openness are related to interest in new experiences and a preference for variation. People who score low on openness are considered to be conventional and traditional in their behavior. People with high level of agreeableness are compassionate and cooperative rather than suspicious and antagonistic towards others. High conscientiousness levels characterize self-discipline, acting dutifully, and aiming for achievement. Costa and McCrae reported extensively on the convergent and discriminant validity of the NEO. Cronbach’s alpha for Neuroticism, Extraversion, Openness to experience, Agreeableness, and Conscientiousness are good in this sample (.85, .87, .72, .79, .86) and are comparable with those in the manual (.79, .79, .80, .75, .83).

Subjective Expressivity: The 16-item Berkeley Expressivity Questionnaire (BEQ; Gross & John, 1995, German version Traue, 1998) assesses individual differences in the behavioral expression of emotions and the willingness to react emotionally. The BEQ consists of three subscales that measure positive emotional expressivity (4 items), negative emotional expressivity (6 items), and the intensity of impulses to express emotions (6 items). Responses are provided using a 7-point Likert scale; rated from 1 (“strongly disagree”) to 7 (“strongly agree”). The BEQ appears to demonstrate strong psychometric properties, with a 2-month test-retest reliability of .86 (Gross & John, 1995). In addition, three studies have supported the three subscale factor structure and convergent and discriminant validity of the BEQ (Gross &

John, 1995, 1997, 1998). Cronbach's alpha for positive expressivity, negative expressivity, and impulse strength are satisfactory in this sample (.62, .75, .77).

2.2.7. Procedure

The experiment was divided into two sessions (assessment of facial reactions, assessment of control variables) which took part on two different days. In both sessions, participants were individually tested and seated in a comfortable chair in a room with a constant temperature (22°) and received identical written and verbal instructions. They were told that the study examines taste and odor perception. No other details about the aims of the study were given. Participants were informed that one session (those in which facial reactions were assessed) of the experiment would be continuously video-recorded. They were, however, not told that their facial expressions would be analyzed specifically, in order to avoid exaggerated or moderated facial expressions. The video camera was placed in front of the participants at a distance of 2.5m. The experimenter who was present in the room during the entire experiment was not visible to the participants but could watch their behavior online via closed circuit TV. All participants gave informed consent, including agreement to be recorded on video.

At the beginning of the session, in which facial reactions were assessed, the electrodes were attached to the participants' face.

Taste presentation: The procedure of taste presentation is the same as reported in study 1 (see section 1.2.4). Taste solutions were placed on a table in front of the participants in small cups numbered from 0 to 10. Mineral water (no. 0) was always presented as the first stimulus. Next, sweet, sour, salty, and umami solutions (no. 1 to 8) were presented in a pseudo-randomized order. 4 different pseudo-randomized taste orders were used. The four taste orders (1, 2, 3, 4) were distributed among the groups as follows: controls 5, 5, 5, 5; anorexics 5, 5, 5, 5; bulimics 4, 4, 6, 5; and binge eaters 3, 4, 4, 4; respectively. Participants received the bitter taste (no. 9, 10) at the end due to its masking effect (Dallenbach & Dallenbach, 1943; Leach & Noble, 1986). For each taste quality, the concentration was applied in ascending order, with low concentration first, followed by the high concentration (see appendic C, Table 2).

Odor presentation: The procedure of taste presentation is the same as reported in study 1 (see section 1.2.4). Odors were presented in a pseudo-randomized order with participants receiving one of 6 different orders. The six odor presentations (1, 2, 3, 4, 5, 6) were distributed among the groups as follows: controls 4, 4, 3, 3, 3, 3; anorexics 4, 4, 3, 3, 3, 3; bulimics 4, 4, 3, 3, 2, 3; and binge eaters 3, 2, 3, 3, 2, 2; respectively. The neutral odor was always presented as the fourth stimulus (see appendix C, Table 4).

Moreover, the order of the taste and odor experiment, as well as the order of the sessions, was counter-balanced. Half of the participants received the odors first (n = 38, 10 controls, 10 anorexics, 10 bulimics, 8 binge eaters), whereas the other half received the tastes (n = 36, 10 controls, 10 anorexics, 9 bulimics, 7 binge eaters) first. Half of the participants participated in the facial reaction session first (n = 39, 10 controls, 10 anorexics, 11 bulimics, 8 binge eaters), whereas the other half participated in the control variable session (n = 35, 10 controls, 10 anorexics, 8 bulimics, 7 binge eaters) first.

At the end of the experiment, the electrodes were removed from the participant's face and each participant was asked to fill in questionnaires (DEBQ, BDI, NEO-FFI, BEQ, see section 2.2.6.). The entire experiment lasted approximately 2 hours.

In the control-variables-session, taste sensitivity, odor sensitivity, and bitter sensitivity were assessed in this order (see section 2.2.5.). The second session lasted approximately 30 minutes.

2.2.8. Statistical analysis

Repeated measures ANOVAs were conducted for taste ratings (changes from water) and odor ratings for intensity, pleasantness, and mood with taste quality (bitter, salty, sour, sweet, umami) or odor type (banana, fish, garlic, licorice, clove, cinnamon) as the within-subjects factor, and group (Anorexia, Bulimia, Binge-Eating, controls) as the between-subjects factor. For the taste quality and odor type evaluation, one-factorial ANOVAs were carried out, to explore whether the groups differed in taste and odor perception.

Taste-elicited overall facial activity was investigated in 5 (taste quality: bitter, salty, sour, sweet, umami) × 2 (taste concentration: low, high) × 4 (group: Anorexia, Bulimia, Binge-Eating, controls) repeated measures ANOVAs for the observation periods before swallowing and after swallowing separately. Odor-elicited overall facial activity was tested in a 7 (odor quality: banana, fish, garlic, licorice, clove, cinnamon, probe) × 4 (group: Anorexia, Bulimia, Binge-Eating, controls) repeated measures ANOVA.

To explore whether the groups differed in their specific facial reactions in response to tastes and odors, the frequencies single facial reactions, i.e. Action Units, elicited by tastes and odors were compared by Mann-Whitney U-Tests for differences among proportions.

To analyze EMG activity in response to tastes, a 6 (taste quality) × 8 (time: means for 0-500ms, 500-1000ms, 1000-1500ms, 1500-2000ms, 2000-2500ms, 2500-3000ms, 3000-3500ms, 3500-4000ms) × 4 (group) ANOVA was conducted separately for each muscle, separately for each taste concentration, and separately for each observation period. EMG data were incomplete over the corrugator, levator, and zygomaticus muscle in response to tastes. The total sample in response to low and high concentrations before swallowing was 73 (data of 1 bulimic women missing), in response to the low concentration after swallowing 72 (data of 1 bulimic and 1 anorexic women missing), and in response to the high concentration after swallowing 71 (data of 1 bulimic, 1 anorexic, 1 bingeing women missing), respectively.

For the analysis of EMG activity in response to odors, a 6 (odor) × 8 (time: means for 0-500ms, 500-1000ms, 1000-1500ms, 1500-2000ms, 2000-2500ms, 2500-3000ms, 3000-3500ms, 3500-4000ms) × 4 (group) ANOVA was conducted separately for each muscle. The means for the factor time in response to tastes and odors are referred to as period 1, 2, 3, 4, 5, 6, 7, and 8 in the following. EMG data were incomplete over the corrugator, levator, and zygomaticus muscle in response to tastes. The total sample consisted of 71 woman (data of 3 bulimic women missing, in 2 women no EMG data was recorded; for 1 woman no triggers were sent). For all ANOVAs, a Bonferroni correction was applied for single comparisons in case of significant main effects or significant interaction effects.

2.3. Results

2.3.1. Subjective reactions

The groups did not differ in perceived **taste intensity**, $F(3, 70) = .09$, $p > .05$. Moreover, the taste concentration × group interaction failed to reach statistical significance, $F(3, 70) = 2.49$, $p = .067$. Perceived taste intensity, however, differed across tastes, $F(4, 280) = 21.60$, $p < .001$, and across taste concentration, $F(1, 70) = 859.54$, $p < .001$. Both main effects were qualified by a significant taste quality × taste concentration interaction, $F(4, 280) = 52.07$, $p < .001$. In particular, the low concentrated salty taste was rated as less intense than the low concentrated sour, sweet, and umami taste (*ps* < .001). Likewise, the low concentrated bitter taste was perceived as less intense than the low concentrated sweet and umami taste (*ps* < .05). In contrast, the low concentrated sour taste was rated as more intense than the low concentrated bitter, sweet, and umami taste (*ps* ≤ .001). With regard to the high taste concentrations, the umami taste was rated as less intense than the bitter, salty, sour, and sweet taste (*ps* ≤ .002). The other interaction effects were non-significant (*ps* > .05).

Taste pleasantness differed across groups, $F(3, 70) = 2.76$, $p = .049$. Post-hoc tests, however, yielded no significant group differences (*ps* > .05). Further repeated measures ANOVAs (separately for each taste quality) revealed that the groups significantly differed in their taste pleasantness in response to the sweet taste, $F(3, 70) = 3.59$, $p = .018$, the salty taste, $F(3, 70) = 3.10$, $p = .032$. Anorexic and bulimic patients ($p = .050$, $p = .019$) reported a higher pleasantness of the sweet taste compared to patients with Binge-Eating Disorder (Figure 7). Post-hoc tests of the pleasantness of the salty taste yielded no significant differences (*ps* > .05).

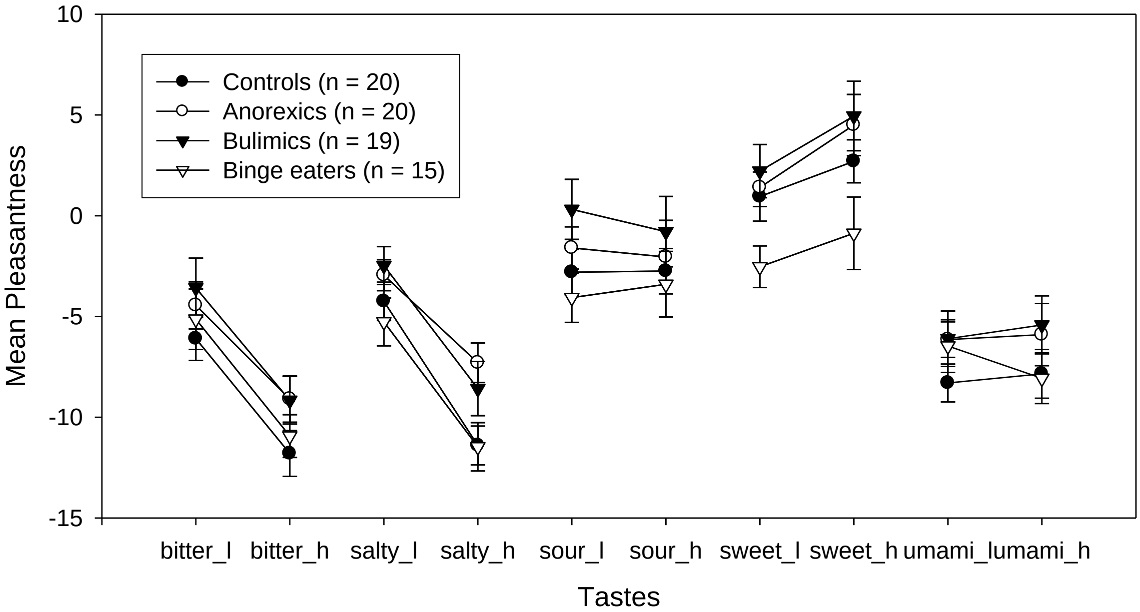


Figure 7: Pleasantness ratings for the tastes differing in concentration (l – low, h – high) in healthy controls, patients with Anorexia, Bulimia, and Binge-Eating Disorder – average deviations (Means ± *SEM*) from ratings for mineral water.

There were significant main effects of taste quality, $F(4, 280) = 81.00$, $p < .001$, and taste concentration, $F(1, 70) = 38.59$, $p < .001$, which were qualified by a significant taste quality × taste concentration interaction, $F(4, 280) = 46.88$, $p < .001$. More specifically, the low and highly concentrated sweet tastes were rated as more pleasant than the low and high concentrations of the bitter, sour, and umami taste (*ps* < .002). In addition, low and high concentrations of the sour taste were rated as more pleasant than the low and highly concentrated bitter and umami taste (*ps* ≤ .007). The highly concentrated umami taste was rated as more pleasant than the highly concentrated bitter taste (*ps* < .001). In contrast, low and high concentrations of the salty taste were rated as less pleasant than the low and high concentrations of the sweet and umami taste (*ps* < .001). Moreover, the highly concentrated salty taste was rated as less pleasant than the highly concentrated sour taste ($p < .001$). Other interaction effects were non-significant (*ps* > .05).

Perceived **mood in response to the tastes** did not differ across groups, $F(4, 280) = 1.49$, $p > .05$. There were significant main effects of taste quality, $F(4, 280) = 27.10$, $p < .001$, and taste concentration, $F(1, 70) = 31.60$, $p < .001$, which were qualified by a significant taste quality × taste concentration interaction, $F(4, 280) = 16.23$, $p < .001$. In particular, participants'mood was better in response to the low concentrated sweet and sour taste when compared to the low concentrations of the bitter and umami taste (*ps* < .05). Mood was rated as higher in response to the low concentrated sweet taste than in response to the low concentrated salty taste ($p \leq .001$). Likewise, the highly concentrated sweet taste elicited a better mood compared to the highly concentrated bitter, sour, and umami taste (*ps* < .05). Moreover, the highly concentrated sour taste elicited a better mood than the highly concentrated bitter and umami taste (*ps* ≤ .002). Mood was rated as better in response to the high concentrations of the sour and sweet taste than in response to the highly concentrated salty taste (*ps* < .001). The other interaction effects were non-significant (*ps* > .05).

The groups differed in their **taste quality evaluation** of the highly concentrated salty taste (how salty?), $F(3, 73) = 3.50$, $p = .020$), and the highly concentrated sweet taste (how sweet? how savory?), $F(3, 73) = 4.18$, $p = .009$, $F(3, 73) = 4.04$, $p = .010$). Controls and bulimics rated the high salty taste as more salty when compared to binge eaters ($p = .031$, $p = .036$). In contrast, binge eaters rated the high sweet taste as less sweet when compared to controls ($p = .041$), anorexics ($p = .016$), and bulimics ($p = .022$); however they rated it as more savory when compared to controls ($p = .018$) and bulimics ($p = .020$). The groups did not differ in their taste quality rating of the other tastes (*ps* > .05).

The groups were comparable in their perceived **odor intensity**, $F(3, 70) = 2.21$, $p = .095$. Perceived odor intensity, however, differed across odors, $F(5, 350) = 40.11$, $p < .001$. In particular, banana and cinnamon were rated as less intense than fish and garlic (*ps* < .001). Banana was rated as more intense than clove ($p = .012$), whereas cinnamon was rated as less intense than clove ($p < .001$). Participants rated garlic as more intense than licorice and clove (*ps* < .001), fish as more intense than licorice ($p < .001$), and clove as more intense than licorice ($p < .001$).

The groups differed in their **odor pleasantness** of cinnamon, $F(15, 350) = 2.30$, $p = .005$ (odor × group interaction), as indicated by a higher pleasantness level in anorexic patients than in binge eaters ($p = .042$), which can be seen in Figure 8.

Moreover, the analysis revealed a significant main effect of odor stimuli, *F*(5, 350) = 97.56, *p* < .001. Participants rated cinnamon as more pleasant than the other tastes (*ps* < .05), and they rated banana as more pleasant than fish, garlic, and clove (*ps* < .001). Both licorice and clove were rated as more pleasant than fish and garlic (*ps* ≤ .001). Licorice was rated as more pleasant than clove (*p* < .001).

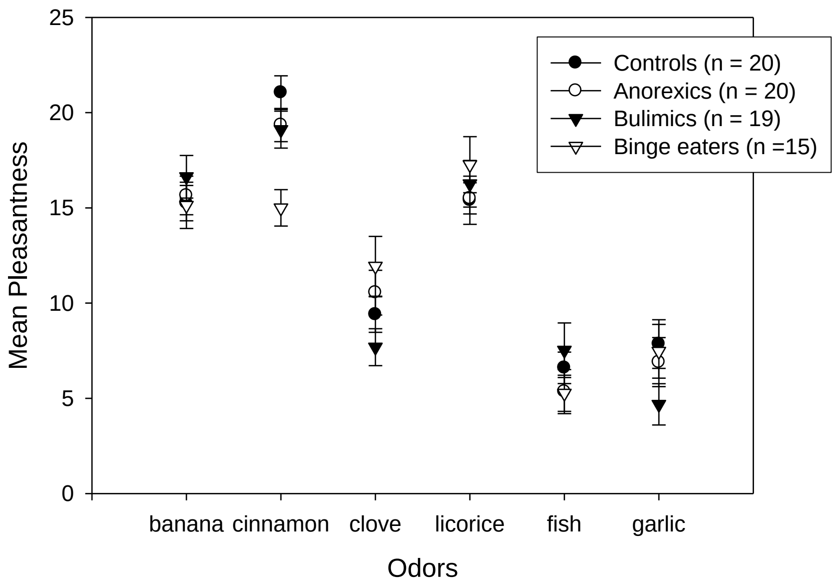


Figure 8: Pleasantness ratings for different odors (Means ± *SEM*) in healthy controls, patients with Anorexia, Bulimia, and Binge-Eating Disorder.

The groups differed in their **mood** after smelling garlic, *F*(15, 350) = 2.15, *p* = .016 (odor × group interaction), indicated by a mood decline in bulimic patients when compared to controls (*p* = .009). There was also a significant main effect of odor stimuli, *F*(5, 350) = 21.75, *p* < .001. In particular, participants' mood declined after smelling fish, garlic, and clove than after smelling banana, cinnamon, and licorice (*ps* ≤ .007).

The groups differed in their **odor evaluation** of cinnamon (how acid-like? how pungent?), *F*(3, 73) = 7.00, *p* < .001, *F*(3, 73) = 3.49, *p* = .020), and licorice (how menthol-like?), *F*(3, 73) = 2.81, *p* = .045. Binge eaters perceived cinnamon as more acid-like when compared to controls (*p* = .001), anorexics (*p* = .001), and bulimics (*p* = .002). Also, binge eaters rated cinnamon as more pungent than controls (*p* = .012). Controls rated licorice as more menthol-like than binge eaters (*p* = .034). The groups did not differ in their odor rating of the other odors.

In general, the groups were mostly comparable in perceived intensity, pleasantness, mood, and stimulus evaluation in response to tastes and odors. Unexpectedly, binge eaters rated the sweet taste as less pleasant than the anorexic and bulimic patients, which might be due to desirability effects. It might also be argued that the sweetness of the sugar solution was not sweet enough for binge eaters, who perceived the sweet taste as less sweet than the other groups. Furthermore, anorexics preferred cinnamon to a greater extent than did binge eaters. Garlic elicited a greater mood decline in bulimic patients when compared to controls. Among all groups, the sweet taste was the most pleasant taste, and the sour taste was more pleasant than the bitter, salty, and umami taste. Moreover, banana and cinnamon were the most pleasant odors, whereas fish and garlic were the most unpleasant ones among all groups.

2.3.2. Overall facial activity

In the following, the results for overall facial activity, i.e. the sum of all facial reactions observed, in response to tastes and odors will be explicated.

Taste-elicited overall facial activity before swallowing: Overall facial activity significantly differed across groups, $F(3, 70) = 5.71$, $p = .001$ (Figure 9), which was indicated by a higher facial activity in bulimics and binge eaters when compared to anorexics ($p = .005$, $p = .006$). The taste quality × group interaction reached no statistical significance, $F(12, 280) = 1.61$, $p = .096$. Bulimic patients displayed more facial reactions in response to the salty ($p = .01$), sour ($p = .006$), and sweet taste ($p = .01$) than did anorexic patients. Binge eaters expressed more facial reactions than did anorexic patients in response to the bitter ($p = .044$), salty ($p = .005$), and umami taste ($p = .001$).

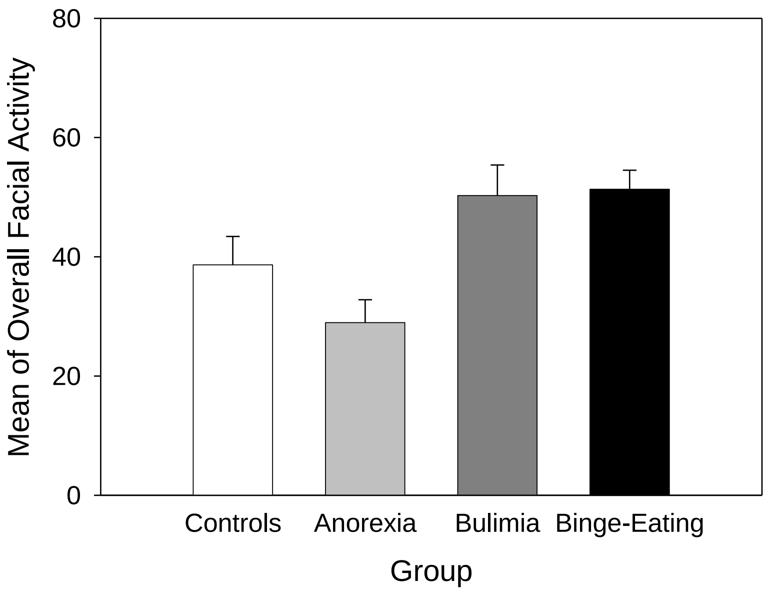


Figure 9: Overall facial activity (Means ± *SEM*) in response to tastes before swallowing in healthy controls ($n = 20$), patients with Anorexia ($n = 20$), Bulimia ($n = 19$), and Binge-Eating Disorder ($n = 15$).

Moreover, the significant main effects of taste quality, $F(4, 280) = 18.04$, $p < .001$, and taste concentration, $F(1, 70) = 123.26$, $p < .001$, were qualified by a significant taste quality × taste concentration interaction, $F(4, 280) = 4.76$, $p = .002$. More specifically, the low concentrated sour taste elicited a higher overall facial activity than did the low concentrated bitter, salty, sweet, and umami taste ($ps \leq .009$). The high concentration of the sour taste elicited more facial reactions than the high concentrations of the sweet ($p < .001$) and umami taste ($p = .003$). Likewise, the highly concentrated bitter and salty taste evoked more facial reactions than the sweet taste ($p \leq .001$). Within each taste quality, the low concentration elicited a lower overall facial activity than the high concentration ($ps < .001$). The other interaction effects were not significant (taste concentration × group, taste quality × taste concentration × group; $ps > .05$).

Overall facial activity in response to water was comparable across groups, $F(3, 73) = .43$, $p > .05$, with each group showing between 1 and 2 facial actions (controls: $M = 1.7$, $SD = 1.6$; anorexics: $M = 1.4$, $SD = 1.6$; bulimics: $M = 1.9$, $SD = 2.0$; binge eaters: $M = 1.9$, $SD = 1.5$).

Taste-elicited overall facial activity after swallowing: The groups differed in their overall facial activity in response to the bitter, sour, sweet, and umami taste (Figure 10), but not in response to the salty taste, $F(12, 280) = 2.15$, $p = .016$ (taste quality × group interaction). In response to the sour and sweet taste, bulimic patients displayed a higher overall facial activity than did controls ($p < .001$, $p = .023$) and anorexic patients ($p < .001$, $p = .007$). Bulimic patients expressed more facial reactions in response to the umami taste than did anorexic patients ($p = .026$). In response to the bitter, sour, and umami taste, binge eaters expressed more facial reactions when compared to anorexic patients ($p = .004$, $p = .058$, $p = .028$). Binge eaters also displayed a higher facial activity in response to the sour taste when compared to controls ($p = .024$). The main effect of group was also significant, $F(3, 70) = 6.75$, $p < .001$.

The analysis revealed a significant main effect of taste quality, $F(4, 280) = 18.83$, $p < .001$, and taste concentration, $F(1, 70) = 42.44$, $p < .001$. These effects were qualified by a significant taste quality × taste concentration interaction, $F(4, 280) = 3.36$, $p = .012$. In particular, the low concentrated sour taste elicited a higher overall facial activity than the low concentrated bitter and salty taste ($ps < .001$). The highly concentrated sour taste evoked more facial reactions than the highly concentrated bitter, salty, sweet, and umami taste ($ps < .001$). For each taste quality, the low concentration elicited a lower overall facial activity than the high concentration (*ps* < .05). The other interaction effects were not significant (taste concentration × group, taste quality × taste concentration × group; *ps* > .05).

Moreover, the groups were comparable in the frequency of their facial reactions elicited by water, $F(3, 73) = .43$, $p > .05$. On average, each group displayed 4 facial actions (controls: *M* = 4.1, *SD* = 2.9; anorexics: *M* = 3.8, *SD* = 2.4; bulimics: *M* = 4.9, *SD* = 2.5; binge eaters: *M* = 4.0, *SD* = 2.2) in response to water.

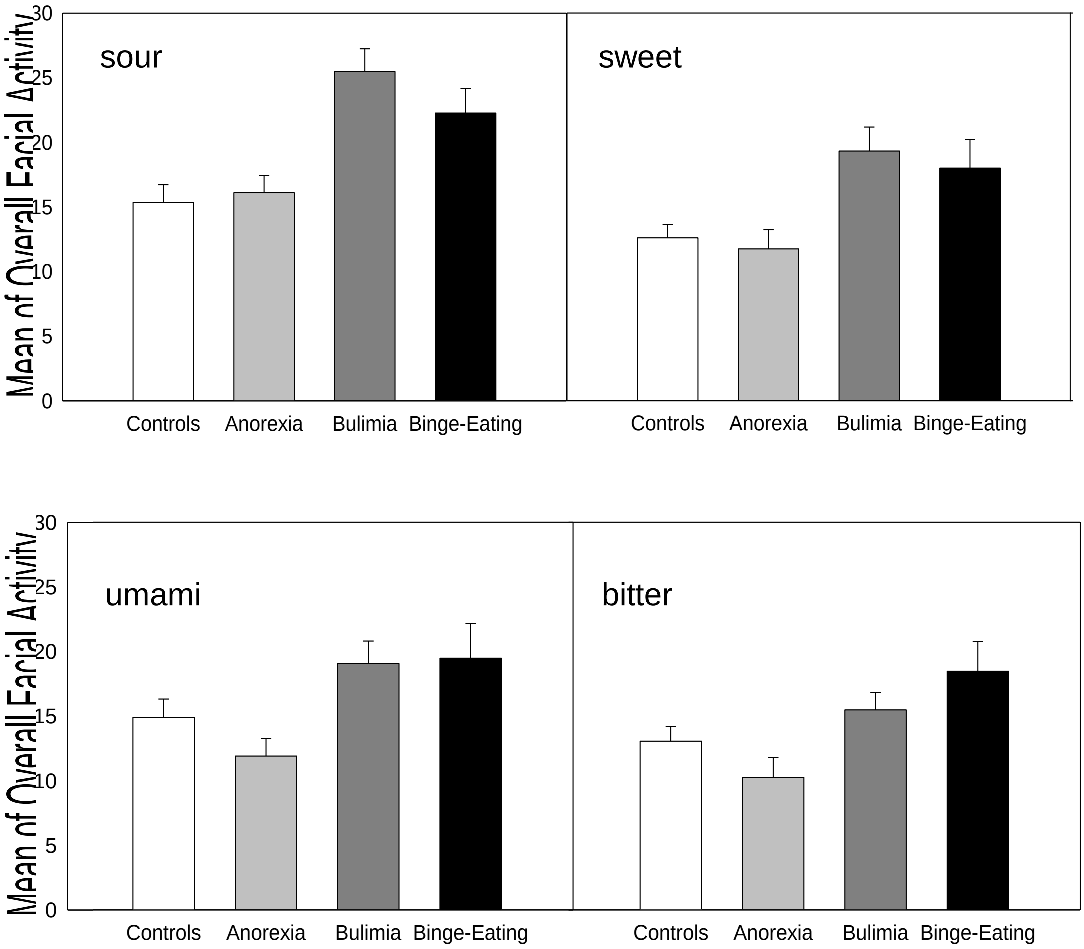


Figure 10: Overall facial activity (Means ± *SEM*) in response to the sour, sweet, umami, and bitter taste after swallowing in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* = 19), and Binge-Eating Disorder (*n* = 15).

Odor-elicited overall facial activity: The groups did not differ in their overall facial activity in response to odors, $F(3, 67) = .24$, $p > .05$ (Figure 11). Different odors, however, differed in the frequency of facial reactions, $F(6, 402) = 21.86$, $p < .001$. Participants exhibited a higher overall facial activity in response to fish and garlic when compared to banana, cinnamon, licorice, and the neutral odor (*ps* < .001). In response to clove, participants showed a higher overall facial activity than in response to cinnamon and the neutral odor (*ps*

< .05) and a lower overall facial activity than in response to garlic (p = .001). The odor × group interaction was non-significant, $F(18, 402) = .49$, $p = .92$.

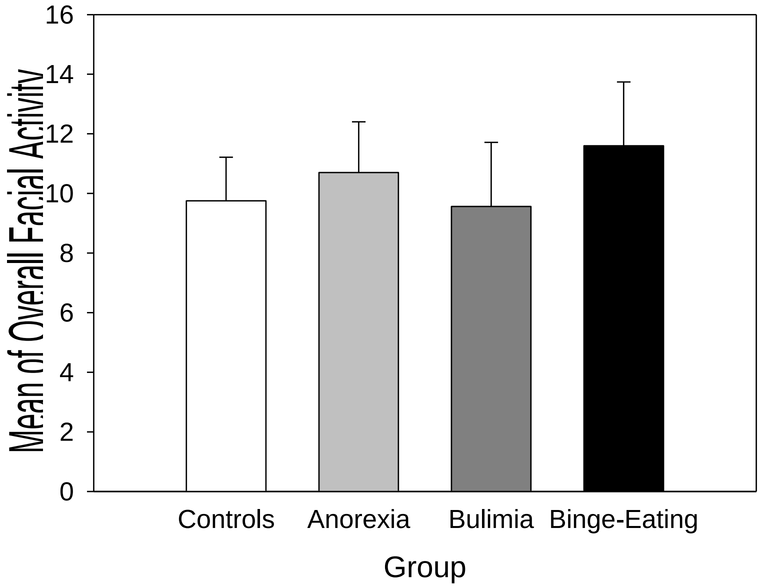


Figure 11: Overall facial activity (Means ± *SEM*) in response to odors in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* = 19), and Binge-Eating Disorder (*n* = 15).

To sum up, patients with Bulimia and Binge-Eating Disorder displayed a greater overall facial activity than did anorexic patients in response to all tastes before swallowing. After swallowing, patients with Bulimia and Binge-Eating Disorder exhibited a greater overall facial activity in response to the sour taste and bulimics exhibited a greater overall facial activity in response to the sweet taste when compared to controls. Moreover, bulimics and binge eaters were found to be more responsive facially when compared to anorexics in their response to some tastes, i.e. sour, umami, sweet, and bitter tastes. In response to the salty taste, the groups exhibited an equal frequency of facial reactions. Unexpectedly, neither before nor after swallowing did anorexic patients show a decreased taste-elicited overall facial activity compared to controls. The groups displayed a similar frequency of overall facial activity in response to odors.

2.3.3. Specific facial activity

The following section describes the group differences in specific facial reactions in response to tastes and odors (not Bonferroni corrected). Please see Appendix A for specific facial reactions when a Bonferroni correction was applied.

Single Action Units in response to tastes: Binge eaters and bulimics showed more positive and negative facial reactions in response to the low **sweet taste,** and negative facial reactions in response to the high sweet taste. Frequencies of selected Action Units in response to the sweet tastes across groups are listed in Table 5.

Before swallowing of the **low concentrated sweet taste**, binge eaters more often expressed appetitive reactions such as the dimpler (AU 14) and lip press (AU 24) when compared to anorexics (p = .034, p = .011) and controls (p = .042, p = .005). Likewise, bulimics displayed lip press (AU 24) more often when compared to anorexics and controls (p = .034, p = .020). After swallowing of the low concentrated sweet taste, binge eaters showed more negative facial reactions as indicated by brow lower (AU 4), when compared to controls (p = .006), but also more positive facial reactions as indicated by lip wipe (AU 37), when compared to bulimics (p = .018) and controls (p = .016).

After the low sweet taste had been swallowed, bulimics and binge eaters showed the dimpler (AU 14) more often when compared to controls (p = .030, p = .037) and lip press (AU 24) more often when compared to anorexics (p = .009, p = .010). In addition, both bulimics and binge eaters opened their mouth (AU 25 + 26) more frequently in response to the low concentrated sweet taste after swallowing when compared to anorexics (p = .005, p = .003, p = .047, p = .013).

Before swallowing of the **highly concentrated sweet solution**, both bulimics and binge eaters were disgusted as was indicated by more displays of upper lip raise (AU 10) when compared to controls (p = .006, p = .043). Moreover, bulimics displayed upper lip raise more often than did anorexics (p = .015). Binge eaters displayed lip corner depress (AU 15), a negative reactions, more often than controls (p = .016) and chin raise (AU 17) more often than anorexics (p = .046) before swallowing. After swallowing of the high sweet taste, bulimics clearly showed negative facial displays such as brow lower (AU 4) and upper lip raise (AU 10) more often when compared to anorexics (p = .032, p = .015) and controls (p = .032, p = .006). Gaping (AU 26) was expressed more often by bulimics and controls when compared to anorexics (p = .002, p = .042). Binge eaters displayed lower lip depress (AU 16) more often when compared to anorexics and controls (ps = .039) which is also indicative of negative emotions.

In response to the **bitter tastes**, binge eaters showed more negative displays before swallowing, whereas bulimics showed more negative facial displays after swallowing (Table 5). Before swallowing of the **low concentrated bitter taste**, binge eaters displayed the negative facial reaction of lip corner depress (AU 15) more frequently when compared to anorexics (*p* = .039), bulimics (*p* = .044), and controls (*p* = .039). Before and after swallowing of the low concentrated bitter taste, binge eaters opened their mouth (AU 26) more often when compared to anorexics (*p* = .029, *p* = .032). Bulimics were also found to open their mouth (AU 25 + 26) more frequently than anorexics (*p* = .006, *p* = .001) after swallowing of the low concentrated bitter taste. Anorexics displayed lids tight (AU 7) more frequently in response to the low concentrated bitter taste before swallowing when compared to bulimics (*p* = .023).

Table 5: Frequencies of selected Action Units (AUs) in response to the low and high concentration of the bitter and the sweet taste in healthy controls (C, *n* = 20), patients with Anorexia (AN, *n* = 20), Bulimia (BN, *n* = 19), and Binge-Eating Disorder (BE, *n* = 15).

		sweet								bitter							
		low				high				low				high			
AUs		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 4	pre	5	5	5	3	9	7	13	9	3	6	4	5	17	16	20	13
	post	0	3	5	6	4	4	11	8	5	6	10	7	15	12	15	11
AU 6	pre	0	0	0	1	0	2	1	0	0	0	0	0	1	2	1	0
	post	0	0	0	0	0	1	0	0	0	0	0	1	2	1	0	1
AU 10	pre	2	3	3	1	4	5	13	8	2	3	3	3	19	17	18	13
	post	3	2	5	2	4	5	13	6	3	5	6	3	18	16	18	11
AU 12	pre	2	1	0	1	0	2	1	0	0	0	0	0	1	2	2	0
	post	0	0	1	2	3	3	1	1	1	1	1	2	4	1	1	1
AU 14	pre	14	10	26	16	16	9	21	9	17	17	21	16	5	5	11	5
	post	19	24	33	25	21	26	32	19	21	16	22	28	14	8	11	18
AU 15	pre	0	1	1	1	0	1	3	4	0	0	0	3	8	3	7	11
	post	0	2	2	1	1	2	2	2	1	0	0	1	4	3	8	6
AU 24	pre	7	8	19	15	15	9	18	11	9	9	14	11	13	9	12	10
	post	20	15	30	27	20	26	33	25	23	19	20	19	12	15	10	18
AU 25	pre	0	0	1	1	1	0	2	1	1	0	2	1	1	0	0	0
	post	27	17	36	28	29	22	37	25	24	15	35	19	21	15	18	28
AU 26	pre	1	0	1	2	4	1	5	1	2	1	4	6	1	0	2	3
	post	26	19	38	32	35	23	43	25	27	13	36	21	20	15	21	27
AU 37	pre	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	post	0	3	0	4	1	1	1	3	0	0	2	2	0	0	1	1

Note: The data represent the number of participants who showed Action Units.

Before swallowing of the **highly concentrated bitter taste**, binge eaters showed negative facial displays of lip corner depress (AU 15) and lip tight (AU 23) more frequently when compared to anorexics (*p* = .002, *p* = .039) and controls (AU 23: *p* = .039). After swallowing, binge eaters showed the dimpler (AU 14) more often when compared to anorexics (*p* = .003) and bulimics (*p* = .023). Bulimics expressed nose wrinkle (AU 9) more frequently than anorexics and controls (*ps* = .033). After swallowing of the highly concentrated bitter taste, controls opened their mouth (AU 26) more often than anorexics (*p* = .042).

The **salty tastes** elicited more often negative facial displays in binge eaters before swallowing, as well as the positive facial display of smiling after swallowing of the highly concentrated salty taste. Bulimics also showed negative facial displays, albeit to a lesser extent than did binge eaters. Frequencies of selected Action Units in response to the salty tastes across groups are listed in Table 6.

Before swallowing of the **low concentrated salty taste**, binge eaters lowered their brows (AU 4) more often when compared to anorexics (*p* = .017). Before swallowing of the highly concentrated salty taste, binge eaters showed negative displays of lids tight (AU 7) more often when compared to anorexics (*p* = .039) and nose wrinkle (AU 9) more often compared to anorexics and controls (*ps* = .039). In addition, binge eaters displayed lip corner depress (AU 15) more frequently when compared to anorexics (*p* = .002), bulimics (*p* = .031), and controls (*p* < .001), as well as chin raise (AU 17) more often when compared to anorexics (*p* = .015). Also, binge eaters expressed nostril dilate (AU 38) and closed their eyes (AU 43) more frequently than did anorexics (*p* = .016, *p* = .030), bulimics (*p* = .018, *p* = .007), and controls (AU 43: *p* = .030) during tasting of the high salty taste. After swallowing, binge eaters smiled (lip corner pull, AU 12) more frequently when compared to controls (*p* = .016). Bulimics did not differ in their specific reactions before swallowing of the low salty taste, but they opened their mouth (AU 25 + 26) more frequently when compared to anorexics (*p* = .013, *p* = .003) and controls (AU 26: *p* = .049) after swallowing.

Before swallowing of the **highly concentrated salty taste**, bulimics expressed inner brow raise (AU 1) and lip press (AU 24) more often than did controls (*p* = .007, *p* = .029). Before and after swallowing of the high concentrated salty taste, bulimics expressed the negative display of brow lower (AU 4) more often than anorexics (*p* = .032, *p* = .013).

In response to the **sour tastes**, binge eaters and bulimics clearly showed more negative facial reactions such as brow lower (AU 4), upper lip raise (AU 10), and lip corner depress (AU 15). Bulimics, moreover, expressed the positive facial display of lip wipe (AU 37) in response to the high sour taste. Frequencies of selected Action Units in response to the sour tastes across groups are listed in Table 6.

Before swallowing of the **low concentrated sour taste**, binge eaters expressed negative facial reactions such as brow lower (AU 4) more often when compared to bulimics (*p* = .041) and upper lip raise (AU 10) more often when compared to anorexics (*p* = .016). Bulimics more often displayed upper lip raise (AU 10) and the dimpler (AU 14) than did anorexics (*p* = .032, *p* = .045) and lip press (AU 24) more often than anorexics (*p* = .042) and controls (*p* = .010). They also showed outer brow raise (AU 2) more often than controls (*p* = .033). After swallowing of the low concentrated sour taste, bulimics displayed the dimpler (AU 14) and mouth opening (AU 25 + 26) more often than did anorexics (*p* = .014, *p* = .047, *p* = .016) and controls (*p* < .001, *p* = .011, *p* = .005). In contrast, binge eaters talked (AU 50) more after swallowing of the low concentrated sour taste when compared to anorexics (*p* = .039) and bulimics (*p* = .044).

Table 6: Frequencies of selected Action Units (AUs) in response to the low and high concentration of the salty and the sour taste in healthy controls (C, *n* = 20), patients with Anorexia (AN, *n* = 20), Bulimia (BN, *n* = 19), and Binge-Eating Disorder (BE, *n* = 15).

		salty								sour							
		low				high				low				high			
AUs		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 4	pre	7	3	9	8	16	13	21	14	11	9	7	13	16	10	16	12
	post	6	6	6	7	15	9	18	13	7	7	9	10	11	12	20	13
AU 6	pre	0	0	0	0	0	1	0	2	1	1	0	1	2	3	2	1
	post	0	0	0	0	0	3	2	5	1	1	0	3	5	2	0	3
AU 10	pre	2	3	5	4	18	16	21	12	11	7	14	13	20	15	17	13
	post	4	3	5	4	18	17	17	12	8	9	9	7	12	15	16	14
AU 12	pre	0	0	0	0	0	1	1	2	1	2	1	1	2	3	2	1
	post	1	1	1	1	0	3	1	6	4	2	4	5	8	6	4	6
AU 14	pre	21	15	23	14	11	8	10	4	14	8	27	10	10	6	19	7
	post	19	17	22	16	18	18	14	7	12	23	37	19	22	17	37	19
AU 15	pre	0	0	2	3	3	6	9	14	5	2	4	7	5	3	7	7
	post	1	0	1	4	4	8	9	7	5	4	1	3	1	4	2	10
AU 24	pre	10	10	19	7	11	14	20	12	9	12	22	9	18	11	22	13
	post	13	23	25	19	16	15	15	8	23	21	28	19	19	25	41	27
AU 25	pre	1	0	2	1	1	0	1	0	0	1	1	0	3	0	4	0
	post	26	21	36	23	26	16	25	19	21	24	39	24	29	25	47	27
AU 26	pre	1	1	2	2	2	1	1	2	1	2	3	0	3	1	6	2
	post	24	19	37	24	26	16	25	18	24	25	43	23	34	24	49	31
AU 37	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	0	1	0	0	1	0	2	0	4	3	0	0	4	1

Note: The data represent the number of participants who showed Action Units.

Before swallowing of the **highly concentrated sour taste**, binge eaters more often displayed the negative facial displays of lip corner depress (AU 15) and chin raise (AU 17) when compared to anorexics (*p* = .043, *p* = .017) and lip tight (AU 23) less often than anorexics (*p* = .012). After swallowing, lip corner depress was also expressed more often by binge eaters when compared to bulimics (*p* = .014) and controls (*p* = .004). Binge eaters pressed their lips (AU 24) more often than did controls (*p* = .022) and opened their mouth

(AU 26) more often than anorexics (*p* = .028). Controls displayed upper lip raise (AU 10) more often than anorexics (*p* = .018) before swallowing of the highly concentrated sour taste.

Before swallowing of the highly concentrated sour taste, bulimics displayed brow lower (AU 4) and lip press (AU 24) more frequently than anorexics (*p* = .047, *p* = .024). They also showed inner brow raise (AU 1) more often than binge eaters (*p* = .041) and controls (*p* = .022). After swallowing of the highly concentrated sour taste, bulimics expressed the dimpler (AU 14), lip press (AU 24), and mouth opening (AU 25 + 26) more often than did anorexics (*p* = .002, *p* = .004, *p* = .003, *p* = .001) and controls (*p* = .011, *p* < .001, *p* = .009, *p* = .025). They also showed lip stretch (AU 20) more often when compared to controls (*p* = .033). In addition, after swallowing, bulimics displayed lip wipe (AU 37) more frequently in response to the highly concentrated sour taste when compared to anorexics and controls (*ps* = .033).

Binge eaters and bulimics showed more negative facial reactions in response to the low concentrated **umami taste**, thus indicating displeasure. The highly concentrated umami taste elicited negative facial displays in bulimics, but positive displays in binge eaters (Table 7).

Before swallowing of the **low concentrated umami taste**, binge eaters more frequently showed the negative facial reactions of brow lower (AU 4) and upper lip raise (AU 10) than did anorexics (*p* = .004, *p* = .001); also, they showed the negative facial reactions of lip corner depress (AU 15) and chin raise (AU 17) more frequently than did controls (*p* = .042, *p* = .049). Binge eaters also opened their mouth (AU 26) more frequently than did anorexics during tasting of the low and highly concentrated umami solution (*p* = .016, *p* = .039) and than did bulimics during tasting of the low concentrated umami solution (*p* = .018). Binge eaters displayed inner brow raise (AU 1) more frequently in response to the low concentrated umami taste when compared to anorexics, bulimics, and controls (*p* = .039, *p* = .044, *p* = .039).

In response to the low concentrated umami taste before swallowing, bulimics showed the negative facial display of upper lip raise (AU 10) more often when compared to anorexics (*p* = .003) and the dimpler (AU 14) more often compared to controls (*p* = .040). Controls expressed lids tight (AU 7) more often than did bulimics (*p* = .023) and upper lip raise (AU 10) more often than anorexics (*p* = .040).

Before swallowing of the **high concentrated umami solution**, binge eaters expressed inner brow raise (AU 1) more often when compared to anorexics (*p* = .039) and outer brow raise (AU 2) more often when compared to anorexics and bulimics (*p* = .039, *p* = .044).

Controls opened their mouth (AU 26) more frequently than anorexics (*p* = .037) in response to the highly concentrated umami taste before swallowing.

After swallowing of the highly concentrated umami taste, binge eaters more frequently displayed the positive facial reactions of smiling including cheek raise (AU 6) and lip corner pull (AU 12) when compared to anorexics (*ps* = .039), bulimics (AU 6: *p* = .044), and controls (*ps* = .039). Bulimics showed lower lip depress (AU 16) more often than did controls and anorexics, (*p* = .033, *p* = .007) and opened their mouth (AU 25/26) more often than did anorexics (*p* = .019, *p* = .009) and controls (AU 26: *p* = .024) in response to the highly concentrated umami taste.

Table 7: Frequencies of selected Action Units (AUs) in response to the low and high concentration of the umami taste, and water in healthy controls (C, *n* = 20), patients with Anorexia (AN, *n* = 20), Bulimia (BN, *n* = 19), and Binge-Eating Disorder (BE, *n* = 15).

		umami								water			
		low				high							
AUs		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 4	pre	10	5	9	12	12	10	11	12	4	1	2	1
	post	14	11	15	10	12	10	16	12	4	9	4	0
AU 6	pre	0	0	0	1	1	0	0	2	0	0	0	0
	post	0	0	1	2	0	0	0	4	0	0	0	0
AU 10	pre	6	1	9	6	11	8	14	11	0	0	0	0
	post	11	4	10	10	11	15	17	11	1	2	1	0
AU 12	pre	1	1	0	1	1	0	0	2	0	1	1	1
	post	2	4	2	3	0	0	1	5	1	0	2	1
AU 14	pre	14	15	25	10	17	19	25	10	11	14	15	11
	post	20	18	19	19	16	16	19	18	17	12	19	14
AU 15	pre	2	1	3	3	3	2	5	6	0	0	0	0
	post	5	1	8	5	6	3	2	5	0	0	0	0
AU 24	pre	9	9	11	11	13	10	15	11	7	8	12	7
	post	14	22	23	24	18	22	29	15	18	14	14	14
AU 25	pre	1	0	0	1	0	0	0	0	1	0	0	0
	post	28	17	31	18	29	21	35	20	15	15	22	13
AU 26	pre	1	0	0	4	4	0	1	5	0	1	0	2
	post	29	17	32	21	26	22	40	22	15	14	24	13
AU 37	pre	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	1	1	1	0	0	0	4	1	0	0	0

Note: The data represent the number of participants who showed Action Units.

Facial responses to **water** were found to differ less among the groups (Table 7). After swallowing, bulimics opened their mouth (AU 26) more often than did anorexics (*p* = .018) and controls (*p* = .044). Anorexics displayed brow lower (AU 4) more often in response to water after swallowing, when compared to binge eaters (*p* = .012).

Single Action Units in response to odors: The analysis for each Action Unit showed that the groups were comparable in the frequency of their specific facial displays. However, bulimics showed inner brow raise (AU 1) more frequently than did controls and anorexics ($ps = .046$) in response to garlic.

In sum, binge eaters and bulimics displayed more negative facial reactions than did anorexics or controls in response to the bitter, salty, sour, sweet, and umami tastes. Both bulimics and binge eaters showed ambivalent reactions, including both negative facial reactions, as well as positive facial reactions in response to the low sweet taste, but both clearly rejected the highly concentrated sweet taste as indicated by negative displays. Binge eaters also showed ambivalent reactions in response to the highly concentrated salty and umami taste. Bulimics showed ambivalent reactions in response to the highly concentrated sour taste.

2.3.4. Electromyographic activity

This section will describe the results of electromyographic activity over the corrugator, levator, and zygomaticus muscle in response to tastes and odors.

Corrugator activity in response to low concentrated tastes: The groups neither differed in their corrugator activity before swallowing, $F(3, 69) = 1.14$, $p > .05$, nor after swallowing, $F(3, 68) = 1.11$, $p > .05$ (main effect of group). Before swallowing, there was a significant main effect of taste quality, $F(5, 345) = 3.38$, $p = .021$, and time, $F(7, 483) = 7.40$, $p < .001$. These effects were qualified by a significant taste quality × time interaction, $F(35, 2415) = 2.31$, $p = .039$. In response to the umami taste, participants exhibited a higher corrugator amplitude than in response to the sweet taste for the period 6 ($p = .046$), 7 ($p = .026$), and 8 ($p = .015$). The umami taste also elicited a heightened corrugator activity compared to the sour taste ($p = .045$) and water ($p = .054$) for the period 5. There were no significant interaction effects ($ps > .05$).

After swallowing, corrugator activity differed across the groups over time, $F(21, 476) = 2.43$, $p = .014$ (Figure 12). Post-hoc tests indicated that the corrugator activity in bulimic patients tended to increase from period 2 compared to period 4 ($p = .067$). In contrast, corrugator activity of controls decreased from period 3 compared to period 8 ($p = .008$). There was no significant main effect of group, $F(3, 68) = 1.12$, $p > .05$. Corrugator activity varied across time, $F(7, 476) = 3.11$, $p = .031$), but not across taste quality, $F(5, 340) = .86$, $p > .05$). The other interaction effects were non-significant ($ps > .05$).

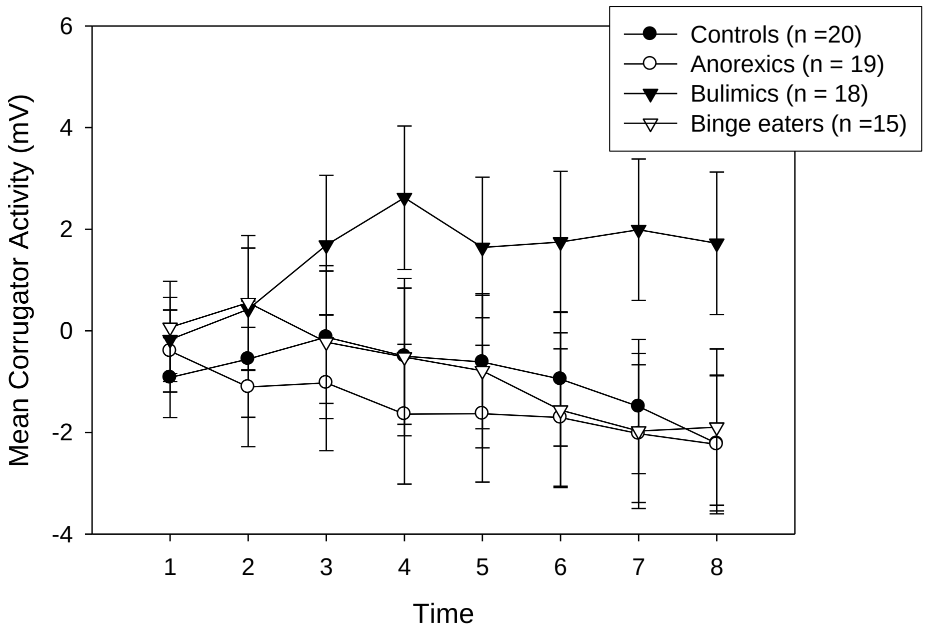


Figure 12: Mean Corrugator activity (Means ± *SEM*) in response to low concentrated tastes after swallowing in healthy controls, patients with Anorexia, Bulimia, and Binge-Eating Disorder.

Corrugator activity in response to highly concentrated tastes: The groups did not differ in their corrugator activity in response to high concentrations neither before swallowing, $F(3, 69) = .12$, $p > .05$, nor after swallowing, $F(3, 67) = .33$, $p > .05$. Before swallowing, corrugator activity varied across taste qualities, $F(5, 345) = 6.52$, $p < .001$. The bitter and the sour taste elicited a greater corrugator activity compared to water ($p < .001$, $p = .029$) and the sweet taste ($p < .001$, $p = .013$). Moreover, the bitter taste elicited a greater activity than the salty taste ($p = .037$). Corrugator activity significantly increased over time, $F(7, 438) = 2.96$, $p = .048$, as indicated by a higher amplitude at period 3 compared to period 1 ($p = .003$). The time × group interaction, $F(21, 438) = 2.02$, $p = .058$, was almost significant and indicated that binge eaters exhibited a greater corrugator activity when compared to bulimics for period 1 ($p = .016$). The other interaction effects were non-significant (*ps* > .05).

After swallowing, corrugator activity significantly decreased over time, $F(7, 469) = 12.65$, $p < .001$, with a higher activity for the periods 1, 2, 3, 4 compared to periods 5, 6, 7, and 8 (*ps* < .05). There was a tendency of taste quality × time interaction, $F(35, 2345) = 1.83$, $p = .093$, with the sour taste eliciting a higher corrugator amplitude than water ($p = .016$). There were no significant interaction effects (*ps* > .05).

Levator activity in response to low concentrated tastes: Before swallowing, the groups exhibited a comparable levator activity (group, $F(3, 69) = 1.93$, $p > .05$; taste quality × group interaction, $F(15, 345) = 1.27$, $p > .05$). This is illustrated in Figure 13.

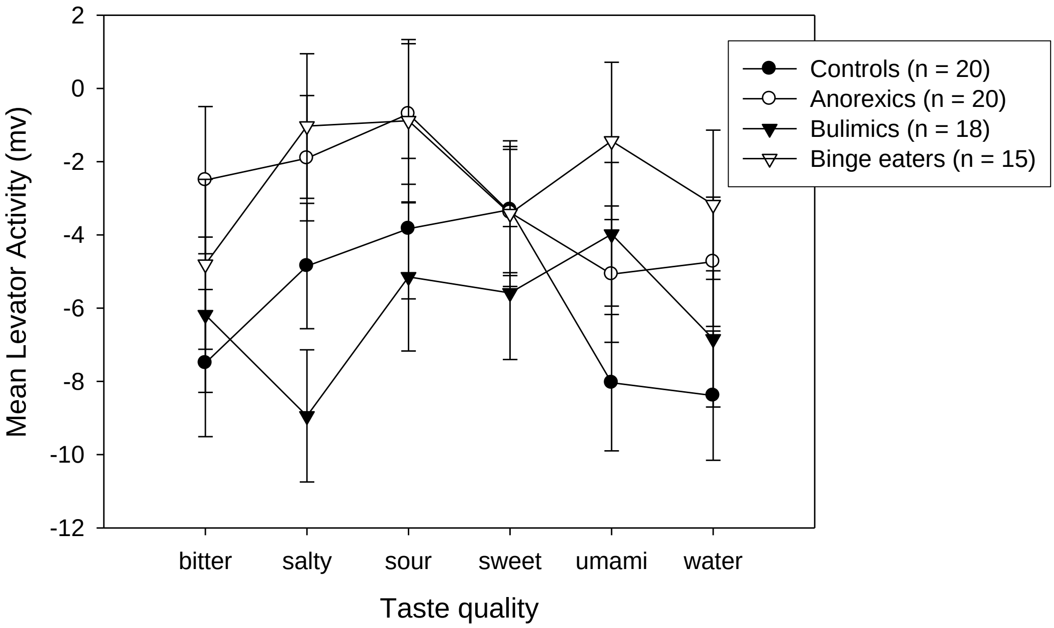


Figure 13: Mean Levator activity (Means ± *SEM*) in response to the low concentrated bitter, salty, sour, sweet, and umami tastes, and water before swallowing in healthy controls, patients with Anorexia, Bulimia, and Binge-Eating Disorder.

The main effect of taste quality, $F(5, 345) = 2.17$, $p = .065$, failed to reach statistical significance. However, there was a significant main effect of time, $F(7, 483) = 9.57$, $p < .001$, qualified by a significant taste quality × time interaction, $F(35, 2415) = 1.89$, $p = .033$. More specifically, the sour taste elicited a greater levator acitivity than water for the periods 3-6 (*ps* < .05). The other interaction effects were non-significant (*ps* > .05).

After swallowing, levator activity differed across time, $F(7, 476) = 6.07$, $p < .001$, with greater levator activity for period 1 compared to period 6, 7, and 8, as well as for period 2 compared to period 8 (*ps* < .05). The groups were comparable in their levator activity, $F(3, 68) = .47$, $p > .05$. The other main effects as well as interaction effects were non-significant (*ps* > .05).

Levator activity in response to highly concentrated tastes: The groups did not differ in their levator activity in response to high concentrations neither before swallowing, $F(3, 69) = .63$, $p > .05$, nor after swallowing, $F(3, 67) = .11$, $p > .05$.

Before swallowing, there was a significant main effect of taste quality, $F(5, 345) = 6.95$, $p < .001$, which was qualified by a significant taste quality × time interaction, *F*(35,

2415) = 2.68, $p = .004$. In particular, the sour, bitter, umami, and salty taste elicited a greater levator activity than water for some periods (sour: 3-5 and 7-8; bitter: 3-8; umami: 3-5 and 7; salty: 6; *ps* < .05). The bitter taste could be differentiated from the sweet taste by a greater levator amplitude for the period 4, 5, and 6 (*ps* < .05). Likewise, the sour taste elicited a greater levator activity than the sweet taste for the period 3 and 4 (*ps* < .05). The other main effects, as well as interaction effects, were non-significant (*ps* > .05).

After swallowing, levator activity differed across time, $F(7, 469) = 5.34$, $p = .003$, as indicated by a decreased levator activity from period 2 compared to period 7 and 8 (*ps* > .05). The other main effects as well as interaction effects were non-significant (*ps* > .05).

Zygomaticus activity in response to low concentrated tastes: Zygomaticus activity did not differ across groups, neither before swallowing, $F(3, 69) = .82$, $p > .05$, nor after swallowing, $F(3, 68) = .11$, $p > .05$. However, before swallowing zygomaticus activity differed significantly across time, $F(7, 483) = 3.25$, $p = .019$, as indicated by a decrease in zygomaticus activity over time (from period 1 to period 2 and 5) (*ps* < .05). The other main effects as well as interaction effects were non-significant before as well as after swallowing (*ps* > .05).

Zygomaticus activity in response to highly concentrated tastes: Zygomaticus activity did not differ across groups, neither before swallowing, $F(3, 69) = .77$, $p > .05$, nor after swallowing, $F(3, 67) = .74$, $p > .05$. After swallowing, zygomaticus activity differed significantly across the different taste qualities, $F(5, 335) = 2.76$, $p = .041$, with the bitter and the sweet taste eliciting a greater zygomaticus activitiy than water (*ps* < .05). Moreover, zygomaticus activity differed across time after swallowing, $F(7, 469) = 4.85$, $p = .001$. Zygomaticus activity decreased from period 2 and 4 when compared to period 7 and 8 (*ps* < .05). The other main effects as well as interaction effects were non-significant before and after swallowing (*ps* > .05).

Corrugator activity in response to odors: The groups did not differ in their corrugator activity in response to odors, $F(3, 67) = .53$, $p > .05$. The significant main effects of odor type, $F(6, 402) = 9.40$, $p < .001$, and time, $F(7, 469) = 8.54$, $p < .001$, were qualified by a significant odor type × time interaction, $F(42, 2814) = 2.53$, $p = .012$. More specifically, garlic elicited a higher corrugator activity when compared to cinnamon, licorice, and the neutral odor for almost the whole presentation time, i.e. for period 2-8 (*ps* < .05). Fish also elicited a greater corrugator activity when compared to cinnamon (period 2-4, and 8), licorice (period 3 and 4), and the neutral odor (period 2-4, and 8) (*ps* < .05). Garlic and fish also elicited more activity than banana (garlic: period 2-4, fish: period 3) (*ps* $< .05$). Other interaction effects were not significant (*ps* $> .05$).

Levator activity in response to odors: The groups did not differ in their levator activity in response to odors, $F(3, 67) = .17$, $p > .05$. The significant main effects of odor type, $F(6, 402) = 7.24$, $p < .001$, and time, $F(7, 469) = 6.69$, $p < .001$, were qualified by a significant odor type × time interaction, $F(42, 2814) = 2.04$, $p = .043$. For period 2, garlic elicited a greater levator activity than banana, cinnamon, licorice, and neutral odor (*ps* $< .05$), and clove elicited a greater activity than cinnamon, licorice, and neutral odor (*ps* $< .05$). Garlic and fish elicited a higher levator activity when compared to banana (except period 3, when compared to fish), cinnamon, and the neutral odor for the periods 3-6 (*ps* $< .05$). Over time, clove elicited a greater levator activity than did the neutral odor for the periods 3-5 (*ps* $< .05$). At the end of the smelling period, fish elicited a higher activity than banana for the periods 7 and 8 (*ps* $< .05$). Both fish and garlic elicited a greater levator activity than the neutral odor for period 8 (*ps* $< .05$). Other interaction effects were not significant (*ps* $> .05$).

Zygomaticus activity in response to odors: The groups did not differ in their zygomaticus activity in response to odors, $F(3, 67) = .83$, $p > .05$. The analysis revealed significant main effects of odor type, $F(6, 402) = 5.52$, $p = .001$, and time, $F(7, 469) = 4.62$, $p = .003$. Fish elicited a higher zygomaticus activity when compared to banana ($p = .026$), cinnamon ($p = .033$), and the neutral odor ($p = .006$). Also, garlic elicited a higher activity than did banana ($p = .075$, tendency) and the neutral odor ($p = .033$). Zygomaticus activity increased over time with lower zygomaticus amplitudes for period 1 when compared to periods 3-8 (*ps* $< .05$). All interaction effects were not significant (*ps* $> .05$).

All findings considered electromyographic activity over the corrugator, levator, and zygomaticus muscle was comparable between patients with eating disorders and controls. Thus the electromyographic results did not correspond to the facial reactions as assessed by FACS. However, it was shown that facial muscle activity differed across different tastes and odors. A greater corrugator activity of the low umami and high bitter taste before swallowing indicated the unpleasant nature. Before swallowing, the highly concentrated unpleasant tastes (bitter, umami, and salty) and the pleasant sour taste elicited a greater levator activity than water and the sweet taste. The greater corrugator and levator activity before swallowing was associated with the sour taste, which indicates its aversive nature despite subjectively being rated as pleasant. Zygomaticus activity did not differentiate between pleasant and unpleasant tastes. Higher corrugator and levator activity were associated with odor unpleasantness, and zygomaticus activity differentiated between pleasant and unpleasant odors.

2.3.5. Taste and odor sensitivity, and personality aspects

The groups were comparable in their taste threshold, *F*(3, 73) = 1.2, *p* > .05.. Controls correctly identified 13 tastes (*SD* = 2.4); anorexic patients 11 tastes (*SD* = 3.0), bulimic patients 12 tastes (*SD* = 3.1), and binge eaters 12 tastes (*SD* = 1.8). Thus all groups remain within the normal range of taste identification (at least 9 tastes have to be identified correctly).

The groups differed in their odor threshold, *F*(3, 73) = 3.1, *p* = .034. Controls had an odor threshold of 8.7 (*SD* = 1.5), anorexic patients of 8.1 (*SD* = 1.7), bulimic patients of 7.5 (*SD* = 1.8), and binge eaters of 7.0 (*SD* = 2.0). According to the normative data in healthy participants (Hummel, Kobal, Gudziol, & Mackay-Sim, 2007), the groups were in the range of normal odor threshold (16-35 years, *M* = 9.4, *SD* = 2.6; 36-55 years, *M* = 9.1, *SD* = 3.1). Binge eaters had a significantly lower odor threshold than controls (*p* = .034).

Figure 14 depicts the tri-modal distribution of the PROP intensity ratings and the unimodal distribution of the NaCl intensity ratings.

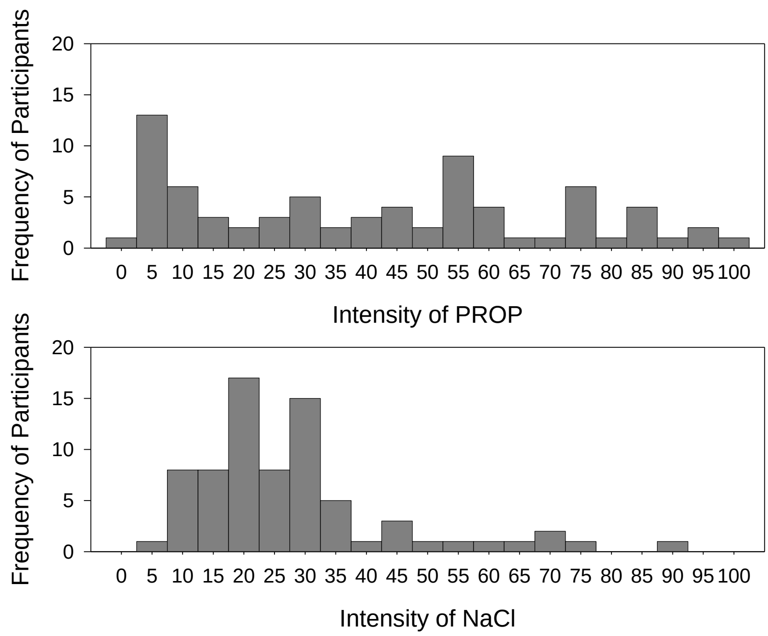


Figure 14: Distribution of intensity ratings for PROP and NaCl in the total sample (*N* = 74).

To investigate bitter sensitivity, a non-hierarchical cluster analysis (K-means) with a 3-cluster solution of the perceived PROP intensity revealed the following cut-off points: Intensity scores from 0 to 25 refer to non-tasters (*n* = 28), intensity scores from 26 to 64 refer to medium-tasters (*n* = 29), and intensity scores from 65 to 100 refer to super-tasters (*n* = 17). The proportion of non-tasters, medium-tasters, and super-tasters across the groups was as follows: non-tasters Controls (*n* = 7), Anorexia (*n* = 9), Bulimia (*n* = 5), BED (*n* = 7), medium-tasters Controls (*n* = 10), Anorexia (*n* = 7), Bulimia (*n* = 9), BED (*n* = 3), and super-tasters Controls (*n* = 3), Anorexia (*n* = 4), Bulimia (*n* = 5), BED (*n* = 7). The frequency of non-, medium-, and super-tasters did not differ among the groups ($Chi^2 = 5.1$, $p > .05$). When the groups were classified into non-tasters and tasters, the frequency of non-tasters and tasters also did not differ across the groups ($Chi^2 = 2.1$, $p > .05$).

Moreover, the groups differed in their level of depression (BDI, $F(3, 73) = 20.6$, $p < .001$), in eating behavior (DEBQ, external eating behavior, $F(3, 73) = 14.6$, $p < .001$, emotional eating behavior, $F(3, 73) = 32.8$, $p < .001$, restrained eating behavior, $F(3, 73) = 20.4$, $p < .001$), in some personality traits (NEO-FFI, neuroticism, $F(3, 73) = 25.5$, $p < .001$, extraversion, $F(3, 73) = 9.2$, $p < .001$, and openness to experience, $F(3, 73) = 4.1$, $p < .05$, agreeableness, $F(3, 73) = 2.8$, $p < .05$), and in negative expressivity (BEQ, $F(3, 73) = 3.3$, $p < .05$). Overall, eating-disordered patients were more depressed than controls (*ps* < .001).

Table 8: Ratings (Means ± *SD*) of the level of depression, eating behaviors, personality characteristics, and expressivity.

	Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
BDI***	5.1	4.6	26.8	11.2	20.2	10.9	22.2	8.5
DEBQ								
External eating behavior***	33.0	5.9	26.4	6.9	39.5	7.3	37.5	6.7
Emotional eating behavior***	21.0	6.9	23.1	10.0	38.2	6.7	41.1	5.8
Restrained eating behavior***	22.3	6.6	41.1	9.7	35.3	7.6	28.7	7.6
NEO-FFI								
Neuroticism***	1.7	0.5	2.8	0.5	2.7	0.4	2.9	0.5
Extraversion***	2.7	0.4	1.9	0.6	2.3	0.6	1.9	0.7
Openness to experience*	2.6	0.5	2.1	0.6	2.3	0.5	2.5	0.5
Agreeableness*	2.7	0.4	2.5	0.7	2.5	0.5	2.1	0.6
Conscientiousness	2.7	0.9	2.7	0.5	2.4	0.6	2.6	0.6
BEQ								
Negative Expressivity*	4.3	1.3	3.1	1.2	3.5	1.0	3.6	1.1
Positive Expressivity	4.9	1.1	4.1	1.2	4.9	1.3	4.8	0.8
Impulse strength	4.6	1.1	4.2	1.3	4.8	1.5	5.0	1.0
Expressivity	73.1	14.9	60.2	16.3	69.4	16.6	70.8	12.0

**p* < .05, ****p* < .001.

Anorexic patients had a lower external eating behavior when compared to the other groups (*ps* < .05); bulimic patients had a higher external eating behavior than controls ($p = .020$). Patients with Bulimia Nervosa and Binge-Eating Disorder had a higher emotional eating behavior than anorexics and controls (*ps* $< .001$). Patients with Anorexia Nervosa had a higher restrained eating behavior than controls and binge eaters (*ps* $< .001$). Bulimic patients had a higher restrained eating behavior than controls ($p < .001$). Eating-disordered patients were more neurotic than controls (*ps* $<.001$) and less extrovert (except bulimics) than controls (*ps* $\leq .001$). Anorexics were less open to new experiences than controls ($p = .012$) and reported to express negative emotions less than controls ($p = .019$). Binge eaters reported to be less agreeable than controls ($p = .035$).

2.4. Discussion

The present experiment is the first that examined whether facial reactions in response to tastes and odors are altered in patients with eating disorders in quantitative and qualitative terms. It was explored whether patients with eating disorders differ from controls in their overall facial activity in response to different tastes (1) and odors (2). Moreover, it was investigated whether eating-disordered patients display distinct facial reactions in response to tastes (3) and odors compared to controls (4). Lastly, this study examined whether electromyographic activity in response to tastes and odors (5) differs across the groups.

Taste-elicited overall facial activity: Overall facial activity in response to tastes (1) was expected to be higher in bulimics and binge eaters when compared to controls, which was partly confirmed by the data. In contrast, patients with Anorexia were expected to display a reduced overall facial activity when compared to controls, which was not confirmed. Before swallowing, patients with Bulimia and Binge-Eating Disorder displayed a greater overall facial activity to generally all tastes (except water) when compared to anorexic patients, but not to controls. After swallowing, bulimics and binge eaters exhibited a greater overall facial activity in response to the sour taste and bulimic patients also displayed a greater facial activity in response to the sweet taste when compared to controls. In addition, bulimics and binge eaters displayed a greater overall facial activity in response to some tastes (sour and umami, bulimics: sweet, binge eaters: bitter) when compared to anorexic patients. This heightened overall facial activity in bulimics and binge eaters might be due to a greater reactivity to food which is determined by dysfunctional cognitions and behaviors regarding food intake. Ingestion underlies a high cognitive control with the intention to avoid high-calorie foods in order to prevent weight gain. Thus, these patients restrict their food intake over long periods of time but then fail to maintain dieting from time to time, resulting in a binge. Prior to a binge, bulimics and binge eaters experience a strong desire or craving for food stimuli which they usually avoid. During and after a binge, the mood declines and they experience negative emotions such as shame and guilt about overeating (Schöttke et al., 2006; Eversmann et al., 2007) which in turn leads to purging in order to prevent weight gain. Ingestion is therefore linked to ambivalent affect. Moreover, bulimics and binge eaters are easily attracted by the sight, smell, or thought of food due to their greater food reactivity. In general, they are more prone for eating in response to external food cues and internal emotional states (e.g. Hilbert & Tuschen-Caffier, 2007).

Interestingly, the groups exhibited an equal frequency of facial reactions in response to the salty tastes after swallowing as well as in response to water during both observation periods. Due to the aversive nature of the highly concentrated salty taste in general, it might have been accompanied by many facial displays in all participants. The low concentrated salty taste might have been too low in concentration to induce facial reactions as indicated by lower intensity ratings when compared to the other tastes. Likewise, the neutal taste water did not induce more facial reactions in bulimics and binge eaters, since it is neither appetitive nor aversive. Therefore, taste concentration as well as taste quality influences facial activity. In this study, two different taste concentrations, i.e. low and high, were administered for the five basic tastes. Medium concentrations, however, were not applied but might have also produced group effects since these concentrations may be more representative for the concentrations in real food stimuli.

Unexpectedly, anorexic patients did not display a decreased but rather a similar taste-elicited overall facial activity than did controls during both observation periods. It can therefore be ruled out that anorexics' heightened self-control and impairments in emotional expression such as difficulties in expressing emotions towards others (alexithymia) and their avoidance of emotional expressions (Bruch, 1962, 1991) reduce their facial activity. Nevertheless, anorexic patients tended to show less facial reactions than controls before swallowing. In general, anorexics' facial expressiveness in response to tastes is comparable to that of the controls.

Overall, bulimics' and binge eaters' heightened taste-elicited overall facial activity may be associated with their greater reactivity to food. A binge is characterized by fast eating, giving up dietary intentions, gobbling food, chewing incompletely, lack of control when eating, and presumably by a greater facial activity. This increased facial expressiveness as a means of food reactivity might be learned and might also be present during normal eating as has been shown in this study. However, the index of overall facial activity does not differentiate between the valences of facial reactions, and it therefore provides no information whether the tastes elicited more positive or more negative facial reactions. The specific facial displays, however, provide this information and will be explained in the next section.

Specific facial activity: Patients with eating disorders were expected to show altered gustofacial reactions in response to all tastes, in particular to the sweet tastes (3). More specifically, patients with Anorexia and Bulimia were expected to express more negative facial reactions, whereas binge eaters were expected to show more positive facial reactions in response to the sweet tastes. The results suggest that both bulimics and binge eaters displayed ambivalent, i.e. positive as well as negative, facial reactions in response to the low concentrated sweet taste indicating pleasure as well as displeasure, and negative reactions in response to the highly concentrated sweet taste indicating displeasure. Therefore, the data confirmed the hypothesis regarding the negative facial displays – but not the positive displays – in bulimics as well as the positive facial displays – but not the negative facial displays – in binge eaters. Unexpectedly, anorexic patients did not show more negative facial displays in response to the sweet tastes.

Ambivalent facial reactions in bulimics and binge eaters were present after swallowing of the low concentrated sweet taste, whereas positive reactions were present before swallowing. Thus swallowing and ingestion of the taste solution might be accompanied by negative emotions such as the anxiety to gain weight (Eiber et al., 2002) or disgust (Troop & Baker, 2009). Bulimics' facial reactions were characterized by the positive display of lip press (AU 24) and the negative display of mouth opening or gaping (AU 25 + 26). Binge eaters' facial reactions were characterized by the positive displays of the dimpler (AU 14), lip press (AU 24), lip wipe (AU 37), and by the negative displays of brow lower (AU 4) and mouth opening (AU 25 + 26). Lip press (AU 24) has been found to be a frequent display in response to the sweet taste in healthy adults (Greimel et al., 2006) and its occurrence was potentiated in both bulimics and binge eaters. As has been shown in the first study, the frequency of the dimpler (AU 14) depends on the valence of the taste quality, with the highly pleasant tastes eliciting higher frequencies and the highly unpleasant tastes eliciting lower frequencies of the dimpler. Both lip press (AU 24) and the dimpler (AU 14) might represent positive facial displays in bulimics and binge eaters in order to keep the flavor in the mouth by pressing the lips together or to get more of the taste into the mouth by pulling the lip corner inwards, respectively. Lip wipe (AU 37) has been found to be a frequent reaction to the sweet taste in newborns (Ganchrow et al., 1983; Steiner, 1973, 1977, 1979; Steiner et al., 2001) and in adults (Greimel et al., 2006; Perl et al., 1992; Steiner et al., 1993) and probably serves to savor every drop of the palatable taste. Mouth opening or gaping (AU 25 + 26) has been reported as a frequent reaction in response to unpleasant tastes (Rosenstein & Oster, 1988; Steiner, 1973, 1977, 1979) and serves to expel the unpleasant taste out of the mouth. Here, gaping indicates the aversive nature of the low sweet taste in bulimics and binge eaters. On the one hand bulimics and binge eaters seem to be attracted by the low sweet taste as indicated by positive displays; on the other hand they seem to reject the taste as indicated by negative displays.

In contrast, both bulimics and binge eaters were found to clearly reject the highly concentrated sweet taste as indicated by negative facial reactions. Both patient groups displayed the prototypical disgust reaction as indicated by upper lip raise (AU 10) (Darwin 1872; Ekman & Friesen, 1975; Hu et al., 1999; Izard, 1971; Rozin et al., 2000; Rozin et al., 1994; Vrana, 1993) in response to the highly concentrated sweet taste before swallowing (and bulimics also after swallowing). This finding corresponds to an increased subjective disgust sensitivity in response to threatening eating disorder–relevant stimuli, e.g. high calorie foods, which was evidenced in bulimic patients (Davey, Buckland, Tantow, & Dallos, 1998; Griffiths & Troop, 2006; Harvey, Troop, Treasure, & Murphy, 2002; Troop, Treasure, & Serpell, 2002; Troop, & Baker, 2009) as is ppresumably associated with the anxiety to gain weight. After swallowing bulimics displayed brow lower (AU 4) which also characterizes a disgust expression in response to unpleasant tastes (Horio, 2003). Brow lower (AU 4), however, can also be associated with other negative emotions, e.g. anger, or with cognitively demanding tasks.

Moreover, binge eaters displayed lip corner depress (AU 15) before swallowing and lower lip depress (AU 16) after swallowing of the high sweet taste. Lip corner depress (AU 15), which had been related to disgust by Darwin (1872), was also a frequent facial reaction in response to unpleasant tastes in newborns (Steiner, 1973, 1977, 1979) and in adults (see first study). The highly concentrated sweet taste might counteract patients' intention to avoid food containing sugar in order to prevent weight gain and may represent their feeling of guilt as a result of having eaten the sugary solution. As indicated by negative facial displays, the highly concentrated sweet taste is aversive for bulimics and binge eaters since it signals carbohydrates and potential energy and therefore a threat for weight loss. However, gaping (AU 25 + 26), i.e. an index of displeasure in newborns (Rosenstein & Oster, 1988; Steiner, 1973, 1977, 1979) and adults (Greimel et al., 2006), was displayed equally by bulimics, binge eaters, and controls. This finding highlights the aversive nature of the highly sweet taste even for controls – a finding which was also evident in the first study. The negative facial displays elicited by the sweet tastes in bulimics do not correspond to the perceived pleasantness since the low and high sweet tastes were equally liked by bulimics and controls. A similar finding was reported by Drewnowski et al. (1987) for the low sweet taste, but not for the high sweet taste. Facial data and subjective pleasantness corresponded stronger in binge eaters who liked the sweet tastes less than did anorexics and bulimics.

In contrast to bulimics and binge eaters, anorexics did not express more negative facial displays in response to the sweet tastes. Although anorexic patients have an extreme fear to gain weight and a heightened disgust sensitivity (Davey et al., 1998; Griffiths & Troop, 2006; Harvey et al., 2002; Troop et al., 2002), this is neither indicated by their subjective pleasantness ratings nor their facial reactions. Instead, anorexics rated the sweet tastes as equally pleasant as did controls, which corresponds to the finding of Simon et al. (1993) but contradicts the heightened preference for sweet tastes in anorexia of Garfinkel (1974) and Garfinkel et al. (1979). It might be argued that anorexics hide their facial reactions (Bruch, 1962, 1991) regarding tastes by display rules (Ekman, 1978) such as attenuating their emotional states in response to tastes. Display rules have been observed in anorexic patients during therapy sessions (Bänninger-Huber, Müller, Barbist, & Schranz, 2004) as indicated by more masking smiles (AU 12) in order to control anger. In this study, however, anorexics might have attenuated rather than have masked their facial displays. The argument that anorexics may hide their expression at least to a certain extent arises from the finding that controls exhibited gapings (AU 26) more often than did anorexics in response to the highly sweet taste after swallowing, as well as in response to other tastes (highly sour, low and highly umami taste, highly bitter taste). The question of whether anorexics had hidden their facial reactions can not be fully answered here but there is evidence that supports anorexics' lower facial expressiveness. In further research, it would be helpful to clarify this aspect by conducting a study in private, in which anorexic patients do not know that their reactions are recorded on video.

In sum, the gustofacial responses in patients with bulimia and binge-eating disorder – but not in patients with anorexia – are altered in response to the sweet tastes. Bulimics' and binge eaters' facial displays are characterized by ambivalent reactions in response to the low concentrated sweet taste and by negative reactions in response to the highly concentrated sweet taste. Thus the innate preference for sweet tastes as indicated by positive displays is shifted in these patients towards an aversion as indicated by negative or ambivalent facial displays. Anorexics might control their reactions to a certain extent as they were not found to display negative facial reactions in response to the sweet tastes.

The gustofacial pattern in response to the other tastes was also altered in bulimics and binge eaters as indicated by more negative or positive facial reactions. In particular, bulimics and binge eaters displayed more negative facial reactions indicating displeasure such as brow lower (AU 4), nose wrinkle (AU 9), upper lip raise (AU 10), lip corner depress (AU 15), lower lip depress (AU 16), chin raise (AU 17), lip stretch (AU 20), and gaping (AU 25 + 26) in response to the unpleasant bitter, salty, sour, and umami tastes. Many of these facial displays have already been discussed above on the basis of their negative nature. In addition, nose wrinkle (AU 9) has been reported as a frequent reaction in response to unpleasant tastes in newborns (Rosenstein & Oster, 1988; Steiner, 1973, 1977, 1979) as well as lower lip depress (AU 16) in adults (Steiner et al., 1993) and corresponds to the findings here. Moreover, many of these negative facial reactions were frequently displayed by newborns (Ganchrow et al., 1983; Rosenstein & Oster, 1988, 1997; Steiner, 1973, 1977, 1979, Steiner et al., 2001), children (Zeinstra et al., 2009), and adults (Greimel et al., 2006; Perl et al., 1992; Steiner et al., 1993) in response to unpleasant tastes. The results suggest that these negative facial displays are exaggerated in bulimics and binge eaters, which is probably due to their greater food reactivity.

Apart from the negative facial reactions, bulimics and binge eaters also displayed positive facial reactions in response to some unpleasant tastes. Bulimics displayed the dimpler (AU 14), lip press (AU 24), and lip wipe (AU 37) in response to the sour tastes indicating pleasure which do not correspond to the subjective pleasantness ratings. Moreover, binge eaters displayed the positive display of smiling (AU 12, AU 6 + 12) more frequently in response to the highly concentrated salty and umami taste. Smiling has been reported as frequent facial reaction elicited by the sweet taste in newborns (Mennella & Beauchamp, 1997; Steiner, 1987; Steiner et al., 2001) and adults (Greimel et al., 2006). However, smiles were also frequent reactions in response to the bitter taste (Greimel et al., 2006) and in response to bitter, salty, and sour tastes in the first study. Thus the facial display of smiling which is incompatible with the unpleasant taste experience may have activated display rules, i.e. smiling to mask the experienced negative emotions (Bänninger-Huber et al., 2004; Ekman & Friesen, 1982). Furthermore smiling may serve as a self-regulatory coping strategy which enables individuals to distract themselves from threat (Ansfield, 2007; Keltner & Bonanno, 1997; Kunz et al., 2009) such as unpalatable tastes.

It has been shown that bulimics and binge eaters display more specific facial reactions than controls and anorexics in response to some tastes which was mostly indicated by a higher frequency of negative facial reactions. These differences do not seem to be due to differences in sensory taste perception, i.e. intensity, which is consistent with the findings of other studies (Drewnowski et al., 1987; Franko et al., 1993; Simon et al., 1993; Sunday & Halmi, 1990) or hedonic taste perception, i.e. pleasantness. Rather, these differences might be due to a greater reactivity in bulimics and binge eaters in response to tastes. It is therefore concluded that any oral sensation, except for water, is accompanied by a greater facial activity in bulimics and binge eaters.

Another explanation might be that oral habituation is slower in patients with Bulimia and Binge-Eating Disorder in response to food. It has been shown, that obese women habituate slower to repeated pleasant food cues as indicated by greater mouthing movements which may relate to the greater reinforcing value of food (Saelens & Epstein, 1996). This might correspond at least in part to the facial displays in response to the low concentrated sweet taste since bulimics and binge eaters displayed more mouthing movements, i.e. lip press (AU 24) and the dimpler (AU 14), indicating pleasure. The mouthing movements may reflect the role of motivation and reinforcing value of food, with a decrease of mouthing to be associated with a reduction in the reinforcing value of food in healthy adults (Epstein, Paluch, & Coleman, 1996). In contrast, habituation in response to repeated unpleasant tastes has never been investigated. It is expected that bulimics and binge eaters habituate more slowly to repeated unpleasant tastes which is not due to the greater reinforcing value of these tastes but rather due to the greater food reactivity. This prediction arise from the finding, that bulimics and binge eaters displayed more specific mouth movements in response to unpleasant tastes. A further study might investigate habituation processes in eating disorders in response to repeated pleasant and unpleasant tastes by using both observational and electromyographic systems. Moreover, in further studies the role of food reactivity as a means of increased taste-elicited facial activity should be investigated

Odors: Overall facial activity (2) and specific facial reactions (4) in response to odors were expected to be similar between patients with eating disorders and controls. These hypotheses were confirmed for patients with eating disorders and controls exhibiting the same frequency of facial reactions, as well as similar single facial reactions in response to odors. The absence of an increased odor-elicited overall facial activity might relate to the fact that odors are simply not as aversive for patients with eating disorders as food is. Odors do not reflect a threat since the smelling of odors is not associated with the intake of calories. In contrast, the eating of food (or, in this case, taste solutions) is experienced as highly aversive by patients with eating disorders since they have an extreme fear of gaining weight and are also disgusted by food (Troop & Baker, 2009). The absence of group differences in odor-elicited facial activity in this study might also be due to the fact that, in general, odors are less likely to induce facial reactions than tastes, which had already been demonstrated in the first experiment. Unpleasant odors induced the highest overall facial activity primarily indicated by an increase of negative facial reactions, whereas pleasant odors elicited the lowest overall facial activity which was not associated with an increase of positive facial reactions. As discussed in the first experiment, the odors used in the studies were everyday odor stimuli, which were less invasive and less aversive for participants than the tastes were. Humans are always surrounded by odors, and they might consequently be more able to control facial reactions to odors than facial reactions to tastes.

Electromyographic activity: This study assessed facial reactions by electromyography in order to investigate whether electromyographic activity in eating disorders differs from controls in response to tastes and odors (5). Anorexics and bulimics were expected to display greater corrugator and levator activities, i.e. muscles which characterize negative facial reactions, in accordance with the FACS hypotheses. Binge eaters were expected to show a higher zygomaticus activity, which relates to the positive facial display of smiling. None of these hypotheses were confirmed by the data.

Electromyographic activity over the corrugator, levator, and zygomaticus muscle did not differentiate between patients with eating disorders and controls. Therefore, the electromyographic results did not correspond to the facial reactions as assessed by FACS. The rather meager correspondence between FACS and EMG has been already reviewed by Fridlund and Izard (1983) who discussed the greater baseline level in depressed patients as a possible factor for a similar facial muscle activity compared to controls. Moreover, Ellgring (1989) argued that “It is still unclear to what extent the electromyographically measured muscular activity becomes apparent on the facial surface” (p. 52). By the use of EMG, no group differences, but taste quality differences were detected. Facial electromyographic activity differed among tastes, which is consistent with many studies using EMG (Armstrong et al., 2007; Chapman et al., 2009; Horio, 2003; Hu et al., 1999). High concentrations of the unpleasant bitter taste and the pleasant sour taste elicited a greater corrugator activity when compared to the sweet taste and water, which is consistent with the findings of Horio (2003). During tasting of the highly concentrated unpleasant tastes (bitter, umami, and salty), the pleasant sour taste and unpleasant odors levator activity was higher when compared to pleasant or neutral tastes (water and sweet) and odors which is in line with the findings of Armstrong et al. (2007), Chapman et al. (2009), and Hu et al. (1999). Zygomaticus activity did not differentiate between the pleasant and unpleasant tastes, which corresponds to the finding by Armstrong et al. (2007). These results indicate that EMG is an advantageous method studying facial reactions in response to different tastes and odors, but less appropriate studying differences between individuals.

One advantage of EMG is that it measures subtle facial expressions (Cacioppo et al., 1992; Dimberg, 1990; Vrana, 1993), e.g. in mimicry studies, in which the muscular activity is often not visible. In contrast, this study used taste and odor stimuli that elicited a higher muscular activity with mostly visible facial reactions. It is therefore argued that FACS is more appropriate to study facial behavior in response to strong emotional stimuli between different individuals. Moreover, FACS seems to be more precise in the differentiation of facial reactions. For instance, zygomaticus activity in the EMG may produce similar activities even when different facial reactions around the mouth regions are performed, e.g. the dimpler (AU 14) or lip stretch (AU 20). Thus facial activity as assessed by EMG may be confounded with the muscle activity of other facial muscles, which can bedifferentiated when using FACS.

In summary, bulimics and binge eaters exhibited a greater taste-elicited overall facial activity than did anorexics in response to all tastes, and than controls in response to some tastes. This heightened taste-elicited overall facial activity might be due to their greater reactivity in response to food. Moreover, bulimics' and binge eaters' gustofacial patterns are altered which is indicated by negative reactions (disgust) in response to all tastes and positive reactions in response to some tastes. Unexpectedly, anorexic patients were comparable with controls in their taste-elicited overall facial activity. However, it might be argued that anorexics attenuate or hide their expressions in response to many tastes at least to a certain extent. The groups did not differ in their quantitative and qualitative facial reactions to odors since odors reflect no threat for shape and weight for eating-disordered patients. There is no correspondence between facial reactions as assessed by FACS and electromyography, as well as between facial reactions obtained by FACS and subjective pleasantness. It is argued that facial reactions might provide a better evidence of persistent dysfunctional eating-disordered symptoms, such as greater food reactivity in response to tastes, rather than subjective pleasantness ratings in patients with eating disorders. Thus, the facial data provide a more reliable measure than subjective pleasantness, which includes several problems, e.g. answering and retrospective biases. The study has several limitations. It must be examined whether real food stimuli that normally consist of composite tastes, would also elicit a greater facial activity in bingeing women; thus the ecological validity might be lower in this study since pure taste solutions were used. Moreover, the frequencies of facial reactions were of interest rather than the dynamics of facial reactions.

3. Study 3 – "*Facial reactions in response to tastes, odors, and cartoons in Bulimia Nervosa and Attention-Deficit Hyperactivity Disorder*"

3.1. Aims, specific research questions, and hypotheses

The third study examined whether deficits in inhibitory control are associated with a greater taste-elicited overall facial activity. Therefore patients with Attention-Deficit Hyperactivity Disorder (ADHD), who suffer from executive control deficits, were a suitable reference group to compare facial activity with those of patients with Bulimia Nervosa (BN). According to the second experiment, bulimics displayed a greater taste-elicited overall facial, which was explained by the increased reactivity to food. However, many researchers argue that patients with Bulimia Nervosa suffer from impulse control deficits (Rosval et al., 2006; Marsh et al., 2009; Mobbs et al., 2008; Nederkoorn et al., 2004), that are comparable to the symptoms in Attention-Deficit Hyperactivity Disorders. Thus, the main aim of this study is to investigate whether the heightened overall facial activity elicited by tastes is moderated by deficits in inhibitory control in patients with Bulimia and ADHD. To test this, spontaneous facial activity and suppressed facial activity are assessed in response to different tastes, odors, and cartoons in patients with Bulimia, ADHD, and healthy controls. The measurement of spontaneous facial reactions to these stimuli, in which participants received no instruction, was carried out in accordance with the previous experiments. In addition, the measurement of suppressed facial activity, in which participants where asked not to show any feelings regarding the stimuli, was implemented in this study. The suppression of facial reactions requires a behavioral/motor inhibition which might be more difficult to perform by individuals with deficient impulse control. This study aimed to specifically explore

(1) … taste-elicited overall facial activity in patients with Bulimia Nervosa and ADHD during spontaneous and suppressed facial activity
(2) … odor-elicited overall facial activity in patients with Bulimia Nervosa and ADHD during spontaneous and suppressed facial activity
(3) … overall facial activity elicited by another modality than food, in this case cartoons, in patients with Bulimia Nervosa, ADHD, and healthy controls during spontaneous and suppressed facial activity
(4) … whether patients with Bulimia Nervosa, ADHD, and healthy controls differ in their specific facial activity, i.e. Action Units, in response to tastes, odors, and cartoons

(5) … whether electromyographic activity in response to tastes and odors differs between patients with Bulimia Nervosa, ADHD, and healthy controls

(6) … whether medication in ADHD patients has an influence on facial activity in response to tastes, odors, and cartoons.

The following questions were addressed to explore the issues mentioned above.

(1) **Do patients with Bulimia Nervosa and ADHD display a higher overall facial activity in response to tastes during spontaneous and suppressed facial activity?** It was expected that patients with ADHD exhibit an increased taste-elicited overall facial activity during spontaneous and suppressed facial activity due to their deficient inhibitory control (Claes et al., 2002; Fahy & Eisler, 1993; Kaye et al., 1995; Kaye et al., 2004; Lacey & Evans, 1986; Nederkoorn et al., 2004; Steiger, 2004; Vitousek & Manke, 1994; Westen & Harnden-Fischer, 2001). In patients with Bulimia, a greater overall facial activity in response to tastes during spontaneous reactions was expected in order to replicate the finding of the second study. In contrast, no greater facial activity was expected in bulimic patients during the facial suppression task since they do not suffer from inhibitory deficits to such an extent than do ADHD patients.

(2) **Does overall facial activity in response to odors differ between Bulimia Nervosa, ADHD, and healthy controls during spontaneous and suppressed facial activity?** It was expected that ADHD patients display a greater overall facial activity than controls in response to odors during spontaneous and suppressed facial activity due to their deficient impulse control. In contrast, bulimic patients were not expected to show more facial reactions than controls in accordance with the finding of the second experiment. More specifically, the second study indicated that bulimics and controls expressed the same level of spontaneous overall facial activity in response to odors presumably since odors reflect no threat for shape and weight. Likewise, no differences were expected between bulimics and controls during the facial suppression task in the present study.

(3) **Does overall facial activity in response to cartoons differ between Bulimia Nervosa, ADHD, and healthy controls during spontaneous and suppressed facial activity?**
It was expected that ADHD patients display a greater overall facial activity in response to cartoons than controls during spontaneous and suppressed facial activity

due to their deficient impulse control. No differences were expected between bulimics and controls during spontaneous and suppressed facial activity.

(4) Do patients with Bulimia Nervosa, ADHD, and healthy controls differ in the frequency of specific facial reactions, i.e. Action Units, in response to tastes, odors, and cartoons?

It was expected that the groups display specific facial reactions differently. Patients with Bulimia Nervosa and ADHD were expected to show more negative facial displays, e.g. brow lower (AU 4), upper lip raise (AU 10), and lip corner depress (AU 15), in response to tastes when compared with controls during spontaneous and suppressed facial activity. This higher frequency of negative facial displays in ADHD patients might be due to their deficient inhibitory control, whereas in bulimic patients is might be due to a greater food reactivity. ADHD patients, but not bulimics, were expected to show more specific facial reactions than controls in response to odors during both tasks. In response to cartoons, smiling including cheek raise and lip corner pull (AU 6 + 12) are considered as the most relevant facial reaction elicited by cartoons. It was expected that ADHD patients display more smiles than controls during spontaneous and suppressed facial activity due to their inhibitory deficits. Bulimic patients were expected to show the same frequency of smiles as controls during spontaneous and suppressed facial activity since their deficits in inhibitory control are less severe when compared to ADHD patients.

(5) Do patients with Bulimia Nervosa, ADHD, and healthy controls differ in their electromyographic activity for different facial muscles, i.e. corrugator, levator, zygomaticus, in response to tastes and odors during spontaneous and suppressed facial activity?

It was expected that bulimic and ADHD patients who display more negative facial reactions in response to tastes correspondingly show increased amplitudes of the corrugator and levator, i.e. muscles which characterize negative facial reactions when activated, during both spontaneous and suppressed facial activity. No group differences for corrugator, levator, and zygomaticus activity were expected in response to odors.

(6) Does the facial activity differ between medicated and non-medicated ADHD patients?

It was expected that non-medicated ADHD patients display a higher overall facial activity in response to tastes, odors, and cartoons and more smiling in response to cartoons compared with medicated patients, during the spontaneous task and the facial suppression task.

3.2. Methods

3.2.1. Participants

Patients with Bulimia Nervosa (BN) and healthy persons were recruited through internet advertisement and patients with Attention-Deficit Hyperactivity Disorder (ADHD) were recruited from the University Clinic of Würzburg of the Department of Psychiatry, Psychosomatics and Psychotherapy to voluntarily take part in this study.
Overall, 41 women participated in this study. 5 women were excluded from the data analysis due to several problems (1 woman had a Binge-Eating Disorder, 1 control woman did not follow the instructions exactly, 1 ADHD woman due to a damaged video, and 2 control women due to technical problems). Thus, the total sample consisted of 36 women with 12 BN patients, 12 ADHD patients, and 12 healthy controls.

Using the criteria from the International Classification of Mental Disorders (ICD-10, Dilling et al., 2005) experienced clinical psychologists diagnosed 10 women with ADHD of the combined type (F90.0), 1 woman with ADHD of the predominantly inattentive type (F98.8), and 1 woman with ADHD of the predominantly hyperactive-impulsive type (F90.1). During participation in the experiment 7 ADHD patients were medicated with Medikinet Retard, whereas 5 ADHD patients remained non-medicated. However, 3 ADHD patients participated in a double-blind randomized controlled trial on the efficacy of methylphenidate and/or psychotherapy on ADHD at the University Clinic of Würzburg and thus did not know whether they receive medication or placebo. Based on the participants’ opinion whether they believe to receive medication or not, they were assigned to the non-medicated (n = 2) vs. medicated (n = 1) group. Women with Bulimia Nervosa were diagnosed according to the ICD-10 criteria of the SIAB-S (Fichter & Quadflieg, 1999; see section 2.2.2.).

Participants were native speakers of German, free from colds, food allergies, nasal allergies, and olfactory or gustatory disorders at the moment of the test. They abstained from eating and drinking for at least 1.5 hours prior to the experiment and received € 20 for their 3-hour participation.

Table 9 lists demographic characteristics of the sample. The mean age of the participants was 32.2 years (SD = 9.8) and ranged from 18 to 54 years. The groups differed in their age, $F(2, 35) = 17.73$, $p < .001$. ADHD patients were significantly older than controls ($p = .018$) and bulimic patients ($p < .001$). Moreover, controls were older than bulimic patients ($p = .022$).

Table 9: Sample characteristics.

	Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age*	32.1	7.9	23.7	3.6	40.8	8.5
BMI (kg/m²)	25.1	5.3	21.0	3.1	26.7	10.3
Weight (in kg)	73.2	19.0	60.0	7.5	76.0	24.2
Height (in cm)	169.8	7.8	169.1	5.2	166.6	5.8

*$p < .001$.

The groups were comparable in their BMI (Body Mass Index), $F(2, 35) = 2.2$, $p = .127$, and body weight, $F(2, 35) = 2.6$, $p = .087$. However, the BMI of controls and ADHD patients indicated slight overweight (BMI > 25), whereas bulimic patients were within the range of normal weight (BMI 20-25). 26 participants were non-smokers and 10 participants were smokers (Controls: $n = 4$, Bulimics and ADHD: $n = 3$, each). The frequency of smokers did not differ across the groups. Please see the appendix C (Table 40) for further sample characteristics.

3.2.2. Eating and Attention-Deficit Hyperactivity pathology

All participants were characterized by the Structured Inventory for Anorectic and Bulimic Eating Disorders (SIAB-S, Fichter & Quadflieg, 1999). The SIAB-S has already been explained in section 2.2.2. Participants completed the SIAB-S before they participated in the study. According to ICD-10 criteria of the SIAB-S, none of the ADHD patients and healthy controls had a past or a current eating disorder. Within the bulimic group, 6 women had been diagnosed with Bulimia Nervosa (ICD-10, F 50.2) at present (= at the time of the experiment) and 6 women had been diagnosed with Bulimia Nervosa in the past. Those women with a Bulimia Nervosa diagnosis in the past did not fulfill all ICD-10 criteria for Bulimia Nervosa at present (3 women fulfilled 3 criteria, 2 women fulfilled 2 criteria, and 1 woman fulfilled 1 criterion). 2 women reported less than 2 binges a week over a period of three months and reported vomiting less than 2 times a week; 1 woman reported less than 2 binges a week over a period of three months; 1 woman reported 2 binges a week, however, over a period of less than three months; 1 woman reported no engagement in vomiting; and 1 woman reported less than 2 binges a week over a period of three months, no vomiting, and no craving/ preoccupation with food. Despite the subclinical Bulimia Nervosa of these 6 patients at the time of the test, they were included in the study. None of the bulimics patients was currently hospitalized during the participation in the experiment. Half of the bulimic patients reported being hospitalized in the past due to a diagnosis of Bulimia Nervosa (n = 4) or Anorexia Nervosa (n = 2). 3 bulimic patients reported that they were undergoing therapeutical treatment at the time of their participation in the experiment.

Bulimic patients and healthy controls were also characterized by the self-report questionnaire for the assessment of the diagnosis of Attention-Deficit Hyperactivity Disorder in adults (ADHD-SR, Rösler et al., 2004) according to DSM-IV and ICD-10 criteria. The ADHD-SR consists of 22 items. Participants rate to what extent a statement is appropriate on a 4-point scale from 0 (“not present”) to 3 (“stongly present”). According to the DSM-IV, the diagnosis of ADHD is present when 6 items of the inattention criteria (item 1-9) as well as the hyperactive-impulsive criteria (items 10-18) are rated positively (score > 0). According to the ICD-10, the diagnosis of ADHD is present when 6 items of the items 1-9, 3 items of the items 10-14, and 1 item of items 15-18 are rated positively (score > 0). For scientific purposes and due to overestimation of the symptoms by the participants in this study, it was useful to decide that a score of 2 instead of 1 is rated as positive which is also recommended by the Bundesärztekammer. Rösler et al. (2004) reported good internal consistencies for inattention .89 (DSM-IV, ICD-10), hyperactivity/ impulsivity .82 (DSM-IV), hyperactivity .72 (ICD-10), impulsivity .78 (ICD-10), and total score .90, respectively. However, internal consistencies in this sample are lower with .82, .73, .73, .55, and 87 respectively. According to the ADHD-SR (Rösler et al., 2004), none of the bulimic patients and controls tested suffered from ADHD. The ADHD-SR was completed by the bulimic patients and healthy controls after their participation in the study. None of the ADHD patients was hospitalized during their participation in the experiment.

3.2.3. Taste stimuli, odor stimuli, and cartoons

Taste stimuli: Taste stimuli were solutions of 3.20mM PROP (6-*n*-Propylthiouracil) for bitter taste (Merck-VWR, Darmstadt, Germany), 1.0M NaCl for salty taste, 0.05M citric acid for sour taste, 0.83M sucrose for sweet taste (Adler Apotheke, Dinkelsbühl, Germany), and 0.2M glutamate for umami taste (Ajinomoto Foods, Germany). In this study, high taste concentrations were administered which were all above the detection threshold, i.e. citric acid 0.0023M, NaCl 0.01M, sucrose 0.01M (Birbaumer & Schmidt, 1999), PROP (non-tasters >1.8 x 10^{-4}mol/l PROP, super-tasters <3.2 x 10^{-5}mol/l PROP, Drewnowski et al., 1997), and MSG 0.009M (Lugaz et al., 2002). The choice of concentrations was determined according to criteria set up successfully in the first and the second study.

Evian mineral water (ph 7.2) served as the control taste (neutral taste). All solutions were dispensed in 5ml distilled water and were presented at room temperature (20-22°). They were placed on a table in front of the participants in small cups numbered from 1 to 6. Before and after testing, taste solutions were stored in the refrigerator. Taste solutions were removed from the refrigerator at least 3 hours prior to testing to ensure an up-to-room-temperature warmth, which was measured by a thermometer immediately before testing. Each taste stimulus was presented twice in a disposable cup with a maximum content of 20ml. The stimuli were colorless to avoid that participants guessed the taste quality in the cups before actually tasting the stimuli. Taste solutions were freshly prepared a few days prior to the experiment. Please see the appendix A for the preparation of the taste solutions.

Odor stimuli: Odor stimuli were pen-like odor dispensing devices of the "Sniffin' Sticks" test (Kobal et al., 1996; see section 1.2.2.). In this study, 4 of the 16 common odors from the odor identification test were used, i.e. banana, cinnamon, fish, and garlic. These odors were selected according to their perceived pleasantness in the second study with banana and cinnamon representing the pleasant pole, and fish and garlic representing the unpleasant pole.

Cartoons: In a pre-study, 16 participants (12 female, 4 male) rated the funniness of 34 cartoons taken from the internet on a 4-point scale ranging from 1 ("very funny") to 4 ("not funny at all"). Participants were native speakers of German and half of them were students of psychology (n = 8). Their mean age was 27.2 years (SD = 1.8) and ranged from 24 to 31 years. The funniest 6 cartoons were selected for this study. The selection of the funniest cartoons was based on descriptive characteristics (see appendix C, Table 58 and 59). Cartoons with number 4 (marriage), 6 (isle), 8 (plant), 11 (beaver), 27 (kangaroo), and 29 (fish fingers) were chosen.

3.2.4. Dependent variables – Subjective and facial reactions

Subjective reactions: Participants were instructed to rate intensity, pleasantness, mood, and perceived quality for each taste and odor stimulus. Intensity, pleasantness, and mood in response to each stimulus were rated on verbally anchored scales from 1 to 25, using a method of category scaling developed by Heller (1985) (see section 1.2.3. for explanation). For the identification of taste quality and odor type, the same method as in study 2 was used. To identify tastes, participants had to decide how bitter, salty, sour, sweet, savory, and neutral the taste was using 5-point scales ranging from 1 (“not at all”) to 5 (“extreme”). To identify odors, participants used the same scale how acid-like, fishy, menthol-like, sugary, artificial, and pungent the odor smelled. Participants rated the funniness of cartoons on a 4-point scale ranging from 1 (“very funny”) to 4 (“not funny at all”). In the part of the study evaluating suppressed facial activity, participants rated how difficult it was to hide any feelings when tasting or smelling and how good they performed the suppression of facial reactions in response to tastes and odors. For this purpose 5-point scales ranging from 1 to 5 (with endpoints “very easy” and “very difficult”, “very good” and “very bad”) were used.

Facial reactions: Facial reactions were assessed by video recordings and by electromyography. Facial expressions from videos were analyzed using the **Facial Action Coding System** (Ekman et al., 2002; see section 1.2.4. and appendix A). A parameter of overall facial activity was defined as the total number of AUs shown (multi-occurrence of AUs from 1-40; cf. Ellgring 1989). Specific facial reactions refer to the frequency of each single Action Unit.

One trained FACS coder, blind to stimulus condition, analyzed the videos in slow motion and frame by frame and coded the apex (moment of the most intense facial expression) of each facial expression. Facial reactions in response to tastes were separately assessed during two observation periods, i.e. before swallowing (a) and after swallowing (b), to exclude facial activity due to swallowing. In contrast to the previous studies, the observation period before swallowing in this study was slightly changed. Since the observation period in the previous studies began after stimulus contact and due to the observation that participants grimaced at the moment the first drop of the liquid reached the tongue, this observation period was temporally reset and raised from 4s to 5s in this study. Thus, the observation period before swallowing (a) began when the first drop of the liquid in the cup reached the tongue with the cup still at the mouth. The second observation period began after the participants had swallowed the liquid (b) and was similar to the previous studies. This observation period lasted 4s. The observation period for facial odor reactions began when the participant had placed the pen’s tip 2cm in front of both nostrils and lasted 4s. The facial expression analysis in response to cartoons was not time-related since participants differ in their reading speed and reading comprehension. Instead, all facial reactions which occurred in response to the cartoons were coded. Thus the observation period for facial cartoon reactions was not fixed and differed among participants.

Inter-rater reliability (IR) of FACS coding was not assessed in this experiment due to good reliability data in response to tastes and odors in the previous experiments.

Facial muscular activity was recorded using bipolar placements of Ag-AgCl surface electrodes on the left side of the face in accordance with the guidelines of Fridlund and Cacioppo (1986). EMG activity was recorded over the zygomaticus major, corrugator supercilii, levator labii, and thyrohyoideus muscle (to record swallowing). The explanation of this method is similar to section 2.2.4.

Facial EMG responses were averaged over intervals of 500ms during 5 seconds for each muscle group (corrugator, levator, zygomaticus) before swallowing and during 4 seconds for each muscle group (corrugator, levator, zygomaticus) after swallowing. This resulted in 10 different periods before swallowing and 8 different periods after swallowing. The responses were expressed as change in activity from the prestimulus level, which was defined as the mean activity during the last second before stimulus onset.

3.2.5. Taste and odor sensitivity

For the assessment of taste sensitivity, bitter sensitivity, and odor sensitivity the same methods from the second study were used. Taste sensitivity was assessed by taste strips (Müller et al., 2003), bitter sensitivity by the 1-solution test (Prescott et al., 2000, 2001; Tepper et al., 2001), and odor sensitivity by the Sniffin' Sticks odor threshold test (Kobal et al., 1996). Please see the explanation of the methods in section 2.2.5.

3.2.6. Personality aspects

The assessment of personality aspects included participants' level of depression, eating behavior, personality traits, and subjective expressivity in accordance to the questionnaires used in the second study. Depressivity was assessed by the Beck Depression Inventory (BDI, Beck et al., 1961; German version by Hautzinger et al., 1995). Internal consistencies are good in this sample (.86).

The Dutch Eating Behavior Questionnaire (DEBQ, German version by Grunert, 1989; Dutch version by van Strien et al., 1986) was used to assess eating behavior. Cronbach's alpha for emotional, external, and restraint eating behavior are very good in this sample (.95, .82, .90) and are comparable with those of Grunert (1989, .82, .91, .91).

Participants' personality was assessed by the NEO Five-Factor Inventory (NEO-FFI, Costa & McCrae, 1993; German version by Borkenau & Ostendorf, 1993). Cronbach's alpha for neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness are satisfactory in this sample (.83, .70, .67, .76, .79).

The Berkeley Expressivity Questionnaire (BEQ, Gross & John, 1995; German version by Traue, 1998) was used to assess behavioral expression of emotions and the willingness to react emotionally. Cronbach's alpha for positive expressivity, negative expressivity, and impulse strength are satisfactory in this sample (.61, .66, .74). Please see section 2.2.6. for further description of the questionnaires.

3.2.7. Procedure

The experiment was divided into two sessions, i.e. the assessment of facial reactions and the assessment of control variables, which took place on two different days. In both sessions, participants were individually tested and seated in a comfortable chair in a room (Department of Clinical Psychology, Marcusstraße 9-11) with a constant temperature (22°) and received identical written and verbal instructions. They were told that the study examines taste and odor perception. No other details about the aims of the study were given. Participants were informed that one session (those in which facial reactions were assessed) of the experiment would be continuously video-recorded and that electrodes would be attached to their face. They were, however, not told that their facial expressions would be analyzed specifically, in order to avoid exaggerated or moderated facial expressions. The video camera was placed in front of the participants at a distance of 2.5m. The experimenter who was present in the room during the entire experiment was not visible to the participants but could watch their behavior online via closed circuit TV. All participants gave informed consent, including agreement to be recorded on video.

At the beginning of the session, in which facial reactions were assessed, the electrodes were attached to the participant's face. This session was divided into two parts. In the first part of the experiment, participants' spontaneous facial reactions in response to tastes, odors, and cartoons were assessed. They received no specific instruction. In the second part of the experiment, participants were instructed to hide their facial reactions in response to tastes, odors, and cartoons ("Do not show any feelings regarding the stimulus"). The stimuli were presented in the same order in both parts of the experiment; first tastes, then odors, and cartoons last. However, the order of each stimulus modality differed in both parts in order to exclude that participants anticipated the following stimulus. Tastes and odors were presented according to the procedure of the first experiment (see section 1.2.4.).

During the assessment of spontaneous facial reactions in response to tastes, mineral water (no. 1) was presented as the first stimulus. Next, sweet, sour, salty, and umami solutions (no. 2 to 5) were presented in a pseudo-randomized order with three participants of the bulimic group, of the ADHD group, and of the control group each receiving one of the four different taste orders. The pseudo-randomized taste orders had been used successfully in the previous studies. Participants received the bitter taste (no. 6) at the end due to its masking effect (Dallenbach & Dallenbach, 1943; Leach & Noble, 1986).

During the assessment of suppressed facial reactions in response to tastes, mineral water (no. 3) was presented as the third stimulus. Sweet, sour, salty, and umami solutions (no. 1-2 and 4-5) were presented again in a pseudo-randomized order that was different from the taste order during the assessment of the spontaneous facial reactions (see appendix C, Table 02). The four taste orders (1, 2, 3, 4) were equally distributed among the groups as follows: controls 3, 4, 3, 2, Bulimia Nervosa 3, 4, 3, 2, and ADHD 3, 4, 3, 2, respectively. Participants received the bitter taste (no. 6) again at the end due to its masking effect.

Odors were presented in a pseudo-randomized order with 3 participants of each subgroup receiving one of 4 different orders (see appendix C, Table 05) during the spontaneous and suppressed task. In response to tastes and odors, participants rated how difficult it was to hide their feelings when tasting or smelling and how good they performed the suppression of facial reactions in response to these stimuli.

Moreover, the order of the sessions differed across groups due to the schedule of the room. All participants in the control group started with the session of the assessment of facial reactions. In the Bulimia Nervosa group, 9 participants started with the assessment of facial reactions, whereas 3 started with the assessment of control variables. In the ADHD group, 7 participants started with the first session, whereas 5 started with the assessment of control variables. In both parts of the study, participants received different cartoons. Half of the participants (6 of each subgroup) received 3 cartoons in the first part of the study, half of the participants received the same cartoons in the second part of the study.

At the end of the experiment, the electrodes were removed from the participant’s faces and they were asked to fill in questionnaires (DEBQ, BDI, NEO-FFI, and BEQ). The entire session lasted approximately 2 hours.

In the control variables session, taste sensitivity, odor sensitivity, and bitter sensitivity were assessed in this order (see section 2.2.5.) This session lasted approximately 30 minutes.

3.2.8. Statistical analyses

Repeated measures ANOVAs were conducted for taste ratings (changes from water) and odor ratings for intensity, pleasantness, and mood with taste quality (bitter, salty, sour, sweet, umami) or odor type (banana, cinnamon, fish, garlic) as the within-subjects factor and group (bulimia, ADHD, controls) as the between-subjects factor. These analyses were conducted for spontaneous and suppressed facial reactions separately. For the taste quality and odor type evaluation, one-factorial ANOVAs were carried out, to explore whether the groups differed in taste and odor perception. To explore task difficulty and task performance in response to tastes and odors, repeated measures ANOVAs were conducted with taste quality (bitter, salty, sour, sweet, umami, water) or odor type (banana, cinnamon, fish, and garlic) as the within-subjects variable, and group (bulimia, ADHD, controls) as the between-subject variable.

To test whether the groups rated the cartoons as equally funny, one-factorial ANOVAs were conducted for spontaneous and suppressed facial reactions.

Taste-elicited overall facial activity was investigated in 6 (taste quality) × 2 (observation period) × 3 (group) repeated measures ANOVAs for spontaneous and suppressed facial reactions separately. In order to compare both observation periods, taste-elicited overall facial activity was related to the time of each observation period (facial activity before swallowing divided by 5s, facial activity after swallowing divided by 4s).

Odor-elicited overall facial activity was tested in a 4 (odor quality) × 3 (group) repeated measures ANOVA for spontaneous and suppressed facial reactions separately. One-factorial ANOVAs were carried out to explore overall facial activity in response to cartoons (the mean of all cartoons was used) during spontaneous and suppressed facial activity. For all ANOVAs, a Bonferroni correction was applied for single comparisons in case of significant main effects or significant interaction effects.

To explore whether the groups differed in their specific facial reactions in response to tastes and odors the frequencies of single facial reactions, i.e. Action Units, elicited by tastes and odors were compared by Mann-Whitney U-Tests for differences among proportions. For the cartoons, the total number of smiles (AU 6 + 12) across all cartoons was compared by Mann-Whitney U-Tests for the spontaneous and suppressed reactions.

To analyze EMG activity in response to tastes, a 6 (taste quality) × 10/8 (time: 10 periods before swallowing, 8 periods after swallowing) × 3 (group) ANOVA was conducted separately for each muscle, separately for each observation period, and separately for spontaneous and suppressed facial reactions.

For the analysis of EMG activity in response to odors, a 4 (odor) × 8 (time: means for 0-500ms, 500-1000ms, 1000-1500ms, 1500-2000ms, 2000-2500ms, 2500-3000ms, 3000-3500ms, 3500-4000ms) × 3 (group) ANOVA was conducted separately for each muscle and separately for spontaneous and suppressed facial reactions. Means for the factor time are in the following referred to as period 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 before swallowing and period 1, 2, 3, 4, 5, 6, 7, and 8 after swallowing.

3.3. Results

3.3.1. Subjective reactions

Subjective reactions in response to tastes during spontaneous facial reactions: Perceived **taste intensity** of the bitter taste - but not of the other tastes - differed across groups, $F(8, 132) = 3.54$, $p = .010$ (significant taste quality × group interaction, Figure 15). There was a tendency that ADHD patients rated the bitter taste as more intense than did bulimic patients ($p = .056$) and controls ($p = .079$).

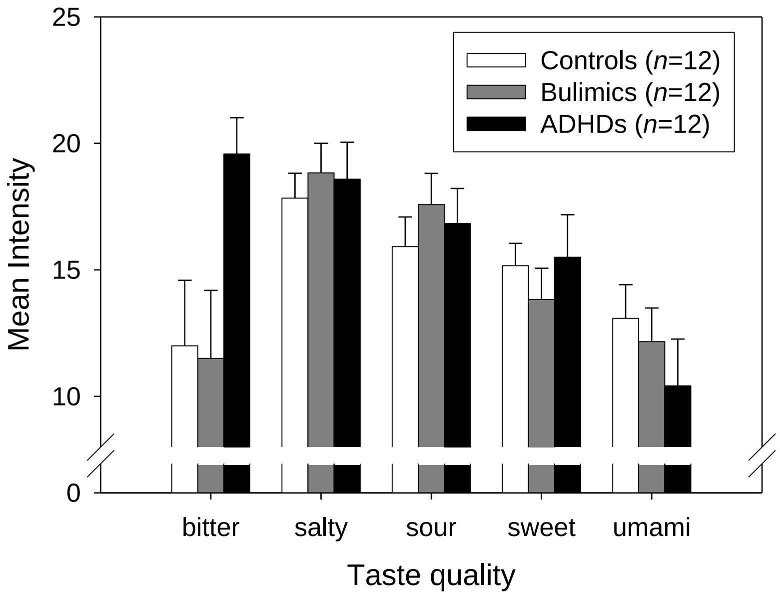


Figure 15: Intensity ratings for the bitter, salty, sour, sweet, and umami taste in healthy controls, patients with Bulimia, and Attention-Deficit Hyperactivity Disorder (ADHD) – average deviations (Means ± *SEM*) from ratings for mineral water.

Moreover, participants rated the tastes as differently intense, $F(4, 132) = 12.53$, $p < .001$. The salty taste was rated as more intense than the other tastes (*ps* $< .05$). The umami taste was rated as less intense compared with the sour and the sweet taste (*ps* $< .05$). There was no main effect of group, $F(2, 33) = .49$, $p > .05$.

Taste pleasantness differed significantly across taste qualities, $F(4, 132) = 32.00$, $p < .001$. Participants rated the sweet taste as more pleasant compared with the other tastes (*ps* $< .05$). The salty taste was rated as less pleasant in relation to the umami and the sour taste (*ps* $< .05$). Also, the sour taste was rated as more pleasant compared with the bitter taste ($p < .05$). There was no main effect of group, $F(2, 33) = .28$, $p > .05$, and no taste quality × group interaction, $F(8, 132) = 1.72$, $p = .116$.

Perceived **mood** was rated differently **after tasting** the stimuli, $F(4, 132) = 12.38$, $p < .001$. Mood declined after tasting the bitter, salty, and umami taste compared to the sweet taste (*ps* $< .05$). The bitter taste decreased mood as compared to the sour taste ($p < .05$). There was no main effect of group, $F(2, 33) = .54$, $p > .05$, and no taste quality × group interaction, $F(8, 132) = 1.70$, $p = .112$.

The groups differed in their **taste quality evaluation** of the sour taste (how savory?), $F(2, 35) = 4.12$, $p = .025$, and bitter taste (how bitter), $F(2, 35) = 3.54$, $p = .040$. ADHD patients tended to rate the sour taste as more savory compared to controls and bulimics (*ps* $= .055$). They also tended to perceive the bitter taste as more bitter than the other groups (*ps* $= .083$). The groups did not differ in their taste quality rating of the other tastes.

Subjective reactions in response to tastes during suppressed facial reactions: Perceived **taste intensity** differed across taste qualities, $F(4, 132) = 7.43$, $p < .001$. Participants rated the salty and the sour taste as more intense than the umami taste (*ps* $< .05$). The sour taste was rated as more intense than the sweet taste ($p < .05$). There was no main effect of group, $F(2, 33) = 1.15$, $p > .05$, and no taste quality × group interaction, $F(8, 132) = 1.66$, $p = .132$.

Taste pleasantness differed significantly across taste qualities, $F(4, 132) = 23.00$, $p < .001$. Participants rated the sour and the sweet taste as more pleasant than the bitter, salty, and umami taste (*ps* $< .05$). There was no group effect, $F(2, 33) = .28$, $p > .05$, and no taste quality × group interaction, $F(8, 132) = 1.72$, $p = .116$.

Mood differed **after tasting** the stimuli, $F(4, 132) = 12.38$, $p < .001$. Mood declined after tasting the bitter, salty and umami taste compared to the sweet taste and the sour taste (*ps* $< .05$). There was no group effect, $F(2, 33) = .54$, $p > .05$, and no taste quality × group interaction, $F(8, 132) = 1.70$, $p = .112$.

The groups differed in their **taste quality evaluation** of water (how savory?), *F*(2, 35) = 3.67, *p* = .036. Controls tended to rate water as more savory compared to bulimic and ADHD patients (*ps* = .076). They also tended to perceive the bitter taste as more bitter than the other groups (*ps* = .083). The groups did not differ in their taste quality rating of the other tastes.

Perceived **task difficulty**, *F*(5, 165) = 24.53, *p* < .001, and **task performance**, *F*(5, 165) = 12.92, *p* < .001, differed significantly across taste qualities (main effects for both variables). Participants reported that the facial reactions in response to the bitter, salty, sour, and umami taste were more difficult to hide compared to the facial reactions elicited by water and the sweet taste (*ps* < .001). Moreover, participants rated their performance as better when asked to hide facial reactions in response to water and to the sweet taste when compared to the bitter, salty, sour, and umami taste (*ps* < .05). There was no main effect of group for task difficulty, *F*(2, 33) = .63, *p* > .05, and for task performance, *F*(2, 33) = .01, *p* > .05, as well as no significant taste quality × group interaction for both variables, *F*(10, 165) = 1.82, *p* > .05 and *F*(10, 165) = 1.24, *p* > .05, respectively.

Subjective reactions in response to odors during spontaneous facial reactions: Perceived **odor intensity** was affected by odor type, *F*(3, 99) = 15.76, *p* < .001. Banana was rated as less intense than garlic (*p* = .003). Participants rated cinnamon as less intense than banana (*p* = .016), fish (*p* = .001), and garlic (*p* < .001). There was no main effect of group, *F*(2, 33) = 1.22, *p* > .05, and no odor × group interaction, *F*(6, 99) = .648, *p* = .05.

Odor pleasantness differed significantly across odor stimuli, *F*(3, 99) = 60.77, *p* < .001. Participants rated banana and cinnamon as more pleasant compared to fish and garlic (*ps* < .001). There was no group effect, *F*(2, 33) = .93, *p* > .05, and no odor × group interaction, *F*(6, 99) = 1.58, *p* = .168.

Mood differed **after smelling** the odor stimuli, *F*(3, 99) = 13.81, *p* < .001. Participant’s mood declined after smelling fish and garlic when compared to smelling banana (*p* = .005, *p* = .007) and cinnamon (*p* < .001, *p* = .001). There was no group effect, *F*(2, 33) = .24, *p* > .05, and no odor × group interaction, *F*(6, 99) = 1.26, *p* > .05.

The groups differed in their **odor evaluation** of cinnamon (how pungent?), *F*(2, 35) = 3.35, *p* = .047. Controls tended to rate cinnamon as more pungent compared to bulimic patients (*p* = .070). The groups did not differ in their odor rating of the other odors.

Subjective reactions in response to odors during suppressed facial reactions: Perceived **odor intensity** differed across groups and odors, *F*(6, 99) = 2.48, *p* = .038 (significant odor × group interaction). However, post-hoc tests did not reveal significant differences. There was a significant main effect of odor stimuli, $F(3, 99) = 13.55$, $p < .001$, as indicated by higher intensities of fish and garlic when compared to banana and cinnamon (*ps* $< .05$). There was no main effect of group, $F(2, 33) = .01$, $p > .05$.

Odor pleasantness differed significantly across odor stimuli, $F(3, 99) = 40.24$, $p < .001$. Banana and cinnamon were rated as more pleasant than fish and garlic (*ps* $< .001$). There was no group effect, $F(2, 33) = .97$, $p > .05$, and no odor × group interaction, $F(6, 99) = 2.09$, $p = .087$. Bulimics patients tended to like garlic more compared to ADHD patients.

Mood differed **after smelling** the odor stimuli, $F(3, 99) = 9.21$, $p < .001$, as indicated by mood decline after smelling fish and garlic when compared with banana and cinnamon (*ps* $< .05$). There was no group effect, $F(2, 33) = .05$, $p > .05$, and no odor × group interaction, $F(6, 99) = 1.27$, $p > .05$.

The groups differed in their **odor evaluation** of garlic (how acid-like?), $F(2, 35) = 3.71$, $p = .035$). Bulimics tended to rate garlic as more acid-like compared to ADHD patients ($p = .056$). The groups did not differ in their odor rating of the other odors.

Perceived **task difficulty** differed significantly across odor stimuli, $F(3, 99) = 6.06$, $p = .002$. Participant's facial reactions elicited by fish were more difficult to hide compared with facial reactions elicited by banana ($p = .045$) and cinnamon ($p = .012$). Facial reactions in response to garlic were more difficult to hide compared to facial reactions in response to banana ($p = .013$). The groups did not differ in their difficulty rating, $F(2, 33) = .11$, $p > .05$. There was no significant odor × group interaction, $F(6, 99) = 1.38$, $p > .05$.

Perceived **task performance** did not differ across odor stimuli, $F(3, 99) = 1.38$, $p > .05$, group, $F(2, 33) = .52$, $p > .05$, or across odor stimuli × group, $F(6, 99) = .96$, $p > .05$.

Funniness of cartoons during spontaneous facial reactions: The groups rated the cartoon marriage, $F(2, 17) = .09$, $p > .05$, isle, $F(2, 17) = .26$, $p > .05$, plant, $F(2, 17) = .78$, $p > .05$, kangaroo, $F(2, 17) = .30$, $p > .05$, beaver, $F(2, 17) = .23$, $p > .05$, and fish fingers, $F(2, 17) = .76$, $p > .05$, as equally funny.

Funniness of cartoons during suppressed facial reactions: The groups differed in their rating of the funniness of the isle cartoon, $F(2, 17) = 6.33$, $p = .010$. Bulimics rated the isle cartoon more funny than did the controls ($p = .009$) during the facial suppression task. The groups did not differ in their rating of funniness of the cartoon marriage, $F(2, 17) = .65$, $p > .05$, plant, $F(2, 17) = .07$, $p > .05$, kangaroo, $F(2, 17) = .16$, $p > .05$, beaver, $F(2, 17) = .54$, $p > .05$, and fish fingers, $F(2, 17) = .08$, $p > .05$.

In sum, the groups were mostly comparable in perceived intensity, pleasantness, mood, and stimulus evaluation in response to tastes and odors. However, ADHD patients tended to perceive the bitter taste as more intense than bulimics and controls during spontaneous facial activity. During the assessment of spontaneous facial reactions, the sweet taste was the most pleasant taste, the sour taste was more pleasant than the bitter and salty taste, and the bitter, salty, and umami taste were equally unpleasant. During the facial suppression task, the sweet and the sour taste were rated as more pleasant than the other tastes. Banana and cinnamon were rated as more pleasant than fish and garlic which was the case during spontaneous and suppressed facial reactions. It was more difficult for participants to hide their facial reactions in response to unpleasant tastes (bitter, salty and umami) and the pleasant sour taste compared to the sweet taste and water and they rated their performance likewise. Facial reactions in response to unpleasant odors (fish and garlic) were more difficult to hide compared to pleasant odors (banana, cinnamon). The groups rated the cartoons as equally funny except for the isle cartoon during the facial suppression task.

3.3.2. Overall facial activity

In the following, the results for overall facial activity, i.e. the sum of all facial reactions observed, in response to tastes, odors, and cartoons will described.

Spontaneous taste-elicited overall facial activity: As expected, taste-elicited overall facial activity, i.e. the total number of facial reactions observed, differed across groups, $F(2, 33) = 4.10$, $p = .027$, (Figure 16). Patients with Bulimia Nervosa and patients with ADHD produced more facial reactions than controls ($p = .022$, $p = .016$). There was a significant main effect of taste quality, $F(5, 165) = 36.40$, $p < .001$, observation period, $F(1, 33) = 165.11$, $p < .001$, as well as a significant taste quality × observation period interaction, $F(5, 165) = 3.62$, $p = .008$. Participants displayed more facial reactions after swallowing than before swallowing across each taste quality (*ps* $< .001$). Before and after swallowing, water elicited less facial reactions when compared to the other tastes (*ps* $< .05$). Before swallowing, the sweet taste and the umami taste elicited fewer facial reactions than the sour and the salty taste (*ps* $< .05$). Moreover, the sweet taste elicited fewer reactions than did the bitter taste ($p < .05$). After swallowing, the sour taste elicited more facial reactions than the sweet and bitter taste (*ps* $< .05$). The other interaction effects (taste quality × group, group × observation period, taste quality × observation period × group) were not significant (*ps* $> .05$).

In sum, patients with BN and ADHD were characterized by a heightened taste-elicited overall facial activity which confirms the first hypothesis. Moreover, it has been shown that the complexity of facial reactions depends on both taste quality and observation period.

Suppressed taste-elicited overall facial activity: Taste-elicited overall facial activity tended to differ across groups, $F(2, 33) = 2.86$, $p = .071$. ADHD patients displayed more facial reactions than controls ($p = .007$; Figure 16).

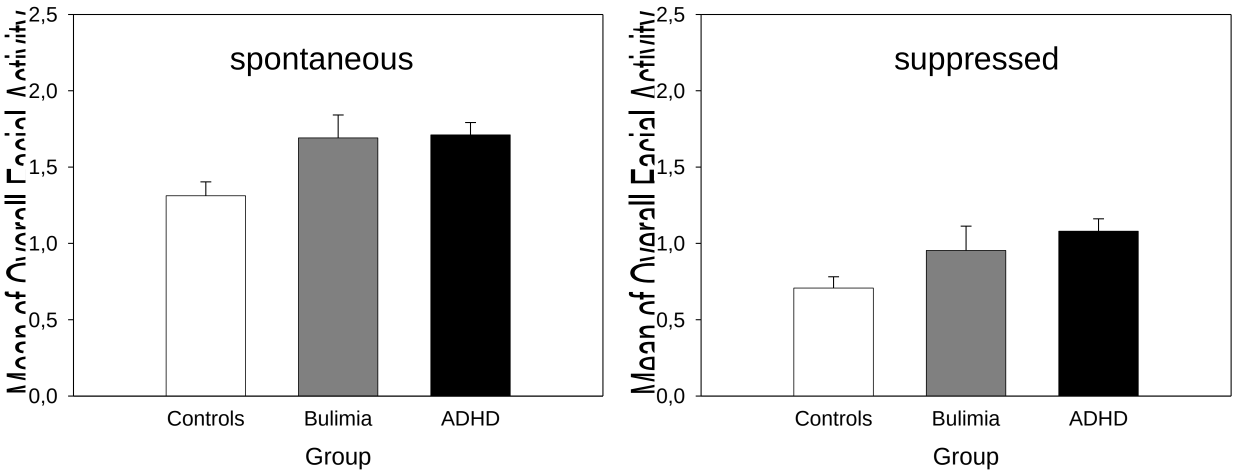


Figure 16: Overall facial activity (Means ± *SEM*) during spontaneous and suppressed facial reactions in response to tastes in healthy controls ($n = 12$), patients with Bulimia ($n = 12$), and Attention-Deficit Hyperactivity Disorder (ADHD, $n = 12$).

Moreover, there was a significant main effect of observation period, $F(1, 33) = 55.54$, $p < .001$, which indicated a higher overall facial activity after swallowing than before swallowing ($p < .001$). In contrast to spontaneous taste-elicited overall facial activity, the analysis of the suppressed taste-elicited overall facial activity revealed no taste quality × observation period interaction, $F(5, 165) = 1.99$, $p = .104$, and no main effect of taste quality, $F(5, 165) = 1.87$, $p = .119$. Therefore, the participants had successfully displayed the same frequency of facial reactions in response to all taste stimuli in order to follow the instruction to suppress their facial reactions. The other interaction effects (taste quality × group, group × observation period, taste quality × observation period × group) were not significant (*ps* >. 05). In sum, the results indicate that ADHD patients - but not BN patients - displayed a higher taste-elicited facial activity than did controls during the facial suppression task.

Spontaneous odor-elicited overall facial activity: The groups did not differ in their overall facial activity in response to odors (group, $F(2, 33) = .10$, $p > .05$; odor × group interaction, $F(6, 99) = 1.33$, $p = .252$). This result is depicted in Figure 17.

Overall facial activity in response to odors differed across different odor stimuli, $F(3, 99) = 12.10$, $p < .001$. Garlic elicited more facial reactions compared with banana ($p < .001$) and cinnamon ($p < .001$). Also, garlic tended to elicit more frequently facial reactions than fish ($p = .055$). Fish elicited more facial reactions than cinnamon ($p = .008$).

Contradictory to the second hypothesis, ADHD patients did not display more facial reactions in response to odors than controls. As expected, BN patients displayed as many facial reactions as did controls.

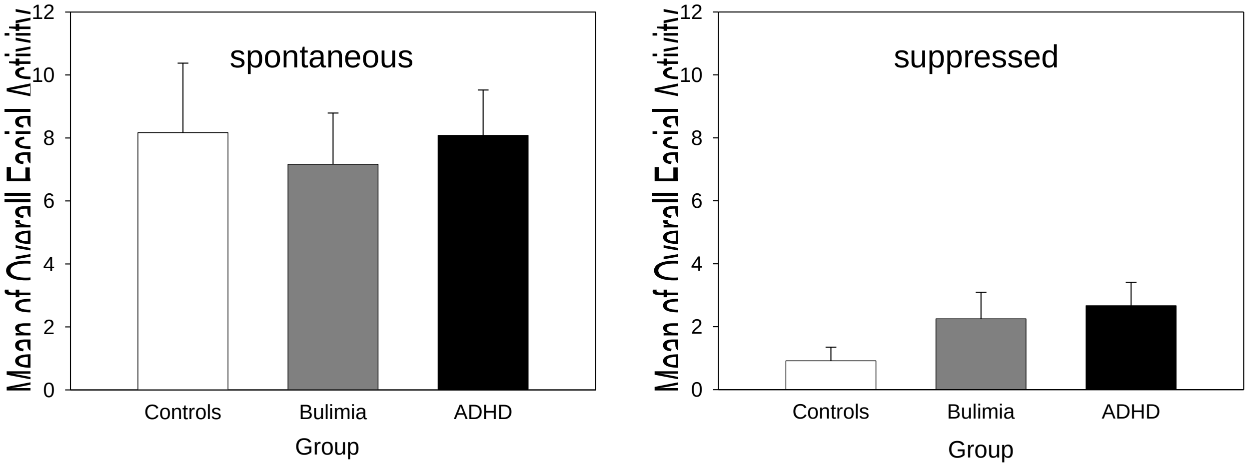


Figure 17: Overall facial activity (Means ± *SEM*) during spontaneous and suppressed facial reactions in response to odors in healthy controls (n = 12), patients with Bulimia (n = 12), and Attention-Deficit Hyperactivity Disorder (ADHD, n = 12).

Suppressed odor-elicited overall facial activity: Overall facial activity in response to odors did not differ across odor stimuli, $F(3, 99) = 1.58$, $p > .05$, across group, $F(2, 33) = 1.73$, $p > .05$, and across odor × group, $F(6, 99) = .76$, $p > .05$. Thus, the groups displayed the same frequency of facial reactions in response to different odor stimuli in order to follow the instruction to suppress facial reactions. Unexpectedly, ADHD patients did not show more odor-elicited facial reactions than controls. However, both bulimic (M = 2.3, SEM = 0.8) and ADHD patients (M = 2.7, SEM = 0.7) tended to display more facial reactions in response to odors than did controls (M = 0.9, SEM = 0.4).

Spontaneous overall facial activity elicited by cartoons: There was no group effect in the overall facial activity in response to cartoons during spontaneous facial activity, $F(2, 35) = 1.17$, $p > .05$. Unexpectedly, ADHD patients did not show more facial reactions in response to cartoons when compared with controls.

Suppressed overall facial activity elicited by cartoons: The groups did not differ in their overall facial activity in response to cartoons during the facial suppression task, $F(2, 35) = 2.35$, $p = .111$. This finding contradicts the third hypothesis with ADHD patients being more expressive in response to cartoons than controls.

In summary, it has been shown that patients with Bulimia and ADHD exhibited a greater taste-elicited overall facial activity than controls during the assessment of spontaneous reactions. During the facial suppression task, ADHD patients – but not BN patients – exhibited a greater taste-elicited overall facial activity than controls. The groups expressed a similar frequency of facial reactions in response to odors and cartoons during both spontaneous and suppressed facial reactions. Despite not significant, BN and ADHD patients tended to display more reactions than controls in response to odors during the facial supression task.

3.3.3. Specific facial activity

The following section describes the group differences in specific facial reactions in response to tastes and odors (not Bonferroni corrected). Please see Appendix A for specific facial reactions when a Bonferroni correction was applied.

Spontaneous taste-elicited facial reactions: In general, the groups differed in several specific facial reactions among the taste qualities (Mann-Whitney U-Tests).

In response to the **bitter taste**, ADHD patients displayed negative facial reactions, i.e. brow lower (AU 4), lids tight (AU 7), upper lip raise (AU 10), and jaw drop (AU 26) more frequently than controls (p = .007, p = .004, p = .002, p = .028) and bulimic patients (p = .046, p = .045, p = .032, p = .028) before swallowing. Also, ADHD patients expressed negative facial displays of lip corner depress (AU 15) and chin raise (AU 17) more often than bulimic patients (p = .032, p = .028) before swallowing. ADHD patients displayed cheek raise (AU 6) more often than controls (p = .032) and bulimic patients (p = .032) before swallowing. After swallowing ADHD patients showed lip corner depress (AU 15) more frequently than controls (p = .012) and bulimic patients (p = .004).

In response to the **salty taste**, ADHD patients (p = .029) and bulimic patients (p = .008) displayed lip press (AU 24) more frequently than controls before swallowing. Controls smiled (lip corner pull, AU 12) more often compared with ADHD patients (p = .045) and bulimic patients (p = .004) before swallowing. Also, ADHD patients displayed brow lower (AU 4) more frequently than did controls (p = .023) before swallowing. After swallowing, ADHD patients expressed cheek raise (AU 6) and talked more often (AU 50) than bulimic patients (p = .028, p = .032).

In response to the **sour taste**, ADHD patients showed chin raise (AU 17) and lip press (AU 24) more frequently than controls (p = .028, p = .048) before swallowing. Controls displayed cheek raise (AU 6) more often than bulimic patients (p = .032). After swallowing, ADHD patients showed lip press (AU 24) more frequently than controls (p = .003) and bulimic patients (*p* = .037). Bulimic patients showed lip suck (AU 28) more often when compared to controls (*p* = .033).

In response to the **sweet taste** and the **umami taste**, bulimic patients displayed the dimpler (AU 14) more frequently than did controls (*p* = .007, *p* = .003) before swallowing. In response to the umami taste, ADHD patients displayed the dimpler (AU 14) more often than controls (*p* = .025) and lid tight (AU 7) more often than bulimic patients (*p* = .039).

In response to **water**, bulimic patients displayed the dimpler (AU 14) more frequently than controls (*p* = .027) before swallowing, whereas ADHD patients displayed it more often than controls (*p* = .039) after swallowing.

As expected, spontaneous taste-elicited facial reactions in ADHD patients were characterized by negative facial displays. ADHD patients expressed negative facial displays in response to unpleasant tastes, i.e. bitter, salty, sour, and umami, such as brow lower (AU 4), lid tight (AU 7), upper lip raise (AU 10), lip corner depress (AU 15), chin raise (AU 17), and jaw drop (AU 26). Bulimic patients produced positive facial displays such as the dimpler (AU 14) and lip press (AU 24) in response to the salty, sweet, umami taste, and water.

Suppressed taste-elicited facial reactions: In general, the groups differed in several specific facial reactions among the taste qualities (Mann-Whitney U-Tests).

In response to the **bitter taste**, ADHD patients showed brow lower (AU 4) more frequently than controls before swallowing (*p* = .014) and after swallowing (*p* = .035). Both ADHD and bulimic patients displayed lip press (AU 24) more often before swallowing (*p* = .021, *p* = .034).

In response to the **salty taste**, ADHD patients displayed lip press (AU 24) more frequently than controls (*p* = .017) before swallowing.

In response to the **sour taste**, ADHD patients displayed lip press (AU 24) more frequently than controls before swallowing (*p* = .017) and after swallowing (*p* = .008). Before swallowing, ADHD patients showed brow lower (AU 4) more often than controls (*p* = .028). Bulimic patients showed lip press (AU 24) more often than controls (*p* = .045). After swallowing, ADHD patients opened their mouth more frequently (AU 25 + 26) and expressed the dimpler (AU 14) more frequently than controls (*p* = .023, *p* = .049, *p* = .023) and bulimic patients (*p* = .017, *p* = .033, *p* = .048).

The groups did not differ in their specific facial reactions in response to the **sweet taste**. In response to the **umami taste**, ADHD and bulimic patients showed lip press (AU 24) more frequently than controls (*p* = .035, *p* = .014) before swallowing. Controls smiled more often (AU 12) when compared to ADHD patients and bulimic patients (*ps* = .032).

In response to **water**, ADHD patients displayed the dimpler (AU 14) more often than controls (p = .026).

As expected, taste-elicited facial reactions in ADHD and bulimic patients were characterized by negative facial displays during the facial suppression task. ADHD patients produced negative facial displays, e.g. brow lower (AU 4), lips part (AU 25), and jaw drop (AU 26) in response to each taste quality except the sweet taste. Bulimic patients displayed lip press (AU 24) in response to the bitter, sour, and umami taste.

Spontaneous odor-elicited facial reactions: In general, the groups displayed similar specific facial reactions in response to odor stimuli (Mann-Whitney U-Tests). ADHD patients, however, displayed nostril dilate (AU 38) more frequently in response to garlic than controls and bulimic patients (ps = .033).

Suppressed odor-elicited facial reactions: ADHD patients displayed brow lower (AU 4) more frequently in response to garlic than controls (p = .032) (Mann-Whitney U-Tests).

Spontaneous smiles elicted by cartoons: Unexpectedly, ADHD patients did not show more smiles, which includes cheek raise and lip corner pull (AU 6 + 12). The frequency of smiles was comparable across all groups during spontaneous facial reactions (Figure 18) in response to cartoons (Mann-Whitney U-Tests, ps > .05).

Suppressed smiles elicited by cartoons: The groups differed in the number of smiles (AU 6 + 12) during facial suppression (Mann-Whitney U-Tests). ADHD patients (p = .027) and bulimic patients (p = .031) displayed more smiles than controls (Figure 18). This finding was expected for ADHD patients but not for bulimic patients.

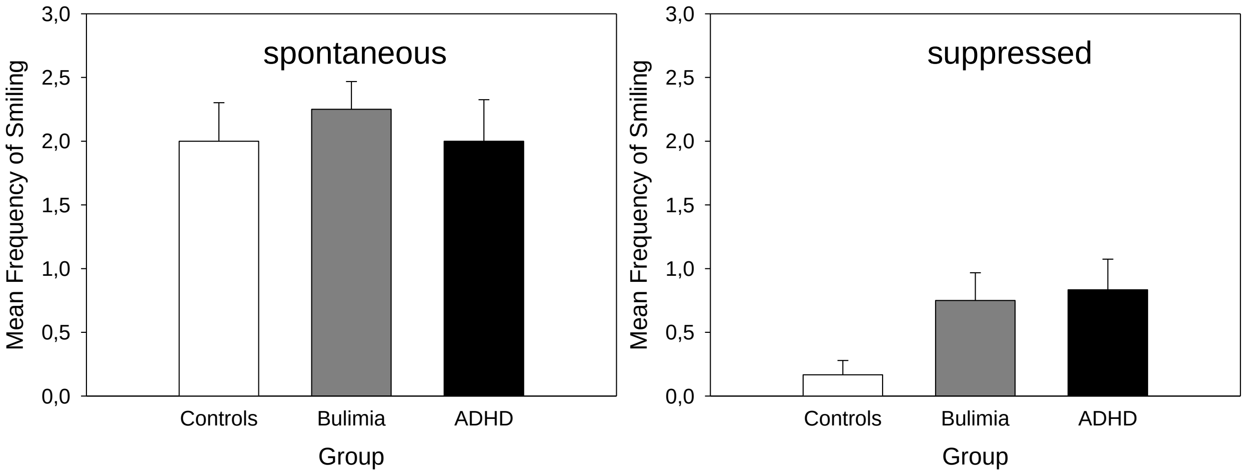


Figure 18: Mean Frequency of smiles (AU 6 + 12) during spontaneous and suppressed facial reactions in response to cartoons in healthy controls (n = 12), patients with Bulimia (n = 12), and Attention-Deficit Hyperactivity Disorder (ADHD, n = 12).

3.3.4. Electromyographic activity

In this section the results of electromyographic activity over the corrugator, levator, and zygomaticus muscle in response to tastes and odors are described.

Corrugator activity during spontaneous taste-elicited facial reactions: Before swallowing, the groups differed in their corrugator activity across the taste qualities, $F(10, 160) = 2.10$, $p = .048$ (significant taste quality × group interaction). ADHD patients exhibited a greater corrugator activity than controls in response to the bitter taste ($p = .046$) but not in response to the other tastes (*ps* > .05). Figure 19 depicts this finding.

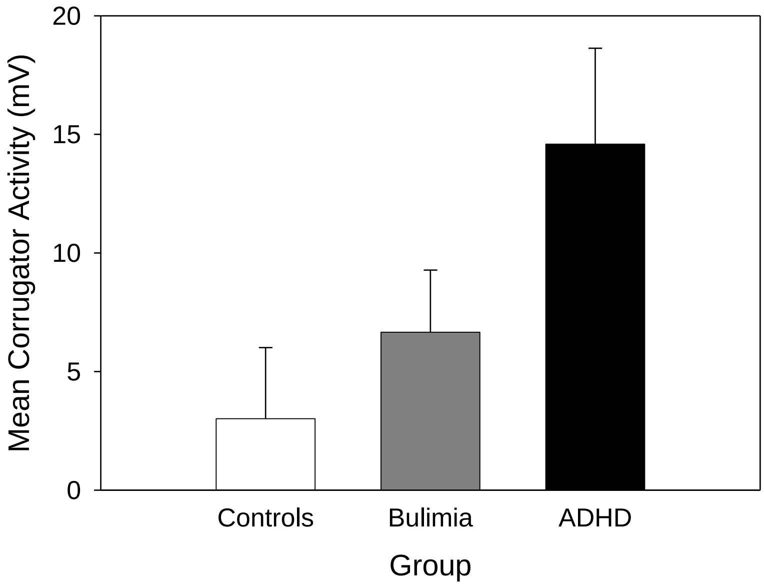


Figure 19: Mean Corrugator activity (Means ± *SEM*) during spontaneous facial reactions in response to tastes before swallowing in healthy controls ($n = 11$), patients with Bulimia ($n = 12$), and Attention-Deficit Hyperactivity Disorder (ADHD, $n = 12$).

Moreover, the corrugator activity varied across taste qualities over time, $F(45, 1440) = 3.20$, $p = .002$ (taste quality × time interaction). Water elicited a lower corrugator activity when compared to the salty, bitter, and sour taste from period 1-10 (*ps* < .05), and when compared to the umami taste for the period 3 and 4 as well as for the period 10 (*ps* < .05). In addition, the sweet taste elicited a lower corrugator activity than the bitter taste from period 2 to 9, compared with the salty taste from period 1 to 5, and compared with the sour taste from period 1 to 4 (*ps* < .05). The salty taste elicited a stronger corrugator activity than did the bitter taste for period 2 and 3 (*ps* < .05). The umami taste evoked a lower corrugator activity than the bitter taste for period 6 and than the sour taste for period 2 (*ps* < .05). The sour taste elicited a higher activity than the bitter taste for period 2 ($p < .05$). The analysis also revealed a main effect of taste quality, $F(5, 160) = 13.78$, $p < .001$, and a marginal main effect of time, $F(9, 288) = 2.59$, $p = .061$. There was no main effect of group, $F(2, 32) = .86$, $p > .05$, and no other significant interaction effects.

After swallowing, corrugator activity significantly differed across time, $F(7, 231) = 5.29$, $p = .011$. Post-hoc tests, however, indicated no significant differences over time (*ps* > .05). The analysis revealed no additional main effects or interaction effects (*ps* > .05).

Corrugator activity during supressed taste-elicited facial reactions: Corrugator activity did not differ across groups, neither before swallowing, $F(2, 32) = .32$, $p > .05$, nor after swallowing, $F(2, 32) = .45$, $p > .05$. Before swallowing, corrugator activity decreased across time, $F(9, 288) = 8.95$, $p < .001$. Corrugator activity was significantly higher for period 2 and 3 when compared to the periods 8, 9, and 10, and higher for period 4 when compared to period 9 (*ps* < .05). There was no significant main effect of taste quality, $F(5, 160) = 1.74$, $p > .05$, and no interaction effects (*ps* > .05).

After swallowing, corrugator activity decreased across time, $F(7, 224) = 6.83$, $p = .001$, as indicated by higher corrugator amplitudes for periods 2, 3, and 4 when compared to the period 8 (*ps* < .05). Moreover, corrugator activity tended to differ across taste qualities, $F(5, 160) = 2.35$, $p = .086$, with umami and water eliciting a higher amplitude than the sour taste (*ps* < .05). The other interactions effects were non-significant (*ps* > .05).

Levator activity during spontaneous taste-elicited facial reactions: Before swallowing, the groups differed significantly in their levator amplitude at different times, $F(18, 288) = 2.67$, $p = .024$ (significant time × group interaction). As can be seen in Figure 20, bulimic patients tended to exhibit a greater levator activity than did ADHD patients at period 3 ($p = .065$), 4 ($p = .070$), 5 ($p = .077$), 9 ($p = .066$), and 10 ($p = .076$).

Moreover, the groups tended to differ in the amplitude across tastes, $F(10, 160) = 1.92$, $p = .075$ (taste quality × group interaction) with bulimic patients showing a higher levator activity than ADHD patients in response to the sweet ($p = .048$) and the umami taste ($p = .049$). The main effect of group, however, was not significant, $F(2, 32) = 2.29$, $p > .05$. The significant main effects of taste quality, $F(5, 160) = 3.27$, $p = .019$, and time, $F(9, 288) = 53.95$, $p < .001$, were qualified by a significant taste quality × time interaction, $F(45, 1440) = 1.89$, $p = .046$. The umami taste elicited a lower levator activity when compared with the sour taste for the period 3, 4, 5, 6, 7, and 9 (*ps* < .05), and when compared with the salty taste for the periods 3 and 6 (*ps* < .05). The sweet taste elicited a lower amplitude than the sour taste from periods 5 to 7 (*ps* < .05). Water elicited a lower activity than did the sour taste for period 6 and 7 (*ps* < .05). The other interaction effects were non-significant (*ps* > .05).

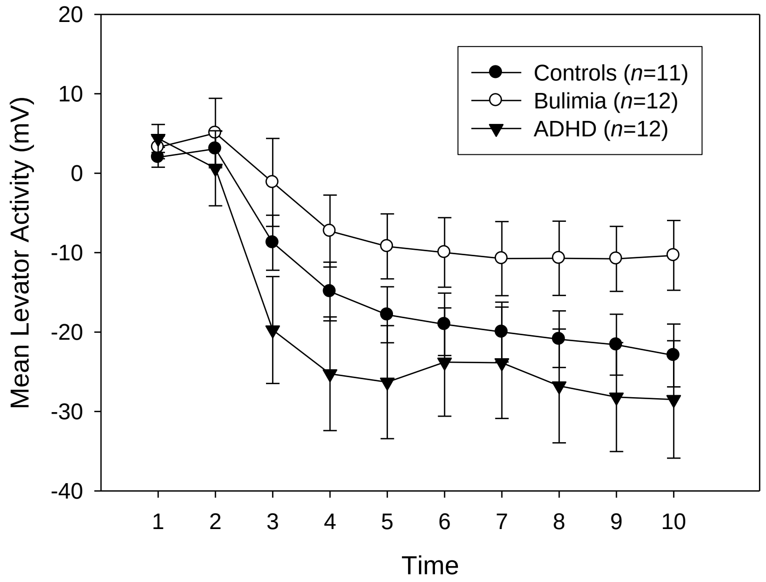


Figure 20: Mean Levator activity (Means ± *SEM*) during spontaneous facial reactions in response to tastes before swallowing in healthy controls, patients with Bulimia, and Attention-Deficit Hyperactivity Disorder (ADHD).

After swallowing, the groups did not differ in their levator activity (group, $F(2, 33) = .67$, $p > .05$, taste quality × group, $F(10, 165) = 1.08$, $p > .05$). The other main effects or interaction effect were non-significant (*ps* > .05).

Levator activity during suppressed taste-elicited facial reactions: Bulimics exhibited a higher levator activity from period 2 to 10 (*ps* < .05) than did ADHD patients (Figure 21).

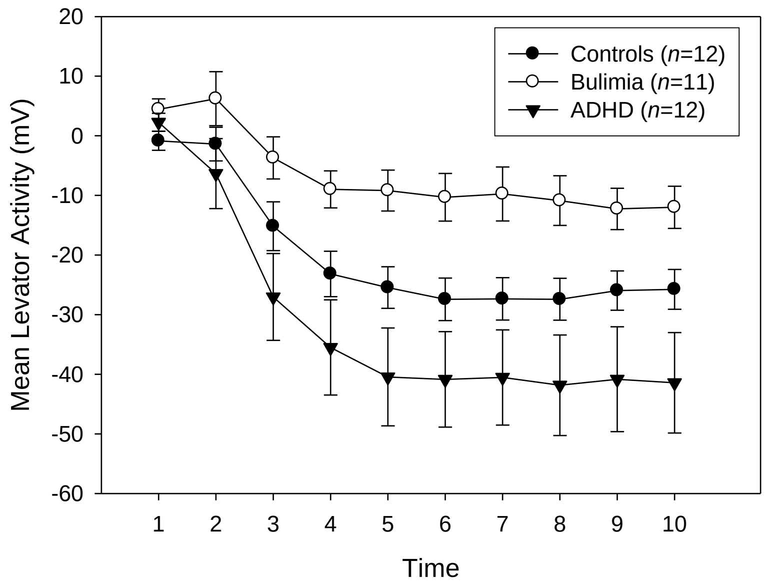


Figure 21: Mean Levator activity (Means ± *SEM*) during suppressed facial reactions in response to tastes before swallowing in healthy controls, patients with Bulimia, and Attention-Deficit Hyperactivity Disorder (ADHD).

This finding is in line with the levator activity during spontaneous taste-elicited facial reactions. The ANOVA revealed significant main effects of group, $F(2, 32) = 6.48$, $p = .004$, and time, $F(9, 288) = 65.42$, $p < .001$, qualified by a significant time × group interaction, $F(18, 288) = 4.28$, $p = .002$. The main effect of taste quality, as well as the other interaction effects were non-significant ($ps > .05$).

After swallowing, the levator activity did not differ across groups (group, $F(2, 32) = 1.33$, $p > .05$, taste quality × group, $F(10, 160) = 1.59$, $p > .05$). However, levator activity decreased across time, $F(7, 224) = 7.09$, $p = .001$, with higher amplitudes for period 1, 2, and 3 when compared to period 8 ($ps < .05$). The main effect of taste quality, as well as the other interaction effects were non-significant ($ps > .05$).

Zygomaticus activity during spontaneous taste-elicited facial reactions: Zygomaticus activity did not differ across groups neither before swallowing, $F(2, 32) = .49$, $p > .05$, nor after swallowing, $F(2, 33) = 1.47$, $p > .05$. Zygomaticus activity decreased across time before swallowing, $F(9, 288) = 22.90$, $p < .001$, and after swallowing, $F(7, 231) = 3.98$, $p = .005$. Before swallowing, the activity increased at the beginning for period 1 and 2 and then decreased over time (1 > 8, 10; 2/3 > 4-10; 4 > 10, $ps < .05$). After swallowing, zygomaticus activity decreased when comparing period 4 with period 7 ($p < .05$). The main effect of taste quality and the other interaction effects were not significant ($ps > .05$).

Zygomaticus activity during suppressed taste-elicited facial reactions: The groups did not differ in their zygomaticus activity before swallowing, $F(2, 32) = .76$, $p > .05$, and after swallowing, $F(2, 32) = 1.02$, $p > .05$. Zygomaticus activity in response to tastes differed across time before swallowing, $F(9, 288) = 38.44$, $p < .001$, and after swallowing, $F(7, 224) = 4.08$, $p = .006$. Before swallowing, zygomaticus activity increased from period 1 to period 2 ($p = .001$). It then decreased from period 1 and 3 when compared to period 4 to 10 and it decreased from period 2 when compared to period 3 to 10. After swallowing, zygomaticus activity increased from period 2 to period 7 ($p = .024$) and increased from period 3 compared to period 5, 6, and 7 ($ps = .05$). The analysis revealed no additional main effects or interaction effects ($ps > .05$).

Corrugator activity during spontaneous odor-elicited facial reactions: The groups did not differ in their corrugator activity in response to odors (group, $F(2, 33) = .24$, $p > .05$, odor type × group, $F(6, 99) = .27$, $p > .05$). There was a significant main effect of odor stimuli, $F(3, 99) = 6.23$, $p = .003$, with fish and garlic eliciting a greater corrugator activity than banana ($ps < .05$) and fish eliciting a greater activity than cinnamon ($p = .059$). Despite the significant time effect, $F(7, 231) = 4.31$, $p = .014$, and significant odor stimuli × time interaction, $F(21, 693) = 2.53$, $p = .041$, post-hoc tests revealed no significant differences over time and across the odors over time ($ps > .05$). The main effect of group and interaction effects were not significant ($ps > .05$).

Corrugator activity during suppressed odor-elicited facial reactions: The groups did not differ in their corrugator activity in response to odors (group, $F(2, 33) = .43$, $p > .05$, odor type × group, $F(6, 99) = 1.50$, $p > .05$. There was a significant main effect of time, $F(7, 231) = 6.62$, $p < .001$. Corrugator activity significantly increased from period 1 to period 3, 4, 5, 6, 7, and 8 ($ps < .05$). Other main effects and interactions were not significant ($ps > .05$).

Levator activity during spontaneous and suppressed odor-elicited facial reactions: The groups did not differ in their levator activity in response to odors during spontaneous facial reactions (group, $F(2, 33) = 1.14$, $p > .05$, odor type × group, $F(6, 99) = 1.42$, $p > .05$) and during suppressed facial reactions (group, $F(2, 33) = .25$, $p > .05$, odor type × group, $F(6, 99) = 1.25$, $p > .05$). Other main effects and interaction effects were also non-significant ($ps > .05$).

Zygomaticus activity during spontaneous and sppressed odor-elicited facial reactions: The groups did not differ in their zygomaticus activity in response to odors during spontaneous facial reactions (group, $F(2, 33) = .95$, $p > .05$, odor type × group, $F(6, 99) = 1.86$, $p > .05$) and during suppressed facial reactions (group, $F(2, 33) = .91$, $p > .05$, odor type × group, $F(6, 99) = 1.15$, $p > .05$). Other main effects and interaction effects were also non-significant ($ps > .05$).

To conclude, ADHD patients exhibited a greater corrugator activity than controls during spontaneous taste-elicited facial reactions which corresponds to the FACS finding that ADHD patients displayed more often brow lower (AU 4) than controls. Moreover, bulimics exhibited a greater levator activity than ADHD patients during both spontaneous and suppressed facial reactions, which was more pronounced for the sweet and the umami taste. In addition, it was shown that corrugator and levator activity differed among tastes during the assessment of spontaneous facial reactions. In particular, the unpleasant tastes (bitter and salty) and the sour taste were found to elicit a greater corrugator activity compared to water and the sweet taste. The sour taste elicited a greater levator atcivity than the sweet and umami taste and water. Corrugator activity differed among odors with the unpleasant odors (fish, garlic) eliciting a greater activity than the pleasant odors (banana, cinnamon).

3.3.5. Taste and odor sensitivity, and personality aspects

The groups were comparable in their taste threshold, $F(2, 35) = .77$, $p > .05$. Controls correctly identified 12 tastes (*SD* = 2.0); bulimic patients (*SD* = 2.0) and ADHD patients correctly identified 11 tastes (*SD* = 2.2). Thus all groups remain within the normal range of taste identification (at least 9 tastes have to be identified correctly).

Moreover, the groups did not differ in their odor threshold, $F(2, 35) = .92$, $p > .05$. Controls had an odor threshold of 8.2 (*SD* = 1.6), BN patients of 8.3 (*SD* = 0.9) and ADHD patients of 7.6 (*SD* = 1.5). According to the normative data in healthy participants (Hummel et al., 2007), the groups were in the range of normal odor threshold (16-35 years, *M* = 9.4, *SD* = 2.6; 36-55 years, *M* = 9.1, *SD* = 3.1). Medicated ADHD patients, non-medicated ADHD patients, bulimics, and controls did not differ in their odor threshold, $F(3, 35) = .75$, $p > .05$. It has been shown recently that odor sensitivity is improved in ADHD patients without medication when compared with healthy controls, whereas medicated patients did not differ from controls (Romanos et al., 2008).

Figure 22 depicts the tri-modal distribution of the PROP intensity ratings and the unimodal distribution of the NaCl intensity ratings.

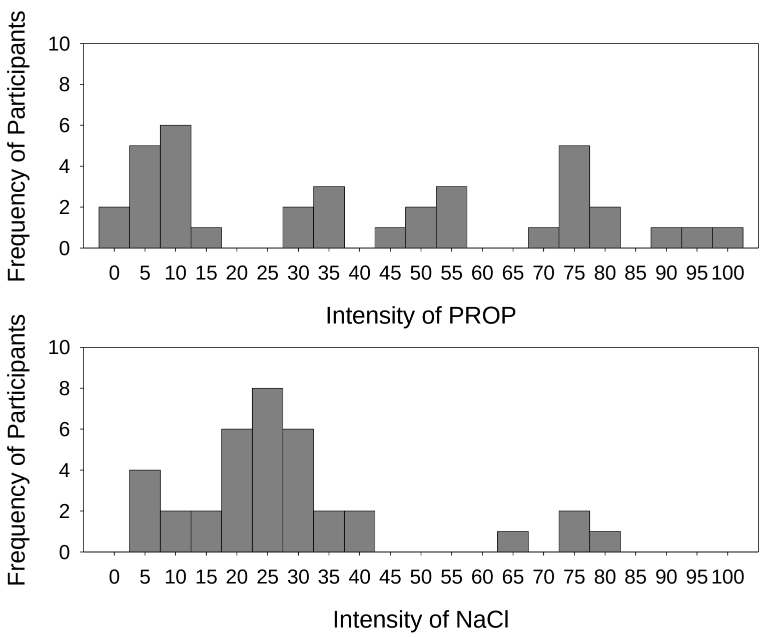


Figure 22: Distribution of intensity ratings for PROP and NaCl in the total sample ($N = 36$).

To investigate bitter sensitivity, a non-hierarchical cluster analysis (K-means) with a 3 cluster solution of the perceived PROP intensity revealed the following cut-off points. Intensity scores from 0 to 15 refer to non-tasters ($n = 14$), intensity scores from 16 to 69 refer to medium-tasters (*n* = 11), and intensity scores from 70 to 100 refer to super-tasters (*n* = 11). The proportion of non-tasters, medium-tasters and super-tasters across the groups was as follows. In the non-taster group were 7 controls, 6 bulimics, and 1 patient with ADHD. In the medium-taster group were 1 control woman, 4 bulimics, and 6 patients with ADHD. In the super-taster group were 4 control women, 2 bulimics, and 5 patients with ADHD. The frequency of non-, medium-, and super-tasters tended to differ among the groups ($Chi^2 = 9.2$, $p = .057$). When the groups were classified into non-tasters and tasters, the frequency of non-tasters and tasters significantly differed across the groups ($Chi^2 = 7.2$, $p = .027$). Within the ADHD group there were more tasters (*n* = 11) and fewer non-tasters (*n* = 1) when compared to the BN group (non-tasters *n* = 6, tasters *n* = 6) and the controls (non-tasters *n* = 7, tasters *n* = 5).

As can be seen in Table 10, the groups differed in their level of depression (BDI), $F(2, 35) = 4.53$, $p = .018$, in eating behavior (DEBQ, emotional eating behavior, $F(2, 35) = 10.17$, $p < .001$, restrained eating behavior, $F(2, 35) = 14.22$, $p < .001$), and in neuroticism (NEO-FFI, $F(2, 35) = 10.79$, $p < .001$).

Table 10: Ratings (Means ± *SD*) of the level of depression, eating behaviors, personality characteristics, and expressivity.

	Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)	
	M	*SD*	*M*	*SD*	*M*	*SD*
BDI*	6.0	5.9	14.3	5.4	8.7	9.0
DEBQ						
External eating behavior	30.5	6.3	35.3	5.3	29.7	5.8
Emotional eating behavior***	23.4	7.2	37.3	8.1	25.1	9.2
Restrained eating behavior***	27.3	6.3	36.8	4.9	23.7	7.2
NEO-FFI						
Neuroticism***	1.5	0.7	2.6	0.5	2.2	0.4
Extraversion	2.5	0.4	2.2	0.5	2.3	0.5
Openness to experience	2.4	0.4	2.5	0.7	2.4	0.4
Agreeableness	2.8	0.6	2.7	0.6	2.7	0.4
Conscientiousness	2.4	0.6	2.2	0.5	2.3	0.6
BEQ						
Negative Expressivity	4.4	1.0	3.7	1.0	4.4	1.1
Positive Expressivity	5.3	0.8	5.3	1.4	5.1	0.8
Impulse strength	4.8	1.0	4.8	1.3	5.2	1.0
Expressivity	76.5	8.4	72.4	17.4	77.8	13.2

*$p < .05$, ***$p < .001$.

In sum, bulimic patients were more depressive than controls (*p* = .021). Bulimics had a higher emotional eating behavior and restrained eating behavior than did patients with ADHD (*p* = .004, *p* < .001) and controls (*p* = .001, *p* = .003). Bulimics (*p* < .001) and ADHD (*p* = .025) were more neurotic than controls.

3.3.6. Influence of ADHD medication on facial activity

To explore whether non-medicated ADHD patients (*n* = 5) differ from medicated ADHD patients (*n* = 7) in their overall facial activity in response to tastes, odors, and cartoons, and their frequency of smiles in response to cartoons, Mann-Whitney U-Tests for differences among proportions were calculated.

Spontaneous and suppressed taste-elicited overall facial activity: During spontaneous facial reactions, non-medicated ADHD patients (*M* = 38.2, *SD* = 3.0) displayed more facial reactions than medicated ADHD patients (*M* = 26.0, *SD* = 10.3) before swallowing (*p* = .051), but not after swallowing (*p* = .14). Likewise during suppressed facial reactions, non-medicated ADHD patients (*M* = 25.8, *SD* = 1.3) displayed more facial reactions than medicated ADHD patients (*M* = 20.1, *SD* = 6.5) before swallowing (*p* = .050), but not after swallowing (*p* = .42). Interestingly, the effect was reversed after swallowing since non-medicated ADHD patients displayed less spontaneous and suppressed facial reactions than medicated ADHD patients

Spontaneous and suppressed odor-elicited overall facial activity: Both medicated and non-medicated ADHD patients did not differ in the overall facial activity in response to odors (*ps* > .05).

Overall facial activity and smiles in response to cartoons during spontaneous and suppressed facial reactions: Both medicated and non-medicated ADHD patients did not differ in the overall facial activity in response to cartoons during both tasks (*ps* > .05). However, non-medicated ADHD patients (*M* = 1.4, *SD* = 0.5) smiled more often (*p* = .038) than medicated ADHD patients (*M* = 0.4, *SD* = 0.8) during the facial suppression task.

3.4. Discussion

The present experiment examined (1) whether patients with Bulimia and ADHD exhibit a heightened taste-elicited overall facial activity during spontaneous and suppressed facial activity. Moreover, it was investigated whether overall facial activity in response to odors (2) and cartoons (3) differs between patients with Bulimia Nervosa, ADHD, and healthy controls during spontaneous and suppressed facial activity. It was also explored whether the groups differ in their specific facial activity in response to tastes, odors, and cartoons during spontaneous and suppressed facial activity (4). This study further examined whether electromyographic activity in response to tastes and odors (5) differs across the groups during spontaneous and suppressed facial activity. Lastly, it was investigated whether non-medicated and medicated ADHD patients display a similar facial activity (6).

Taste-elicited overall facial activity: Overall facial activity in response to tastes was expected to be higher in patients with Bulimia and ADHD during both spontaneous and suppressed facial activity (1). The results confirmed the hypothesis regarding the heightened taste-elicited overall facial activity in patients with ADHD during both spontaneous and suppressed facial reactions. This greater facial activity in response to tastes in ADHD patients is due to their executive function deficits. ADHD patients suffer from a deficient inhibitory motor control, i.e. a deficient suppression of prepotent motor responses (Lijffijt et al., 2005; Nigg, 2001; Oosterlaan et al., 1998; Sergeant et al., 2002), which might have caused the greater taste-elicited overall facial activity during both spontaneous as well as suppressed facial reactions in this study. Moreover, the suppression of facial reactions requires a behavioral/motor inhibition which is more difficult to perform by individuals with executive function problems such as in ADHD. These patients are less able to suppress their behavioral responses, here facial reactions, on verbal command. To date, inhibitory deficits have never been linked to a greater facial expressiveness in ADHD patients.

As expected, patients with Bulimia displayed a greater taste-elicited overall facial activity during spontaneous facial reactions, whereas they did not exhibit a greater taste-elicited overall facial activity during the facial suppression task when compared to controls. Thus bulimic patients were as able as controls to reduce their facial responses, unlike ADHD patients, on verbal command. Both patients with Bulimia and patients with ADHD have inhibitory deficits in common (Barkley, 1997; Marsh et al., 2009; Mobbs et al., 2008; Sonuga-Barke, 2003; Steiger, 2004). Moreover, researchers have linked Bulimia Nervosa with heightened impulsivity and behavioral disinhibition (Claes et al., 2002; Fahy & Eisler, 1993; Kaye et al., 1995; Kaye et al., 2004; Lacey & Evans, 1986; Steiger, 2004; Vitousek & Manke, 1994; Westen & Harnden-Fischer, 2001) as well as deficits in motor impulsivity (Rosval et al., 2006; Marsh et al., 2009; Mobbs et al., 2008; Nederkoorn et al., 2004). In the latter studies, participants were asked to suppress behavioral responses, which is comparable to the instruction to inhibit facial reactions here.

However, it seems to be more likely that the underlying mechanism of the greater taste-elicited facial responsiveness is related to the greater food reactivity in patients with Bulimia Nervosa. This is supported by the finding that bulimics were as able as controls to suppress their facial reactions, which is a task that requires an inhibition of behavioral responses. In bulimic patients, any oral stimulation might be linked with higher facial activity due to the ambivalent affect-laden link to food stimuli (Berridge, 2007, 2009; Drobes et al., 2001), or, in other words, due to the greater reactivity to food. This food-related reactivity is determined by dysfunctional cognitions and behaviors in bulimics. Ingestion underlies a high cognitive control with the intention to avoid high-calorie foods in order to prevent weight gain. Therefore, bulimic patients restrict their food intake over long periods of time and fail to maintain dieting from time to time, resulting in a binge. Prior to a binge, bulimic individuals experience a strong desire or craving for food stimuli which they usually avoid. During and after a binge, bulimics’ mood declines and they experience negative emotions such as shame and guilt about overeating (Eversmann et al., 2007; Schöttke et al., 2006) which in turn leads to purging in order to prevent weight gain. Ingestion is therefore linked to ambivalent affect in bulimics, which is particularly related to anxiety and disgust in response to food (Troop & Baker, 2009). Moreover, bulimic patients might be easily attracted by the sight, smell, or thought of food due to their greater food reactivity. In general, bulimics are more prone for eating in response to external cues and internal emotional states. In contrast, ADHD patients do not suffer from dysfunctional eating behavior (usually if they do not have a comorbid eating disorder).

One may argue that bulimics are better able to suppress facial reactions in response to tastes than ADHD patients, since they suffer from inhibitory motor deficits to a lesser extent. Bulimic patients have less severe deficits in voluntary control processes than ADHD patients. Consciousness about facial expressivity enables bulimic patients to successfully control and inhibit their facial reactions in response to tastes, which ADHD patients are incapable of. Consciousness may also stop reactivity to food in patients with Bulimia for a short period of time. It is, however, unclear, whether facial reactions can be reduced for longer periods, when a behavioral response becomes conscious. In sum, the similar taste-elicited overall facial activity during facial suppression between bulimics and controls highlights the role of food reactivity rather than deficient inhibitory control for patients with Bulimia. In contrast, a greater taste-elicited facial activity is associated with inhibitoy deficits in patients with ADHD.

Odor-elicited overall facial activity: Overall facial activity in response to odors was expected to be higher in ADHD patients but similar in bulimic patients when compared to controls, during both spontaneous and suppressed facial activity (2). The hypothesis was not confirmed for ADHD patients, whereas it was confirmed for bulimic patients. In fact, ADHD patients displayed the similar level of overall facial activity in response to odors when compared to controls during both spontaneous and suppressed facial reactions. However, during the facial suppression task there was a tendency that ADHD patients (as well as bulimic patients) displayed a greater overall facial activity in response to odors when compared to controls, although not significantly. Overall it can be concluded that ADHD patients do not exhibit a greater odor-elicited facial activity during facial reactions, which one would not predict with respect to their deficient inhibitory control.

As expected, bulimic patients did not differ from controls in their odor-elicited overall facial activity during spontaneous facial reactions which replicates the previous finding in the second experiment. Since odors reflect no threat for shape and weight for patients with Bulimia, they are not more facially reactive in response to odors. This was even the case during the facial suppression task. Likewise to tastes, bulimic patients are able to suppress facial reactions in response to odors on verbal command.

The absence of group differences in odor-elicited facial activity in this study might be, as alternative explanation, due to the fact that, in general, odors are less likely to induce facial reactions than tastes, which had already been demonstrated in the first and second experiment. Unpleasant odors induced the highest overall facial activity primarily indicated by an increase of negative facial reactions, whereas pleasant odors elicited the lowest overall facial activity which was not associated with an increase of positive facial reactions. On average, women displayed 2 facial reactions in response to one odor in this study. As discussed in the first experiment, the odors used in the studies were everyday odor stimuli which were less invasive and less aversive for participants than the tastes. The use of more aversive odors might have produced more facial reactions in ADHD patients due to their inhibitory control deficits, but not more facial reactions in bulimics, since odors do not represent a threat for body weight unlike tastes.

Facial activity in response to cartoons: In this study, cartoons were used in order to administer a modality which is not related to food. It was expected that overall facial activity and the specific facial display of smiling (AU 6 + 12) in response to cartoons would be higher in ADHD patients but not in bulimic patients during both spontaneous and suppressed facial activity (3, 4). These hypotheses were only partly confirmed. Unexpectedly, ADHD patients were comparable to controls and bulimic patients in their overall facial activity in response to cartoons during spontaneous and suppressed reactions. In general, like odors, the cartoons were found to induce less facial reactions compared to tastes. However, the experimental situation (the knowledge of being video-recorded) might have resulted in a low emotional expressivenenss, which might not be so low in a naturalistic context.

With regard to the specific facial reaction of smiling, which is the characteristic facial display of joy and exhilaration (Ekman & Friesen, 1982; Ruch, 1995), the hypothesis was partly confirmed for ADHD patients. ADHD patients smiled more often during the facial suppression task than did controls but not during spontaneous facial activity. This result is consistent with a greater deficient inhibitory motor control in ADHD patients (Lijffijt et al., 2005; Nigg, 2001; Oosterlaan et al., 1998; Sergeant et al., 2002). Bulimic patients, unexpectedly, also smiled more often during the facial suppression task than did controls, and, expectedly, they did not smile more often during spontaneous facial activity. The first result might be confounded by the funniness rating. Bulimics rated the isle cartoon as funnier than controls during the facial suppression task, which might have caused more smiles in bulimics. Therefore is not argued that bulimic patients smiled more often due to their deficient inhibitory control (Marsh et al., 2009; Mobbs et al., 2008; Rosval et al., 2006).

Specific facial activity: As expected the groups differed in their specific facial reactions to tastes (4). Indeed, taste-elicited facial reactions in patients with ADHD and Bulimia were characterized by negative facial displays indicating displeasure during both spontaneous and suppressed facial activity. However, ADHD patients produced more negative facial reactions when compared to bulimic patients. More precisely, ADHD patients expressed negative facial displays in response to unpleasant tastes and water such as brow lower (AU 4), lid tight (AU 7), upper lip raise (AU 10), lip corner depress (AU 15), chin raise (AU 17), lips part (AU 25), and jaw drop (AU 26). Upper lip raise (AU 10) and brow lower (AU 4) have been found to be frequent reactions to unpleasant tastes in newborns (Rosenstein & Oster, 1988; Steiner, 1973) and in adults (Greimel et al., 2006; Steiner et al., 1993). Upper lip raise has often been associated with the prototypical disgust reaction (Darwin, 1872; Ekman & Friesen, 1975; Hu et al., 1999; Izard, 1971; Rozin et al., 2000; Rozin et al., 1994; Vrana, 1993). Brow lower characterizes disgust expressions to unpleasant tastes as well (Horio, 2003); it is, however, also associated with other negative emotions, e.g. anger, or with cognitively demanding tasks. Lip corner depress (AU 15) and chin raise (AU 17) have been related to disgust by Darwin (1872) and by Ekman and Friesen (1975), respectively. In accordance with the first study, lip corner depress is linked with taste unpleasantness in adults. Lids tight (AU 7) might reflect a defensive response to aversive taste stimulation in ADHD patients and has been shown to be a frequent reaction elicited by tastes, in the first experiment. Lips part (AU 25) and jaw drop (AU 26) have been found as frequent displays in newborns (Steiner, 1973, 1977, 1979) and adults (Greimel et al., 2006) in response to the bitter taste in order to expel the unpleasant substance from the mouth. According to the previous experiments, the dimpler (AU 14) and lip press (AU 24, see also Greimel et al. (2006) were regarded as rather positive facial reactions, which were shown in this study by bulimics in response to all tastes and by ADHD patients in response to some tastes. Overall, ADHD patients may display more negative reactions due to their deficient inhibitory control, whereas bulimic patients due to their greater reactivity to food in general. It can be ruled out that the group differences in the specific facial reactions are explained by differences in taste pleasantness since the groups rated the tastes as equally pleasant/unpleasant.

ADHD patients were expected to show more specific facial reactions in response to odors during both tasks (4). As expected, ADHD patients displayed brow lower (AU 4) and nostril dilate (AU 38) more frequently in response to garlic during suppressed and spontaneous facial activity, respectively. These results are in line with a greater deficient inhibitory motor control in ADHD patients (Lijffijt et al., 2005; Nigg, 2001; Oosterlaan et al., 1998; Sergeant et al., 2002). As has been said, odors may be less effective to elicit many facial responses, which in turn may have diminished the chance to detect more group differences in this study. A further study should use more aversive odors to induce facial reactions.

Electromyographic activity: It was expected that patients with Bulimia and ADHD who display more negative facial reactions in response to tastes, correspondingly show increased amplitudes in the corrugator and levator, i.e. muscles which characterize negative facial reactions, during spontaneous and suppressed facial activity (5). Indeed, ADHD patients exhibited a higher corrugator activity in response to the bitter taste before swallowing during spontaneous facial activity than did controls. This EMG finding corresponds to the higher frequency of brow lower (AU 4) obtained by FACS in ADHD patients elicited by the bitter taste for the same observation period. Moreover, bitter sensitivity was related to this effect since more ADHD patients were tasters, and thus perceived the high bitter taste as more intense (Bartoshuk et al., 1994; Drewnowski et al., 2001) compared to the other groups. During facial suppression, the groups expressed a similar corrugator activity.

With respect to the levator activity, bulimic patients had higher amplitudes when compared to ADHD patients over time, during spontaneous and suppressed facial activity.

Higher levator activity characterizes a disgust reaction (Darwin, 1872; Ekman & Friesen, 1975; Hu et al., 1999; Izard, 1971; Rozin et al., 2000; Rozin et al., 1994; Vrana, 1993) and corresponds to upper lip raise (AU 10) in the FACS. During spontaneous facial activity, bulimic patients exhibited a higher levator activity than did ADHD patients during tasting the sweet and umami taste. Thus, bulimic patients were more disgusted by these tastes. However, there is no correspondence between EMG and FACS, since AU 10 was not displayed more often by bulimic patients. After swallowing, the groups neither differed in their corrugator nor levator activity during spontaneous facial activity. Likewise, zygomaticus activity did not differentiate between groups during spontaneous and suppressed facial activity before and after swallowing.

Taste unpleasantness was associated with higher corrugator and levator activity. Corrugator activity differed across taste qualities with unpleasant tastes (bitter, salty, sour, and umami) eliciting a higher corrugator activity when compared to water and the sweet taste at specific times. These results correspond to the finding of Horio (2003) with human adults showing greater corrugator amplitudes to disliked than to preferred or less preferred tastes. Moreover, levator activity in response to tastes differed across time before swallowing which corresponds to the finding by Hu et al. (1999) and Armstrong et al. (2007), who found that taste unpleasantness is associated with higher levator activity, while taste pleasantness is associated with lower levator activity. On the subjective level, however the groups rated tastes as equally pleasant/unpleasant. In contrast, zygomaticus activity did not differ across tastes, which is inconsistent with the finding of Armstrong et al. (2007) who found zygomaticus activity to be discriminating between all tastes and water as well as between water and sucrose in children.

In general, there were more EMG differences in this study when compared to the second study. In part, this might be due to the fact that the observation period before swallowing was defined differently. Overall it might be argued, that EMG is less sensitive to providing a holistic picture of facial activity between different individuals. Corrugator and levator were indicators of pleasantness, whereas this was not the case for zygomaticus major. As expected, there were no group differences for corrugator, levator and zygomaticus activity in response to odors.

ADHD medication: Expectedly, the results indicate that non-medicated ADHD patients displayed more facial reactions in response to tastes during spontaneous and suppressed facial activity before swallowing and more smiles in response to cartoons during the facial suppression task. Thus, methylphenidate regulates the core symptoms of ADHD, which seems to be even effective for the reduction of facial responses to tastes and cartoons. Methylphenidate, however, seems to be uneffective to reduce facial reactions in response to odors, which might be due to the fact that odors are not eliciting many facial reactions. These results presented definitively need further validation and should be investigated in a sample with a higher number of participants.

One might argue what would happen if bulimics have been medicated with methylphenidate. possibility to disentangle both mechanisms, if they are not strongly interrelated, would be to medicate bulimics with methylphenidate in order to study their facial responsiveness to food. When methylphenidate reduces bulimics' spontaneous facial reactions in response to tastes, then it is likely that deficient inhibitory control moderates facial activity in bulimics. If, however, facial reactions to tastes would be similar either with or without medication, then it is likely that increased food reactivity moderates facial responsiveness. In contrast, methylphenidate should have no effect on suppressed reactions, since bulimics are able to suppress their expressions on verbal command even without medication.

In sum, the higher spontaneous facial activity elicited by tastes in patients with ADHD indicates a deficient inhibitory control of facial reactions. This is the first study demonstrating that deficient inhibitory motor control in patients with ADHD is associated with a greater facial expressiveness. ADHD patients who were less able to suppress their facial reactions in response to tastes, odors, and cartoons suffer from more severe deficits in executive functions and therefore may generally have more problems with voluntary control of emotional expression than do bulimic patients. In contrast, bulimics' heightened spontaneous taste-elicited facial activity and their ability to suppress taste-elicited facial reactions might be due to greater food reactivity in these patients. Their higher frequency of smiles during facial suppression was associated with a greater funniness of one cartoon. In addition, the increase of spontaneous overall facial activity in response to tastes in bulimic patients which had first been demonstrated in the second study was successfully replicated here. Therefore, the greater taste-elicited overall facial activity in bulimic patients during spontaneous facial reactions can be regarded as a robust finding.

III. General Discussion

Tasting and smelling is often accompanied by emotions and facial reactions, which indicate whether the food is liked or whether the food is disliked. Within the project this has been shown for healthy adults, patients with eating disorders, and Attention-Deficit Hyperactivity Disorder. Thus, facial reactions elicited by tastes and odors are a signal of food acceptance or food rejection (and sometimes a social communication signal) as indicated by positive or negative facial displays, respectively.

In the beginning of the introduction a model was presented in which the role of possibly moderators influencing facial reactions in response to tastes and odors was highlighted. The effects of some moderators on the relationship between gustatory and olfactory stimuli on facial reactions, which are mediated by the innate preference for sweet tastes and aversion against bitter tastes, were investigated here. The project aimed to specifically investigate the moderating role of age, eating pathology, and inhibitory control deficits. The main focus was thereby on the facial reactions, but the studies included subjective and physiological levels as well as, in order to study the full range of affective responses to tastes and odors. Moreover, the advantage of a multi-level analysis is that measures are not equally sensitive in studying affective behavior (see FACS and EMG, FACS and subjective ratings).

The first study addressed the question of whether adults' facial reactions in response to tastes and odors correspond to those facial reactions observed in newborns. Age was expected to moderate facial expressiveness in response to tastes and odors. With increasing age, adults learn to voluntarily control their facial reactions by display rules. This was insofar confirmed since adults expressed less positive facial reactions in response to the sweet taste, and distinct facial displays in response to the unpleasant tastes, which were not observed in newborns. More specifically, adults displayed the social smile (with higher concentrations) in response to the unpleasant tastes. Thus, adults masked their negative feeling regarding the unpleasant tastes by an incompatible facial display, which serves as a social communication signal. In contrast, newborns do not exhibit such a voluntary facial control.

In addition, the results have indicated that adults express mostly similar facial reactions like newborns confirming the view that taste- and odor-elicited facial displays are quite stable across ontogeny. This finding thus confirms reflex-like innate gustofacial and olfactofacial responses in healthy adults. These facial reactions were indicated by negative facial displays in response to unpleasant tastes and odors, and by the positive facial display of lip suck in response to pleasant tastes, but not in response to odors. In general, innate taste aversions seem to be quite robust and thus less likely to shift to a preference, whereas innate taste preferences seem to be more likely to shift to an aversion. According to the first study the innate preference for sweet tastes underlies hedonic shifts over time that is mostly due to food experiences and food attitudes. In fact, the sweet taste becomes less pleasant with increasing age, as indicated by less positive facial reactions. Such hedonic shifts were also expected in patients with eating disorers, who have an extreme anxiety to gain weight or who perceive food as threatening.

Therefore, the second study addressed the question of whether the gustofacial and olfactofacial responses are altered in patients with eating disorders. Dysfunctional eating behaviors were expected to moderate facial expressiveness in response to tastes but not in response to odors. Food signals energy, and thus food is perceived as a threat for shape and weight in patients with eating disorders. In contrast, the smell of odors is not associated with any caloric intake.

Indeed, facial reactions in response to tastes differentiated between patients with eating disorders and controls, quantitatively and qualitatively. The FACS results indicated that bulimics and binge eaters displayed a higher taste-elicited facial activity than did anorexic patients and/or controls which might be due to their greater food reactivity and the strong affect-laden link to food stimuli. Moreover, the gustofacial pattern in response to the tastes is altered in patients with binges, in particular in response to the sweet taste. Bulimics and binge eaters showed ambivalent displays in response to the low sweet taste and negative displays (disgust) in response to the high sweet taste. Moreover, the gustofacial reactions in response to the bitter, salty, sour, and umami tastes were altered in bulimics and binge eaters. It seems that any oral stimulation is accompanied by stronger facial responses in these patients. Unexpectedly, anorexics did neither show a lower facial activity nor did they show negative displays in response to the tastes as compared to the other groups. It may therefore be concluded that anorexics are less reactive to food cues compared to bulimics and binge eaters.

The groups did not differ in their quantitative and qualitative facial reactions to odors, since odors reflect no threat to shape and weight for eating-disordered patients. No substantial group differences were found in EMG activity, thus EMG might be less sensitive for the recording of facial reactions in response to tastes and odors. Likewise, subjective ratings did not correspond with the facial data, thus facial reactions may provide a more reliable measure for the affective value of tastes and odors.

Deficient inhibitory control might have also been associated with a greater facial expressiveness in response to tastes and odors in patients with dysfunctional eating behavior. Some researchers have already linked impulsivity and behavioral disinhibition to eating disorders, which are also core symptoms of patients with Attention-Deficit Hyperactivity Disorder. Therefore the third study examined whether deficits in inhibitory control are associated with a greater overall facial activity in response to tastes, odors, and cartoons in patients with Bulimia and Attention-Deficit Hyperactivity Disorder (ADHD). It was expected that facial motor control is disinhibited in ADHD patients resulting in a higher frequency of facial reactions in response to all stimuli.

In accordance to the finding of the second study, bulimics displayed a greater taste-elicited overall facial activity during sponataneous facial reactions, but not during the facial suppression task, which accounts for their increased reactivity to food cues. More specifically, they are attracted or disgusted by the sight and smell of food which is expressed by a greater facial activity. Likewise, ADHD patients displayed a greater overall facial activity in response to tastes, odors, and cartoons during the facial suppression task, which, in contrast to bulimics, is due to their deficient inhibitory control. The results suggest that ADHD patients may have more problems in voluntarily controlling emotional expressions than Bulimia Nervosa patients. In addition, bulimics were found to smile more often in response to cartoons when they were asked to suppress their facial behavior, which however was confounded by funniness rating of the cartoons.

In sum, ADHD patients' greater expressiveness in response to tastes, odor, and cartoons might be due to their deficient inhibitory control, whereas bulimics' greater expressiveness in response to tastes might be due to greater food reactivity.

For the first time it was shown that eating disorders and altered facial reactions as well as deficient inhibitory control and altered facial reactions are linked with each other. The results from study 2 and 3 definitively need further validation. However, the finding of a heightened taste-elicited overall facial activity in bulimics found in study 2 has been already replicated in study 3. Other variables which were also discussed as moderator in the model of facial reactions were not directly investigated in this study. Rather some of these moderators were assessed in this study in order to control for their influences on facial reactions to tastes and odors, as it was the case for taste and odor sensitivity and subjective expressivity.

In conclusion, facial reactions have contributed to a better understanding of emotional reactions in response to food stimuli in patients with eating disorders, Attention-Deficit Hyperactivity Disorder, and healthy controls. Gustofacial and olfactofacial reactions have been highlighted as indicator representing peoples' corresponding emotional states and as social-communicative signals.

Appendix A: FACS and EMG, further results, preparation of taste stimuli

A01: Measurement of facial reactions with FACS and EMG
A02: Intensity of specific facial reactions (study 1)
A03: Facial reactions to tastes before and after swallowing (study 1)
A04: Taste-elicited overall facial activity for both observation periods (study 2)
A05: Specific facial reactions (Bonferroni correction, study 2)
A06: Manipulation check of suppression of facial reactions (study 3)
A07: Influence of bitter sensitivity on intensity and overall facial activity (study 3)
A08: Herstellung der Geschmacksproben

Appendix B: Instructions and rating scales

B01: Patienteninformation
B02: Einwilligung
B03: Instruktionen zum Geschmacksversuch
B04: Skalen für die Einschätzung der Geschmacksreize
B05: Qualitätsprofil der Geschmacksreize
B06: Instruktionen zum Geruchsversuch
B07: Skalen für die Einschätzung der Geruchsreize
B08: Qualitätsprofil der Geruchsreize
B09: Instruktion und Skala zur Einschätzung der Witze
B10: Witze in Studie 3
B11: Nachbefragungsbogen
B12: Demographische Daten

Appendix C: Tables and Figures

Table C01: Concentrations of the taste solutions in study 1, 2, and 3
Table C02: Order of taste stimuli in study 1, 2, and 3
Table C03: Order of odor stimuli in study 1
Table C04: Order of odor stimuli in study 2
Table C05: Order of odor stimuli in study 3

Study 1:
Table C06: Sample characteristics
Table C07: Intensity, pleasantness, and mood ratings in response to the tastes
Table C08: Identification rates of the tastes
Table C09: Intensity, pleasantness, and mood ratings in response to odors
Table C10: Identification rates of odors
Table C11: Frequency of Action Units in response to tastes – all AUs counted
Table C12: Frequency of Action Units in response to tastes – AUs counted once per person
Table C13: Inter-Rater Reliability for the taste codings
Table C14: Frequency of Action Units in response to odors – all AUs counted
Table C15: Frequency of Action Units in response to odors – AUs counted once per person
Table C16: Inter-Rater Reliability for the odor codings

Study 2:
Table C17: Diagnostic criteria of eating disorders

Table C18: Recruitment of eating-disordered patients in specialized clinics
Table C19: Sample characteristics
Table C20: Intensity, pleasantness, and mood ratings in response to the tastes
Table C21: Intensity, pleasantness, and mood ratings in response to the odors
Table C22: Frequency of Action Units in response to low concentrated tastes – all AUs counted
Table C23: Frequency of Action Units in response to highly concentrated tastes – all AUs counted
Table C24: Inter-Rater Reliability of taste codings
Table C25: Frequency of Action Units in response to odors – all AUs counted
Table C26: Inter-Rater Reliability of odor codings
Table C27: Corrugator activity in response to tastes
Table C28: Levator activity in response to tastes
Table C29: Zygomaticus activity in response to tastes
Table C30: Corrugator activity in response to odors
Table C31: Levator activity in response to odors
Table C32: Zygomaticus activity in response to odors
Table C33: SIAB-S subscales for the present and past state
Table C34: Comparisons across groups of the SIAB-S present state
Table C35: Comparisons across groups of the SIAB-S past state
Table C36: Results of the debriefing questionnaire
Table C37: Identification rates of the taste quality of the taste strips
Table C38: Overview of conditions (order of tastes, odors, session)

Study 3:

Table C39: Diagnostic criteria of childhood and adult Attention-Deficit Hyperactivity
Table C40: Sample characteristics
Table C41: Intensity, pleasantness, and mood ratings in response to the tastes
Figure C03: Taste stimuli profile
Table C42: Intensity, pleasantness, and mood ratings in response to the odors
Figure C03: Odors stimuli profile
Table C43: Perceived task difficulty and task performance in response to tastes and odors
Table C44: Frequency of Action Units during spontaneous facial reactions in response to tastes – all AUs counted
Table C45: Frequency of Action Units during suppressed facial reactions in response to tastes – all AUs counted
Table C46: Frequency of Action Units during spontaneous and suppressed facial reactions in response to odors – all AUs counted
Table C47: Frequency of Action Units during spontaneous facial reactions in response to cartoons – all AUs counted
Table C48: Frequency of Action Units during suppressed facial reactions in response to cartoons – all AUs counted
Table C49: Corrugator activity during spontaneous facial reactions in response to tastes
Table C50: Levator activity during spontaneous facial reactions in response to tastes
Table C51: Zygomaticus activity during spontaneous facial reactions in response to tastes
Table C52: Corrugator activity during suppressed facial reactions in response to tastes
Table C53: Levator activity during suppressed facial reactions in response to tastes

Table C54: Zygomaticus activity during suppressed facial reactions in response to tastes
Table C55: Corrugator activity during spontaneous and suppressed facial reactions in response to odors
Table C56: Levator activity during spontaneous and suppressed facial reactions in response to odors
Table C57: Zygomaticus activity during spontaneous and suppressed facial reactions in response to odors
Table 58: Funniness rating of 34 cartoons.
Table 59: Box Plots of the funniness rating of 34 cartoons.
Table 60: Correlations (Pearson) between specific facial reactions and funniness rating of each cartoon
Table 61: Correlations (Pearson) between specific spontaneous or suppressed facial reactions and funniness rating of each cartoon
Table 62: SIAB-S subscales for the present and past state
Table 63: Comparisons across groups of the SIAB-S present state
Table 64: Comparisons across groups of the SIAB-S past state
Table 65: Results of the debriefing questionnaire
Table 66: Identification rates of the taste quality of the taste strips
Table 67: Subscales of the ADHS-SR questionnaire
Table 68: Overview of conditions (order of tastes, odors, cartoons, session)

Appendix A: FACS and EMG, further results, preparation of taste stimuli

A01: Measurement of facial reactions with FACS and EMG

Facial reactions can be measured by observational system such as the Facial Action Coding System (FACS, Ekman & Friesen, 1978; Ekman et al., 2002) or by electromyography. In the next sections each method will be individually described and advantages and disadvantages of each method are identified.

The **Facial Action Coding System** (FACS, Ekman & Friesen, 1978) is an objective, standardized, and descriptive system to classify every conceivable human facial expression. Based upon a notational system of the anatomy of facial movements by the Swedish anatomist Hjortsjö (1970), FACS was developed by Paul Ekman and Wallace Friesen in 1978 and slightly revised in 2002 (Ekman et al.). Coders manually classify facial expressions according to the FACS criteria while viewing recorded facial behavior in slow motion or frame by frame. FACS consists of 44 different facial displays which include 30 Action Units (AUs) and 14 miscellaneous actions. Visible facial muscle movements relate to a number for Action Units (AU). AUs have a specified anatomic basis, whereas for miscellaneous actions anatomic related muscles have not been established (see Table). The goal of FACS is to describe the movements and underlying muscular actions rather than to make inferences about the meanings of facial behaviors. According to the FACS criteria in the manual, each facial action is precisely described on the basis of anatomical appearance changes. Facial actions can be classified singly or in combination. Each facial action consists of 3 stages: the onset of the facial action, the apex in which the action reaches the maximum expression, and the offset of the facial action. Dependent on the research question, FACS coders' task is to (1) determine which Action Unit(s) represent the observed facial movement, (2) to score the intensity of facial actions, and (3) to score the asymmetry or unilaterality of facial reactions. The intensity of a facial movement can be rated for almost all Action Units on a 5-point scale (A – trace, B – slight, C – marked, D – severe, E – extreme). It may happen that the intensity of facial expressions on one side of the face is stronger than on the other side of the face - a phenomenon which is called facial asymmetry (Borod, 1993; Borod, Haywood, & Koff, 1997; Ekman, Hager, & Friesen, 1981). For certification as a FACS coder the proficiency test is required. Certified coders have successfully reached a level of agreement with a reference coder of at least .70 (reliability averaged across all AUs) and thus can reliably classify facial reactions according to the FACS criteria. Agreement or inter-rater reliability (IR) is defined by the [(number of AUs on which Coder 1 and Coder 2 agreed) × 2] divided by the total

Table 1: Action Unit in the FACS and the muscles involved to from their appearance.

AU	Name	Muscles
1	Inner Brow Raise	Frontalis, pars medialis
2	Outer Brow Raise	Frontalis, pars lateralis
4	Brow Lower	Depressor glabellae, Depressor supercilii, Corrugator supercilii
5	Upper Lid Raise	Levator palpebrae superioris
6	Cheek Raise	Orbicularis oculi, pars orbitalis
7	Lids Tight	Orbicularis oculi, pars palpebralis
8	Lips Toward	Orbicularis Oris
9	Nose Wrinkle	Levator labii superioris alaeque nasi
10	Upper Lip Raise	Levator labii superioris, caput infraorbitalis
11	Nasolabial Deepen	Zygomaticus minor
12	Lip Corner Pull	Zygomaticus major
13	Sharp Lip Pull	Levator anguli oris (Caninus)
14	Dimpler	Buccinator
15	Lip Corner Depress	Depressor anguli oris (Triangularis)
16	Lower Lip Depress	Depressor labii inferioris
17	Chin Raise	Mentalis
18	Lip Pucker	Incisivii labii superioris, Incisivus labii inferioris
19	Tongue Show	
20	Lip Stretch	Risorius
21	Neck Tighten	
22	Lip Funnel	Orbicularis oris
23	Lip Tight	Orbicularis oris
24	Lip Press	Orbicularis oris
25	Lips Part	Depressor labii inferioris, relaxed Mentalis and Orbicularis oris
26	Jaw Drop	Relaxed Masseter, Temporalis and Pterygoideus
27	Mouth Stretch	Pterygoideus, Digastric
28	Lip Suck	Orbicularis oris
29	Jaw Thrust	
30	Jaw to Sideways	
31	Jaw Clench	
32	Bite	
33	Blow	
34	Puff	
35	Cheek Suck	
36	Tongue Bulge	
37	Lip Wipe	
38	Nostril Dilate	Nasalis, pars alaris
39	Nostril Compress	Nasalis, pars transversa, Depressor septi nasi
41	Lids Droop	Relaxed Levator palpebrae superioris
42	Slit	Orbicularis oculi
43	Eyes Closed	Relaxed Levator palpebrae superioris
44	Squint	Orbicularis oculi, pars palpebralis
45	Blink	Relaxed Levator palpebrae superioris, tensed Orbicularis oculi
46	Wink	Orbicularis oculi

Note: AU 41, 42, and 44 not included in FACS (Ekman, Friesen, & Hager, 2002), some Action Units are not innervated by a specific muscle.

number of AUs scored by the two coders. The proficiency test does not require an agreement of the intensity scoring. FACS can be used reliably to code spontaneous facial expressions, which has been demonstrated recently by Sayette, Cohn, Wertz, Perrott, & Parrott (2001) for the reliability of FACS coding for single AUs and for single AU intensities. Several studies revealed good inter-rater reliabilities (Ekman, 1988; Frank, Ekman, & Friesen, 1993; Hess & Kleck, 1990). In general, an agreement of .80 in empirical studies is required to ensure reliable FACS coding, which is often successfully fulfilled. In sum, FACS is a comprehensive fine-graded and reliable system to classify human facial expression.

Electromyography (EMG) is a method to record muscular contraction with the electromyograph detecting the electrical activity generated by stimulated muscle cells. If a muscle is stimulated, the electrical events of the muscle action potential cause a brief reversal (depolarization) of the resting membrane potential which is recorded as the EMG response (see Goldstein, 1972).

There are two different approaches in which EMG activity can be measured either by surface electrodes which are located on the skin over the muscle, or by monopolar needle electrodes which are inserted into the skin (subcutaneous) or directly into the muscle (intramuscular). As a consequence of their non-invasive nature, surface electrodes are more appropriate for psychophysiological studies in humans. Surface EMG activity is recorded using bipolar placements of Ag/AgCl surface electrodes on the left side of the face according to the guidelines of Fridlund and Cacioppo (1986). In addition, a ground or a reference electrode may be used. EMG recording are susceptible for several artifacts. It is likely that other physiological signals in the area of the electrodes that do not originate in skeletal muscle are depicted in the EMG response (Goldstein, 1972; Schandry, 1998; Rösler, 2001). Movements can also cause artifacts in EMG response and are less likely to be controlled (Schandry, 1998). Moreover, a cross talk between different muscles may occur, in which activity of one muscle spreads to another muscle (Loeb, 1986; Vrana, 1993). There are several studies contributing to the good reliability of EMG measurement for different muscles (Ferstl, Rief, & Naumann, 1985; see review Sauermann, 1985; Tassinary, Cacioppo, & Geen, 1989).

EMG has been used in a variety of contexts to measure hedonic, emotional, and cognitive responses to both auditory and visual stimuli (Schwartz et al., 1976; Schwartz et al., 1979; Dimberg, 1982; Cacioppo, Petty, Losch, & Kim, 1986), imagery (Schwartz, Ahern & Brown, 1980; Vrana 1993), odors (Armstrong et al., 2007; Jäncke & Kaufman, 1994), and tastes (Armstrong et al., 2007; Chapman et al., 2009; Epstein & Paluch, 1997; Hu et al., 1999; Horio, 2003). EMG studies of facial responses to hedonic stimuli consistently indicate that the

3 commonly used muscles for detecting changes are the corrugator supercilii, levator labii, and zygomaticus major. Studies that used electromyography to assess facial reactions in response to tastes and odors found that the levator labii muscle, i.e. upper lip raise (AU 10), is indicative for taste unpleasantness (Armstrong et al., 2007; Chapman et al., 2009; Hu et al., 1999) and for odor unpleasantness (Armstrong et al., 2007; Jäncke & Kaufman, 1994). Unpleasant stimuli elicit a higher levator labii activity, whereas pleasant stimuli elicit a lower levator labii activity. The activity of the levator labii, which is the lifting of the middle of the upper lip (FACS, AU 10), has often been associated with the prototypical disgust reaction (Darwin, 1872; Ekman & Friesen, 1975; Horio, 2003; Hu et al., 1999; Izard, 1971; Rozin et al., 2000; Rozin et al., 1994; Vrana, 1993, 1994). Moreover, greater corrugator activity (AU 4) was found in response to unpleasant tastes compared to more pleasant tastes in adults (Horio, 2003). In contrast, the zygomaticus major, indicative for smiling (AU 12), did not differentiate between the four basic tastes and different odors in children (Armstrong et al., 2007). In an adult sample, however, greater zygomaticus activity was found in response to the pleasant tastes (Jäncke & Kaufman, 1994). To sum up, electromyographic studies have consistently found a greater corrugator and levator activity associated with unpleasant tastes and odors, whereas conflicting results have been reported for the zygomaticus major activity.

Both measures have advantages and disadvantages, which are referred to in the following. FACS is a reliable fine-grained and comprehensive system to describe the muscular appearance changes in the face. Even facial movements that are too subtle and rapid, i.e. microexpressions, can be measured by FACS. In contrast to EMG, FACS can be made unobtrusive. Facial behavior has to be recorded on video before it can be analyzed according to the FACS criteria. The recordings can be overt so that the participants are aware of being video-recorded or can be covert so that they are unaware. The advantage to record facial expressions unobtrusively is that the focus of attention and self awareness do not influence facial displays. Dependent on the research questions, facial reactions of special interest can be observed. Despite these advantages, FACS is a relatively time-consuming method which requires a lot of experience in coding, extensive training, and repeated viewing of videos, using slow motion. The FACS coding requires the presence of human observers, which are highly trained, as well as technique to ensure recording and watching of facial behavior (video camera, cassettes, and a computer). FACS can not detect changes in muscle tension. Moreover facial expression analysis with FACS requires a very good quality of video material, in which the face is frontally recorded (Kappas, Hess, Barr, & Kleck, 1994). The frontal view is sometimes difficult to achieve, especially in unobtrusive situations or when the participants move too much during the experiment.

In contrast to FACS, EMG does not need a trained person to code facial expressions. However, the EMG signal also requires a trained person for data analysis. In comparison with FACS, EMG requires less time to learn the method and to perform data analysis. EMG, however, requires time to attach electrodes prior to the experiment and this time depends on the number of muscle regions of interest. EMG recording is able to detect muscle action potentials that are too weak or brief to produce a visible facial movement (Cacioppo, Martzke, Petty, & Tassinary, 1988; Cacioppo, Bush, & Tassinary, 1992; Dimberg, 1990; Vrana, 1993). Thus EMG can sensitively measure covert facial activity which can not be assessed by observational techniques (Cacioppo, Fridlund, & Izard, 1983; Martzke, Petty, & Tassinary, 1988; Vrana, 1993). Facial EMG requires expensive amplification, filtering, and integrating hardware, as well as a computer and specialized software for signal processing. Often cross talk is a problem in EMG recordings, in which muscular activity is not exclusively associated with one muscle. Participants are limited in their movements during recordings (cables). In contrast to FACS, facial behavior is difficult to be unobtrusively recorded by EMG since electrodes are attached to the participants' face. Therefore the attention is focused on the face, which increases self awareness of participants (Hager & Ekman, 1983; Frank & Ekman, 1993). As Manstead (1991) pointed out, advantages of EMG are its immediacy, precision, sensitivity, and objectivity. FACS provides the same precision, sensitivity, and objectivity, and furthermore can be made unobtrusive. However, FACS is characterized by its nonimmediacy since facial behavior has to be classified by a coder. Both methods are established for facial expression analysis and have a satisfactory to good reliability and validity. The facial analysis of subtle actions over time can be best done by EMG. The analysis of stimuli that elicit visible facial actions can be best studied with FACS that provides a holistic view rather than a cut of the changes in the face.

Few studies have compared facial activity using both methods, FACS and EMG. Two studies revealed a good convergent validity between both methods (Ekman, Schwartz, & Friesen, 1988; unpublished data; Schneider-Düker, Heine, & Heine, 1986). However, the studies also showed that EMG sensitively measured covert facial movements and that several Action Units could not be detected by EMG response. Overall, both measures have advantages and disadvantages. The purpose of their combined use, which will be done in the second and third study, is to minimize each measure's weaknesses. Three muscles, i.e. corrugator, levator, and zygomaticus muscle, have been already reported to correlate with stimulus unpleasantness or pleasantness in electromyographic studies. These muscles refer to facial reactions that can be also assessed with FACS.

A02: Intensity of specific facial reactions (study 1)

Tastes: Intensity of several Action Units was affected by taste concentration of taste quality. More specifically, intensity of negative facial reactions, i.e. brow lower, nose wrinkle, and upper lip raise was higher with increasing concentration of bitter, salty, and umami tastes. Also, in response to the sweet taste, brow lower was displayed more intense. Intensity of positive facial reactions, i.e. smiling, increased across concentrations of bitter and salty tastes. In contrast, facial intensity to sour tastes was unaffected by taste concentration.

In response to the bitter taste, analysis of variance revealed main effects of taste concentration for inner brow raise (AU 1), outer brow raise (AU 2), brow lower (AU 4), cheek raise (AU 6), upper lip raise (AU 10), lip corner pull (AU 12) and lip corner depress (AU 15) and jaw drop (AU 26). Subjects displayed stronger intensities of brow lower and upper lip raise to the medium and to the high concentration than to the low concentration. Lip corner depress was also displayed more intense when comparing the high with the low concentration. Subjects smiled more intense and therefore they displayed stronger intensities of cheek raise and lip corner pull to the high than to the low and to the medium concentration. The typical surprise expression was more intense to the high concentration than to the low concentration. Subjects opened their mouth more when comparing the high with the medium concentration.

In response to the salty taste, analysis of variance revealed main effects of taste concentration for inner brow raise (AU 1), outer brow raise (AU 2), brow lower (AU 4), cheek raise (AU 6), nose wrinkle (AU 9), upper lip raise (AU 10), lip corner pull (AU 12) and lip corner depress (AU 15). Brow lower, nose wrinkle and lip corner depress were displayed more intense to the high concentration than to the low concentration. Also, upper lip raise was more intense with increasing concentration, i.e. from low to medium, from low to high and from medium to high concentration.

When comparing high and low concentration, subjects displayed stronger intensities of surprise by inner and outer brow raise, as well as stronger intensities of brow lower, cheek raise, and lip corner pull.

In response to the umami taste, analysis of variance revealed main effects of taste concentration for inner brow raise (AU 1), brow lower (AU 4), nose wrinkle (AU 9) and upper lip raise (AU 10) and lip press (AU 24). Subjects displayed brow lower with greater intensity to the medium and to the high concentration than to the low concentration. Upper lip raise was displayed more intense to the medium concentration than to the low concentration. For the sweet taste, analysis of variance revealed a main effect of taste concentration for brow lower (AU 4). Brow lower was displayed more intense to the high concentration than to the low concentration. For the sour taste, analysis of variance revealed no main effect of taste concentration for any specific facial reaction.

To sum up, intensity of several Action Units was greater with increasing concentration of bitter, salty, sweet and umami tastes. Intensity of negative facial reactions was higher with increasing concentration of these taste qualities. For bitter and salty tastes also intensity of smiling and surprise increased across concentration. In contrast, intensity of sour tastes was unaffected by taste concentration.

		bitter			salty			sweet			umami		
Source	AU	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*
Taste concentration	1	2	3.97	.021	2	8.77	.000	2			2	3.88	.023
	2	2	3.69	.027	2	9.37	.000	2			2		
	4	2	8.60	.000	2	7.07	.001	2	5.42	.005	2	10.57	.000
	6	2	13.12	.000	2	12.12	.000	2			2		
	9	2			2	3.22	.042	2			2	4.06	.019
	10	2	15.38	.000	2	24.72	.000	2			2	11.05	.000
	12	2	17.00	.000	2	21.61	.000	2			2		
	15	2	5.58	.005	2	6.52	.002	2			2		
	26	2	3.82	.024	2			2			2		
error		162			162			162			162		

A03: Facial reactions to tastes before and after swallowing (study 1)

Some facial reactions were displayed more frequently after swallowing than before swallowing. For all taste qualities of low, medium, and high concentrations, lips part (AU 25) and mouth gaping (AU 26) occurred more frequently after swallowing than before swallowing (*ps* < .05). This is not surprising, since the participants had to keep the solutions in their mouth for at least 5s, and were consequently less able to open their mouth. Additionally, the following facial displays occurred more often after swallowing than before swallowing: lip corner pull (AU 12) in response to low and medium sweet taste and high umami taste; dimpler (AU 14) in response to low, medium, and high sweet taste, low umami taste, and low and medium salty taste; lip press (AU 24) in response to low and medium sweet taste, low sour taste, and medium and high umami taste; bow lower (AU 4) in response to high sweet taste; lower lip depress (AU 16) in response to high sour taste; upper lip raise (AU 10) and mouth corner depress (AU 15) in response to high umami taste. In response to the bitter taste, facial reactions were equally observed before and after swallowing. Lids tight (AU 23) in response to the medium sour taste was the only facial display that occurred more often before swallowing than after swallowing.

A04: Taste-elicited overall facial activity for both observation periods (study 2)

The groups differed in their overall facial activity in response to the taste qualities, $F(12, 280) = 2.46$, $p = .005$ (taste quality × group interaction). In response to the sweet taste, bulimics and binge eaters displayed more facial reactions when compared to controls ($p = .003$, $p = .045$) and anorexic patients ($p < .001$, $p = .004$). In response to the salty taste, bulimics and binge eaters expressed more facial reactions when compared to anorexics ($p = .008$, $p = .005$). Bulimics expressed a higher overall facial activity in response to the sour taste than controls ($p = .001$) and anorexics ($p < .001$). The same pattern was found for binge eaters who displayed more facial reactions compared to anorexics ($p = .035$). In response to the bitter and umami taste, binge eaters displayed more facial reactions when compared to controls ($p = .052$, $p = .045$) and anorexics ($p = .001$, $p < .001$). Bulimics displayed more facial reactions in response to the bitter and umami taste when compared to anorexics ($p = .027$, $p = .003$). There was also a significant main effect of group, $F(3, 70) = 9.78$, $p < .001$. Furthermore, the analysis revealed significant main effects of taste quality, $F(4, 280) = 30.85$, $p < .001$, and taste concentration, $F(1, 70) = 104.51$, $p < .001$, which were qualified by a significant taste quality × taste concentration interaction, $F(4, 280) = 4.50$, $p = .002$. Low and high concentrations of the sour taste elicited more facial reactions compared to the low and high concentration of the bitter ($ps < .001$), salty ($ps < .001$), sweet ($ps < .001$), and umami taste ($p = .034$, $p < .001$). Also, the low concentrated umami taste elicited a higher overall facial activity than did the low concentrated bitter ($p = .036$) and salty taste ($p = .046$). Within high concentrations, more facial reactions were displayed in response to the salty taste compared to the sweet taste ($p = .018$).

A05: Specific facial reactions (Bonferroni correction, study 2)

	Before swallowing	After swallowing
Bitter_high	AU 15: BE>AN*	AU 14: BE>AN*
Salty_low		AU 26: BN>AN*
Salty_high	AU 1: BN>C* AU 15: BE>AN/C*	
Sour_low		AU 14, 26: BN>C*
Sour_high		AU 14, 24, 25, 26: BN>AN* AU 24: BN>C* AU 15: BE>C*
Sweet_low	AU 24: BE>C*	AU 4: BE>C* AU 25, 26: BN>AN*
Sweet_high	AU 10: BN>C*	AU 10: BN>C*
Umami_low	AU 4: BE>AN* AU 10: BN>AN*	

Note: C – Controls, AN – Anorexia Nervosa, BN – Bulimia Nervosa, BE – Binge-EAting Disorder
$^{*}p \leq .008$.

A06: Manipulation check of suppression of facial reactions (study 3)

In order to test whether the participants performed the task to suppress their facial reactions in response to tastes, odors, and cartoons successfully, overall facial activity was compared by repeated measures ANOVAs for each stimulus modality. Overall facial activity was expected to be lower in the suppressed task when compared to the spontaneous task in each subgroup. The analyses revealed that overall facial activity differed across task for tastes, $F(1, 33) = 112.22$, $p < .001$, odors, $F(1, 33) = 38.0$, $p < .001$, and cartoons, $F(1, 33) = 91.79$, $p < .001$. As expected, participants displayed fewer facial reactions during the suppressed task in response to tastes ($M = 47.5$, $SD = 21.2$), odors ($M = 8.2$, $SD = 5.0$), and cartoons ($M = 3.8$, $SD = 4.6$) than during the spontaneous task in response to these stimuli (tastes: $M = 81.3$, $SD = 22.1$; odors: $M = 16.5$, $SD = 8.8$; cartoons: $M = 10.47$, $SD = 4.8$), respectively. There was no significant task × group interaction for tastes, $F(2, 33) = .44$, $p > .05$, odors, $F(2, 33) = .56$, $p > .05$, and cartoons, $F(2, 33) = .24$, $p > .05$, which indicates that all groups successfully suppressed their facial reactions in response to the stimuli. In sum, each subgroup accomplished the task to suppress facial reactions, which was even the case for ADHD patients who suffer from deficient inhibitory control contributing to inattention, hyperactivity, and impulsiveness.

A07: Influence of bitter sensitivity on intensity and overall facial activity (study 3)

Intensity rating: When correcting for Prop Ratio (intensity rating of 0.32mM PROP divided by intensity rating of 0.1M NaCl) in a further repeated measures ANOVA, the taste quality × group interaction did not reach statistical significance, $F(8, 128) = 2.22$, $p = .070$. Thus the group differences of bitter intensity are explained by the bitter sensitivity. The main effect of taste quality remained significant, $F(4, 128) = 9.92$, $p < .001$, and the main effect of group remained non-significant, $F(2, 32) = .065$, $p > .05$.

Spontaneous taste-elicited overall facial activity: Since the overall facial activity in response to the bitter taste might be moderated by the genetically determined bitter sensitivity in terms of Prop Ratio, ANOVAs were conducted for each observation period, once without and then with correcting for PROP Ratio. Prop Ratio was defined by intensity rating of 0.32mM Prop divided by intensity rating of 0.1M NaCl.

When uncorrected for Prop Ratio, the groups differed in their overall facial activity in response to the bitter taste before swallowing, $F(2, 35) = 8.02$, $p = .001$, and after swallowing, $F(2, 35) = 3.37$, $p = .046$. Thus, ADHD patients produced a significantly greater amount of facial reactions than did controls before swallowing ($p = .002$) and after swallowing ($p = .013$) of the bitter taste. When corrected for Prop Ratio, the analysis revealed that the higher overall facial activity elicited by the bitter taste in ADHD patients before swallowing could not be explained by the bitter sensitivity, since the group effect remained significant, $F(2, 32) = 6.68$, $p = .004$. Again, ADHD patients displayed more facial reactions than did controls before swallowing ($p = .003$). However, after swallowing the bitter sensitivity could explain the group differences ($F(2, 32) = 2.40$, $p = .107$) since the group effect between ADHD patients and controls disappeared ($p = .227$).

In general, ADHD patients' overall facial activity in response to the bitter taste seems not be affected by bitter sensitivity before swallowing. Thus the higher facial activity elicited by the bitter taste in ADHD patients might be due to other causes, presumably deficient inhibitory deficits. After swallowing, however, ADHD patients' overall facial activity elicited by the bitter taste seems to be moderated by bitter sensitivity.

Suppressed taste-elicited overall facial activity: To explore whether overall facial activity elicited by the bitter taste is moderated by the genetically determined bitter sensitivity in terms of Prop Ratio, ANOVAs without and with correction for PROP Ratio were conducted for each observation period. When uncorrected for Prop Ratio, the groups differed in their overall facial activity in response to the bitter taste before swallowing, $F(2, 35) =$

4.93, *p* = .013. ADHD patients produced significantly more facial reactions than controls before swallowing of the bitter taste (*p* = .014). When corrected for Prop Ratio, the group difference remained significant, *F*(2, 32) = 4.02, *p* = .028, with ADHD patients displaying more facial reactions than controls before swallowing (*p* = .026). Overall, the higher overall facial activity of the bitter taste before swallowing in ADHD patients was not affected by the bitter sensitivity. Thus the higher facial activity elicited by the bitter taste in ADHD patients might be due to other causes, presumably deficient inhibitory deficits.

A08: Specific facial reactions (Bonferroni correction, study 3) Next page!

This Table lists all significant differences in specific reactions. *Italic letters* refer to $p \leq .07$, normal letters refer to $p \leq .05$, and **bold face letters** (Bonferroni corrected) refer to $p \leq .017$.

	bitter		salty		sour		sweet		umami		water	
AU	spontaneous	suppressed	spontaneous	suppressed	spontaneous	suppressed	spontaneous	suppressed	spontaneous	suppressed	spontaneous	suppressed
2	*ns*	*ns*	*ns*	*ns*	*ns*	After: *ADHD<BN* *BN>C*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
4	Before **ADHD>C** ADHD>BN	Before **ADHD>C** *ADHD>BN* After ADHD>C	Before ADHD>C	*ns*	*ns*	Before ADHD>C	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
6	Before ADHD>C/BN	*ns*	After *:BN<C* ADHD>BN	*ns*	Before BN<C	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
7	Before **ADHD>C** ADHD>BN	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	After ADHD>BN	*ns*	*ns*	*ns*
10	Before **ADHD>C** ADHD>BN	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
12	*ns*	*ns*	Before:ADHD<C **BN<C**	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	Before BN/ADHD<C	*ns*	*ns*
14	*ns*	*ns*	*ns*	*ns*	*ns*	After ADHD>C/BN	Before **BN>C**		Before ADHD>C **BN>C**		Before BN>C After ADHD>C	Before ADHD>C
15	Before ADHD>BN After **ADHD>C/BN**	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
17	Before ADHD>BN	*ns*	*ns*	*ns*	Before ADHD>C	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
23	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	After *:BN>C* *ADHD<BN*	*ns*	*ns*
24	*ns*	Before ADHD/BN>C	Before: ADHD>C **BN>C** After *ADHD/BN>C*	Before **ADHD>C**	Before:ADHD>C After **ADHD>C** ADHD>BN	Before:**ADHD>C,** BN>C After**: ADHD>C**	*ns*	*ns*	*ns*	Before ADHD>C **BN>C**	*ns*	*ns*
25	*ns*	*ns*	*ns*	*ns*	*ns*	After :ADHD>C **ADHD>BN**	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
26	Before ADHD>C/BN	*ns*	*ns*	*ns*	*ns*	After ADHD>C/BN	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
28	*ns*	*ns*	*ns*	*ns*	After : BN>C	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
34	Before:ADHD<C	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
50	*ns*	*ns*	After:ADHD>BN	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

A09: Herstellung der Geschmacksproben

Die Herstellung der Geschmackslösungen erfolgte in einem Raum des Lehrstuhls für Psychologie I an der Universität Würzburg. Materialien für die Herstellung der Lösungen waren mehrere Vierkant – Enghalsflaschen, Messbecher, Wasserkocher, Glasmessflaschen, Trichter, destilliertes Wasser und die Geschmacksstoffe 6-n-Propylthiouracil (PROP), Zitronensäure, Natriumchlorid, Saccharose und Mononatriumglutamat. Destilliertes Wasser wurde von einer Apotheke (Bavaria Apotheke, Würzburg, Demineral Cubitaine) bezogen. Der Bitterstoff PROP wurde von der Firma Merck-VWR (Darmstadt), Zitronensäure und Natriumchlorid von einer weiteren Apotheke (Adler Apotheke, Dinkelsbühl) und Saccharose, der handelsübliche Zucker, im Supermarkt erworben. Mononatriumglutamat wurde kostenfrei von Ajinomoto Foods Deutschland GMBH zur Verfügung gestellt. Für die Applikation der Lösungen wurden Aufziehspritzen mit 5 ml bzw. 10 ml Fassungsvermögen von der Firma A. Hartenstein (Würzburg) verwendet. Kleine und große Plastikbecher wurden von der Firma Festartikel Hirschfeld (Wuppertal) erworben.
6-n-Propylthiouracil ($C_7H_{10}N_2OS$): Für die Herstellung der PROP-Lösungen wurde 1 Liter destilliertes Wasser mit dem Wasserkocher abgekocht. 544 mg PROP-Pulver wurden in die 1-Liter - Glasflasche gefüllt und das auf lauwarme Temperatur abgekühlte destillierte Wasser wurde hinzugegeben. Die Mischung in der Glasflasche wurde dann so lange geschüttelt bis sich das Pulver vollständig aufgelöst hatte. Von dem Inhalt wurden 900 ml PROP-Lösung mit einer Konzentration von 3.20 mM mit dem Messbecher entnommen und in eine 1000 ml – Vierkant – Enghalsflasche gefüllt und beschriftet. Die restlichen 100 ml in der 1 l-Glasflasche wurden mit 900 ml destilliertem Wasser aufgefüllt und geschüttelt. Von dieser 0.32 mM konzentrierten Lösung wurden dann erneut 900 ml in eine weitere 1000 ml – Vierkant – Enghalsflasche gefüllt und beschriftet. Die restlichen 100 ml in der 1 l-Glasflasche wurden mit 900 ml destilliertem Wasser aufgefüllt und geschüttelt, wodurch sich eine PROP- Lösung mit einer Konzentration von 0.032 mM ergab. Insgesamt standen drei verschiedene PROP-Konzentrationen zur Verfügung.
Zitronensäure ($C_6H_8O_7$), Natriumchlorid (NaCl), Saccharose ($C_{12}H_{22}O_{11}$) und Mononatriumglutamat ($NaC_5NO_4H_8$): Im Gegensatz zur Herstellung der bitteren Lösungen (PROP) standen für die Herstellung der sauren, salzigen, süßen und umami- Lösungen für jede Konzentration abgewogene Mengen abgefüllt in kleinen Plastiktüten zur Verfügung. Das Abwiegen dieser Stoffe erfolgte in einer Apotheke (Adler Apotheke, Dinkelsbühl). Nach Abkochen des destillierten Wassers wurde der komplette Inhalt einer in einer Plastiktüte enthaltenen Geschmacksqualität in die 1 l- Glasflasche geleert und mit 1 Liter lauwarmen destilliertem Wasser aufgefüllt, geschüttelt und in eine 1000 ml – Vierkant – Enghalsflasche umgefüllt. Diese Prozedur wiederholte sich für die übrigen Geschmacksstoffe. Auf den Vierkant - Enghalsflaschen wurde die Geschmacksqualität, Konzentrationsstufe und Herstellungsdatum mit Edding vermerkt. Aufgrund der bakteriellen Anfälligkeit der Lösungen wurden sie im Kühlschrank bzw. bei längerer Nichtverwendung im Gefrierfach gelagert. Beim Eingefrieren der Lösungen durfte das Fassungsvermögen der 1 l-Flaschen maximal bis zu 80% ausgeschöpft werden, um den Ausdehnungsprozess der Lösungen beim Gefriervorgang zu berücksichtigen. Die Haltbarkeit der Lösungen im gefrorenen Zustand beträgt ca. 8 bis 12 Monate.

Appendix B: Instructions and rating scales

B01: Patienteninformation

Sehr geehrte Patientin,

Diese Patienteninformation informiert Sie über das Forschungshaben mit dem Titel:

„Emotionale Reaktionen auf Geschmacks- und Geruchsreize bei Personen mit Essstörungen“

Wir „Forscher“ möchten Sie um Ihre Beteiligung an diesem Projekt bitten. Zuvor erläutern wir Ihnen die Ziele des Projekts, benennen Verantwortliche, Ansprechpartner und beteiligte Stellen (1. und 2.). Wir beschreiben den Ablauf des Projektes und Ihren Anteil daran (3.). Als Schwerpunkte schildern wir, woher und wie die Forschungsdaten erhoben werden und wie wir mit den Daten umgehen (Stichworte: Ethik, Freiwilligkeit und Datenschutz; 4. und 5.). Auf der Grundlage dieser Informationen können Sie in aller Ruhe Ihre Entscheidung treffen, ob Sie teilnehmen möchten oder nicht. Diese Information können Sie in jedem Fall behalten. Falls Ihnen etwas unklar ist, können Sie Ihren Ansprechpartner befragen (auch später, wenn Sie sich bereits entschieden haben).

1.) Wer ist die verantwortliche Stelle für das Forschungsvorhaben?

Hauptverantwortung: Dipl.-Psych. Romy Weiland von der Universität Würzburg, Lehrstuhl 1 Klinische Psychologie, Marcusstrasse 9-11, 97070 Würzburg, Tel.: 0931/312837

2.) Worum geht es bei diesem Forschungsvorhaben? Warum findet es während der Rehabilitation statt?

Sie erhalten in der Klinik alle notwendigen und geeigneten Untersuchungen/Behandlungen, die zur wesentlichen Besserung oder Wiederherstellung Ihrer Gesundheit und Leistungsfähigkeit beitragen. Wir sind ständig bemüht, unser Behandlungsangebot den neuesten Erkenntnissen anzupassen und auch einen eigenen Beitrag hierzu zu leisten. Deshalb unterstützen wir das Forschungsvorhaben **„Emotionale Reaktionen auf Geschmacks- und Geruchsreize bei Personen mit Essstörungen“** von Frau Romy Weiland. Unsere Ärzte und weitere Mitarbeiter(innen) unserer Rehabilitationseinrichtung sind aktiv an der Sammlung der Daten beteiligt und bilden die Verbindungsstelle zu dem Forschungsinstitut. Ziel dieses Projektes ist es, emotionale Reaktionen auf Geschmacks- und Geruchsreize bei Patienten mit verschiedenen Essstörungen (Anorexie, Bulimie, Binge-Eating Störung) zu untersuchen. Für die Datenauswertung werden statistische Programme verwendet. Je mehr Personen teilnehmen, umso aussagekräftiger werden die Ergebnisse. Es war deshalb naheliegend, die Daten in einer Rehabilitationseinrichtung zu erheben, in der regelmäßig viele Patienten mit Essstörungen behandelt werden. Die Daten werden unter Einbeziehung der Patientinnen erhoben.

3.) Wie läuft das Projekt ab? Was sollen Sie tun?

Durch unsere Rehabilitationseinrichtung wurde vorab geprüft, ob Sie für die Teilnahme an dem Forschungsprojekt überhaupt in Frage kommen. Das ist der Fall. Sollten Sie sich für eine Teilnahme entscheiden, werden Daten folgendermaßen erhoben: Mitarbeiter der

Rehabilitationseinrichtung und Dipl.- Psych. Romy Weiland der Universität Würzburg werden mit Ihrer Einwilligung Daten aus der Krankenblattakte entnehmen. Davon sind auch Angaben betroffen, die unserer Rehabilitationseinrichtung von den Leistungsträgern zur Durchführung der Rehabilitationsmaßnahme übermittelt wurden, z.B. Vordiagnosen, Medikation und Gewicht. Selbstverständlich wollen wir auch die im Verlaufe Ihres Aufenthaltes gewonnenen medizinischen Daten nutzen. Ohne diese Daten ist das gesamte Forschungsvorhaben nicht sinnvoll durchzuführen. Wir bitten Sie daher, in die Nutzung dieser Daten einzuwilligen (siehe Einwilligung).

Die Untersuchung findet an 3 verschiedenen Terminen in der Klinik statt. Zur Teilnahme am Versuch sollten Sie folgende Voraussetzungen erfüllen: Vorliegen einer Essstörung (Anorexie, Bulimie, Binge-Eating Störung), Nichtraucherin, Rechtshänderin, keine Störung des Geschmacks- und Geruchssinns. Am zweiten und dritten Termin ist es notwendig, dass Sie 2 Stunden vor der Untersuchung nichts mehr essen (kein Bonbon, Kaugummi, Kaffee), nicht rauchen, nicht die Zähne putzen und am besten nur noch Wasser trinken. Sollten Sie am Tag der Untersuchung eine Erkältung haben, wird ein neuer Termin mit Ihnen vereinbart.
Die 3 Termine laufen folgendermaßen ab:

1. Termin: Am ersten Termin füllen Sie einen Fragebogen aus. Zum Ausfüllen dieses Fragebogens werden durchschnittlich 30-60 Minuten benötigt.
2. Termin: Am zweiten Termin sollen Sie mehrere Geschmacks- und Geruchsproben anhand verschiedener Merkmale, z.B. Intensität, einstufen. Während des Geschmacks- und Geruchsversuchs, wird die Gesichtsmuskelaktivität gemessen (siehe Erklärung Elektromyogramm) und der gesamte Versuch wird mit einer Videokamera aufgezeichnet. Weiterhin füllen Sie noch weitere Fragebögen aus. Der zweite Termin wird ca. 90 Minuten dauern.
3. Termin: Am dritten Termin wird Ihre Geschmacks- und Geruchsschwelle bestimmt. Dieser Termin wird ca. 30 Minuten in Anspruch nehmen.

Als Vergütung für die Teilnahme erhalten Sie nach Beendigung des 3. Termins € 20. Dieses Geld soll Sie für das dreimalige Teilnehmen am Versuch und das während dieser Zeit nicht in Anspruch genommene fakultative therapeutische Angebot, Ihren Freizeitverlust, sowie Ihren Verzicht auf Essen und Genussmittel zwei Stunden vor zwei Versuchsterminen entschädigen.

4.) Wie wird mit den Forschungsdaten umgegangen? Wer erfährt die Namen der Teilnehmerinnen (Datenschutz)?

Datenschutzrechtliche Bestimmungen sind immer dann zu beachten, wenn Daten einer Person zugeordnet werden können. Für die wissenschaftliche Auswertung spielt Ihr Name jedoch keine Rolle. Wie es die Datenschutzgesetze fordern, werden die für die Auswertung vorgesehenen Daten ohne Personenbezug streng getrennt von den Namen aufbewahrt (§ 40 BDSG, Bundesdatenschutzgesetz). Namen benötigen wir nur, um Ihre Einwilligung zur Teilnahme an der Studie zu dokumentieren. Wir verwenden in den Forschungsdaten nicht Ihren Namen. Ihr Name wird durch eine Forschungsnummer (Codenummer) ersetzt. Wir führen eine Zuordnungsliste (Aufbau: die Forschungsnummer, Name). Diese Liste ist nur Frau Romy Weiland und wenigen Klinikmitarbeitern zugänglich. Die Liste wird niemandem bekannt gegeben, auch nicht dem wissenschaftlichen Forschungsinstitut (Universität Würzburg). Nach Abschluss der Datenerhebung ist die Zuordnungsliste nicht mehr erforderlich und wird vernichtet. Alle Fragebögen und die Daten aus der Patientenakte der Rehabilitationseinrichtung sind nur mit der Forschungsnummer gekennzeichnet. Durch die Forschungsnummer können Daten aus der Patientenakte, die von Ihnen ausgefüllten Fragebögen und Videoaufzeichnungen zusammengefügt und ausgewertet werden. Ihr Name ist nicht erforderlich. Das Forschungsinstitut erhält für die Auswertung nur Daten mit Forschungsnummer und kann keinen Personenbezug herstellen. Da die Anonymisierung der Videoaufzeichnungen nicht durch Vergabe einer Forschungsnummer zu erreichen ist, ist es aus datenschutzrechtlichen Gründen nötig, dass Frau Romy Weiland die Aufnahmen unter Ihrer ständigen Kontrolle hat und nur Ihr und einer weiteren an der Auswertung beteiligten Person zugänglich sind. Sobald die Videos ausgewertet sind, werden diese gelöscht. Alle Auswertungen werden anonym, also ohne Ihren Namen durchgeführt. Weder aus den Forschungsdaten noch aus den Ergebnissen kann auf Sie oder andere Teilnehmer zurückgeschlossen werden. Die Zuordnung zu Namen ist also nur Ihrer Rehabilitationseinrichtung möglich und nur in dem Zeitraum, in dem Daten erhoben werden. Die erhobenen Daten werden nicht in der Rehabilitationseinrichtung aufbewahrt, sondern sofort der Universität Würzburg zugeleitet. Durch diese strenge Trennung erreichen wir, dass niemand unnötig Forschungsdaten mit Ihrem Namen verbinden kann. Dennoch gelten die Forschungsdaten in diesem Zeitraum als „personenbezogene Daten" im Sinne der Datenschutzgesetze. Wir dürfen die Daten deshalb nur mit Ihrer ausdrücklichen, freiwilligen und schriftlichen Einwilligung erheben und auswerten (§ 4b BDSG). Zudem sind alle Forscher zum vertraulichen Umgang mit Ihren Daten verpflichtet worden. Die Forschungsdaten werden gespeichert und mit Statistikprogrammen ausgewertet. Alle Ergebnisse sind nie auf Einzelpersonen bezogen. Aus den Ergebnissen kann auch nicht auf Ihren Namen geschlossen werden. Um zu verhindern, dass die gespeicherten Forschungsdaten später mit anderen Daten vermischt und darüber ggf. wieder einer Person zugeordnet werden können, werden alle Daten nach der Auswertung gelöscht.

5.) Freiwilligkeit

Ihre Teilnahme an dem Projekt ist freiwillig. **Ihre Daten werden nur verwendet werden, wenn Sie die Einwilligung unterschrieben haben.** Sofern Sie eine Teilnahme nicht wünschen, brauchen Sie die Einwilligung nicht abzugeben. Sie müssen Ihre Entscheidung nicht begründen oder rechtfertigen. Weder aus der Teilnahme noch aus einer Nichtteilnahme erwachsen Ihnen Nachteile. Wie auch Ihre Entscheidung ausfallen mag, sie hat auf die Durchführung Ihrer Rehabilitationsmaßnahme keinen Einfluss. Sie können jederzeit, also auch bei bereits erteilter Einwilligung und ohne Angabe von Gründen ausscheiden. Teilen Sie Ihren Wunsch dann bitte Dipl.-Psych. Romy Weiland mit. Wir werden dann Ihren Namen in der Zuordnungsliste unkenntlich machen. Wenn Sie es ausdrücklich wünschen, werden wir auch Ihre für die Forschung gesammelten Daten löschen.

6.) Bitte um Teilnahme

Wenn Sie das Vorangegangene gelesen haben, Ihnen der Inhalt klar ist und Sie an der Studie teilnehmen möchten, bitten wir Sie, die Einwilligungserklärung zu unterschreiben und bei Dipl.-Psych. Romy Weiland abzugeben. Sie erhalten eine Durchschrift. Bewahren Sie auch dieses Informationsschreiben auf, damit Sie jederzeit nachlesen können, in was Sie eingewilligt haben. Sollten Sie nicht teilnehmen wollen, müssen Sie nichts unternehmen. Ihre Daten werden nur verwendet, wenn Sie eingewilligt haben.

7.) Was erfährt meine Krankenkasse oder mein Rentenversicherungsträger?

Dieses Forschungsvorhaben erfolgt im eigenen Interesse der Universität Würzburg und wird von der Burg-Klinik unterstützt. Ihre Krankenkasse und Ihr Rentenversicherungsträger sind über die Durchführung des Projektes informiert und erhalten anonyme Ergebnisdaten. Es wird niemandem mitgeteilt, welche Patienten teilgenommen haben oder nicht.

B02: **Einwilligung**

(ein Exemplar für die Forschung, ein Exemplar für die Patientin

Name:___________ Vorname:___________ Geburtsdatum:___________

Ich bin über Inhalt und Zweck des Forschungsvorhabens **„Emotionale Reaktionen auf Geschmacks- und Geruchsreize bei Personen mit Essstörungen"**; das in Verantwortung von Dipl.-Psych. Romy Weiland von der Universität Würzburg am Institut für Psychologie durchgeführt und ausgewertet werden soll, informiert worden. Zu diesem Zweck wurde mir ein Informationsschreiben ausgehändigt.
Mir wurde versichert, dass keine personenbezogenen Angaben (Name, Geburtsdatum, Adresse) oder sonstige Angaben, welche Rückschlüsse auf meine Person zulassen, an Dritte weitergegeben werden und dass im Zusammenhang mit dieser Untersuchung erhobene Daten gelöscht werden, sobald sie für die weitere wissenschaftliche Auswertung nicht mehr erforderlich sind.
Mir wurde zugesichert, dass die Videoaufzeichnungen unter der ständigen Kontrolle von Frau Romy Weiland sind und nur ihr und einer weiteren an der Auswertung beteiligten Person zugänglich sind. Sobald die Videos ausgewertet sind, werden diese gelöscht.
Für meine Teilnahme erhalte ich nach Beendigung des 2. Termins € 20.
Ich möchte das Forschungsvorhaben durch meine Beteiligung unterstützen und willige ein, an der Studie „Emotionale Reaktionen auf Geschmacks- und Geruchsreize bei Personen mit Essstörungen" teilzunehmen und Fragebogen auszufüllen, die mir ausgehändigt werden. Insbesondere bin ich damit einverstanden, dass Mitarbeiter der Rehabilitationseinrichtung Diagnosen, Medikation, Behandlungsergebnisse – auch soweit diese von einer Krankenkasse oder einem Rentenversicherungsträger oder anderen Sozialleistungsträgern zur Verfügung gestellt wurden – aus der Krankenblattakte entnehmen und unter einer Forschungsnummer an das wissenschaftliche Forschungsinstitut übermitteln. Ich entbinde die Mitarbeiter der Rehabilitationseinrichtung insoweit von ihrer Schweigepflicht.

Ich weiß, dass ich jederzeit meine Einwilligung mit Wirkung für die Zukunft zurücknehmen kann. Unter diesen Voraussetzungen erkläre ich meine Einwilligung für die Teilnahme an dem Forschungsvorhaben.

Ort:________ Datum:________ Unterschrift Patientin:________________

B03: Instruktionen zum Geschmacksversuch

Im Folgenden erhalten Sie mehrere Geschmacksproben, die Sie bitte einstufen. Die Geschmacksproben befinden sich vor Ihnen auf dem Tisch. Diese sollen Sie in aufsteigender Reihenfolge (0-10) kosten. (Studie 3: Unterdrückung: **Versuchen Sie sich nicht anmerken zu lassen, wie Ihnen die Geschmacksprobe schmeckt**). Beachten Sie dabei folgendes:

1. **Spülen** Sie sich vor der ersten Geschmacksprobe und zwischen jedem der folgenden Geschmacksproben Ihren Mund gründlich **mit Wasser** aus. **Schlucken** Sie das Wasser nach dem Spülen hinunter.

2. Nehmen Sie den Becher mit der ersten Geschmacksprobe und nehmen Sie den **gesamten Inhalt vollständig in den Mund**. Behalten Sie die Geschmacksprobe dann für **5 Sekunden im Mund.** (Studie 3: Unterdrückung: Versuchen Sie sich **nicht anmerken zu lassen**, **wie** Ihnen die **Geschmacksprobe schmeckt**.)

3. **Schlucken Sie nach 5 Sekunden die Geschmacksprobe hinunter** und lassen Sie den Geschmack kurz auf sich wirken.

4. Beurteilen Sie jetzt die Geschmackprobe hinsichtlich ihrer **Intensität**, ihrer **Angenehmheit, ihrer Qualität** und stufen Sie Ihre momentane **Stimmung** ein.

5. **Spülen** Sie nun Ihren Mund **mit Wasser** aus und **schlucken** Sie das Wasser nach dem Spülen hinunter. Sie dürfen soviel Wasser nehmen, wie Sie möchten. Schenken Sie sich Wasser nach, wenn der Becher leer ist.

6. Werfen Sie den Becher in den Abfalleimer.

7. Geben Sie dem Versuchsleiter nun ein Zeichen, z.B. indem Sie **„Fertig“** rufen. Der Versuchsleiter wird daraufhin **45 Sekunden** mit einer Stoppuhr messen und Ihnen nach diesen 45 Sekunden ein Zeichen (**„Nächste Lösung“**) geben, dass Sie die nächste Geschmacksprobe kosten dürfen. Während dieser Zeit sollten Sie nicht erneut mit Wasser spülen.

Bleiben Sie während des gesamten Versuchs ruhig und aufrecht sitzen, vermeiden Sie es während des Kostens, kurz vorher oder kurz danach zu sprechen und bewegen Sie sich so wenig wie möglich. Wenden Sie sich jetzt bitte an den Versuchsleiter.

B04: Skalen für die Einschätzung der Geschmacksreize

Geschmacksprobe 0:

Bitte kreuzen Sie an,

wie **intensiv** diese **Probe** geschmeckt hat:

wie **gut** diese **Probe** geschmeckt hat:

wie Ihre **momentane Stimmung** ist:

Intensität		Geschmack		Stimmung	
25		25		25	
24		24		24	
23	sehr stark	23	sehr gut	23	sehr gut
22		22		22	
21		21		21	
20		20		20	
19		19		19	
18	stark	18	gut	18	gut
17		17		17	
16		16		16	
15		15		15	
14		14		14	
13	mittel	13	mittel	13	mittel
12		12		12	
11		11		11	
10		10		10	
9		9		9	
8	schwach	8	schlecht	8	schlecht
7		7		7	
6		6		6	
5		5		5	
4		4		4	
3	sehr schwach	3	sehr schlecht	3	sehr schlecht
2		2		2	
1		1		1	

B05: Qualitätsprofil der Geschmacksreize

Geschmacksprobe 0						
Versuchen Sie bitte die geschmacklichen Qualitäten der Geschmacksprobe zu beschreiben:						
		gar nicht	**etwas**	**mittel**	**sehr**	**äußerst**
1.	salzig	1	2	3	4	5
2.	süß	1	2	3	4	5
3.	bitter	1	2	3	4	5
4.	sauer	1	2	3	4	5
5.	herzhaft	1	2	3	4	5
6.	neutral	1	2	3	4	5

B06: Instruktionen zum Geruchsversuch

Im Folgenden werden Ihnen Geruchsstifte präsentiert, die Sie einschätzen sollen. Die Geruchsstifte befinden sich vor Ihnen auf dem Tisch. Beginnen Sie mit dem Riechen der Stifte von **links**. (Studie 3: Unterdrückung: **Versuchen Sie sich nicht anmerken zu lassen, wie Sie den Geruch finden.**) Beachten Sie dabei folgendes:

1. Ziehen Sie vor dem Versuch die bereitliegenden **Handschuhe** an.

2. Nehmen Sie den ersten Geruchsstift aus der Halterung und entfernen Sie die **Kappe** vom Stift. Halten Sie den geöffneten Geruchsstift **2 cm mittig vor beide Nasenlöcher** und riechen Sie **5 Sekunden** daran. (Studie 3: Unterdrückung: Versuchen Sie dieses Mal sich **nicht anmerken zu lassen**, **wie** Sie den **Geruch finden**.)

3. Lassen Sie nun den Geruch kurz auf sich wirken.

4. **Verschließen** Sie den Geruchsstift durch Aufsetzen der Kappe. Stellen Sie den Stift in die Halterung zurück.

5. Beurteilen Sie jetzt den Geruch hinsichtlich seiner **Intensität**, seiner **Angenehmheit, seiner Qualität** und stufen Sie Ihre momentane **Stimmung** ein.

6. Geben Sie dem Versuchsleiter ein Zeichen, z.B. indem Sie **„Fertig“** rufen. Der Versuchsleiter wird daraufhin **30 Sekunden** mit einer Stoppuhr messen und Ihnen nach diesen 30 Sekunden ein Zeichen (**„Nächster Stift“**) geben, dass Sie den nächsten Geruchsstift nehmen dürfen.

Bleiben Sie während des gesamten Versuchs ruhig und aufrecht sitzen, vermeiden Sie es während des Kostens, kurz vorher oder kurz danach zu sprechen und bewegen Sie sich so wenig wie möglich.
Wenden Sie sich jetzt bitte an den Versuchsleiter. Fragen Sie, wenn Sie irgendetwas nicht verstanden haben. Es wird zu Beginn eine Übung durchgeführt, die Sie mit dem Ablauf vertraut macht.

B07: Skalen für die Einschätzung der Geruchsreize

Geruchsprobe 0:

Bitte kreuzen Sie an,

wie **intensiv** diese **Probe** gerochen hat:

wie **gut** diese **Probe** gerochen hat:

wie Ihre **momentane Stimmung** ist:

Intensität		Geschmack		Stimmung	
25		25		25	
24		24		24	
23	sehr stark	23	sehr gut	23	sehr gut
22		22		22	
21		21		21	
20		20		20	
19		19		19	
18	stark	18	gut	18	gut
17		17		17	
16		16		16	
15		15		15	
14		14		14	
13	mittel	13	mittel	13	mittel
12		12		12	
11		11		11	
10		10		10	
9		9		9	
8	schwach	8	schlecht	8	schlecht
7		7		7	
6		6		6	
5		5		5	
4		4		4	
3	sehr schwach	3	sehr schlecht	3	sehr schlecht
2		2		2	
1		1		1	

B08: Qualitätsprofil der Geruchsreize

Geruch 0						
Versuchen Sie bitte die Geruchsqualität zu beschreiben:						
		gar nicht	**etwas**	**mittel**	**sehr**	**äußerst**
1.	säuerlich	1	2	3	4	5
2.	fischig	1	2	3	4	5
3.	mentholartig	1	2	3	4	5
4.	süßlich	1	2	3	4	5
5.	künstlich	1	2	3	4	5
6.	stechend	1	2	3	4	5

B09: Instruktion und Skala zur Einschätzung der Witze

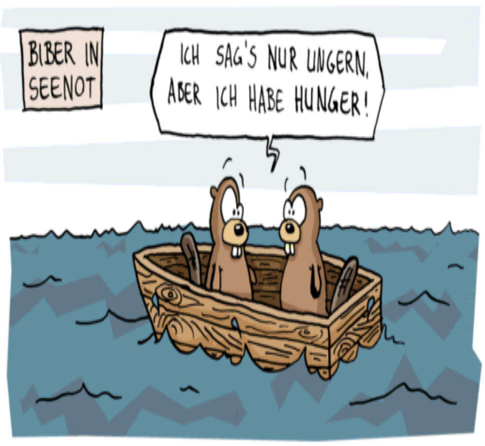
Witze

Im Folgenden erhalten Sie mehrere Witze (nur bei Studie 3). Beurteilen Sie bitte, wie witzig Sie diese Witze finden. (Studie 3: Unterdrückung: **Versuchen Sie sich nicht anmerken zu lassen, wie Ihnen die Witze gefallen.**)

Bitte kreuzen Sie an, wie witzig Sie diesen Cartoon finden.

sehr witzig	witzig	nicht witzig	gar nicht witzig
1	2	3	4

B10: Witze in Studie 3



B11: **Nachbefragungsbogen**

1. Haben Sie gewusst oder vermutet, dass ich Sie über einen Fernseher während des gesamten Versuchs sehen konnte?

□ Ja □ Nein

Bei Nein-Antwort: Ende der Nachbefragung!

2. Hatte dieses Wissen oder diese Vermutung von mir „gesehen zu werden" einen Einfluss auf Ihr Verhalten?

□ Ja □ Nein

Bei Ja-Antwort:

2.1 Welches Verhalten wurde durch dieses Wissen/ diese Vermutung „gesehen zu werden" beeinflusst?

____

3. Hatte das Wissen oder Ihre Vermutung von mir „gesehen zu werden" einen Einfluss auf Ihre Mimik?

□ Ja □ Nein

Bei Ja-Antwort:

4. Haben Sie an sich selbst aufgrund dieses Wissens/ dieser Vermutung stärkere oder schwächere Reaktionen in Ihrer Mimik bemerkt?

□ schwächere Reaktionen □ stärkere Reaktionen

B12: Demographische Angaben

Bitte füllen Sie nun diese Angaben zu Ihrer Person aus:

Alter: ____ Jahre **Studienfach:** ___________ **Semester**: _____

Geschlecht:
- ☐ weiblich
- ☐ männlich

Ist **Deutsch** Ihre Muttersprache?
- ☐ ja
- ☐ nein (meine Muttersprache ist __________________)

Sind Sie **Rechtshänder** oder **Linkshänder**?
- ☐ rechts
- ☐ links

Körpergröße: _______ cm

Körpergewicht: ______ kg

Höchster Schulabschluss:
- ☐ ohne
- ☐ Hauptschule
- ☐ Realschule / mittlere Reife
- ☐ (Fach-) Abitur
- ☐ Fachhochschule / Universität

Familienstand:
- ☐ ledig
- ☐ verheiratet
- ☐ getrennt lebend / geschieden / verwitwet

Sind sie **Vegetarier(in)**?
- ☐ ja
- ☐ nein

Rauchen Sie?
- ☐ ja Vor wie viel Stunden haben Sie Ihre letzte Zigarette geraucht?____________
- ☐ nein

Leiden Sie unter einer **körperlichen Erkrankung**?
- ☐ ja
- ☐ nein

Leiden Sie unter einer **psychischen Erkrankung**?
- ☐ ja
- ☐ nein

B12: Demographische Angaben – Fortsetzung

Liegt bei Ihnen eine **Störung des Geschmacks- oder Geruchssinns** vor?
□ ja
□ nein

aben Sie irgendwelche **Allergien** (z.B. Lebensmittelallergie, Heuschnupfen)?
□ ja welche?____
□ nein

Sind Sie im Moment **erkältet**?
□ ja
□ nein

Müssen Sie täglich **Medikamente** einnehmen?
□ ja welche?____
□ nein

Vor wie viel Stunden haben Sie das **letzte Mal etwas gegessen**?

□ Unmittelbar bevor ich zu diesem Versuch kam
□ Vor 1 Stunde
□ Vor 2 Stunden
□ Vor 3 Stunden

Haben Sie heute bereits **Kaugummi** gekaut?
□ ja
Wenn ja: Vor wie viel Stunden haben Sie Kaugummi gekaut?

□ Unmittelbar bevor ich zu diesem Versuch kam
□ Vor 1 Stunde
□ Vor 2 Stunden
□ Vor 3 Stunden

□ nein

Liegt derzeit eine **Schwangerschaft** vor?
□ ja
□ nein

Appendix C: Tables and Figures

Table C01 Concentrations of the taste solutions in study 1, 2, and 3.

	Taste stimuli				
	PROP	NaCl	Citric acid	Sucrose	MSG
Study 1	0.032 mM	0.01 M	0.01 M	0.10 M	0.001 M
	0.32 mM	0.1 M	0.03 M	0.42 M	0.05 M
	3.2 mM	1 M	0.05 M	0.83 M	0.1 M
Study 2	0.032 mM	0.02 M	0.005 M	0.05 M	0.01 M
	3.2 mM	1 M	0.05 M	0.83 M	0.2 M
Study 3	3.2 mM	1 M	0.05 M	0.83 M	0.2 M

Table C02 Order of taste stimuli in study 1, 2, and 3.

		Taste number					
Study 1		0	1/2/3	4/5/6	7/8/9	10/11/12	13/14/15
Study 2		0	1/2	3/4	5/6	7/8	9/10
Study 3 (spontaneous part)		0	1	2	3	4	5
Taste order	1	water	salty	sweet	sour	umami	bitter
	2	water	sour	salty	umami	sweet	bitter
	3	water	sweet	umami	salty	sour	bitter
	4	water	umami	sour	sweet	salty	Bitter
Study 3 (suppressed part)		0	1	2	3	4	5
Taste order	1	salty	sweet	water	sour	umami	bitter
	2	sour	salty	water	umami	sweet	bitter
	3	sweet	umami	water	salty	sour	bitter
	4	umami	sour	water	sweet	salty	bitter

Table C03 Order of odor stimuli in study 1.

	Odor number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Subject																
3, 22	1	3	4	16	6	13	2	8	9	10	14	12	15	11	7	5
4, 26	12	16	9	13	15	11	7	14	1	3	5	6	2	8	10	4
5	9	13	16	7	12	4	5	11	15	8	10	1	14	2	3	6
6, 28	3	15	7	8	9	2	14	4	12	11	13	5	16	6	1	10
7, 34	5	4	8	10	11	6	16	15	14	7	3	9	12	13	2	1
8, 27	2	10	15	6	13	1	11	16	3	9	12	8	4	5	14	7
9, 20	11	8	12	9	3	16	6	5	7	1	2	10	13	14	4	15
29	6	12	1	14	2	5	15	3	10	13	4	11	7	9	16	8
11, 21	4	9	11	12	14	15	3	10	8	2	1	13	5	7	6	16
12, 30	7	1	2	4	10	14	8	12	5	16	9	3	6	15	13	11
13, 24	8	5	14	11	1	3	9	7	2	6	15	4	10	16	12	13
14, 31	13	6	5	1	7	10	12	9	16	4	11	14	8	3	15	2
15, 25	14	7	10	2	4	8	1	13	6	5	16	15	9	12	11	3
17, 32	6	4	8	2	9	7	12	13	16	15	14	10	3	1	11	5
18, 33	15	13	12	9	10	11	2	8	14	7	4	6	5	3	16	1

Note: 1-orange, 2-shoe leather, 3-cinnamon, 4-mint, 5-banana, 6-lemon, 7-licorice, 8-turpentine, 9-garlic, 10-coffe, 11-apple, 12-clove, 13-pineapple, 14-rose, 15-anise, 16-fish.

Table C04 Order of odor stimuli in study 2.

Order	Odor presentation					
1	B	F	Cl	probe	G	C	L
2	C	L	G	probe	Cl	B	F
3	L	C	F	probe	B	Cl	G
4	Cl	G	B	probe	F	L	C
5	F	B	L	probe	C	G	Cl
6	G	Cl	C	probe	L	F	B

Note: B-banana, C-cinnamon, Cl-clove, L-licorice, F-fish, G-garlic.

Table C05 Order of odor stimuli in study 3.

Order	Odor presentation			
1	B	F	G	C
2	F	C	B	G
3	C	G	F	B
4	G	B	C	F

Note: B-banana, C-cinnamon, F-fish, G-garlic.

Study 1:

Table C06 Sample characteristics for women (n = 14), men (n = 14), and the total sample (N = 28).

	Women (n = 14)		Men (n = 14)		Total sample (N = 28)	
	n	%	*n*	%	*N*	%
Handedness						
Right-hander	14	100.0	14	100.0	28	100.0
Graduation						
Realschule	1	7.1	2	14.3	3	10.7
Abitur	4	28.6	7	50.0	11	39.3
University	9	64.3	5	35.7	14	50.0
Course of studies						
psychology	7	50.0	4	28.6	11	39.3
biology	1	7.1	2	14.3	3	10.7
biology PhD	4	28.6	0	0.0	4	14.3
business studies	0	0.0	3	21.4	3	10.7
medicine	1	7.1	0	0.0	1	7.1
philosophy PhD	0	0.0	1	7.1	1	7.1
job	1	7.1	3	21.4	4	14.3
unemployed	0	0.0	1	7.1	1	7.1
Marital status						
unmarried	14	100.0	14	100.0	28	100.0
Vegetarianism						
no	13	92.9	14	100.0	27	96.4
yes	1	7.1	0	0.0	1	7.1

Table C07 Intensity, pleasantness, and mood ratings in response to low, medium, and high taste concentrations (bitter, salty, sour, sweet, umami) for women (n = 14), men (n = 14), and the total sample (N = 28) – average deviations (Mean ± *SD*) from ratings for mineral water.

			Women (n = 14)		Men (n = 14)		Total (N = 28)	
Variable	Taste	Concentration	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity								
	water		2.6	1.9	3.7	4.4	3.1	3.4
	bitter	low	5.0	6.2	5.4	6.1	5.2	6.0
		medium	13.2	6.7	10.4	9.5	11.8	8.2
		high	20.1	3.2	17.4	6.2	18.8	5.0
	salty	low	4.7	4.2	4.6	4.6	4.7	4.3
		medium	15.1	4.7	14.6	7.3	14.9	6.0
		high	20.6	3.5	19.5	5.3	20.0	4.4
	sour	low	15.4	3.7	13.5	7.6	14.4	6.0
		medium	18.6	3.4	17.7	5.9	18.2	4.8
		high	19.6	3.3	19.0	5.8	19.3	4.7
	sweet	low	9.6	3.9	8.9	5.2	9.3	4.5
		medium	15.7	4.0	16.6	6.2	16.2	5.2
		high	18.4	2.7	18.1	5.7	18.3	4.4
	umami	low	2.4	4.6	2.6	3.8	2.5	4.1
		medium	13.0	4.0	11.1	6.5	12.1	5.4
		high	14.0	4.8	13.1	7.8	13.5	6.3
Pleasantness								
	water		13.6	3.3	13.6	4.2	13.6	3.7
	bitter	low	-3.5	6.2	-3.4	6.4	-3.4	6.2
		medium	-5.9	7.2	-6.2	7.7	-6.0	7.3
		high	-11.3	3.9	-9.8	5.8	-10.5	4.9
	salty	low	-3.7	4.7	-3.4	4.5	-3.5	4.5
		medium	-6.4	4.4	-6.9	6.9	-6.6	5.7
		high	-9.3	4.1	-9.2	6.9	-9.3	5.6
	sour	low	-0.6	4.9	-1.3	6.9	-1.0	5.9
		medium	-1.4	4.6	-1.8	7.4	-1.6	6.0
		high	-3.3	5.4	-2.4	7.4	-2.8	6.4
	sweet	low	1.4	4.8	0.8	7.0	1.1	5.9
		medium	2.1	6.7	2.1	7.7	2.1	7.1
		high	-0.1	5.2	1.4	8.3	0.7	6.8
	umami	low	0.5	5.0	-1.5	4.7	-0.5	4.9
		medium	-6.3	6.3	-5.7	6.8	-6.0	6.4
		high	-7.4	6.6	-6.6	7.3	-7.0	6.9

Table C07 Continued.

Variable	Taste	Concentration	Women (*n* = 14)		Men (*n* = 14)		Total (*n* = 28)	
			M	*SD*	*M*	*SD*	*M*	*SD*
Mood								
	water		17.4	3.0	16.4	2.6	16.9	2.8
	bitter	low	-3.1	4.6	-1.4	4.6	-2.3	4.6
		medium	-3.4	4.2	-3.1	4.9	-3.2	4.5
		high	-4.6	4.6	-3.6	6.3	-4.1	5.4
	salty	low	-1.4	2.3	-1.6	3.7	-1.5	3.0
		medium	-2.9	2.9	-2.3	5.0	-2.6	4.0
		high	-3.4	3.5	-2.3	5.6	-2.9	4.6
	sour	low	-0.3	2.6	-0.6	4.2	-0.5	3.4
		medium	-0.3	2.5	-0.1	4.9	-0.2	3.8
		high	-0.4	2.8	0.4	5.4	0.0	4.2
	sweet	low	-0.4	3.0	0.0	2.8	-0.2	2.8
		medium	0.0	4.2	0.7	2.8	0.4	3.5
		high	-0.4	3.5	0.3	3.2	0.0	3.3
	umami	low	-0.6	1.9	-0.2	2.5	-0.4	2.2
		medium	-1.9	2.9	-2.9	4.1	-2.4	3.5
		high	-3.2	3.3	-3.3	4.7	-3.3	4.0

Table C08 Identification rates in % of the tastes for women (*n* = 14), men (*n* = 14), and the total sample (*N* = 28).

		Perceived gustative sensation																	
		bitter			sour			salty			sweet			neutral			miscellaneous		
Tested taste		♀	♂	total	♀	♂	total	♀	♂	total	♀	♂	total	♀	♂	total	♀	♂	total
Mineral water		0	0	0	0	0	0	0	0	0	0	0	0	100.0	100.0	100.0	0	0	0
Bitter	low	57.1	50.0	53.6	0	0	0	0	0	0	0	7.1	3.6	35.7	35.7	35.7	7.1	7.1	7.1
	medium	78.6	71.4	75.0	0	7.1	3.6	0	0	0	0	0	0	21.4	21.4	21.4	0	0	0
	high	100	92.9	96.4	0	0	0	0	0	0	0	0	0	0	0	0	0	7.1	3.6
Salty	low	28.6	50.0	39.3	7.1	0	3.6	21.4	14.3	17.9	7.1	0	3.6	28.6	28.6	28.6	7.1	7.1	7.1
	medium	14.3	21.4	17.9	0	0	0	85.7	78.6	82.1	0	0	0	0	0	0	0	0	0
	high	0	0	0	0	0	0	100.0	100.0	100.0	0	0	0	0	0	0	0	0	0
Sour	low	0	7.1	3.6	85.7	92.9	89.3	0	0	0	7.1	0	3.6	0	0	0	7.1	0	3.6
	medium	0	0	0	100.0	100.0	100.0	0	0	0	0	0	0	0	0	0	0	0	0
	high	7.1	0	3.6	92.9	100.0	96.4	0	0	0	0	0	0	0	0	0	0	0	0
Sweet	low	14.3	7.1	10.7	0	0	0	0	0	0	85.7	85.7	85.7	0	0	0	0	7.1	3.6
	medium	0	0	0	0	0	0	0	0	0	92.9	100.0	96.4	0	0	0	7.1	0	3.6
	high	0	0	0	0	0	0	0	0	0	92.9	100.0	96.4	0	0	0	7.1	0	3.6
Umami	low	7.1	7.1	7.1	0	0	0	21.4	14.3	17.9	0	7.1	3.6	71.4	64.3	67.9	0	7.1	3.6
	medium	28.6	14.3	21.4	0	0	0	64.3	78.6	71.4	0	0	0	0	0	0	7.1	7.1	7.1
	high	21.4	35.7	28.6	14.3	0	7.1	50.0	50.0	50.0	0	7.1	3.6	0	0	0	14.3	7.1	10.7

Table C09 Intensity, pleasantness, and mood ratings in response to different odors (Mean ± *SD*) for women (*n* = 14), men (*n* = 14), and the total sample (*N* = 28).

	anise		apple		banana		cinnamon		clove		coffee		fish		garlic	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity																
Women	15.1	5.0	17.6	3.8	18.1	3.3	17.6	5.6	19.3	5.2	17.4	4.8	19.4	3.1	18.9	4.7
Men	15.4	3.2	17.6	2.3	18.8	3.2	16.1	3.0	18.1	4.1	17.7	3.2	18.9	4.3	21.4	2.4
Total	15.2	4.1	17.6	3.1	18.5	3.2	16.9	4.5	18.7	4.6	17.6	4.0	19.1	3.7	20.2	3.9
Pleasantness																
Women	13.7	4.2	14.4	3.2	17.2	3.7	17.3	4.2	9.6	4.6	14.5	5.4	7.9	4.3	9.1	4.6
Men	16.0	3.7	17.6	2.5	18.4	3.5	15.7	4.1	10.4	3.0	16.7	4.1	6.6	4.2	10.1	5.1
Total	14.9	4.1	16.0	3.3	17.8	3.6	16.5	4.1	10.0	3.8	15.6	4.8	7.3	4.2	9.6	4.8
Mood																
Women	15.8	2.8	16.2	3.1	17.0	2.7	16.9	2.8	15.7	3.9	16.6	3.2	15.4	4.1	15.0	3.2
Men	17.6	2.4	17.7	2.1	17.8	2.3	17.6	2.3	15.9	2.8	17.7	2.8	15.1	3.8	15.7	4.0
Total	16.7	2.7	17.0	2.7	17.4	2.5	17.3	2.5	15.8	3.3	17.2	3.0	15.3	3.9	15.4	3.6

	lemon		licorice		mint		orange		pineapple		rose		leather		turpentine	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity																
Women	16.1	5.5	12.4	5.9	19.2	2.9	15.2	5.4	17.3	3.6	16.9	4.5	11.5	5.4	18.1	3.9
Men	16.9	3.4	16.5	3.5	19.3	2.3	16.8	3.4	17.7	2.2	18.4	2.2	13.7	3.4	18.0	2.1
Total	16.5	4.5	14.5	5.2	19.3	2.6	16.0	4.5	17.5	2.9	17.6	3.6	12.6	4.5	18.1	3.1

Pleasantness																
Women	15.7	3.9	13.4	2.8	16.3	3.7	17.8	3.2	17.1	4.3	14.7	4.8	12.8	2.8	13.4	3.9
Men	18.7	2.5	15.8	4.5	18.1	3.6	19.2	2.5	18.1	3.4	16.9	4.9	12.8	3.2	14.3	4.0
Total	17.2	3.5	14.6	3.9	17.2	3.7	18.5	2.9	17.6	3.9	15.8	4.9	12.8	3.0	13.8	3.9
Mood																
Women	16.8	3.2	16.0	3.3	17.0	3.2	16.6	2.9	16.3	3.2	16.5	2.8	15.9	2.9	16.6	2.8
Men	18.3	2.7	17.8	2.9	17.9	2.4	18.1	2.8	18.0	2.3	17.8	3.1	16.5	2.5	17.6	2.6
Total	17.5	3.0	16.9	3.2	17.4	2.8	17.4	2.9	17.1	2.9	17.1	3.0	16.2	2.7	17.1	2.7

Table C10 Identification rates in % of the odors for women (*n* = 14), men (*n* = 14), and the total sample (*N* = 28).

	anise	apple	banana	cinnamon	clove	coffee	fish	garlic	lemon	licorice	mint	orange	pineapple	rose	shoe leather	turpentine
Women	85.7	21.4	92.9	85.7	92.9	85.7	92.9	85.7	64.3	85.7	92.9	85.7	85.7	92.9	84.6	28.6
Men	78.6	42.9	100.0	92.9	85.7	100.0	92.9	92.9	85.7	85.7	100.0	85.7	78.6	78.6	85.7	42.9
Total	82.1	32.1	96.4	89.3	89.3	92.9	92.9	89.3	75.0	85.7	96.4	85.7	82.1	85.7	85.2	35.7

Table C11 Frequency of Action Units (AUs) in response to the bitter, salty, sour, sweet, and umami tastes differing in concentration before and after swallowing (pre and post) for women (*n* = 14) and men (*n* = 14). All AUs were counted; persons might have shown an AU more than once.

		bitter						salty						sour						sweet						umami					
		low		medium		high		low		medium		high		low		medium		high		low		medium		high		low		medium		high	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
AU 1 Inner Brow Raise	pre	0	0	1	2	1	4	0	0	1	2	5	2	3	3	4	6	3	5	1	0	0	2	0	1	0	0	3	2	0	3
	post	0	1	3	1	2	4	0	2	2	3	6	7	1	3	2	4	3	5	0	0	0	1	1	2	1	0	1	3	4	3
AU 2 Outer Brow Raise	pre	0	0	0	2	1	4	0	0	0	1	4	3	3	3	3	5	2	3	1	0	0	1	0	0	0	1	0	2	0	2
	post	0	1	2	1	2	3	0	2	1	3	5	6	0	2	0	4	3	5	0	0	0	1	1	2	0	0	0	0	2	2
AU 4 Brow Lower	pre	0	5	7	8	8	9	4	4	4	8	10	8	6	9	7	9	3	8	0	2	1	4	1	4	0	2	4	10	5	10
	post	3	7	8	7	10	9	4	5	5	8	8	9	3	5	7	3	5	7	3	1	3	4	11	7	5	3	7	11	8	14
AU 5 Lid Raise	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 6 Cheek Raise	pre	0	1	2	1	3	7	0	1	1	3	2	9	6	3	3	3	1	7	0	0	0	0	1	2	0	2	2	2	0	0
	post	0	0	2	0	4	4	0	0	1	2	4	5	5	4	4	4	6	6	1	0	3	3	1	1	2	0	3	2	0	4
AU 7 Lids Tight	pre	0	3	1	5	1	2	1	4	1	5	2	4	4	6	2	8	3	5	1	2	1	2	0	6	3	3	3	3	2	4
	post	0	3	2	2	1	5	0	1	2	1	3	3	2	1	0	3	2	2	0	0	2	0	0	2	0	1	2	4	0	2
AU 9 Nose Wrinkle	pre	0	0	0	0	0	1	0	0	0	4	0	4	0	2	0	1	0	1	0	0	0	0	0	2	0	0	0	1	0	2
	post	1	0	0	1	0	0	0	0	0	1	0	3	1	0	0	0	0	2	0	0	0	0	0	1	0	0	0	2	0	6
AU 10 Upper Lip Raise	pre	1	1	5	6	9	8	0	2	5	10	10	10	6	7	7	8	8	8	0	1	0	4	0	4	0	0	3	8	1	4
	post	2	4	5	10	9	10	1	3	7	8	9	10	5	4	7	7	6	9	1	1	2	3	1	6	2	1	8	7	8	12
AU 11 Naso-labial Deepen	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 12 Lip Corner Pull	pre	0	1	2	1	4	9	0	1	2	6	4	11	5	5	4	4	1	10	3	3	2	4	2	8	0	4	2	2	0	1
	post	1	0	2	3	6	7	1	1	1	3	6	10	6	11	5	7	9	14	9	11	7	10	5	10	4	4	5	2	3	4
AU 13 Sharp Lip Pull	pre	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	3	0	0	0	0	0	3	0	1	0	0	0	0	0	0
	post	0	2	0	1	0	0	0	0	0	0	0	0	4	2	2	2	0	1	0	0	1	0	0	0	0	2	0	1	0	1
AU 14 Dimpler	pre	6	8	2	12	2	1	5	3	1	1	5	5	2	13	3	5	4	6	2	5	4	3	1	3	4	6	3	4	4	6
	post	9	12	7	9	5	6	15	15	7	8	5	6	6	7	11	11	5	10	11	15	12	11	14	15	16	14	9	13	10	8
AU 15 Lip CornerDepress	pre	2	0	4	2	7	3	0	0	3	3	4	4	5	0	9	3	5	2	0	0	0	0	2	1	0	0	1	0	0	0
	post	4	1	1	4	2	7	2	2	6	3	4	7	3	4	6	1	1	3	2	1	3	1	2	1	4	1	2	4	5	5

Table C11 Continued.

		bitter						salty						sour						sweet						umami					
		low		medium		high		low		medium		high		low		medium		high		low		medium		high		low		medium		high	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
AU 16 Lower Lip Depress	pre	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	4	2	1	4	1	1	1	4	1	5	1	2	1	2	1	5	1	1	1	0	1	2	1	2	1	3	2	3
AU 17 Chin Raise	pre	1	2	1	2	2	2	1	0	1	1	2	2	3	1	4	1	3	1	3	1	0	0	2	4	1	4	2	1	4	3
	post	2	0	2	3	1	5	2	0	0	2	2	4	2	3	0	2	2	1	3	2	1	1	0	1	0	2	1	3	3	0
AU 18 Lip Pucker	pre	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	1	1	1	0	0	1	0	0	0
	post	0	0	0	1	0	1	0	0	0	1	0	1	2	0	1	2	0	2	0	0	0	0	0	0	0	2	0	0	0	0
AU 19 Tongue Show	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	1	1	0	2	1	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	3
AU 20 Lip Stretch	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	post	0	0	0	1	1	0	0	0	1	2	0	3	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
AU 21 Neck Tighten	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 22 Lip Funnel	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 23 Lip Tight	pre	0	0	0	0	0	1	0	0	0	1	0	1	1	2	2	2	4	5	0	0	0	0	0	0	0	0	0	2	0	0
	post	0	0	0	1	0	1	0	0	1	1	2	1	2	1	1	2	4	1	0	0	0	0	2	1	0	0	0	0	0	0
AU 24 Lip Press	pre	2	0	3	2	3	3	1	1	3	1	2	2	1	1	2	5	3	3	2	0	0	2	3	3	0	1	3	1	0	3
	post	3	9	5	7	1	6	3	9	4	15	3	8	2	12	5	12	5	11	8	13	6	9	4	12	6	6	8	10	5	5
AU 25 Lips Part	pre	2	1	0	0	1	1	2	1	0	0	0	0	0	2	0	3	0	2	1	2	0	2	2	1	0	1	1	1	3	0
	post	8	9	5	11	9	8	11	10	5	6	6	12	9	18	10	12	8	14	8	18	9	11	11	12	7	11	7	13	6	8
AU 26 Jaw Drop	pre	0	0	2	0	2	2	1	0	2	1	1	3	1	0	2	1	0	1	1	0	1	1	0	2	0	0	0	0	2	1
	post	4	11	6	8	7	17	2	13	7	14	5	15	10	12	10	20	13	17	5	7	6	11	5	10	7	11	4	8	6	16
AU 28 Lip Suck	pre	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0
	post	0	2	1	1	0	2	0	0	0	0	0	0	1	2	0	3	0	2	1	2	0	3	1	3	2	1	0	1	0	3
AU 29 Jaw Thrust	pre	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
	post	2	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Table C11 Continued.

		bitter						salty						sour						sweet						umami					
		low		medium		high		low		medium		high		low		medium		high		low		medium		high		low		medium		high	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
AU 30 Jaw to Sideways	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	1	2	0	0	0	4	0	2	1	2	0	0	0	0
AU 31 Jaw Clench	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	post	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	3	3	2	0	2	0	0	0	2	1	0	0
AU 33 Blow	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 34 Puff	pre	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0
	post	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 35 Cheek Suck	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 36 Tongue Bulge	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
AU 37 Lip Wipe	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	post	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	1	1	0	1	1	1	0	0	0	0	1
AU 38 Nostril Dilate	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
AU 39 Nostril Compress	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 43 Eyes Closed	pre	0	0	0	0	0	1	1	0	0	1	0	0	0	2	0	1	0	2	0	1	0	1	0	0	0	0	0	1	0	1
	post	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
AU 44 Squint	pre	0	0	0	0	0	2	0	0	0	2	1	3	0	1	1	2	1	2	0	0	0	1	0	0	0	0	0	1	0	1
	post	0	1	0	2	2	1	0	0	0	2	0	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	3
AU 50 Speech	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	1	2	0	0	0	1	1	3	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	2

Table C12 Frequency of Action Units (AUs) in response to the bitter, salty, sour, sweet, and umami tastes differing in concentration before and after swallowing (pre and post) for women (n = 14) and men (n = 14). Each AU was counted once even when it was shown more often per persons.

		bitter						salty						sour						sweet						umami					
		low		medium		high		low		medium		high		low		medium		high		low		medium		high		low		medium		high	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
AU 1 Inner Brow Raise	pre	0	0	1	2	1	4	0	0	1	2	5	2	3	3	4	6	3	5	1	0	0	2	0	1	0	0	2	2	0	2
	post	0	1	3	1	2	3	0	2	2	3	5	5	1	3	2	4	3	5	0	0	0	1	1	2	1	0	1	3	4	3
AU 2 Outer Brow Raise	pre	0	0	0	2	1	4	0	0	0	1	4	3	3	3	3	5	2	3	1	0	0	1	0	0	0	1	0	2	0	1
	post	0	1	2	1	2	2	0	2	1	3	4	5	0	2	0	4	3	5	0	0	0	1	1	2	0	0	0	0	2	2
AU 4 Brow Lower	pre	0	5	7	6	8	8	4	4	4	7	8	8	5	9	6	8	3	7	0	2	1	4	1	4	0	2	4	10	4	9
	post	3	6	7	7	8	9	3	5	5	7	7	9	3	4	6	3	4	7	2	1	3	4	8	7	3	3	6	9	5	11
AU 5 Lid Raise	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 6 Cheek Raise	pre	0	1	2	1	3	6	0	1	1	3	2	9	6	3	3	3	1	6	0	0	0	0	1	2	0	2	2	2	0	0
	post	0	0	2	0	4	4	0	0	1	1	4	5	4	2	3	3	5	3	1	0	2	2	1	1	2	0	2	2	0	4
AU 7 Lids Tight	pre	0	3	1	5	1	2	1	4	1	5	2	4	3	6	2	8	3	5	1	2	1	2	0	6	3	3	3	3	2	4
	post	0	3	2	2	1	4	0	1	2	1	3	3	2	1	0	3	2	2	0	0	2	0	0	2	0	1	2	4	0	2
AU 9 Nose Wrinkle	pre	0	0	0	0	0	1	0	0	0	3	0	4	0	2	0	1	0	1	0	0	0	0	0	2	0	0	0	1	0	2
	post	1	0	0	1	0	0	0	0	0	1	0	3	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	2	0	5
AU 10 Upper Lip Raise	pre	1	1	5	6	9	8	0	2	5	9	10	10	6	7	7	8	8	8	0	1	0	4	0	4	0	0	3	8	1	4
	post	2	3	5	9	7	10	1	3	7	6	8	9	5	3	6	6	5	7	1	1	2	2	1	5	2	1	7	6	6	9
AU 11 Naso-labial Deepen	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 12 Lip Corner Pull	pre	0	1	2	1	4	8	0	1	2	5	4	10	4	5	4	3	1	7	2	3	2	2	1	5	0	4	2	2	0	1
	post	1	0	2	3	5	6	1	1	1	3	6	9	5	8	4	5	7	8	6	8	5	7	4	7	3	4	4	2	3	4
AU 13 Sharp Lip Pull	pre	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
	post	0	1	0	1	0	0	0	0	0	0	0	0	2	1	1	2	0	1	0	0	1	0	0	0	0	1	0	1	0	1
AU 14 Dimpler	pre	6	5	2	7	2	1	4	2	1	1	4	4	2	8	2	4	4	4	2	5	3	3	1	4	3	5	3	4	3	4
	post	7	8	5	5	4	5	10	7	6	5	3	5	5	6	6	7	4	8	7	11	9	9	9	10	9	10	6	7	7	5
AU 15 Lip CornerDepress	pre	1	0	3	2	7	2	0	0	3	3	4	4	4	0	7	2	4	2	0	0	0	0	1	1	0	0	1	0	0	0
	post	2	1	1	2	2	5	2	2	6	3	4	6	3	4	5	1	1	2	1	1	2	1	2	1	2	1	2	3	3	5

Table C12 Continued.

		bitter						salty						sour						sweet						umami					
		low		medium		high		low		medium		high		low		medium		high		low		medium		high		low		medium		high	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
AU 16 Lower Lip Depress	pre	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	3	2	1	4	1	1	1	3	1	4	1	2	1	2	1	5	1	1	1	0	1	2	1	2	1	3	2	3
AU 17 Chin Raise	pre	1	1	1	2	2	2	1	0	1	1	2	2	2	1	4	1	3	1	3	1	0	0	2	3	1	3	2	1	2	2
	post	1	0	2	2	1	4	2	0	0	2	2	4	2	3	0	2	2	1	2	2	1	1	0	1	0	2	1	3	3	0
AU 18 Lip Pucker	pre	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	1	1	1	0	0	1	0	0	0
	post	0	0	0	1	0	1	0	0	0	1	0	1	2	0	1	1	0	2	0	0	0	0	0	0	0	2	0	0	0	0
AU 19 Tongue Show	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	1	1	0	2	1	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	3
AU 20 Lip Stretch	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	post	0	0	0	1	1	0	0	0	1	2	0	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
AU 21 Neck Tighten	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 22 Lip Funnel	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 23 Lip Tight	pre	0	0	0	0	0	1	0	0	0	1	0	1	1	1	1	2	3	4	0	0	0	0	0	0	0	0	0	2	0	0
	post	0	0	0	1	0	1	0	0	1	1	2	1	2	1	1	2	3	1	0	0	0	0	2	1	0	0	0	0	0	0
AU 24 Lip Press	pre	2	0	3	2	2	3	1	1	3	1	2	2	1	1	2	5	3	3	2	0	0	2	3	2	0	1	3	1	0	3
	post	2	6	3	5	1	5	1	7	2	7	2	7	2	9	3	10	4	8	7	7	5	6	4	8	5	5	7	8	5	3
AU 25 Lips Part	pre	2	1	0	0	1	1	1	1	0	0	0	0	0	2	0	2	0	1	1	2	0	2	1	1	0	1	1	1	2	0
	post	7	6	5	8	5	5	8	7	4	5	4	8	9	9	8	8	8	9	7	9	7	9	8	7	6	8	3	10	5	5
AU 26 Jaw Drop	pre	0	0	1	0	2	2	1	0	2	1	1	3	1	0	2	1	0	1	1	0	1	1	0	2	0	0	0	0	2	1
	post	4	9	5	6	7	10	1	8	5	8	5	10	8	9	7	12	10	9	5	6	5	8	5	9	5	5	4	7	6	12
AU 28 Lip Suck	pre	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0
	post	0	2	1	1	0	2	0	0	0	0	0	0	1	2	0	3	0	2	1	2	0	2	1	3	2	1	0	1	0	2
AU 29 Jaw Thrust	pre	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
	post	2	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Table C12 Continued.

		bitter						salty						sour						sweet						umami					
		low		medium		high		low		medium		high		low		medium		high		low		medium		high		low		medium		high	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
AU 30 Jaw to Sideways	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	1	2	0	0	0	2	0	2	1	2	0	0	0	0
AU 31 Jaw Clench	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	post	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	2	1	1	0	2	0	0	0	2	1	0	0
AU 33 Blow	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 34 Puff	pre	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0
	post	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 35 Cheek Suck	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 36 Tongue Bulge	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
AU 37 Lip Wipe	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	post	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	1	1	0	1	1	1	0	0	0	0	1
AU 38 Nostril Dilate	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
AU 39 Nostril Compress	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 43 Eyes Closed	pre	0	0	0	0	0	1	1	0	0	1	0	0	0	2	0	1	0	2	0	1	0	1	0	0	0	0	0	1	0	1
	post	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
AU 44 Squint	pre	0	0	0	1	0	2	0	0	0	2	1	3	0	1	1	2	1	2	0	0	0	1	0	0	0	0	0	1	0	1
	post	0	1	0	2	2	1	0	0	0	2	0	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2
AU 50 Speech	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	1	2	0	0	0	1	1	3	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1

Table C13 Frequency of Action Units (AUs) in response to tastes in which both FACS coders agreed upon (**bold face**). AUs observed by one coder are *italic*. Inter-rater reliability (IR) of each Action Unit is listed in the table and general IR in response to tastes is listed below.

AU	1	2	4	6	7	9	10	11	12	13	14	15	16	17	18	20	23	24	25	26	28	29	30	31	34	35	36	37	39	43	44	Coder1
1	**44**																															*3*
2		**33**																														*2*
4			**87**																													*16*
6				**10**																												*8*
7					**20**																											*15*
9						**14**																										*0*
10							**65**																									*11*
11								**1**																								*0*
12									**37**																							*6*
13										**8**																						*0*
14											**115**																					*10*
15												**23**																				*0*
16													**7**																			*3*
17														**19**																		*0*
18															**9**																	*0*
20																**7**																*1*
23																	**11**															*4*
24																		**82**														*4*
25																			**39**													*2*
26																				**74**												*1*
28																					**18**											*1*
29																						**3**										*0*
30																							**2**									*0*
31																								**1**								*2*
34																									**1**							*0*
35																										**1**						*0*
36																											**1**					*0*
37																												**6**				*0*
39																													**0**			*0*
43																														**2**		*1*
44																															**11**	0
Coder 2	*5*	*3*	*7*	*3*	*17*	*3*	*23*	*0*	*4*	*12*	*46*	*21*	*1*	*14*	*2*	*8*	*15*	*28*	*4*	*4*	*2*	*2*	*0*	*2*	*0*	*1*	*0*	*0*	*1*	*5*	*6*	C1:90 C2:239
IR for each AU	.92	.93	.88	.65	.56	.90	.79	1.0	.88	.57	.80	.69	.78	.74	.90	.61	.54	.84	.93	.97	.92	.75	1.0	.33	1.0	.67	1.0	1.0	0.0	.40	.79	

Note: C1 = Coder 1, C2 = Coder 2, IR = Inter-rater reliability [(sum of agreements of Action Units of the coders × 2)/(total sum of Action Units scored by each coder)] = **[(751×2)/(751×2) + 90 + 239)] = (1502 /1831) = .82**. AU 5, 8, 19, 21, 22, 27, 32, 33, 38, and 50 were not observed.

Table C14 Frequency of Action Units (AUs) in response to different odors for the total sample (*N* = 28). Each AU was counted as often as it was shown by each participant.

	Odor stimuli					
Action Unit	banana	cinnamon	clove	coffee	fish	garlic
AU 1 Inner Brow Raise	1	0	5	2	5	1
AU 2 Outer Brow Raise	1	0	4	2	3	1
AU 4 Brow Lower	4	4	17	6	22	17
AU 5 Lid Raise	3	2	0	1	3	0
AU 6 Cheek Raise	0	0	2	0	2	4
AU 7 Lids Tight	10	11	20	19	24	18
AU 9 Nose Wrinkle	2	1	2	0	6	6
AU 10 Upper Lip Raise	5	7	16	9	28	24
AU 12 Lip Corner Pull	2	2	5	3	4	4
AU 13 Sharp Lip Pull	0	0	0	0	0	0
AU 14 Dimpler	3	2	2	6	3	6
AU 15 Lip Corner Depress	0	1	2	3	8	7
AU 16 Lower Lip Depress	0	0	0	0	0	0
AU 17 Chin Raise	1	1	2	2	5	6
AU 18 Lip Pucker	0	0	0	0	0	0
AU 19 Tongue Show	0	1	0	0	0	0
AU 20 Lip Stretch	0	0	1	0	2	3
AU 23 Lip Tight	0	0	0	1	0	1
AU 24 Lip Press	0	0	0	1	0	0
AU 25 Lips Part	3	1	2	3	4	4
AU 26 Jaw Drop	2	1	0	2	1	0
AU 38 Nostril Dilate	0	3	1	1	0	1
AU 43 Eyes Closed	1	0	0	1	3	1

Table C15 Frequency of Action Units (AUs) in response to different odors for the total sample (*N* = 28). Each AU was counted once for each participant when it was shown more often.

Action Unit	Odor stimuli banana	cinnamon	clove	coffee	fish	garlic
AU 1 Inner Brow Raise	1	0	4	2	5	1
AU 2 Outer Brow Raise	1	0	3	2	3	1
AU 4 Brow Lower	3	2	13	6	16	14
AU 5 Lid Raise	3	2	0	1	3	0
AU 6 Cheek Raise	0	0	2	0	2	2
AU 7 Lids Tight	8	10	17	16	19	17
AU 9 Nose Wrinkle	1	1	2	0	4	3
AU 10 Upper Lip Raise	5	6	13	8	18	17
AU 12 Lip Corner Pull	2	2	3	3	3	3
AU 13 Sharp Lip Pull	0	0	0	0	0	0
AU 14 Dimpler	3	2	2	6	3	6
AU 15 Lip Corner Depress	0	1	2	3	6	6
AU 16 Lower Lip Depress	0	0	0	0	0	0
AU 17 Chin Raise	1	1	2	2	5	5
AU 18 Lip Pucker	0	0	0	0	0	0
AU 19 Tongue Show	0	1	0	0	0	0
AU 20 Lip Stretch	0	0	1	0	2	2
AU 23 Lip Tight	0	0	0	1	0	1
AU 24 Lip Press	0	0	0	1	0	0
AU 25 Lips Part	2	1	2	3	3	4
AU 26 Jaw Drop	1	1	0	2	1	0
AU 38 Nostril Dilate	0	2	1	1	0	1
AU 43 Eyes Closed	1	0	0	1	3	1

Table C16 Frequency of Action Units (AUs) in response to odors in which both FACS coders agreed upon (**bold face**). AUs observed by one coder are *italic*. Inter-rater reliability (IR) of each Action Unit is listed in the table and general IR in response to odors is listed below.

AU	1	2	4	5	6	7	9	10	12	14	15	17	20	25	26	43	Coder 1
1	**5**																*1*
2		**5**															*1*
4			**22**														*4*
5				**8**													*1*
6					**3**												*0*
7						**28**											*6*
9							**2**										*0*
10								**14**									*2*
12									**4**								*1*
14										**3**							*0*
15											**4**						*2*
17												**4**					*1*
20													**1**				*0*
25														**13**			*4*
26															**10**		*2*
43																**3**	*0*
Coder 2	*1*	*1*	*5*	*1*	*0*	*1*	*1*	*1*	*0*	*1*	*0*	*1*	*0*	*0*	*2*	*1*	Coder 1: 24 Coder 2: 16
IR for each AU	.83	.83	.83	.88	1.0	.88	.80	.90	.88	.86	.80	.80	1.0	.87	.83	.86	

Note: IR = Inter-rater reliability [(sum of agreements of Action Units of the coders × 2)/(total sum of Action Units scored by each coder)] = **[(129×2)/(129×2) + 24 + 16)] = (258 /298) = .86.** AU 8, 11, 13, 16, 18, 19, 21-24, 27-39, 44, and 50 were not observed.

Study 2:
Table C17 Diagnostic criteria of eating disorders according to the DSM-IV and ICD-10.

Anorexia Nervosa		**Bulimia Nervosa**		**Binge-Eating Disorder**
ICD-10 (F50.0)	DSM-IV (307.10)	ICD-10 (F50.2)	DSM-IV (F307.51)	DSM-IV (F307.50)
A. Weight loss (body weight at least 15% below the normal or expected weight for age and weight) B. Weight loss is self-induced by avoidance of fattening foods, self-induced vomiting, misuse of laxatives, diuretics, appetite suppressants, excessive exercise. C. Self-perception of being too fat, with an intrusive draed of fatness, which leads to a self-imposed low weight threshold. D. Amenorrhea (at least three consecutive cycles) in postmenarchal girls and women. Amenorrhea is defined as periods occurring only following hormone (e.g., estrogen) administration. E. The disorder does not meet criteria A and B for Bulimia. **Subtypes:** **Restricting Type**: no binge-eating or purging behavior, weight loss primarily through dieting, fasting, or excessive exercise. **Bulimic Type**: binge-eating and purging behavior (self-induced vomiting, laxatives, diuretics, or enemas).	A. Refusal to maintain body weight at or above a minimally normal weight for age and height (< 85% of expected weight). B. Intense fear of gaining weight or becoming fat, even though underweight. C. Body image disturbance or dependence of self-evaluation on body shape/weight, denial of seriosness of the low weight. D. Amenorrhea (at least three consecutive cycles) in postmenarchal girls and women. Amenorrhea is defined as periods occurring only following hormone (e.g., estrogen) administration. **Subtypes:** **Restricting Type**: not regularly engaged in binge-eating or purging behavior, weight loss primarily through dieting, fasting, or excessive exercise. **Binge-Eating Type or Purging Type**: regularly engaged in binge-eating OR purging behavior.	A. Recurrent episodes of overeating (at least twice a week over a period of 3 months) in which large amounts of food are consumed in short periods of time. B. Persistent preoccupation with eating, and a strong desire or a sense of compulsion to eat (craving). C. The patients engages in compensatory behavior to counteract weight gain (self-induced vomiting, misuse of laxatives, diuretics, appetite suppressants, thyroid medication, insulin treatment, excessive fasting). D. Self-perception of being too fat, with an intrusive dread of fatness.	A. Recurrent episodes of binge eating characterized by (1) Eating, in a fixed period of time, an amount of food that is definitely larger than most people would eat under similar circumstances. (2) A lack of control over eating. B. Recurrent inappropriate compensatory behavior to prevent weight gain (self-induced vomiting, misuse of laxatives, diuretics, or other medications, fasting, excessive exercise). C. These symptoms occur at least twice a week over a period of 3 months D. Dependence of self-evaluation and self-esteem on body shape and weight. E. The disturbance does not occur exclusively during episodes of anorexia nervosa. **Subtypes:** **Purging type:** self-induced vomiting, use of laxatives, diuretics, or enemas. **Non-purging type:** exercise or excessive fasting after a binge.	A. Recurrent episodes of binge eating characterized by (1) Eating, in a fixed period of time, an amount of food that is definitely larger than most people would eat under similar circumstances. (2) A lack of control over eating. B. Binge eating episodes are associated with three or more of the following: 1. Eating until feeling uncomfortably full. 2. Eating large amounts of food when not physically hungry. 3. Eating much more rapidly than normal. 4. Eating alone. 5. Feeling disgusted, depressed, or guilty after overeating. C. Marked distress regarding binge eating is present. D. Binge eating occurs, on average, at least two days a week for six months. E. The binge eating is not associated with inappropriate compensatory behavior and does not occur exclusively during the course of BN or AN.

Table C18 Recruitment of patients with eating disorders in specialized clinics.

Date of test	Place	Address	Number of Participants	Presentation for staff
04.02.-07.02.08	Bad Grönenbach	Klinik für Psychosomatische Medizin Sebastian-Kneipp-Allee 3a/5 87730 Bad Grönenbach	6	
18.02.-26.02.08	Bad Bodenteich	Seepark Klinik Sebastian- Kneipp- Str.1 29389 Bad Bodenteich	14	11.02.08
13.03.-17.03.08	Bad Oeynhausen	Klinik am Korso Ostkorso 4 32545 Bad Oeynhausen	9	27.02.08
14.04.-18.04.08	Bad Bodenteich	Seepark Klinik Sebastian- Kneipp- Str.1 29389 Bad Bodenteich	11	
23.04.-25.04.08	Stadtlengsfeld	Burg-Klinik Burgstraße 19 36457 Stadtlengsfeld	2	18.01.08
11.06.-16.06.08	Bad Oeynhausen	Klinik am Korso Ostkorso 4 32545 Bad Oeynhausen	11	
	Würzburg	Klinik und Poliklinik für Psychiatrie und Psychotherapie Füchsleinstrasse 15 97080 Würzburg	2	
	Lohr am Main	Krankenhaus für Psychiatrie, Psychotherapie und Psychosomatische Medizin Am Sommerberg 97816 Lohr am Main	1	05.11.07
	Würzburg	Anzeigen www.wuewowas.de	6	

Table C19 Sample characteristics for healthy controls, patients with Anorexia, Bulimia, or Binge-Eating Disorder, and for the total sample.

	Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)		Total sample (*N* = 74)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Handedness										
Right-hander	19	95.0	17	85.0	16	84.2	14	93.3	66	89.2
Left-hander	1	5.0	3	15.0	3	15.8	1	6.7	8	10.8
Graduation										
without	1	5.0	3	15.0	0	0.0	0	0.0	4	5.4
Hauptschule	0	0.0	1	5.0	4	21.0	2	13.3	7	9.5
Realschule	0	0.0	6	30.0	6	31.6	3	20.0	15	20.3
Abitur	19	95.0	8	40.0	6	31.6	7	46.7	40	54.1
University	0	0.0	2	10.0	3	15.8	3	20.0	8	10.8
Profession										
Schooler	1	5.0	8	40.0	5	26.3	1	6.7	15	20.3
Student	17	85.0	5	25.0	6	31.6	4	26.7	32	43.2
Job	2	10.0	7	35.0	6	31.6	10	66.7	25	33.3
House wife	0	0.0	0	0.0	2	10.5	0	0.0	2	2.7
Marital status										
unmarried	20	100.0	19	95.0	14	73.7	12	80.0	65	87.8
married	0	0.0	1	5.0	5	26.3	1	6.7	7	9.5
separated/divorced	0	0.0	0	0.0	0	0.0	2	13.3	2	2.7
Vegetarianism										
no	18	90.0	13	65.0	14	73.7	13	86.7	58	78.4
yes	2	10.0	7	35.0	5	26.3	2	13.3	16	21.6
Psychiatric Disorder										
Depression	0	0.0	4	20.0	7	37.0	4	27.0	15	20.3
Personality Disorder	0	0.0	3	15.0	1	5.3	1	6.6	5	6.8
Posttraumatic Stress Disorder	0	0.0	2	10.0	1	5.3	1	6.6	4	5.4
Social Phobia	0	0.0	0	0.0	0	0.0	1	6.6	1	1.4

Table C20 Intensity, pleasantness, and mood ratings in response to low and high taste concentrations (bitter, salty, sour, sweet, umami) for healthy controls, patients with Anorexia, Bulimia, or Binge-Eating Disorder – average deviations (Mean ± *SD*) from ratings for mineral water.

			Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)	
Variable	Taste	Concentration	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity										
	water		2.7	2.1	2.6	2.2	2.5	2.5	2.7	1.7
	bitter	low	6.7	6.1	6.6	5.9	5.3	7.3	7.1	6.5
		high	20.4	5.2	19.3	6.3	19.6	5.0	18.4	6.1
	salty	low	5.6	3.8	4.6	4.9	4.8	5.6	8.1	5.8
		high	20.8	5.1	21.7	2.7	21.3	3.1	19.4	4.3
	sour	low	14.3	4.6	13.8	3.5	14.4	5.7	15.2	3.6
		high	20.3	2.8	20.9	3.2	20.4	3.3	20.5	3.0
	sweet	low	8.6	3.4	9.4	4.3	8.8	3.5	9.9	3.8
		high	19.8	3.3	20.3	3.1	19.8	3.5	19.5	2.9
	umami	low	10.4	5.3	9.6	6.1	11.6	6.9	12.1	6.2
		high	16.3	3.7	16.6	5.1	16.9	5.0	16.5	4.2
Pleasantness										
	water		15.0	3.5	13.0	3.5	12.5	5.1	15.4	2.8
	bitter	low	-6.1	4.8	-4.5	5.2	-3.6	6.4	-5.1	5.8
		high	-11.8	5.1	-9.1	5.1	-9.2	5.2	-10.9	4.1
	salty	low	-4.3	4.3	-3.0	3.4	-2.5	4.1	-5.3	4.6
		high	-11.4	4.3	-7.3	4.4	-8.6	5.9	-11.5	4.6
	sour	low	-2.8	5.1	-1.6	4.7	0.3	6.5	-4.1	4.8
		high	-2.8	5.0	-2.1	8.1	-0.8	7.6	-3.4	6.3
	sweet	low	1.0	5.5	1.4	4.2	2.2	5.8	-2.5	4.0
		high	2.7	4.8	4.5	6.8	4.9	7.5	-0.9	7.0
	umami	low	-8.3	4.2	-6.2	4.0	-6.1	6.0	-6.5	5.1
		high	-7.9	5.4	-5.9	6.9	-5.4	6.3	-8.1	4.9
Mood										
	water		19.0	3.4	16.4	4.0	16.3	3.0	18.4	2.4
	bitter	low	-2.4	3.6	-3.3	3.4	-3.3	4.0	-3.9	4.3
		high	-4.1	5.3	-5.6	3.6	-6.5	5.3	-6.6	6.0
	salty	low	-1.9	3.3	-2.8	3.9	-2.8	3.6	-3.9	4.1
		high	-3.6	5.2	-5.6	5.5	-5.0	5.1	-6.7	4.8
	sour	low	-1.4	2.6	-1.3	4.4	0.0	3.5	-3.6	5.0
		high	-1.1	3.3	-2.4	3.7	0.2	4.6	-3.2	5.4
	sweet	low	-0.5	1.2	-0.6	2.6	0.1	2.2	-2.1	3.1
		high	0.1	1.7	0.4	3.8	1.6	4.5	-1.2	4.3
	umami	low	-2.7	4.1	-2.9	4.1	-5.5	4.9	-3.8	4.7
		high	-2.8	4.7	-3.9	4.3	-5.7	5.6	-5.3	4.9

Table C21 Intensity, pleasantness, and mood ratings in response to different odors (Mean ± *SD*) for healthy controls, patients with Anorexia, Bulimia, or Binge-Eating Disorder.

	Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity								
probe	12.4	3.7	13.5	4.4	9.7	4.0	11.1	5.0
banana	19.3	3.4	18.3	4.3	17.2	3.7	18.1	3.4
cinnamon	18.1	4.1	16.5	3.7	16.2	4.1	16.4	4.2
clove	20.6	3.8	19.4	3.2	18.1	4.0	19.4	2.4
licorice	17.3	5.0	15.7	2.7	15.7	4.3	15.9	3.5
fish	20.6	3.6	20.7	3.8	19.9	3.1	21.7	1.7
garlic	22.2	2.5	22.2	2.7	22.1	3.0	21.9	2.5
Pleasantness								
probe	18.2	4.6	15.8	5.0	16.7	5.6	16.9	4.1
banana	15.3	4.2	15.7	4.5	16.6	4.9	15.1	4.7
cinnamon	21.1	4.0	19.4	3.9	19.1	4.2	15.0	3.7
clove	9.4	4.2	10.6	5.2	7.7	4.2	11.9	6.1
licorice	15.4	5.7	15.5	3.7	16.3	5.3	17.3	5.7
fish	6.6	3.7	5.4	5.2	7.5	6.2	5.3	3.7
garlic	7.9	5.7	6.9	5.8	4.7	4.7	7.5	5.5
Mood								
probe	18.7	3.8	15.8	4.1	16.5	4.4	17.5	2.9
banana	18.2	3.7	15.9	3.9	17.4	3.7	17.5	3.2
cinnamon	20.0	3.8	17.7	4.6	18.2	3.7	16.9	2.6
clove	17.0	4.5	14.2	4.1	13.5	4.8	16.2	3.9
licorice	18.2	4.7	16.1	3.8	16.4	3.5	17.5	4.3
fish	16.9	5.3	13.0	5.3	13.7	4.8	14.3	4.0
garlic	17.8	3.9	12.8	5.1	11.2	5.4	15.1	3.2

Table C22 Frequency of **Action Units (AUs)** in response to **low concentrations** of the bitter, salty, sour, sweet, umami **tastes**, and water before and after swallowing (pre and post), and both periods combined (total) in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* =19), and Binge-Eating Disorder (*n* = 15). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

		water				bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 1 Inner Brow Raise	pre	1	0	0	1	0	0	1	2	0	1	1	0	1	3	6	2	0	1	0	0	0	0	0	3
	post	1	0	0	1	1	0	1	1	0	2	0	2	1	2	2	2	1	0	0	0	4	0	1	2
	total	2	0	0	2	1	0	2	3	0	3	1	2	2	5	8	4	1	1	0	0	4	0	1	5
AU 2 Outer Brow Raise	pre	0	0	0	1	1	0	2	0	0	0	0	0	0	1	4	1	0	0	0	2	0	0	1	3
	post	0	0	0	1	0	0	2	1	0	0	0	2	0	1	2	1	1	0	1	0	2	0	0	1
	total	0	0	0	2	1	0	4	1	0	0	0	2	0	2	6	2	1	0	1	2	2	0	1	4
AU 4 Brow Lower	pre	4	1	2	1	3	6	4	5	7	3	9	8	11	9	7	13	5	5	5	3	10	5	9	12
	post	4	9	4	0	5	6	10	7	6	6	6	7	7	7	9	10	0	3	5	6	14	11	15	10
	total	8	10	6	1	8	12	14	12	13	9	15	15	18	16	16	23	5	8	10	9	24	16	24	22
AU 5 Lid Raise	pre	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
	total	0	0	1	0	0	0	0	0	0	0	0	0	0	2	1	1	1	1	0	0	0	1	0	0
AU 6 Cheek Raise	pre	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	1
	post	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	3	0	0	0	0	0	0	1	2
	total	0	0	0	0	0	0	0	1	0	0	0	0	2	2	0	4	0	0	0	1	0	0	1	3
AU 7 Lids Tight	pre	2	0	0	1	5	7	1	3	6	4	4	6	14	10	6	8	6	4	1	2	11	5	3	7
	post	2	3	1	0	3	6	5	4	3	2	3	5	6	5	6	2	2	3	1	1	6	5	9	7
	total	4	3	1	1	8	13	6	7	9	6	7	11	20	15	12	10	8	7	2	3	17	10	12	14
AU 9 Nose Wrinkle	pre	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
	post	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	total	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1
AU 10 Upper Lip Raise	pre	0	0	0	0	2	3	3	3	2	3	5	4	11	7	14	13	2	3	3	1	6	1	9	6
	post	1	2	1	0	3	5	6	3	4	3	5	4	8	9	9	7	3	2	5	2	11	4	10	10
	total	1	2	1	0	5	8	9	6	6	6	10	8	19	16	23	20	5	5	8	3	17	5	19	16

Table C22 Continued.

		water				bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 11 Nasolabial Deepen	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	post	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
AU 12 Lip Corner Pull	pre	0	1	1	1	0	0	0	0	0	0	0	0	1	2	1	1	2	1	0	1	1	1	0	1
	post	1	0	2	1	1	1	1	2	1	1	1	1	4	2	4	5	0	0	1	2	2	4	2	3
	total	1	1	3	2	1	1	1	2	1	1	1	1	5	4	5	6	2	1	1	3	3	5	2	4
AU 13 Sharp Lip Pull	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	2	1	1	1	0	0	0	0
	total	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	2	1	1	1	0	0	0	0
AU 14 Dimpler	pre	11	14	15	11	17	17	21	16	21	15	23	14	14	8	27	10	14	10	26	16	14	15	25	10
	post	17	12	19	14	21	16	22	28	19	17	22	16	12	23	37	19	19	24	33	25	20	18	19	19
	total	28	26	34	25	38	33	43	44	40	32	45	30	26	31	64	29	33	34	59	41	34	33	44	29
AU 15 Lip Corner Depress	pre	0	0	0	0	0	0	0	3	0	0	2	3	5	2	4	7	0	1	1	1	2	1	3	3
	post	0	0	0	0	1	0	0	1	1	0	1	4	5	4	1	3	0	2	2	1	5	1	8	5
	total	0	0	0	0	1	0	0	4	1	0	3	7	10	6	5	10	0	3	3	2	7	2	11	8
AU 16 Lower Lip Depress	pre	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	post	0	0	0	1	1	1	1	0	2	0	0	1	1	0	1	3	0	0	1	1	0	0	1	0
	total	0	1	0	1	1	1	1	0	2	0	0	1	1	0	1	3	0	1	1	1	0	0	1	0
AU 17 Chin Raise	pre	5	1	3	2	7	2	5	10	11	3	4	5	12	4	7	4	6	2	5	5	4	4	6	5
	post	3	3	2	0	2	3	2	4	3	2	1	5	2	3	3	3	2	5	6	1	5	3	7	6
	total	8	4	5	2	9	5	7	14	14	5	5	10	14	7	10	7	8	7	11	6	9	7	13	11
AU 18 Lip Pucker	pre	0	0	0	0	0	0	0	0	0	1	1	1	0	0	2	0	1	0	1	1	2	0	1	2
	post	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1
	total	0	0	1	0	0	1	0	0	1	1	1	1	0	1	2	1	1	0	1	1	2	0	1	3
AU 19 Tongue Show	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C22 Continued.

		water				bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 20 Lip Stretch	pre	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	1	0	0	1	0	2	2	1	2	2	0	1	1	0	0	0	1	0
	total	0	0	0	0	0	0	1	0	0	1	0	2	4	1	2	2	0	1	1	0	0	0	1	0
AU 23 Lip Tight	pre	1	0	0	1	2	0	1	0	1	0	1	0	2	1	1	0	0	0	0	0	0	0	0	1
	post	1	1	1	0	1	2	0	2	0	1	1	1	3	5	6	4	1	2	2	0	0	1	0	2
	total	2	1	1	1	3	2	1	2	1	1	2	1	5	6	7	4	1	2	2	0	0	1	0	3
AU 24 Lip Press	pre	7	8	12	7	9	9	14	11	10	10	19	7	9	12	22	9	7	8	19	15	9	9	11	11
	post	18	14	14	14	23	19	20	19	13	23	25	19	23	21	28	19	20	15	30	27	14	22	23	24
	total	25	22	26	21	32	28	34	30	23	33	44	26	32	33	50	28	27	23	49	42	23	31	34	35
AU 25 Lips Part	pre	1	0	0	0	1	0	2	1	1	0	2	1	0	1	1	0	0	0	1	1	1	0	0	1
	post	15	15	22	13	24	15	35	19	26	21	36	23	21	24	39	24	27	17	36	28	28	17	31	18
	total	16	15	22	13	25	15	37	20	27	21	38	24	21	25	40	24	27	17	37	29	29	17	31	19
AU 26 Jaw Drop	pre	0	1	0	2	2	1	4	6	1	1	2	2	1	2	3	0	1	0	1	2	1	0	0	4
	post	15	14	24	13	27	13	36	21	24	19	37	24	24	25	43	23	26	19	38	32	29	17	32	21
	total	15	15	24	15	29	14	40	27	25	20	39	26	25	27	46	23	27	19	39	34	30	17	32	25
AU 28 Lip Suck	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	post	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	2	2	0	2	0	0	0	2
	total	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	2	2	0	2	0	0	0	3
AU 29 Jaw Thrust	pre	1	0	0	0	0	0	0	0	2	0	1	1	0	0	0	2	1	0	0	0	1	0	0	0
	post	0	0	1	0	2	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0
	total	1	0	1	0	2	0	0	0	2	0	2	1	0	0	3	2	1	0	0	0	1	0	0	0
AU 30 Jaw to Sideways	pre	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
	post	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1
	total	1	1	0	1	1	0	1	2	0	0	0	0	0	1	1	1	0	0	2	2	0	0	0	1
AU 31 Jaw Clench	pre	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	1	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0	0	1	2	0	0	0
	total	0	0	2	0	0	0	0	0	1	0	1	2	0	0	0	1	0	0	0	1	2	0	0	0

Table C22 Continued.

		water				bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 33 Blow	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
AU 34 Puff	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 35 Cheek Suck	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	1	0	0	2	0	0	0	2	0	0	1	0	0	0	0	1	0
	total	0	0	0	0	0	0	0	1	0	0	2	0	0	0	2	0	0	1	0	0	0	0	1	0
AU 36 Tongue Bulge	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
AU 37 Lip Wipe	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	0	0	0	0	2	2	1	0	0	1	2	0	4	3	0	3	0	4	1	1	1	1
	total	1	0	0	0	0	0	2	2	1	0	0	1	2	0	4	3	0	3	0	4	1	1	1	1
AU 38 Nostril Dilate	pre	0	1	2	1	0	0	0	0	1	0	2	2	0	0	1	1	1	0	2	1	0	0	1	1
	post	0	0	0	1	1	0	0	1	2	0	1	1	2	0	0	1	3	0	0	1	0	1	1	3
	total	0	1	2	2	1	0	0	1	3	0	3	3	2	0	1	2	4	0	2	2	0	1	2	4
AU 39 Nostril Compress	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	post	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
AU 43 Eyes Closed	pre	0	0	0	0	0	0	1	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0	0	1
	post	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
	total	0	0	0	0	0	0	1	0	0	0	0	1	4	1	1	0	0	0	0	0	0	0	1	1
AU 50 Speech	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	3	0	0	2	0	0	0	1	1
	total	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	3	0	0	2	0	0	0	1	1

Table C23 Frequency of **Action Units (AUs)** in response to **high concentrations** of the bitter, salty, sour, sweet, and umami **tastes**, before and after swallowing (pre and post), and both periods combined (total) in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* =19), and Binge-Eating Disorder (*n* = 15). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

		bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 1 Inner Brow Raise	pre	2	3	5	3	0	2	7	2	2	3	8	1	1	0	1	2	1	0	3	3
	post	5	3	5	3	8	5	7	6	9	6	10	4	3	3	2	0	4	0	2	4
	total	7	6	10	6	8	7	14	8	11	9	18	5	4	3	3	2	5	0	5	7
AU 2 Outer Brow Raise	pre	1	0	3	2	0	1	3	1	3	1	4	1	2	0	1	1	1	0	0	3
	post	4	2	2	2	6	3	9	5	6	3	6	3	2	3	3	0	4	0	2	2
	total	5	2	5	4	6	4	12	6	9	4	10	4	4	3	4	1	5	0	2	5
AU 4 Brow Lower	pre	17	16	20	13	16	13	21	14	16	10	16	12	9	7	13	9	12	10	11	12
	post	15	12	15	11	15	9	18	13	11	12	20	13	4	4	11	8	12	10	16	12
	total	32	28	35	24	31	22	39	27	27	22	36	25	13	11	24	17	24	20	27	24
AU 5 Lid Raise	pre	0	1	1	2	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0
	post	0	1	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	0
	total	0	2	1	2	0	1	2	0	0	2	1	0	0	1	1	0	0	0	1	0
AU 6 Cheek Raise	pre	1	2	1	0	0	1	0	2	2	3	2	1	0	2	1	0	1	0	0	2
	post	2	1	0	1	0	3	2	5	5	2	0	3	0	1	0	0	0	0	0	4
	total	3	3	1	1	0	4	2	7	7	5	2	4	0	3	1	0	1	0	0	6
AU 7 Lids Tight	pre	14	9	12	10	13	11	12	14	13	11	13	10	6	6	7	5	8	8	9	7
	post	8	11	12	11	12	12	14	10	10	13	10	9	3	2	6	4	10	8	9	9
	total	22	20	24	21	25	23	26	24	23	24	23	19	9	8	13	9	18	16	18	16
AU 9 Nose Wrinkle	pre	1	0	0	1	0	0	1	3	0	1	0	1	0	0	0	0	0	0	0	1
	post	0	0	4	2	0	0	1	1	0	0	1	2	0	0	0	0	0	0	0	1
	total	1	0	4	3	0	0	2	4	0	1	1	3	0	0	0	0	0	0	0	2
AU 10 Upper Lip Raise	pre	19	17	18	13	18	16	21	12	20	15	17	13	4	5	13	8	11	8	14	11
	post	18	16	18	11	18	17	17	12	12	15	16	14	4	5	13	6	11	15	17	11
	total	37	33	36	24	36	33	38	24	32	30	33	27	8	10	26	14	22	23	31	22

Table C23 Continued.

		bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 11 Nasolabial Deepen	pre	0	0	0	1	0	0	2	2	0	0	1	0	0	0	0	0	1	0	1	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	total	0	0	0	1	0	0	2	2	0	0	1	0	1	0	0	0	1	0	1	1
AU 12 Lip Corner Pull	pre	1	2	2	0	0	1	1	2	2	3	2	1	0	2	1	0	1	0	0	2
	post	4	1	1	1	0	3	1	6	8	6	4	6	3	3	1	1	0	0	1	5
	total	5	3	3	1	0	4	2	8	10	9	6	7	3	5	2	1	1	0	1	7
AU 13 Sharp Lip Pull	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	2	1	1	0	0
	total	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	2	1	1	0	0
AU 14 Dimpler	pre	5	5	11	5	11	8	10	4	10	6	19	7	16	9	21	9	17	19	25	10
	post	14	8	11	18	18	18	14	7	22	17	37	19	21	26	32	19	16	16	19	18
	total	19	13	22	23	29	36	24	11	32	23	56	26	37	35	53	28	33	35	44	28
AU 15 Lip Corner Depress	pre	8	3	7	11	3	6	9	14	5	3	7	7	0	1	3	4	3	2	5	6
	post	4	3	8	6	4	8	9	7	1	4	2	10	1	2	2	2	6	3	2	5
	total	12	6	15	17	7	14	18	21	6	7	9	17	1	3	5	6	9	5	7	11
AU 16 Lower Lip Depress	pre	0	0	0	0	0	0	1	0	0	0	2	1	0	0	0	0	0	0	0	0
	post	2	2	1	3	0	4	2	3	3	2	3	0	0	0	3	3	1	0	6	2
	total	2	2	1	3	0	4	3	3	3	2	5	1	0	0	3	3	1	0	6	2
AU 17 Chin Raise	pre	11	6	9	5	7	3	6	9	11	4	8	10	9	3	7	8	6	6	8	11
	post	1	4	6	3	5	5	8	5	2	7	9	8	3	2	9	4	7	6	4	4
	total	12	10	15	8	12	8	14	14	13	11	17	18	12	5	16	12	13	12	12	15
AU 18 Lip Pucker	pre	0	0	0	1	0	0	0	1	1	2	0	0	0	0	0	2	0	0	0	1
	post	0	1	1	0	0	2	0	0	2	6	2	1	1	2	0	0	0	1	0	0
	total	0	1	1	1	0	2	0	1	3	8	2	1	1	2	0	2	0	1	0	1
AU 19 Tongue Show	pre	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	total	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1

Table C23 Continued.

		bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 20 Lip Stretch	pre	0	0	4	1	0	0	3	3	1	0	3	1	0	0	0	0	1	0	1	1
	post	6	1	3	7	5	3	7	3	0	3	5	0	1	1	0	1	1	0	0	1
	total	6	1	7	8	5	3	10	6	1	3	8	1	1	1	0	1	2	0	1	2
AU 21 Neck Tighten	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
	total	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
AU 23 Lip Tight	pre	0	0	1	3	1	1	4	2	4	1	9	6	1	1	2	0	1	0	1	0
	post	1	3	1	2	4	2	0	5	3	6	6	9	3	3	2	1	1	2	1	1
	total	1	3	2	5	5	3	4	7	7	7	15	15	4	4	4	1	2	2	2	1
AU 24 Lip Press	pre	13	9	12	10	11	14	20	12	18	11	22	13	15	9	18	11	13	10	15	11
	post	12	15	10	18	16	15	15	8	19	25	41	27	20	26	33	25	18	22	29	15
	total	25	24	22	28	27	29	35	20	37	36	63	40	35	35	51	36	31	32	44	26
AU 25 Lips Part	pre	1	0	0	0	1	0	1	0	3	0	4	0	1	0	2	1	0	0	0	0
	post	21	15	18	28	26	16	25	19	29	25	47	27	29	22	37	25	29	21	35	20
	total	22	15	18	28	27	16	26	19	32	25	51	27	30	22	39	26	29	21	35	20
AU 26 Jaw Drop	pre	1	0	2	3	2	1	1	2	3	1	6	2	4	1	5	1	4	0	1	5
	post	20	15	21	27	26	16	25	18	34	24	49	31	35	23	43	25	26	22	40	22
	total	21	15	23	30	28	17	26	20	36	25	55	33	39	24	48	26	30	22	41	27
AU 28 Lip Suck	pre	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	1	0	0	1	0	1	2	0	0	2	1	0	0	4
	total	0	0	0	0	0	0	1	0	2	1	0	1	2	0	0	2	1	0	0	4
AU 29 Jaw Thrust	pre	2	0	0	0	2	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0
	post	0	0	2	0	0	0	1	0	0	0	3	0	0	0	0	0	2	0	1	0
	total	2	0	2	0	2	1	1	0	0	0	3	0	0	0	0	1	2	0	2	0
AU 30 Jaw to Sideways	pre	1	0	0	1	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	0
	post	0	0	0	0	1	0	0	0	1	0	0	3	0	1	0	0	0	0	1	0
	total	1	0	0	1	1	1	0	2	1	0	0	3	0	2	0	0	0	0	1	0

Table C23 Continued.

		bitter				salty				sour				sweet				umami			
		C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 31 Jaw Clench	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	1	2	0
	total	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	1	2	0
AU 33 Blow	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 35 Cheek Suck	pre	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	2	0
	total	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	2	0
AU 36 Tongue Bulge	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
AU 37 Lip Wipe	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	post	0	0	1	1	0	0	1	0	0	0	4	1	1	1	1	3	0	0	0	4
	total	0	0	1	1	0	0	1	0	0	0	4	1	1	2	1	3	0	0	0	4
AU 38 Nostril Dilate	pre	1	1	0	2	1	0	0	4	0	2	2	2	0	1	2	2	0	0	0	2
	post	1	0	1	1	0	0	1	2	0	0	0	1	2	0	1	2	2	0	0	2
	total	2	1	1	3	1	0	1	6	0	2	2	3	2	1	3	4	2	0	0	4
AU 39 Nostril Compress	pre	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
	post	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
AU 43 Eyes Closed	pre	3	3	2	3	1	1	0	5	4	1	3	0	0	0	0	1	2	2	1	2
	post	1	0	2	1	0	0	0	0	2	0	3	3	0	1	0	0	2	0	1	2
	total	4	3	4	4	0	0	0	0	6	1	6	3	0	1	0	1	4	2	2	4
AU 50 Speech	pre	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	post	1	0	4	1	0	0	0	0	1	3	3	3	0	1	1	2	0	2	3	2
	total	1	0	5	1	0	0	0	0	1	3	3	3	0	1	1	2	0	2	3	2

Table C24 Inter-rater reliability (IR) of tastes codings: Frequency of Action Units (AUs) in response to tastes in which both FACS coders agreed upon (**bold face**), AUs observed by one coder are *italic*; Inter-rater reliability (IR) of each Action Unit is listed in the table and general IR in response to tastes is listed below.

AU	1	2	4	6	7	9	10	12	13	14	15	16	17	18	20	23	24	25	26	29	30	31	34	35	37	38	43	50	Coder 1
1	**4**																												*1*
2		**4**																											*1*
4			**60**																										*24*
6				**7**																									*3*
7					**33**																								*29*
9						**1**																							*0*
10							**59**																						*18*
12								**14**																					*5*
13									**12**																				*0*
14										**150**																			*12*
15											**27**																		*2*
16												**8**																	*5*
17													**32**																*19*
18														**8**															*1*
20															**5**														*2*
23																**5**													*3*
24																	**119**												*30*
25																		**99**											*2*
26																			**79**										*7*
29																				**1**									*0*
30																					**1**								*1*
31																						**6**							*0*
34																							**21**						*3*
35																								**2**					*0*
37																									**1**				*0*
38																										**1**			*0*
43																											**10**		*0*
50																												**1**	*0*
Coder 2	*1*	*1*	*4*	*2*	*10*	*0*	*9*	*4*	*5*	*49*	*14*	*1*	*4*	*4*	*1*	*2*	*20*	*2*	*4*	*1*	*1*	*7*	*6*	*2*	*0*	*1*	*6*	*0*	C1: 168 C2: 164
IR for each AU	.80	.80	.81	.74	.63	1.0	.81	.76	.83	.83	.77	.73	.73	.76	.77	.67	.83	.98	.93	.67	.50	.63	.82	.67	1.0	.67	.77	1.0	

Note: C1 = Coder 1, C2 = Coder 2, IR = Inter-rater reliability [(sum of agreements of Action Units of the coders × 2)/(total sum of Action Units scored by each coder)] = **[(770×2)/(770×2) + 168 + 164)] = (1540 /1872) = .82**. AU 5, 8, 11, 19, 21, 22, 27, 28, 32, 33, 36, and 39 were not observed.

Table C25 Frequency of **Action Units (AUs)** in response to different **odors** in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* = 19), and Binge-Eating Disorder (*n* = 15). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

	probe				banana				cinnamon				clove				licorice				fish				garlic			
Action Unit	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 1 Inner Brow Raise	0	0	0	0	1	0	1	1	1	1	1	0	0	0	2	0	0	0	2	2	0	0	2	1	0	0	3	1
AU 2 Outer Brow Raise	0	1	0	0	0	0	1	0	1	2	1	0	0	0	1	1	0	0	2	2	1	0	1	1	2	0	1	0
AU 4 Brow Lower	5	7	3	4	9	5	2	5	1	2	1	2	10	7	1	7	2	2	0	1	14	10	9	14	17	15	14	8
AU 5 Lid Raise	0	0	0	0	0	0	0	0	1	0	0	1	0	0	4	1	1	0	1	0	0	0	1	0	0	1	0	0
AU 6 Cheek Raise	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	2	2	2	2	1	2	2
AU 7 Lids Tight	3	3	1	1	5	7	3	6	2	4	1	1	10	7	2	8	2	8	2	2	12	11	9	8	13	13	10	8
AU 9 Nose Wrinkle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	1	0	0	0	2
AU 10 Up-per Lip Raise	0	2	0	1	2	2	3	2	0	2	0	0	4	7	0	5	2	1	0	1	9	9	7	9	8	11	8	8
AU 12 Lip Corner Pull	0	1	1	0	2	0	0	0	3	2	1	1	0	0	4	0	0	0	0	1	1	2	2	2	3	1	1	2
AU 13 Sharp Lip Pull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 14 Dimpler	0	0	1	2	1	1	0	0	0	0	1	0	1	0	2	0	1	0	1	1	0	2	1	2	2	0	0	2
AU 15 Lip Corner Depress	0	0	0	0	0	0	1	1	0	0	2	1	0	0	1	0	0	0	0	1	2	3	1	3	0	2	2	2
AU 16 Lower Lip Depress	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
AU 17 Chin Raise	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	2	0	0	0	1	1
AU 18 Lip Pucker	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 19 Tongue Show	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Table C25 Continued.

Action Unit	probe				banana				cinnamon				clove				licorice				fish				garlic			
	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE	C	AN	BN	BE
AU 20 Lip Stretch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0
AU 23 Lip Tight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
AU 24 Lip Press	1	1	0	0	1	0	0	0	0	1	0	1	0	0	1	1	0	0	0	1	1	1	3	0	0	1	1	0
AU 25 Lips Part	0	2	0	0	0	1	0	2	0	2	0	1	0	1	0	0	1	2	1	0	0	2	0	1	0	3	0	0
AU 26 Jaw Drop	1	1	0	0	0	1	0	2	0	1	0	1	0	1	0	0	1	3	1	0	0	2	0	1	0	3	0	0
AU 31 Jaw Clench	0	1	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0
AU 33 Blow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0
AU 38 Nostril Dilate	4	2	1	1	3	3	1	1	5	1	2	2	2	2	0	3	3	1	1	3	1	2	0	2	2	2	2	2
AU 39 Nostril Compress	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0
AU 45 Blink	28	42	24	32	34	42	28	28	29	40	19	25	24	51	20	31	32	32	18	27	29	35	19	29	35	51	30	31
AU 50 Speech	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	2	0

Table C26 Inter-rater reliability (IR) of odor codings: Frequency of Action Units (AUs) in response to odors in which both FACS coders agreed upon (**bold face**), AUs observed by one coder are *italic*; Inter-rater reliability (IR) of each Action Unit is listed in the table and general IR in response to odors is listed below.

AU	1	2	4	5	6	7	10	12	14	15	17	18	24	25	26	31	39	43	Coder 1
1	**3**																		*0*
2		**2**																	*1*
4			**23**																*5*
5				**1**															*0*
6					**3**														*1*
7						**30**													*7*
10							**16**												*3*
12								**5**											*1*
14									**2**										*1*
15										**3**									*1*
17											**4**								*0*
18												**1**							*0*
24													**3**						*1*
25														**1**					*0*
26															**2**				*0*
31																**1**			*0*
39																	**3**		*0*
43																		**7**	*2*
Coder 2	*0*	*0*	*4*	*0*	*1*	*4*	*5*	*1*	*0*	*1*	*1*	*0*	*1*	*0*	*0*	*0*	*1*	*0*	C1: 23 C2: 19
IR for each AU	1.0	.80	.84	1.0	.75	.85	.80	.83	.80	.75	.89	1.0	.75	1.0	1.0	1.0	.86	.88	

Note: IR = Inter-rater reliability [(sum of agreements of Action Units of the coders × 2)/(total sum of Action Units scored by each coder)] = **[(110×2)/(110×2) + 23 + 19)] = (220 /262) = .84**. AU 8, 9, 11, 13, 16, 19, 20-23, 27-30, 32-38, 43, and 50 were not observed.

Table C27 Corrugator activity (in mV) in response to water and low and high concentrations of the bitter, salty, sour, sweet, and umami tastes before and after swallowing over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 20), patients with Anorexia (*n* = 20, before swallowing; *n* = 19, after swallowing), Bulimia (*n* = 18), and Binge-Eating Disorder (*n* = 15; *n* = 14, high concentrations after swallowing).

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
Taste	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	-0.3	0.8	-0.4	1.3	-0.9	2.3	-0.1	1.0	0.2	1.2	0.3	1.2	-0.5	2.4	-0.2	1.0
	2	-0.4	1.5	-0.4	1.6	-0.6	2.8	-0.6	1.3	0.6	2.6	0.4	1.1	-0.3	2.7	-0.2	1.1
	3	0.0	2.2	-0.4	1.7	0.6	6.5	-0.4	1.1	0.4	2.1	1.8	7.4	1.6	8.4	-0.1	1.2
	4	0.3	2.7	-0.4	1.9	0.5	6.3	-0.3	1.1	-0.2	2.1	0.4	1.2	3.1	14.6	-0.2	1.2
	5	0.4	2.4	-0.3	1.6	0.8	6.1	-0.3	1.3	0.9	4.1	0.9	2.6	2.5	13.7	-0.3	1.3
	6	0.5	3.3	-0.4	1.4	0.6	5.5	-0.2	1.3	1.0	2.5	0.7	2.1	1.9	11.7	-0.4	1.7
	7	0.7	3.1	-0.5	1.4	0.6	5.7	-0.2	1.5	1.1	6.6	0.2	1.6	2.0	11.3	-0.6	1.7
	8	0.1	1.7	-0.4	1.4	1.6	10.4	-0.1	1.7	-0.4	3.1	0.3	2.0	2.0	11.5	-0.3	1.5
Bitter low	1	-0.2	2.4	-0.1	1.1	-1.0	2.8	-0.4	1.3	0.4	4.8	-1.0	3.7	-1.3	4.9	-0.9	3.7
	2	-0.5	2.6	0.0	1.6	-1.5	4.2	-0.4	1.8	2.3	9.0	-1.5	5.7	-1.7	8.2	-2.0	7.4
	3	0.5	4.7	0.6	2.1	-1.4	4.5	-0.2	2.4	0.9	6.1	-1.4	7.0	-1.0	11.9	-2.1	9.6
	4	1.3	6.5	0.7	2.5	-1.4	4.5	0.3	2.8	0.2	6.3	-1.4	6.7	-1.4	10.4	-1.3	8.4
	5	1.5	7.9	0.4	2.4	-1.2	4.9	0.3	3.1	-0.4	5.6	-0.8	7.7	-1.6	11.0	-0.8	9.1
	6	2.0	8.9	0.4	2.5	-1.0	5.0	0.3	2.3	-0.4	4.7	-0.7	8.5	-1.0	11.7	-1.4	8.5
	7	1.4	7.9	0.6	3.1	-0.5	6.0	0.3	2.6	-0.1	4.5	-0.8	7.7	1.9	19.9	-3.0	9.6
	8	1.0	6.8	0.4	2.4	0.2	6.9	0.3	3.6	-0.8	5.8	-1.2	7.2	2.2	18.1	-3.0	10.8
Bitter high	1	4.3	15.0	1.2	3.7	0.2	4.9	9.1	24.5	0.5	3.1	-1.3	7.3	0.5	11.6	-2.3	10.2
	2	7.4	16.6	4.5	10.7	4.1	11.1	16.2	47.5	9.2	36.8	-1.9	14.8	1.6	18.7	5.9	45.4
	3	13.1	20.9	10.4	22.2	7.0	16.3	17.5	37.1	3.1	13.7	-2.2	26.7	8.4	30.2	-4.0	16.0
	4	17.1	23.9	7.4	15.7	15.7	36.2	8.5	13.3	2.8	19.4	-2.6	22.3	9.9	32.2	-7.0	14.8
	5	10.8	21.7	7.7	18.2	14.6	32.2	6.2	12.2	-0.8	18.5	-4.1	17.3	2.0	20.7	-8.5	16.1
	6	6.9	20.6	9.1	23.3	9.1	19.6	4.2	10.9	-2.1	21.5	-3.4	13.7	1.6	21.8	-8.8	16.5
	7	5.9	16.1	10.0	27.8	10.4	19.3	1.8	15.3	0.7	23.0	-5.5	16.6	2.9	22.4	-8.0	17.0
	8	7.5	12.8	9.3	25.8	11.6	23.4	-0.1	13.8	0.4	23.6	-6.3	18.2	1.7	22.6	-8.6	17.2

Table C27 Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
Taste	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Salty low	1	0.3	2.6	-0.1	1.3	-0.1	2.3	-0.2	1.8	-0.7	7.8	0.2	2.3	-0.6	3.5	-0.1	2.6
	2	0.1	1.9	0.3	2.2	-0.2	2.8	-0.1	2.3	-1.4	8.1	0.7	3.1	-0.1	5.1	-1.6	7.6
	3	0.1	2.6	-0.1	1.6	1.4	6.8	-0.1	2.9	-1.3	8.8	0.7	3.3	1.5	8.5	-3.7	10.3
	4	0.3	3.3	0.1	1.6	2.1	9.5	-0.9	4.2	-2.9	9.1	0.4	2.8	3.1	9.8	-4.9	11.0
	5	0.6	4.3	-0.2	1.8	0.6	5.1	-1.0	4.5	-2.4	8.8	1.0	3.7	1.7	8.0	-5.9	12.6
	6	0.7	3.7	-0.1	1.7	1.5	8.7	-0.7	3.4	-2.0	7.6	3.4	11.5	2.3	9.0	-6.2	13.9
	7	1.0	3.6	-0.5	1.7	1.5	9.6	-0.3	4.0	-2.9	8.9	1.3	4.6	1.3	8.5	-5.9	14.1
	8	1.3	3.4	-0.7	1.6	0.4	7.8	0.4	5.4	-2.6	9.1	0.4	3.8	1.5	8.8	-5.3	12.4
Salty high	1	-0.9	7.7	-0.5	10.3	2.5	9.7	3.0	4.3	2.2	9.1	-1.9	13.8	-1.9	11.0	-3.6	10.3
	2	-1.4	15.1	0.5	13.5	5.1	22.9	2.7	15.2	6.0	22.5	-2.9	17.3	2.2	20.6	-0.5	17.3
	3	-0.6	18.0	2.9	18.5	6.1	22.0	0.2	21.1	4.5	15.2	-2.4	20.8	-1.8	17.7	4.7	35.5
	4	-0.6	17.5	3.0	19.3	6.4	24.7	1.7	29.4	6.5	26.2	-3.1	19.6	-7.9	21.0	0.6	37.7
	5	0.6	20.6	3.7	23.6	7.4	27.9	-1.1	27.3	4.9	22.7	-4.0	16.0	-9.3	21.2	-4.8	29.4
	6	-0.9	20.6	2.8	22.7	4.9	21.7	-6.6	18.9	1.8	15.4	-4.3	15.0	-9.7	24.4	-8.7	25.9
	7	-3.3	18.2	4.7	23.5	5.7	21.9	-7.7	19.5	2.7	14.3	-5.7	17.3	-12.2	26.7	-8.9	23.0
	8	-1.8	18.9	3.8	22.8	7.2	26.6	-5.9	19.6	1.0	15.0	-7.8	17.6	-12.0	27.0	-9.3	26.3
Sour low	1	0.8	5.7	-0.4	2.1	-1.3	3.3	-1.0	3.6	0.0	4.7	-0.5	1.6	-0.7	2.8	-1.1	4.6
	2	2.7	12.2	-0.5	3.6	-0.6	3.4	-1.0	4.9	0.5	10.0	-3.0	10.1	-0.2	8.2	-0.3	5.2
	3	3.2	15.4	0.2	4.6	1.3	6.6	-1.0	6.7	-0.3	9.5	-3.3	13.3	3.2	22.8	-0.8	4.8
	4	2.4	11.7	0.7	5.5	2.1	12.7	1.7	7.4	-1.6	7.1	-4.9	12.0	7.5	28.2	-0.9	2.9
	5	5.9	14.8	1.1	7.3	0.8	8.5	1.3	6.9	-1.2	8.8	-5.8	12.6	2.8	13.3	-1.4	3.4
	6	6.3	16.4	3.0	11.5	-0.2	5.2	-0.4	5.9	0.1	14.1	-5.8	12.4	3.0	12.8	-2.5	4.7
	7	4.4	11.3	2.8	11.9	-1.3	4.1	1.2	5.5	-1.7	9.0	-6.6	14.0	2.1	9.2	-3.7	8.2
	8	2.9	9.8	1.3	8.5	-1.9	5.6	-0.7	3.4	-3.5	7.5	-6.9	14.0	0.2	4.9	-3.8	7.5

Table C27 Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
Taste	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sour high	1	2.4	4.4	0.7	6.9	-0.9	5.1	4.2	7.8	0.6	7.2	2.6	16.1	-4.0	12.6	3.3	7.8
	2	6.0	13.9	2.4	8.4	2.2	11.5	6.4	12.5	-2.0	9.9	-1.3	24.5	-3.3	23.0	7.8	16.5
	3	7.8	14.7	7.3	19.7	4.7	12.7	5.8	12.4	-4.1	17.8	-4.6	18.6	-5.3	26.9	7.4	18.1
	4	10.4	18.0	7.1	24.2	3.2	12.6	4.8	9.8	-5.0	19.2	-6.3	16.2	-4.8	29.7	2.5	10.7
	5	10.0	17.7	5.8	25.4	1.6	12.6	5.2	9.7	-5.9	17.8	-6.3	16.9	-8.3	23.8	3.0	13.1
	6	11.5	25.1	6.2	22.8	-0.1	10.2	4.2	8.0	-8.3	14.5	-5.0	22.9	-7.1	21.9	0.8	10.9
	7	10.8	23.8	4.9	18.5	0.8	8.7	2.6	5.7	-10.0	13.4	-8.2	22.3	-8.3	21.2	-0.5	9.4
	8	9.7	21.4	5.5	19.5	3.4	12.0	2.6	6.8	-10.5	13.8	-7.9	18.1	-8.5	21.3	-2.6	10.0
Sweet low	1	-0.5	1.9	0.1	2.3	-1.0	2.0	0.5	1.1	-3.1	13.6	0.2	1.3	0.4	2.8	-0.2	1.9
	2	-0.7	2.4	0.5	3.8	-0.7	3.3	-0.1	1.5	-3.7	17.0	0.0	2.3	0.9	4.3	-0.3	4.0
	3	-0.3	3.1	0.1	3.2	-0.4	3.6	0.2	2.0	-2.6	12.5	0.4	1.9	1.0	4.4	-0.9	3.8
	4	0.1	3.5	0.1	2.9	-0.2	4.1	0.1	2.6	-2.9	10.9	0.9	2.3	1.3	5.2	-0.8	3.3
	5	-0.5	2.9	-0.1	2.6	0.5	5.4	0.4	3.1	-3.2	14.6	1.0	3.0	1.6	5.5	-0.6	2.3
	6	0.6	7.2	-0.1	2.7	-0.6	3.9	0.0	3.2	-4.0	14.9	0.5	2.5	1.8	4.8	-1.3	3.8
	7	-1.0	2.7	-0.2	2.9	-0.4	3.7	-0.1	2.6	-4.2	15.1	0.5	3.5	1.3	4.7	-1.6	3.4
	8	-1.6	2.4	-0.2	3.0	0.0	4.1	0.0	3.1	-3.9	15.1	0.4	4.1	0.2	3.9	-1.4	4.3
Sweet high	1	-0.3	2.5	0.6	2.2	-2.8	7.2	-0.3	4.8	0.3	4.6	-0.8	2.0	0.0	4.2	1.4	7.6
	2	-1.0	4.5	0.8	3.5	-2.3	10.7	1.4	14.5	-0.3	5.5	-0.5	2.5	0.7	7.5	0.3	9.9
	3	-1.2	5.1	2.8	11.9	-1.8	10.1	0.9	11.5	0.9	9.3	-0.4	2.5	-1.4	5.6	-1.4	8.3
	4	0.4	5.4	2.4	10.5	-2.5	10.5	-1.1	7.0	0.2	8.2	-0.2	1.9	-2.2	6.5	-2.6	8.9
	5	0.7	7.0	0.8	6.2	-3.1	10.1	-1.2	7.0	-1.5	6.9	-0.8	4.8	-2.5	7.3	-3.4	7.9
	6	-0.2	5.3	-0.1	4.3	-3.0	10.0	-1.0	7.8	-1.2	9.7	-1.5	4.1	-2.7	7.6	-3.2	7.7
	7	1.4	9.8	-0.4	3.7	-3.0	10.5	-1.6	7.8	-1.8	10.4	-1.1	3.4	-3.1	8.4	-2.3	6.6
	8	1.3	8.9	-0.2	4.3	-2.5	11.0	-2.1	7.6	-1.8	12.6	-1.6	4.2	-3.2	8.1	-3.0	6.5

Before swallowing After swallowing

		C		AN		BN		BE		C		AN		BN		BE	
Taste	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Umami	1	0.4	1.0	0.1	1.3	-2.2	7.4	0.0	1.1	-2.4	9.5	-1.5	4.9	1.6	7.8	2.9	8.7
	2	3.4	14.2	0.3	1.1	-2.3	7.8	0.1	2.3	-1.7	13.4	-3.0	10.5	3.9	14.6	7.8	20.1
	3	5.6	21.0	0.5	1.7	-0.7	9.5	4.3	11.0	2.3	16.2	-4.2	15.8	3.8	15.9	6.2	15.9
	4	6.2	17.4	0.7	2.1	0.8	11.2	5.2	11.3	4.4	19.4	-4.8	18.5	2.1	14.4	5.0	17.5
	5	7.4	15.5	0.3	1.8	1.8	13.7	7.2	13.7	2.6	13.7	-5.1	20.7	2.8	16.7	4.1	14.0
	6	8.3	14.2	0.5	2.1	1.0	12.7	5.5	12.6	-0.4	14.9	-5.2	19.1	2.5	16.7	2.4	8.9
	7	7.6	13.4	0.6	2.4	2.4	13.3	3.2	7.9	-1.1	10.4	-5.4	17.0	3.4	16.4	2.9	9.6
	8	6.1	11.0	1.1	3.2	2.3	12.8	3.2	7.1	-2.0	9.2	-5.7	17.2	4.1	18.9	2.3	10.2
Umami	1	2.3	10.3	1.0	2.0	-1.1	3.6	5.6	12.0	2.7	7.6	0.3	3.9	-1.4	5.0	2.9	10.6
	2	6.6	21.0	2.5	7.8	0.4	7.2	9.9	22.6	2.6	9.2	-1.9	7.6	2.7	15.9	4.6	32.4
	3	4.2	18.0	3.2	11.8	2.7	10.9	8.4	17.0	1.7	10.3	-3.5	11.3	4.2	17.4	8.8	49.4
	4	5.5	19.9	3.7	15.9	5.2	16.5	2.6	5.5	-2.1	23.0	-4.8	15.0	1.0	12.8	4.1	33.5
	5	6.1	21.5	5.0	22.1	2.5	11.0	2.2	5.3	-3.8	25.6	-5.8	18.1	0.8	10.0	-3.0	23.1
	6	3.4	13.2	5.5	21.4	1.6	9.2	2.9	5.2	-3.0	16.8	-6.0	18.5	0.8	10.0	-3.0	22.2
	7	4.5	14.8	9.6	31.8	2.1	9.5	1.7	5.1	-2.3	8.8	-6.3	17.5	-2.0	9.5	-4.9	23.2
	8	4.7	16.2	7.8	26.0	2.2	9.2	1.0	4.4	-3.3	9.7	-6.1	16.0	-1.5	9.2	-5.6	22.4

Table C27 Continued.

Table C28: Levator activity (mV) in response to water and low and high concentrations of the bitter, salty, sour, sweet, and umami tastes before and after swallowing over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 20), patients with Anorexia (*n* = 20, before swallowing; *n* = 19, after swallowing), Bulimia (*n* = 18), and Binge-Eating Disorder (*n* = 15; *n* = 14, high concentrations after swallowing).

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	-3.9	4.9	-2.0	7.5	-2.3	3.9	-0.3	2.9	-0.3	8.5	-0.7	4.8	-0.1	3.7	0.9	4.4
	2	-7.8	9.2	-3.9	8.8	-5.3	8.6	-2.1	3.7	-1.9	8.8	-1.4	6.4	-0.8	3.4	1.1	5.5
	3	-9.6	8.8	-4.5	9.0	-6.7	9.0	-3.4	4.6	-4.0	9.6	-0.8	8.5	-0.8	4.4	2.9	6.9
	4	-9.1	9.0	-5.5	10.0	-6.9	9.4	-4.5	3.9	-4.0	8.8	-0.3	7.6	0.0	5.6	1.4	6.7
	5	-8.9	9.4	-5.8	11.8	-7.8	9.5	-3.0	6.4	-2.5	9.2	-1.8	4.1	-1.2	4.5	-0.4	4.1
	6	-9.3	9.3	-5.5	12.8	-8.4	8.7	-4.2	4.5	0.2	13.0	-1.7	5.9	-2.2	3.0	-1.6	4.7
	7	-9.4	9.6	-5.6	11.7	-9.1	8.4	-4.5	5.2	-1.1	8.7	-2.4	5.9	-2.8	3.6	-3.0	3.7
	8	-9.2	9.5	-5.0	11.5	-8.1	8.2	-3.5	5.6	-1.3	11.1	-3.6	4.9	-2.1	3.8	-0.9	9.5
Bitter low	1	-3.6	11.4	-1.2	6.6	-2.6	4.7	-3.5	10.5	2.2	9.3	1.0	5.0	1.2	4.6	1.5	6.5
	2	-7.0	9.9	-2.0	10.7	-5.4	7.0	-1.8	9.6	4.2	8.4	2.1	6.8	0.7	4.8	-0.2	9.5
	3	-7.3	9.6	-3.1	9.3	-6.2	9.8	-3.6	8.7	0.7	5.8	-0.6	5.7	0.7	5.9	6.4	13.3
	4	-7.9	12.4	-3.1	9.6	-6.8	9.7	-4.1	10.4	-1.3	7.7	-1.0	7.4	2.4	7.4	2.8	9.9
	5	-6.9	11.2	-2.8	10.1	-6.8	8.3	-5.4	10.1	-0.6	6.6	0.4	8.1	1.2	6.8	1.2	11.2
	6	-8.5	11.1	-1.5	10.9	-8.2	8.8	-7.0	11.4	1.8	6.0	1.0	8.8	1.2	10.3	-0.2	11.7
	7	-9.2	11.3	-2.2	8.8	-7.1	11.2	-7.1	11.6	1.3	12.5	1.6	8.5	1.8	13.7	-0.1	11.9
	8	-9.7	11.2	-4.0	10.4	-6.5	9.7	-6.0	8.5	-0.3	8.2	0.7	9.2	2.5	15.9	-2.3	10.5
Bitter high	1	1.2	18.8	-1.1	5.1	-1.5	7.9	1.0	3.9	-1.9	7.1	0.0	5.9	2.6	9.6	-2.0	10.1
	2	2.9	31.6	-1.4	10.9	-0.1	15.9	3.8	7.1	6.3	25.2	0.7	13.5	0.6	12.6	-0.9	10.5
	3	8.7	49.0	5.4	25.1	2.5	17.9	6.5	16.2	-0.9	9.9	3.1	15.2	4.7	20.8	2.9	12.2
	4	11.1	48.1	4.5	18.1	4.9	16.3	6.5	16.8	-1.9	18.2	3.4	13.5	2.0	21.4	-0.6	4.2
	5	5.9	32.7	3.8	20.2	2.5	15.9	8.4	15.2	-1.4	14.2	0.8	9.8	-2.6	17.1	-4.2	11.2
	6	3.1	24.7	4.9	24.0	5.2	20.0	7.1	15.0	-0.6	18.0	-0.1	8.1	-0.9	23.1	-3.8	11.9
	7	1.7	23.4	0.7	13.6	5.7	20.8	4.2	13.4	-0.6	12.1	1.3	11.7	-0.9	24.2	-3.0	15.7
	8	-0.9	16.4	0.7	14.0	4.4	21.9	3.9	8.7	-0.3	14.4	-0.6	9.7	-4.5	23.9	-4.5	15.6

Table C28 Continued.

	period	Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Salty low	1	-1.4	4.8	-0.5	3.0	-4.8	7.2	0.0	4.0	0.6	4.1	-0.1	12.4	1.0	3.0	2.7	11.8
	2	-3.9	6.2	-0.9	5.4	-8.5	10.7	0.6	7.0	2.3	12.9	-0.3	8.1	0.6	3.5	2.2	14.0
	3	-5.9	5.8	-2.2	4.3	-8.3	10.3	-0.9	8.3	2.4	11.5	-1.4	7.1	0.8	4.3	-1.9	7.3
	4	-5.0	7.5	-0.7	7.3	-9.4	10.6	-1.7	8.2	3.9	16.2	-0.9	12.7	-0.7	3.3	-2.9	11.1
	5	-4.6	8.0	-3.2	6.2	-9.0	9.9	-1.9	9.6	1.8	15.6	-1.7	10.3	0.4	5.7	-4.4	13.5
	6	-6.0	7.2	-3.5	6.4	-10.3	9.4	-0.6	16.8	2.1	16.4	-1.6	9.2	1.4	5.9	-2.9	16.3
	7	-5.8	7.0	-2.3	8.2	-9.6	11.8	-0.9	17.3	1.6	18.0	-0.2	14.4	0.4	6.8	-5.8	13.6
	8	-6.1	7.7	-1.9	10.9	-11.7	10.6	-2.8	10.0	0.8	16.8	-2.9	10.6	1.0	9.8	-4.0	13.6
Salty high	1	-0.2	9.6	0.4	4.1	-3.0	9.9	-0.1	5.0	0.2	8.0	-4.2	19.7	1.8	7.0	-0.6	11.6
	2	-0.6	21.4	-1.7	11.3	-2.4	17.7	-0.7	8.4	3.7	12.3	-4.1	33.3	3.0	8.4	1.6	18.0
	3	0.2	21.5	-1.8	15.1	-3.3	15.6	-0.6	13.0	-1.2	10.6	-2.3	32.4	0.5	8.4	3.5	19.5
	4	-1.3	16.0	-0.1	14.7	-3.9	16.4	2.7	21.4	4.0	11.9	-2.1	30.8	-2.9	16.4	-1.8	24.6
	5	-1.2	17.2	-0.7	14.2	-1.7	17.8	5.6	32.7	3.0	17.7	-1.8	27.1	-3.3	13.9	-2.6	34.5
	6	-3.7	17.5	-0.1	16.9	-0.1	18.9	6.3	18.9	1.1	16.2	-5.0	25.8	-2.8	21.0	-7.6	38.4
	7	-5.4	14.5	-1.4	18.0	1.5	19.7	1.0	21.4	2.8	15.5	-6.0	29.0	-1.7	23.5	-3.7	30.3
	8	-5.4	12.2	-2.4	17.6	-2.2	16.3	0.5	19.9	3.9	17.4	-7.0	31.2	1.9	27.1	-9.1	38.0
Sour low	1	-2.0	5.7	-2.1	6.2	-3.1	6.2	1.5	4.9	-0.2	10.0	0.3	14.1	-1.0	9.4	3.4	5.2
	2	-4.6	8.8	-1.9	9.6	-5.2	9.9	-0.2	7.2	0.1	11.3	-3.7	19.8	-0.6	10.7	3.1	9.5
	3	-4.9	9.8	0.5	12.5	-4.8	10.4	0.4	10.0	-0.9	11.4	-4.2	21.1	-0.8	11.2	2.4	11.5
	4	-5.1	10.2	-0.7	10.0	-3.6	11.4	-0.9	10.1	-2.4	11.2	-7.0	22.8	0.1	15.1	5.2	12.2
	5	-4.4	9.3	0.8	12.7	-3.4	10.8	-2.8	8.6	-2.1	15.1	-6.2	26.0	2.1	16.7	4.7	8.9
	6	-2.0	12.1	2.9	17.5	-4.9	8.4	-4.4	8.9	-2.7	16.2	-9.9	22.3	-0.6	13.5	4.1	16.4
	7	-4.2	11.4	-1.2	12.1	-7.4	7.9	1.4	16.1	-1.4	15.4	-10.6	22.0	0.2	14.1	-1.7	9.3
	8	-3.5	11.8	-3.8	14.1	-9.0	9.6	-2.1	8.3	-3.9	16.3	-8.4	23.1	-1.6	13.0	-2.9	11.1

Table C28: Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sour high	1	0.5	4.5	-1.4	9.1	-2.6	11.2	5.1	8.7	-3.7	33.7	0.0	9.2	3.7	8.9	-0.9	14.8
	2	3.2	21.3	0.8	17.6	-0.3	20.0	4.5	17.5	0.3	31.1	2.9	13.9	2.4	15.6	3.8	25.0
	3	7.3	32.2	2.6	23.1	5.6	23.7	6.1	21.7	-0.4	33.7	1.9	16.4	-3.6	15.4	-1.6	22.3
	4	10.0	30.4	5.1	26.4	1.2	19.5	8.3	28.7	-2.8	43.5	2.1	16.1	-1.5	18.6	1.1	24.6
	5	7.6	32.3	3.9	26.1	-4.4	21.9	5.2	30.4	-4.2	54.2	0.3	12.1	-0.6	17.3	1.5	31.8
	6	7.0	31.8	3.7	24.8	-6.4	21.2	-0.9	17.3	-7.9	50.3	0.3	15.8	0.0	23.5	-2.9	33.4
	7	4.0	27.3	2.0	19.2	-6.2	24.0	2.5	21.0	-13.4	49.0	-3.0	16.1	-3.4	19.4	-5.1	26.0
	8	1.7	27.7	5.6	20.7	-6.6	19.8	1.4	14.7	-15.2	47.2	-3.4	14.6	-4.3	18.9	-7.9	30.8
Sweet low	1	-2.3	6.3	-1.3	7.6	-3.3	4.3	-0.5	4.6	3.4	6.8	3.1	6.2	1.2	5.6	2.9	6.2
	2	-4.1	8.0	-2.8	7.2	-5.1	7.1	-3.3	4.6	1.9	11.5	0.7	5.7	-0.3	8.3	4.4	9.8
	3	-5.1	7.8	-2.6	9.9	-5.5	8.2	-3.6	5.5	0.0	7.4	-0.3	7.4	-2.0	8.1	-0.4	8.4
	4	-5.0	8.5	-3.7	9.7	-5.5	7.4	-5.0	5.6	2.0	11.8	-0.3	8.6	-1.0	9.7	1.6	9.0
	5	-5.0	8.7	-3.7	9.7	-6.7	8.0	-3.1	6.1	1.9	12.0	1.5	12.1	-1.9	8.4	-0.3	6.6
	6	-3.4	11.4	-4.4	9.0	-5.3	7.2	-4.1	6.8	0.8	10.0	-0.7	9.8	0.4	9.1	-4.0	8.4
	7	-1.0	17.9	-4.3	10.2	-6.6	8.6	-3.5	7.7	-1.0	8.5	0.2	10.5	-1.1	9.6	-2.2	8.0
	8	-0.5	16.5	-4.3	10.1	-6.6	10.6	-4.4	6.9	-1.6	8.2	-0.6	11.2	-0.6	8.3	-2.2	6.5
Sweet high	1	-3.6	7.0	-3.2	6.3	-2.9	5.6	0.6	6.3	3.8	7.7	3.0	8.8	-0.4	7.5	1.2	8.1
	2	-6.6	8.7	-3.8	9.1	-4.2	9.2	0.3	10.2	4.0	9.9	1.8	13.7	-0.5	12.8	4.5	15.0
	3	-7.8	9.9	-2.1	10.2	-4.1	9.1	0.4	12.7	2.8	8.6	-0.4	10.3	-1.9	13.0	1.9	14.7
	4	-9.0	9.8	-1.2	12.4	-4.9	10.5	-1.8	10.4	4.9	15.9	1.4	12.8	1.3	14.7	2.1	16.9
	5	-8.9	10.9	-1.4	12.7	-6.3	9.9	-3.1	7.0	1.6	12.0	0.7	14.2	-3.4	13.0	-2.5	13.0
	6	-6.5	12.8	-0.9	14.0	-3.9	10.9	-3.4	8.2	1.7	8.8	-2.9	13.3	-3.3	13.1	-3.2	14.4
	7	-8.3	11.4	-0.6	15.8	-4.3	9.5	-0.3	11.1	0.0	6.4	-3.3	11.5	-3.0	13.4	-2.2	17.2
	8	-7.1	10.6	-4.2	15.8	-3.9	14.7	-0.3	13.3	0.0	9.2	-2.8	12.2	-3.2	7.8	-6.2	12.3

Table C28: Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Umami low	1	-4.7	6.6	-3.1	7.8	-2.6	6.8	-1.3	4.4	-0.5	4.4	1.0	4.1	0.2	5.9	2.6	6.7
	2	-7.7	9.0	-4.9	9.5	-5.4	8.4	-2.4	6.4	1.4	8.1	-0.6	5.0	-0.4	9.2	5.1	11.4
	3	-8.0	9.5	-6.5	7.6	-5.6	8.4	-3.0	7.2	-1.7	8.8	-1.3	3.9	1.5	8.4	3.4	9.5
	4	-9.0	11.0	-5.1	8.4	-4.8	7.5	-3.4	6.8	-1.2	8.1	-0.5	7.2	2.0	10.2	4.2	9.8
	5	-9.1	11.9	-5.5	11.3	-3.6	7.7	-0.5	12.3	-0.9	7.5	-0.2	6.5	-0.1	11.5	2.6	7.7
	6	-8.3	10.1	-5.8	10.4	-4.0	8.0	-1.2	8.7	-1.2	8.1	-1.4	5.7	-0.5	13.9	-1.4	8.9
	7	-8.7	10.9	-5.4	11.5	-3.4	8.1	1.1	11.7	-2.3	7.8	0.0	7.2	1.9	19.9	3.1	13.6
	8	-8.9	12.4	-4.2	8.2	-2.5	11.7	-0.7	11.6	0.1	9.4	-2.1	6.1	-0.7	15.0	3.7	18.5
Umami	1	-1.4	4.7	-2.4	7.4	-3.8	6.8	0.6	5.5	1.2	7.8	-0.3	6.0	-0.7	5.9	0.3	10.7
	2	-2.3	6.9	-2.6	8.8	-4.6	10.6	0.0	9.8	4.4	13.7	-1.1	6.1	1.1	10.9	4.5	13.5
	3	-1.4	10.6	-1.1	6.4	-3.9	11.6	2.3	12.1	3.6	17.4	-2.2	5.8	2.4	10.2	8.0	19.7
	4	1.2	18.4	-0.9	7.6	-3.9	12.1	1.8	14.9	2.6	13.3	-3.3	6.5	2.2	10.8	3.1	31.2
	5	-0.8	14.4	-0.3	10.5	-3.6	13.2	2.8	16.6	4.0	16.9	-0.7	9.9	0.6	9.4	-3.7	31.3
	6	-2.9	7.9	-0.1	8.7	-7.0	9.4	1.5	19.5	5.3	25.1	0.6	11.3	0.5	10.0	0.2	37.0
	7	-2.0	12.4	-1.4	7.1	-6.6	7.2	1.2	17.2	5.6	28.3	-2.3	7.9	-0.8	9.6	2.2	37.2
	8	-4.0	8.2	0.2	7.9	-7.6	8.2	2.7	21.3	10.3	31.2	-2.8	8.3	0.3	10.2	-1.0	36.8

Table C29 Zygomaticus activity (mV) in response to water and low and high concentrations of the bitter, salty, sour, sweet, and umami tastes before and after swallowing over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 20), patients with Anorexia (*n* = 20, before swallowing; *n* = 19, after swallwoing), Bulimia (*n* = 18), and Binge-Eating Disorder (*n* = 15; *n* = 14, high concentrations after swallowing).

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	-1.8	2.4	-0.4	3.0	-1.0	2.6	-0.8	1.1	-0.7	5.3	-0.7	3.6	-0.5	1.8	0.4	.9
	2	-3.5	4.6	-1.2	3.1	-2.1	3.8	-1.7	1.4	-0.6	5.6	-1.3	4.3	-1.2	1.5	0.4	1.8
	3	-4.0	4.7	-0.9	4.9	-2.3	3.6	-1.7	1.6	-1.5	6.9	-1.4	4.3	-1.0	1.9	0.9	3.1
	4	-3.6	4.7	-0.7	5.9	-2.7	4.1	-1.8	1.6	-2.0	5.8	-1.3	4.2	-0.9	2.4	0.5	2.8
	5	-3.9	5.0	-1.3	5.7	-3.0	3.8	-1.6	1.6	-1.5	4.2	-1.3	3.9	-1.2	2.1	-0.2	2.0
	6	-3.8	4.8	-1.4	5.3	-2.5	3.8	-1.8	1.7	-1.0	6.0	-1.1	4.0	-1.7	1.8	-0.4	2.3
	7	-3.7	5.3	-1.3	4.1	-3.0	3.9	-1.9	1.5	-1.2	3.5	-0.9	4.4	-2.0	2.0	-0.9	1.8
	8	-3.6	5.2	-0.9	4.2	-2.2	4.3	-1.6	1.6	-1.0	5.1	-1.7	3.9	-1.9	2.2	-0.4	3.1
Bitter low	1	-1.2	2.4	-1.2	2.4	-1.8	2.9	-0.4	1.1	-0.3	3.2	-0.6	6.1	-0.2	2.3	0.1	1.8
	2	-1.9	2.6	-0.1	8.8	-2.3	2.7	-0.9	1.7	2.5	7.3	-0.7	8.5	-0.3	1.7	-0.2	2.0
	3	-1.5	2.2	-0.5	5.3	-2.7	3.8	-1.0	2.0	1.5	9.0	-2.6	7.3	0.1	2.6	1.0	3.4
	4	-2.0	3.5	-0.2	6.5	-2.8	3.9	-1.3	2.1	-0.1	6.9	-3.1	7.5	0.1	2.4	1.0	3.2
	5	-1.5	3.2	0.1	7.8	-2.5	4.1	-1.5	2.0	-0.6	4.7	-1.8	8.2	-0.1	2.1	0.6	3.5
	6	-1.9	2.7	0.4	6.8	-2.4	2.6	-1.5	1.9	0.8	4.9	-1.3	5.3	-0.3	1.9	0.1	2.2
	7	-1.7	4.2	0.3	4.6	-2.5	2.7	-1.4	2.2	-0.4	6.1	0.0	4.1	-0.9	1.8	-0.4	2.0
	8	-2.2	3.3	-0.5	3.3	-2.3	3.6	-1.5	2.2	-1.0	4.4	0.9	6.4	-0.4	2.4	0.5	3.1
Bitter high	1	-0.8	6.4	-0.9	2.5	-0.9	2.7	-0.2	1.7	0.8	4.6	1.7	5.1	0.3	1.7	-1.0	4.1
	2	-0.6	8.1	-2.5	5.8	-1.1	3.4	-0.4	1.9	4.7	7.6	1.8	7.3	0.7	3.4	0.2	2.2
	3	1.0	11.5	-0.9	4.5	-1.5	3.9	0.1	2.7	3.1	8.3	4.6	12.5	0.9	4.8	1.6	4.9
	4	0.8	12.9	0.4	4.2	-1.3	3.5	-0.1	3.1	2.2	8.4	3.8	10.1	-0.1	4.8	0.6	2.1
	5	0.0	9.8	-0.3	3.2	-0.6	4.0	1.3	4.5	2.1	7.9	1.4	4.7	-0.5	5.1	-1.0	3.1
	6	-0.5	9.2	-0.5	4.6	-0.6	4.1	1.3	5.1	1.5	6.8	1.8	6.9	1.2	9.9	-1.7	4.3
	7	-0.4	7.6	-0.8	4.9	-1.1	2.9	0.5	2.9	0.1	4.0	2.3	5.9	-0.4	4.1	-1.6	4.0
	8	-0.7	7.4	-1.4	5.3	-1.5	3.2	-0.1	2.6	0.9	5.3	0.7	4.0	-0.5	5.3	-1.1	2.2

Table C29 Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Salty low	1	-1.0	2.1	-0.6	2.5	-1.9	3.8	-0.6	1.5	-0.1	2.1	1.0	4.4	0.3	1.6	0.8	1.8
	2	-2.1	2.7	-1.7	5.3	-2.8	4.3	-1.2	2.0	1.5	5.4	1.4	3.3	-0.1	1.5	0.1	2.0
	3	-2.4	2.2	-1.1	6.0	-2.4	3.7	-1.5	2.1	1.9	7.8	1.4	7.6	-0.2	1.6	0.1	2.6
	4	-2.1	3.2	-0.1	3.7	-2.6	3.4	-1.4	2.2	2.1	8.6	-0.1	2.8	0.2	2.4	-0.1	2.0
	5	-1.8	2.6	-1.1	3.6	-2.7	3.9	-1.6	2.4	1.8	9.7	0.1	3.6	-0.1	2.4	-0.3	3.0
	6	-2.4	2.2	-1.8	6.0	-3.0	3.4	-1.0	4.9	2.4	11.0	-0.3	3.7	0.2	1.8	0.2	2.6
	7	-2.4	2.6	-1.2	5.7	-2.8	3.1	-1.3	4.0	0.8	7.4	0.2	5.3	0.0	1.8	-0.9	1.5
	8	-2.1	2.7	0.2	3.6	-3.0	3.2	-1.9	3.0	1.1	9.1	-1.1	3.3	-0.3	1.8	-0.9	1.4
Salty high	1	0.1	2.0	-0.4	3.7	-1.1	3.2	-0.9	1.7	0.9	4.5	0.6	5.1	0.1	1.5	0.7	2.1
	2	-0.7	3.3	-2.6	11.2	-1.9	3.0	-1.5	3.5	5.2	9.1	1.8	6.8	1.1	3.0	2.6	6.3
	3	-0.2	4.4	-3.9	13.5	-2.2	2.9	-0.2	9.1	1.6	6.0	0.7	7.5	0.3	2.6	1.1	6.3
	4	-0.8	3.7	-1.9	5.7	-2.2	3.3	2.5	17.3	3.2	6.3	1.4	5.7	1.5	4.0	-0.8	5.2
	5	0.5	6.0	-0.7	5.1	-1.9	3.5	4.3	24.9	2.6	7.6	3.9	8.6	0.5	3.0	-1.3	6.2
	6	-0.9	4.9	-1.6	9.3	-1.4	3.4	2.4	15.7	1.8	8.0	0.1	4.8	0.6	7.0	-1.6	4.9
	7	-1.3	4.1	-2.6	10.1	-1.1	4.2	1.3	13.9	1.6	7.0	-1.0	6.3	-0.3	5.4	-1.7	6.4
	8	-1.2	3.1	-1.7	6.5	-1.8	3.4	1.8	12.1	3.1	7.9	-0.6	3.6	1.6	8.1	-2.8	6.6
Sour low	1	-1.3	2.3	-2.0	5.3	-1.2	2.8	-0.4	1.6	-0.3	3.7	1.3	6.9	0.4	3.0	0.7	2.0
	2	-2.3	3.4	-2.6	7.9	-2.0	2.4	-0.8	3.8	0.3	5.0	1.3	7.2	1.1	3.9	0.3	2.5
	3	-2.0	3.8	-0.4	2.7	-1.6	3.1	-1.2	3.5	0.1	5.7	2.8	12.2	0.1	3.1	0.1	2.6
	4	-2.3	3.9	-1.0	2.2	-1.5	3.3	-1.7	2.9	0.1	4.0	-0.6	6.1	0.2	3.5	0.5	3.1
	5	-1.6	3.7	-0.4	3.2	-1.6	3.5	-1.7	3.0	-0.2	4.9	-1.0	7.0	1.2	4.7	0.5	2.4
	6	-0.7	3.9	0.6	6.5	-1.5	3.7	-1.1	3.0	-1.5	5.8	-2.3	6.1	0.3	3.2	2.1	4.6
	7	-1.1	3.9	-1.6	3.2	-2.1	3.2	-0.5	5.0	0.4	6.9	-2.7	6.0	1.1	3.8	0.6	4.9
	8	-0.7	5.0	-2.7	8.1	-2.5	3.2	0.1	6.0	0.2	7.8	-0.6	6.8	0.1	3.3	0.0	3.4

Table C29 Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sour high	1	-0.5	3.1	-1.3	3.5	-2.1	3.2	0.0	2.1	0.6	3.6	0.2	2.8	1.5	3.4	-0.1	3.8
	2	0.0	7.3	-0.8	4.7	-1.1	5.8	-0.5	3.4	3.9	6.4	1.9	4.8	1.2	7.1	2.9	7.3
	3	2.7	13.7	-0.5	5.3	-0.1	8.2	0.6	5.4	2.8	4.4	2.9	7.8	-0.9	7.3	2.3	7.3
	4	2.7	11.2	0.1	6.3	-1.3	4.9	1.1	6.7	4.2	10.3	2.4	7.0	-0.1	7.4	4.1	10.7
	5	1.2	10.0	0.0	5.1	-2.5	6.7	0.6	6.6	1.2	9.7	1.4	5.5	1.0	6.9	4.7	12.8
	6	1.1	9.3	-0.6	4.5	-2.6	7.2	-0.3	8.4	0.1	8.8	1.8	6.3	0.6	8.9	3.3	12.9
	7	-0.8	7.3	-1.2	6.5	-2.1	7.5	-0.1	8.9	-1.9	9.2	0.9	6.0	-0.9	6.5	2.3	8.4
	8	-0.8	8.3	0.0	6.8	-3.2	6.5	1.8	12.6	-1.9	4.5	0.6	5.5	0.4	7.6	3.8	14.0
Sweet low	1	-1.1	2.2	-1.7	6.7	-1.4	2.4	-0.6	1.4	0.7	4.1	1.1	2.9	-0.6	3.4	-0.6	2.1
	2	-1.6	2.9	-1.8	4.3	-1.8	1.9	-1.4	2.4	0.1	6.2	0.9	3.2	-1.1	4.3	-0.7	2.3
	3	-2.0	3.0	-1.1	5.6	-2.0	2.3	-1.5	2.6	0.6	8.0	1.0	5.1	-1.3	3.4	-0.7	2.5
	4	-1.7	2.6	-2.8	9.0	-1.9	3.1	-1.5	3.2	0.6	6.2	0.9	4.1	-0.6	4.3	0.3	3.6
	5	-1.9	2.8	-2.2	6.9	-2.3	2.5	-1.2	2.9	0.7	6.3	1.7	5.5	-1.5	4.3	-1.0	2.8
	6	-0.3	6.2	-1.7	4.4	-2.0	3.1	-1.6	2.7	0.1	5.7	0.9	5.6	-1.1	4.2	-1.4	3.0
	7	-0.8	6.1	-1.3	6.2	-2.1	2.8	-0.6	5.9	-1.7	4.9	1.3	6.0	-1.0	4.0	-0.8	3.3
	8	-0.7	6.3	-2.2	6.7	-2.1	2.7	-0.4	5.9	-1.8	3.3	0.1	3.7	-0.6	4.8	-0.6	2.1
Sweet high	1	-1.2	2.2	-1.4	2.4	-1.5	1.9	-0.4	1.8	0.0	2.1	1.1	3.7	0.6	2.4	0.4	1.6
	2	-2.2	3.2	-2.1	5.9	-1.9	2.8	-1.2	2.0	2.3	8.3	1.3	5.7	0.7	3.1	1.2	3.9
	3	-2.3	4.4	-2.0	5.9	-2.2	2.6	-1.4	2.3	1.9	6.7	0.2	3.4	0.8	4.2	0.7	3.7
	4	-3.0	4.5	-2.3	7.3	-2.0	2.6	-1.5	2.6	2.6	9.1	3.2	9.4	2.7	5.0	1.2	4.4
	5	-2.5	5.3	-1.8	7.0	-2.4	2.7	-1.7	2.5	0.1	6.3	1.6	5.4	0.7	4.2	0.5	2.8
	6	-1.7	5.5	-0.8	4.3	-2.1	3.0	-1.5	2.3	-0.3	4.3	0.8	6.6	-0.1	2.7	0.2	2.4
	7	-2.5	4.9	-0.4	6.3	-2.2	3.1	-1.3	2.5	-0.1	3.4	0.9	5.0	-0.3	3.1	1.3	4.0
	8	-2.0	4.6	-2.1	7.9	-2.1	3.6	-1.2	2.9	-0.1	7.2	1.7	4.9	1.5	5.9	-0.3	2.4

Table C29 Continued.

		Before swallowing								After swallowing							
		C		AN		BN		BE		C		AN		BN		BE	
	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Umami low	1	-1.8	2.3	-2.5	6.7	-1.3	2.6	-1.1	1.3	-1.1	1.7	1.1	5.0	-0.2	1.6	-0.1	1.6
	2	-2.5	2.8	-4.3	10.8	-2.3	3.1	-1.7	1.9	-1.0	3.4	0.1	4.4	0.3	3.0	-0.6	3.2
	3	-2.8	3.2	-3.6	7.4	-2.4	3.1	-1.4	2.6	-1.6	3.9	-0.2	3.4	0.9	3.7	-0.7	3.9
	4	-3.2	4.5	-2.3	6.2	-2.6	3.2	-1.8	2.7	-0.5	4.8	1.2	5.4	0.8	3.3	0.2	4.8
	5	-3.2	4.8	-4.3	9.6	-2.3	3.7	-1.3	3.1	0.1	6.2	1.4	7.3	0.9	3.4	-0.5	5.9
	6	-2.9	3.3	-4.1	11.0	-2.0	3.5	-1.0	3.3	0.2	5.8	0.9	5.1	-0.2	2.2	-1.4	5.5
	7	-2.7	3.9	-3.8	10.6	-2.0	2.3	-0.8	3.0	-1.1	4.4	0.1	2.4	0.2	3.1	-0.6	6.4
	8	-2.9	4.5	-1.6	4.7	-1.7	3.4	-0.9	2.8	-1.2	3.1	-0.9	1.8	-0.5	1.6	-0.9	6.5
Umami	1	-0.8	1.7	-1.8	5.8	-1.1	1.9	-0.4	1.7	1.2	3.1	1.9	8.0	-1.1	2.3	1.2	3.2
	2	-0.9	3.3	-3.3	8.3	-1.8	3.0	-0.7	5.0	2.4	5.6	0.9	8.8	-1.6	3.5	4.4	7.5
	3	-0.6	4.0	-1.3	2.3	-1.6	3.4	-0.3	5.5	1.4	3.7	-0.5	6.7	-0.8	3.9	5.9	13.9
	4	-0.8	3.3	-1.4	7.1	-1.3	3.8	0.9	8.8	1.5	5.3	-0.7	5.2	-0.1	3.9	4.4	14.3
	5	-0.6	3.3	-2.5	8.5	-1.1	4.2	2.4	13.0	1.3	4.7	1.2	6.5	-0.8	6.1	3.8	14.0
	6	-1.1	2.2	-1.6	6.1	-2.2	2.6	3.4	17.8	2.0	5.0	2.6	5.5	-1.0	2.4	5.2	21.8
	7	-0.5	4.3	-2.3	7.0	-2.0	2.7	2.6	17.2	0.8	3.1	0.7	4.9	-0.3	4.6	4.9	20.6
	8	-0.8	4.2	-1.0	2.9	-2.2	2.7	3.9	20.9	2.1	6.3	0.3	4.8	-1.1	3.8	2.0	13.2

Table C30 Corrugator activity (mV) in response to different odors, i.e. probe, banana, cinnamon, clove, licorice, fish, and garlic over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* = 16), and Binge-Eating Disorder (*n* = 15).

		C		AN		BN		BE	
Odor	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Probe	1	0.1	0.8	0.4	1.1	-0.1	1.6	0.2	1.1
	2	0.4	1.9	0.3	1.1	-0.5	2.0	0.4	1.5
	3	0.3	1.9	0.9	2.0	0.1	2.7	0.0	1.0
	4	0.1	1.7	1.0	1.5	0.3	2.9	1.1	3.8
	5	0.2	2.1	1.2	2.3	0.2	3.9	0.0	1.1
	6	0.6	3.2	1.1	1.9	-0.1	3.6	1.2	4.4
	7	0.3	2.4	1.5	2.7	-0.4	3.2	0.4	1.7
	8	0.7	3.2	1.1	1.9	-0.1	2.9	0.2	1.8
Banana	1	0.5	1.5	0.0	0.8	-0.1	1.2	0.7	2.1
	2	1.1	2.4	0.4	1.5	0.3	1.9	2.5	6.2
	3	0.9	1.7	0.6	1.4	1.1	5.3	2.6	4.9
	4	0.4	1.4	0.4	1.1	0.7	4.2	2.8	4.9
	5	0.8	2.5	0.5	1.4	0.9	3.5	2.1	4.3
	6	0.9	1.9	1.7	3.7	1.3	3.1	2.0	3.3
	7	1.1	2.3	2.4	7.1	1.2	3.1	2.1	3.5
	8	1.1	2.6	2.7	7.6	1.7	3.9	2.6	5.9
Cinnamon	1	0.3	0.5	-0.1	1.0	0.2	1.1	0.1	0.5
	2	0.1	0.6	0.3	1.3	-0.3	2.2	0.5	0.8
	3	0.0	0.8	0.5	1.1	-0.5	2.6	0.6	1.0
	4	0.0	0.8	0.5	1.4	-0.4	2.0	0.7	1.0
	5	-0.1	0.7	0.7	1.4	0.5	2.2	1.0	3.0
	6	-0.1	0.6	0.4	1.2	0.7	2.0	0.5	1.5
	7	0.4	2.7	0.5	1.3	0.2	1.7	0.4	1.3
	8	0.2	1.3	0.7	1.7	0.7	3.7	0.1	1.4
Clove	1	0.4	1.6	0.2	0.9	0.8	2.6	0.9	2.3
	2	3.0	6.4	1.8	5.9	1.5	5.6	4.1	8.0
	3	4.1	7.0	5.4	19.9	2.2	5.3	2.7	6.0
	4	5.3	10.0	8.2	25.8	1.2	2.5	2.0	5.0
	5	3.0	5.4	6.4	19.6	1.4	2.8	3.3	5.6
	6	2.9	5.1	4.9	18.2	1.4	2.6	2.5	6.4
	7	3.1	5.1	4.3	16.6	1.1	2.2	2.5	7.1
	8	3.4	5.6	3.1	11.1	1.1	2.3	2.7	6.8
Licorice	1	0.1	1.6	0.0	0.6	0.3	0.9	0.5	2.0
	2	0.1	1.4	0.2	0.8	0.4	1.2	2.2	7.6
	3	0.1	1.2	0.5	1.0	0.5	1.6	2.7	8.5
	4	0.1	1.5	0.8	1.1	0.4	1.5	1.3	3.3
	5	0.4	2.3	0.8	1.1	0.2	1.4	1.6	3.1
	6	0.6	2.6	0.8	1.2	0.2	2.1	1.3	2.8
	7	0.8	2.1	0.8	1.2	0.3	1.8	1.3	2.5
	8	0.7	2.1	0.8	1.2	0.3	1.7	1.5	2.2
Fish	1	0.9	2.6	0.4	1.5	0.8	2.1	1.6	3.9
	2	3.7	9.2	9.3	21.6	1.8	3.6	10.1	19.1
	3	3.7	10.4	9.9	20.3	4.2	6.5	8.1	10.7

Table C30 Continued.

Odor	period	C		AN		BN		BE	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Fish	4	2.3	5.0	8.7	17.9	5.4	9.8	4.3	5.5
	5	1.3	4.0	9.5	20.9	4.8	9.0	2.6	4.0
	6	1.8	5.0	8.8	19.2	4.8	10.0	2.8	3.6
	7	1.2	3.0	7.9	17.2	5.2	11.3	3.0	4.4
	8	1.2	2.5	5.9	12.5	5.7	11.2	3.6	5.7
Garlic	1	0.6	2.4	0.9	3.8	1.0	2.6	5.0	10.4
	2	5.8	8.6	3.6	7.4	3.0	7.2	9.0	15.4
	3	9.3	12.8	5.7	11.5	4.7	9.8	5.6	9.0
	4	8.2	11.7	4.5	7.4	5.3	10.5	2.8	4.4
	5	9.5	16.1	4.4	7.3	3.7	7.6	2.2	4.1
	6	10.2	18.8	5.3	9.1	4.9	9.5	4.4	9.2
	7	9.1	14.7	7.4	13.3	3.7	7.3	4.5	8.3
	8	7.3	11.0	6.8	11.4	4.4	8.8	3.0	5.6

Table C31 Levator activity (mV) in response to different odors, i.e. probe, banana, cinnamon, clove, licorice, fish, and garlic over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* = 16), and Binge-Eating Disorder (*n* = 15).

Odor	period	C		AN		BN		BE	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Probe	1	-0.1	0.6	-0.4	0.9	-0.1	0.7	0.0	1.0
	2	-0.1	0.7	-0.5	1.4	-0.3	0.8	-0.4	0.9
	3	0.0	1.3	-0.1	1.6	0.1	2.4	-0.7	1.2
	4	-0.3	1.1	-0.2	1.9	0.0	1.7	-0.8	2.0
	5	-0.2	1.1	-0.2	2.2	0.1	1.8	-1.2	3.8
	6	-0.1	1.1	0.9	3.2	0.1	2.1	-1.4	4.3
	7	0.0	1.8	0.4	2.9	0.1	1.4	-1.3	4.2
	8	-0.2	1.3	0.2	2.4	0.2	1.7	-1.3	4.0
Banana	1	0.0	1.0	0.0	1.0	-0.2	1.0	0.2	0.9
	2	0.0	1.3	-0.1	1.5	-0.3	1.6	0.0	1.3
	3	-0.1	1.0	0.1	1.4	0.1	1.8	-0.3	1.3
	4	-0.2	1.3	0.1	1.4	0.3	2.3	-0.3	1.5
	5	-0.1	1.4	0.2	0.8	0.1	2.1	-0.5	1.8
	6	-0.4	1.3	0.0	1.3	-0.1	2.1	-0.3	1.7
	7	0.2	2.1	0.2	1.6	-0.1	1.9	-0.3	2.0
	8	-0.1	1.5	0.4	1.5	0.0	2.1	0.0	2.3
Cinnamon	1	-0.1	0.5	0.0	0.5	0.1	0.7	-0.1	0.9
	2	-0.2	0.6	-0.3	0.8	0.0	0.9	-0.5	1.6
	3	-0.1	1.0	0.0	0.9	-0.1	1.0	-0.7	2.9
	4	-0.1	1.0	-0.2	1.1	0.0	0.8	-0.3	1.8
	5	0.4	1.3	-0.2	1.3	0.3	1.1	-0.9	2.6
	6	0.5	1.0	0.1	1.2	0.4	1.4	-1.0	3.2
	7	0.3	0.9	0.9	4.6	0.3	1.8	-1.6	3.8

Table C31 Continued.

		C		AN		BN		BE	
Odor	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cinnamon	8	0.3	1.0	0.1	2.1	0.8	2.9	-1.6	4.8
Clove	1	0.0	0.5	0.5	1.6	0.4	0.8	0.4	1.1
	2	1.0	2.5	0.4	1.8	0.7	1.8	1.3	3.2
	3	1.2	2.4	0.7	2.5	1.0	2.7	0.3	1.9
	4	1.0	1.6	1.2	3.8	1.4	3.8	0.4	2.2
	5	0.4	1.2	1.5	5.3	1.6	4.6	0.7	2.3
	6	0.9	1.6	1.4	5.4	1.2	4.2	1.1	3.2
	7	1.3	3.2	1.5	7.2	1.3	5.4	0.4	1.7
	8	0.7	2.5	1.1	5.9	1.4	5.1	0.0	2.2
Licorice	1	0.3	0.9	0.1	1.0	-0.2	0.8	-0.1	1.0
	2	0.0	1.1	-0.1	1.3	-0.4	0.8	-0.3	1.1
	3	0.1	1.2	0.0	1.7	-0.5	0.8	1.3	7.4
	4	0.2	1.4	-0.1	1.4	-0.6	0.8	2.3	11.8
	5	1.1	3.9	-0.2	1.5	-0.7	0.7	2.6	12.5
	6	0.5	2.4	0.0	2.0	-0.7	0.7	1.9	10.1
	7	0.4	1.8	0.0	2.2	-0.6	0.7	1.6	9.6
	8	0.2	1.6	-0.4	2.4	-0.5	1.0	1.6	9.0
Fish	1	0.0	0.7	-0.4	1.8	-0.1	0.7	-0.1	1.2
	2	0.3	1.1	2.3	5.2	-0.1	0.8	1.4	5.3
	3	1.3	4.2	2.4	4.9	0.3	1.5	1.2	2.4
	4	1.2	3.6	2.6	5.1	1.6	5.5	2.3	4.2
	5	1.4	2.8	2.9	5.1	1.2	3.5	2.2	4.9
	6	1.1	3.0	3.2	5.5	0.9	2.8	3.2	6.5
	7	0.8	2.8	3.4	7.9	0.8	3.5	3.4	6.1
	8	0.8	2.8	2.1	5.0	2.0	5.5	3.4	6.2
Garlic	1	0.5	1.3	0.2	1.6	-0.1	0.9	0.3	2.1
	2	1.2	1.8	1.5	3.7	1.3	3.8	0.5	2.3
	3	2.2	3.1	1.9	4.1	1.8	4.8	0.0	1.8
	4	2.3	4.8	2.7	5.9	2.7	6.2	0.1	1.5
	5	1.9	2.9	2.0	4.7	3.5	7.8	0.6	3.0
	6	2.5	3.5	1.8	4.0	3.3	5.7	2.1	5.7
	7	2.7	4.8	2.7	6.7	1.7	4.1	2.2	8.5
	8	2.4	5.2	2.2	4.6	1.6	4.4	1.8	6.2

Table C32 Zygomaticus activity (mV) in response to different odors, i.e. probe, banana, cinnamon, clove, licorice, fish, and garlic over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* = 16), and Binge-Eating Disorder (*n* = 15).

		C		AN		BN		BE	
Odor	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Probe	1	0.0	0.2	0.0	0.3	-0.1	0.2	-0.1	0.2
	2	0.0	0.2	0.1	0.3	-0.1	0.2	-0.1	0.2
	3	-0.1	0.4	0.1	0.5	-0.1	0.3	-0.1	0.6
	4	-0.1	0.4	0.1	0.5	-0.1	0.3	-0.1	0.6
	5	-0.1	0.3	0.0	0.6	-0.1	0.3	-0.2	0.9
	6	-0.1	0.3	0.1	0.5	-0.1	0.4	-0.2	1.1
	7	-0.1	0.4	0.0	0.7	-0.1	0.4	-0.2	1.2
	8	0.0	0.7	0.0	0.9	-0.1	0.4	-0.2	1.2
Banana	1	0.1	0.2	0.1	0.4	-0.1	0.5	0.0	0.3
	2	0.1	0.2	0.2	0.6	-0.1	0.2	-0.2	0.4
	3	0.1	0.5	0.4	0.7	0.0	0.5	-0.1	0.4
	4	0.1	0.5	0.4	0.7	0.0	0.5	-0.1	0.4
	5	0.1	0.4	0.3	0.6	0.0	0.5	-0.2	0.5
	6	0.1	0.4	0.3	0.8	0.0	0.4	-0.2	0.6
	7	0.5	1.5	0.1	0.6	0.0	0.5	-0.2	0.6
	8	0.1	0.5	0.2	0.6	0.0	0.4	-0.2	0.6
Cinnamon	1	0.0	0.2	0.0	0.6	0.0	0.3	-0.1	0.6
	2	0.0	0.2	0.0	0.4	0.0	0.5	-0.3	1.3
	3	0.1	0.4	0.0	0.5	0.0	0.5	-0.2	0.7
	4	0.1	0.4	0.0	0.5	0.0	0.5	-0.2	0.7
	5	0.4	0.9	0.0	0.6	0.0	0.5	-0.5	1.4
	6	0.4	0.7	0.0	0.6	0.0	0.6	-0.8	2.5
	7	0.3	0.7	0.2	0.7	0.1	0.5	-0.9	3.2
	8	0.2	0.7	0.0	0.6	0.2	0.7	-0.9	3.2
Clove	1	0.1	0.3	0.0	0.6	0.0	0.4	-0.1	0.2
	2	0.8	2.9	0.0	0.8	0.0	0.4	0.1	0.5
	3	0.4	2.2	0.0	0.8	0.6	1.4	-0.1	0.3
	4	0.4	2.2	0.0	0.8	0.6	1.4	-0.1	0.3
	5	0.1	0.8	0.1	1.1	0.4	1.0	-0.1	0.2
	6	0.3	1.3	0.1	1.0	0.3	0.6	-0.1	0.3
	7	1.0	3.7	0.1	1.1	0.2	0.7	-0.1	0.2
	8	0.6	2.5	0.0	1.1	0.3	0.6	-0.1	0.2
Licorice	1	0.0	0.1	0.0	0.6	0.0	0.4	-0.1	0.3
	2	-0.1	0.2	0.1	0.7	0.0	0.4	-0.2	0.5
	3	0.0	0.7	0.0	0.6	-0.1	0.8	0.3	2.6
	4	0.0	0.7	0.0	0.6	-0.1	0.8	0.3	2.6
	5	0.2	1.2	0.0	0.8	-0.1	0.9	0.5	3.0
	6	0.2	1.3	0.0	0.9	-0.1	1.0	0.4	2.3
	7	0.3	1.1	0.0	1.1	-0.1	1.1	0.3	2.2
	8	0.3	1.3	-0.1	0.9	0.0	1.1	0.2	2.0
Fish	1	0.1	0.3	-0.1	0.5	0.1	0.4	0.0	0.3
	2	0.2	0.6	0.8	2.6	0.0	0.3	0.2	0.5
	3	0.5	1.0	1.2	3.4	0.2	0.5	0.8	1.0

Table C32 Continued.

		C		AN		BN		BE	
Odor	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Fish	4	0.5	1.0	1.2	3.4	0.2	0.5	0.8	1.0
	5	0.6	1.1	0.4	1.2	0.2	0.6	0.7	1.1
	6	0.5	1.0	0.4	1.2	0.1	0.5	0.9	1.5
	7	1.2	3.7	0.5	1.5	0.2	0.5	1.9	4.0
	8	0.7	1.5	0.5	1.4	0.3	0.9	2.2	5.8
Garlic	1	0.0	0.3	0.2	0.7	0.0	0.4	-0.1	0.2
	2	0.4	1.7	0.3	0.5	0.6	1.4	0.0	0.2
	3	1.0	2.4	0.7	1.1	1.6	4.2	0.3	1.7
	4	1.0	2.4	0.7	1.1	1.6	4.2	0.3	1.7
	5	0.8	2.2	0.5	1.1	1.6	3.5	0.2	2.1
	6	1.1	2.7	0.5	0.9	0.9	2.3	0.3	2.7
	7	1.6	4.2	0.4	0.8	0.4	1.2	0.6	3.6
	8	1.3	3.6	0.3	0.8	0.7	1.6	1.1	4.2

Table C33 SIAB-S subscales for the present and past state (Mean ± *SD*) in healthy controls (*n* = 20), patients with Anorexia (*n* = 20), Bulimia (*n* =19), and Binge-Eating Disorder (*n* = 15).

	Controls			**Anorexia nervosa**			**Bulimia nervosa**			**Binge-Eating Disorder**		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
SIAB-S present												
1. General Psychopathology and Social Integration	20	0.2	0.2	20	1.9	0.7	19	1.6	0.5	15	1.8	0.7
2. Bulimic Symptoms	20	0.2	0.3	20	1.7	1.5	19	3.0	0.7	15	2.6	1.1
3. Body Image and Slimness Ideal	20	0.6	0.3	20	2.5	1.0	19	2.2	0.8	15	1.8	0.6
4. Sexuality and Body Weight	20	0.3	0.5	20	2.0	1.0	19	1.2	0.9	15	1.1	0.8
5. Methods to counteract Weight Gain. Substance Abuse. Fasting	20	0.1	0.0	20	0.4	0.4	19	0.4	0.3	15	0.2	0.2
6. Atypical Binges	20	0.2	0.3	20	0.7	1.2	19	1.8	0.9	15	1.5	0.6
Total Score	20	0.3	0.1	20	1.6	0.6	19	1.6	0.4	15	1.5	0.4
SIAB-S past												
1. Bulimic Symptoms	20	0.3	0.4	20	1.3	1.3	19	3.2	0.9	15	2.8	0.7
2. General Psychopathology	20	0.5	0.5	20	1.7	1.2	19	2.2	0.8	15	2.5	0.8
3. Slimness Ideal	20	0.8	0.4	20	1.9	1.3	19	2.5	0.8	15	2.5	0.7
4. Sexuality and Social Integration	20	0.9	0.8	20	1.4	1.0	19	1.7	0.8	15	2.2	0.8
5. Body Image	20	0.3	0.2	20	1.5	0.8	19	1.6	0.9	15	1.0	0.7
6. Methods to counteract Weight Gain. Substance Abuse. Fasting. Autoaggression	20	0.1	0.1	20	0.5	0.6	19	0.8	0.6	15	0.7	0.5
7. Atypical Binges	20	0.3	0.4	20	0.5	1.0	19	2.2	0.8	15	2.1	0.6
Total Score	20	0.4	0.3	20	1.3	0.9	19	2.0	0.6	15	2.0	0.4

Table C34 Comparisons across groups of the SIAB-S present state.

Present state	General Psychopathology and Social Integration	Bulimic Symptoms	Body Image and Slimness Ideal	Sexuality and Body Weight	Methods to counteract Weight Gain. Substance Abuse. Fasting	Atypical Binges	Total Score
C vs. AN	AN > C***	AN > C*	AN > C***	AN > C***	AN > C*	*ns*	AN > C***
C vs. BN	BN > C***	BN > C***	BN > C***	BN > C*	BN > C***	BN > C***	BN > C***
C vs. BE	BE > C***	BE > C***	BE > C***	BE > C*	*ns*	BE > C***	BE > C***
AN vs. BN	*ns*	BN > AN*	*ns*	AN > BN*	*ns*	BN > AN*	*ns*
AN vs. BE	*ns*	*ns*	AN > BE*	AN > BE*	*ns*	*ns*	*ns*
BN vs. BE	*ns*	*ns*	*ns*	*ns*	BN > BE*	*ns*	*ns*

***$p \leq .001$, *$p < .05$. Note: C-Controls (n = 20), AN-Anorexia Nervosa (n = 20), BN-Bulimia Nervosa (n =19), BE-Binge-Eating Disorder (n = 15).

Table C35 Comparisons across groups of the SIAB-S past state.

Past state	Bulimic Symptoms	General Psychopathology	Slimness Ideal	Sexuality and Social Integration	Body Image	Methods to counteract Weight Gain. Substance Abuse. Fasting. Autoaggression	Atypical Binges	Total Score
C vs. AN	AN > C*	AN > C***	AN > C*	*ns*	AN > C***	*ns*	*ns*	AN > C***
C vs. BN	BN > C***	BN > C***	BN > C***	BN > C*	BN > C***	BN > C***	BN > C***	BN > C***
C vs. BE	BE > C***	BE > C***	BE > C***	BE > C***	BE > C*	BE > C*	BE > C***	BE > C***
AN vs. BN	BN > AN***	*ns*	*ns*	*ns*	*ns*	*ns*	BN > AN***	BN > AN*
AN vs. BE	BE > AN***	*ns*	*ns*	AN > BE*	*ns*	*ns*	BE > AN***	BE > AN*
BN vs. BE	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

***$p \leq .001$, *$p < .05$. Note: C-Controls (n = 20), AN-Anorexia Nervosa (n = 20), BN-Bulimia Nervosa (n =19), BE-Binge-Eating Disorder (n = 15).

Table C36 Results of the debriefing questionnaire.

		Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)		Total sample (*N* = 74)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Did you know/guess that I was watching you during the experiment?	No	8	40.0	8	40.0	8	42.1	4	26.7	28	37.8
	Yes	12	60.0	12	60.0	11	57.9	11	73.3	46	62.2
Did this knowledge have an influence on your behavior?	No	8	40.0	9	45.0	10	52.6	11	73.3	38	51.4
	Yes	4	20.0	3	15.0	1	5.3	0	0.0	8	10.8
Did this knowledge have an influence on your facial expressions?	No	11	55.0	11	55.0	10	52.6	9	60.0	41	55.4
	Yes	1	5.0	1	5.0	1	5.3	2	13.3	5	6.8
Did your facial expressivity increase or decrease?	Increase	0	0.0	1	5.0	0	0.0	1	6.7	2	2.7
	Decrease	1	5.0	0	0.0	1	5.3	1	6.7	3	4.1

Table C37 Identification rates of the taste quality of the taste strips in total and in % in healthy controls, patients with Anorexia, Bulimia, and Binge-Eating Disorder.

		Controls (*n* = 20)		Anorexia Nervosa (*n* = 20)		Bulimia Nervosa (*n* = 19)		Binge-Eating Disorder (*n* = 15)	
	Strip number	*n*	%	*n*	%	*n*	%	*n*	%
sweet	A1	20	100.0	19	95.0	18	94.7	14	93.3
	A2	20	100.0	19	95.0	18	94.7	14	93.3
	A3	18	90.0	12	60.0	15	78.9	12	80.0
	A4	10	50.0	6	30.0	10	52.6	7	46.7
sour	B1	20	100.0	19	95.0	19	100.0	14	93.3
	B2	19	95.0	17	85.0	15	78.9	14	93.3
	B3	14	70.0	12	60.0	14	73.7	9	60.0
	B4	2	10.0	2	10.0	3	15.8	1	6.7
salty	C1	18	90.0	18	90.0	18	94.7	14	93.3
	C2	19	95.0	17	85.0	16	84.2	12	80.0
	C3	10	50.0	10	50.0	15	78.9	13	86.7
	C4	13	65.0	11	55.0	15	78.9	11	73.3
bitter	D1	19	95.0	18	90.0	17	89.5	14	93.3
	D2	18	90.0	16	75.0	15	78.9	13	86.7
	D3	17	85.0	16	75.0	13	68.4	12	80.0
	D4	12	60.0	8	40.0	8	42.1	2	13.3

A3 (sweet): C > AN, $p = .031$; C3 (salty): C > BE; D4 (bitter): C > BE.

Table C38

Controls					Anorexia Nervosa					Bulimia Nervosa					Binge-Eating Disorder				
	Order					Order					Order					Order			
Ss	Taste	Odor	session	began with	Ss	Taste	Odor	session	began with	Ss	Taste	Odor	session	began with	Ss	Taste	Odor	session	began with
64	4	2	2	Odor	**8**	1	1	1	Odor	**79**	4	4	2	Odor	**1**	2	1	2	Taste
37	3	4	2	Odor		3	6	2	Taste	**3** **86**	3	2	1	Odor	**60**	4	2	1	Taste
38	2	2	1	Odor		1	4	1	Taste	**5**	4	1	1	Taste	**20**	2	1	1	Taste
73	4	2	1	Taste	**11**	1	2	1	Odor	**7**	4	5	1	Odor	**26**	1	4	1	Odor
41	3	3	2	Odor	**12**	3	2	2	Taste	**9**	3	6	2	Odor	**25**	3	2	1	Odor
42	1	5	1	Taste		2	1	1	Taste	**17**	3	4	2	Odor	**30**	3	6	2	Odor
59	1	1	1	Taste	**14**	2	5	1	Odor	**22**	1	6	1	Taste	**29**	4	4	2	Taste
72	4	3	1	Taste	**18**	1	5	1	Taste	**85**	1	3	2	Odor	**69**	4	1	1	Odor
47	3	1	2	Taste	**19**	4	3	2	Taste	**16**	2	1	1	Odor	**83**	4	5	1	Taste
50	2	6	2	Odor	**21**	3	2	1	Odor		2	5	2	Odor	**71**	3	4	1	Taste
74	1	1	2	Odor	**23**	4	7	2	Odor	**27**	1	4	1	Odor		1	6	1	Taste
52	4	3	1	Odor	**58**	4	6	1	Taste	**33**	2	3	2	Taste	**77**	1	3	1	Odor
53	4	6	2	Taste	**49**	2	1	2	Odor	**82**	3	1	2	Taste		2	5	1	Odor
57	2	2	2	Taste	**44**	3	1	1	Taste	**39**	4	2	1	Taste	**31**	2	3	2	Odor
61	2	4	2	Odor	**35**	1	4	2	Taste	**28**	4	1	2	Taste		3	1	2	Taste
62	1	6	1	Odor	**40**	4	4	1	Odor	**15**	3	3	1	Taste		4	2	2	Odor
75	2	4	1	Taste	**54**	4	5	2	Taste	**84**	2	6	1	Odor	**80**	3	3	2	Taste
65	1	5	2	Odor	**34**	3	6	2	Odor	**46**	2	2	2	Taste	**81**	2	6	2	Odor
67	3	5	1	Taste	**32**	2	2	2	Taste		1	2	2	Taste		1	2	2	Taste
68	3	1	1	Taste	**56**	3	4	1	Taste	**24**	1	5	1	Taste	**70**	1	5	2	Odor
					48	2	3	2	Odor										
					55	1	3	2	Odor										
					66	2	6	1	Taste										

1. session = Taste- and Odorexperiment, 2. session = Taste Threshold, Odor Threshold, Bittersensitivity

Study 3:

Table C39 Diagnostic criteria of childhood and adult Attention-Deficit Hyperactivity Disorder according to Diagnostic & Statistical Manual of Mental Disorders (DSM-IV, 2000).

<table>
<tr><td colspan="2">I. Either A or B:</td></tr>
<tr><td>(A.) Six or more of the following signs of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level:

Predominantly inattentive type - Children
Inattention:

1. Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
2. Often has trouble keeping attention on tasks or play activities.
3. Often does not seem to listen when spoken to directly.
4. Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions).
5. Often has trouble in organizing activities.
6. Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework).
7. Often loses things needed for tasks and activities (such as toys, school assignments, pencils, books, or tools).
8. Is often easily distracted.
9. Often forgetful in daily activities.</td><td>(B.) Six or more of the following signs of hyperactivity-impulsivity have been present for at least 6 months to an extent that is disruptive and inappropriate for developmental level:

Predominantly hyperactive-impulsive type - Children
Hyperactivity:

1. Often fidgets with hands or feet or squirms in seat.
2. Often gets up from seat when remaining in seat is expected.
3. Often runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless).
4. Often has trouble playing or enjoying leisure activities quietly.
5. Is often "on the go" or often acts as if "driven by a motor".
6. Often talks excessively.

Impulsiveness:

1. Often blurts out answers before questions have been finished.
2. Often has trouble waiting one's turn.
3. Often interrupts or intrudes on others (example: butts into conversations or games).</td></tr>
<tr><td>Adults

1. Procrastination
2. Indecision, difficulty recalling and organizing details required for a task
3. Poor time management, losing track of time
4. Avoiding tasks or jobs that require sustained attention
5. Difficulty initiating tasks
6. Difficulty completing and following through on tasks
7. Difficulty multitasking
8. Difficulty shifting attention from one task to another</td><td>Adults

1. Chooses highly active, stimulating jobs
2. Avoids situations with low physical activity or sedentary work
3. May choose to work long hours or two jobs
4. Seeks constant activity
5. Easily bored
6. Impatient
7. Intolerant to frustration, easily irritated
8. Impulsive, snap decisions and irresponsible behaviors
9. Loses temper easily, angers quickly</td></tr>
<tr><td colspan="2">(C.) Combined hyperactive-impulsive and inattentive type

Six or more symptoms of inattention and six or more symptoms of hyperactivity-impulsivity are present.</td></tr>
<tr><td colspan="2">II. Some signs that cause impairment were present before age 7 years.
III. Some impairment from the signs is present in two or more settings (school/work, at home).
IV. There must be clear evidence of significant impairment in social, school, or work functioning.
V. The signs do not happen only during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder. The signs are not better accounted for by another mental disorder (such as Mood Disorder, Anxiety Disorder, Dissociative Identity Disorder, or a Personality Disorder).</td></tr>
</table>

Table C40 Sample characteristics.

	Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)		Total sample (*N* = 36)	
	n	%	*n*	%	*n*	%	*n*	%
Handedness								
Right-hander	11	91.7	12	100.0	11	91.7	34	94.4
Left-hander	1	8.3	0	0.0	1	8.3	2	5.6
Highest Graduation								
Hauptschule	0	0.0	0	0.0	1	8.3	1	2.8
Realschule	3	25.0	0	0.0	7	58.3	10	27.8
Abitur	5	41.7	9	75.0	2	16.7	16	44.4
Universität/Fachhochschule	4	33.3	3	25.0	2	16.7	9	25.0
Profession								
Pupil	0	0.0	0	0.0	1	8.3	1	2.8
Student	8	66.7	11	91.7	0	0.0	19	52.8
Job	4	33.3	1	8.3	11	91.7	16	44.4
Marital status								
unmarried	10	83.3	12	100.0	2	16.7	24	66.7
married	1	8.3	0	0.0	8	66.7	9	25.0
separated/divorced	1	8.3	0	0.0	2	16.7	3	8.3
Vegetarianism								
no	12	100.0	10	83.3	12	100.0	34	94.4
yes	0	0.0	2	16.7	0	0.0	2	5.6

Figure C03 Taste stimuli profile.

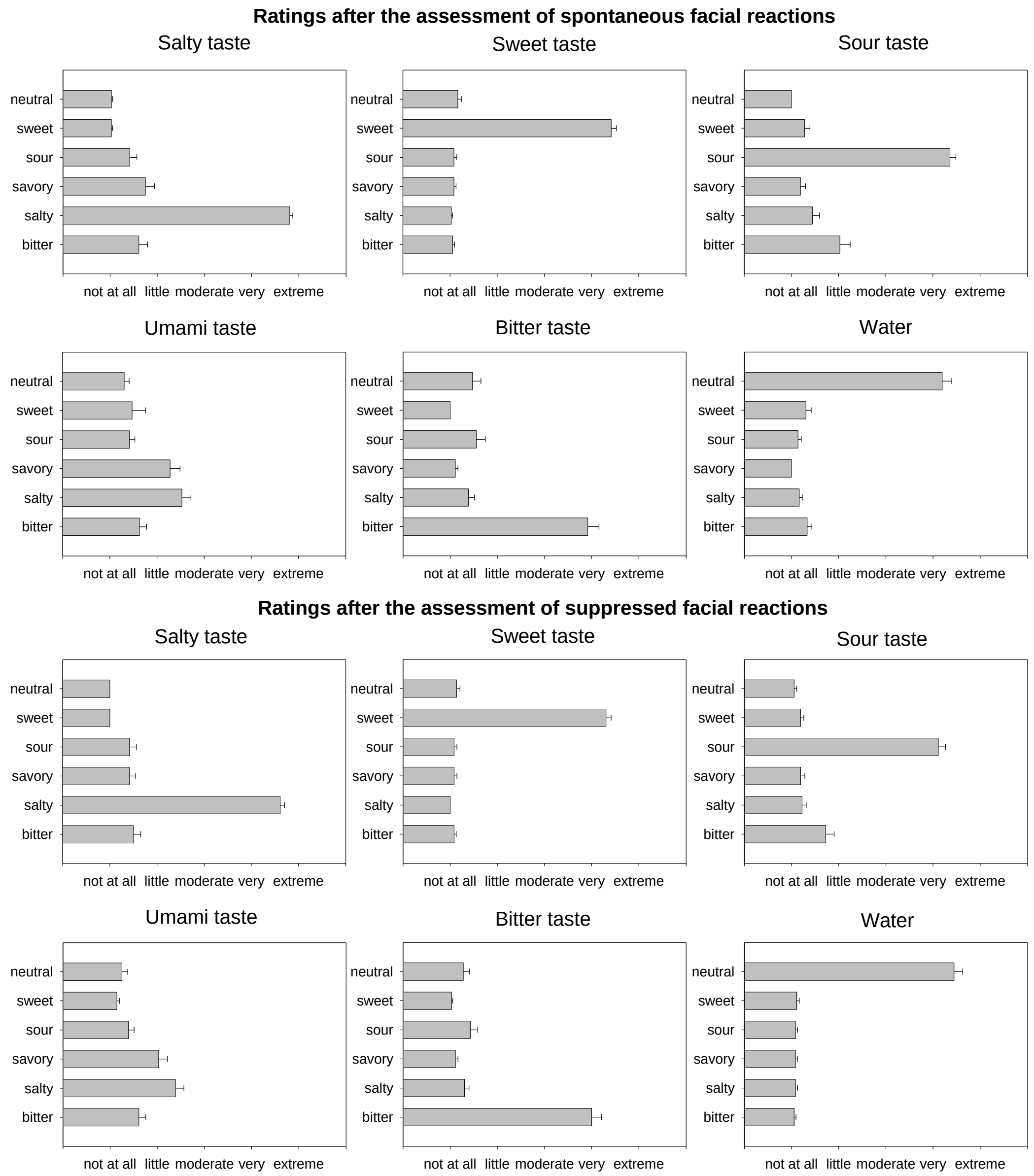


Table 41 Intensity, pleasantness, and mood ratings in response to the bitter, salty, sour, sweet, and umami tastes, and water for healthy controls, patients with Bulimia, or Attention-Deficit Hyperactivity Disorder – average deviations (Mean ± *SD*) from ratings for mineral water.

	Spontaneous reactions						Suppressed reactions					
	Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)		Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity												
water	5.5	3.5	3.4	3.3	3.9	4.4	5.1	3.8	3.2	2.9	3.2	2.0
bitter	12.0	9.0	11.5	9.3	19.6	5.0	15.7	5.3	13.6	6.4	18.8	4.2
salty	17.8	3.4	18.8	4.0	18.6	5.1	15.8	6.3	19.2	3.9	18.4	3.5
sour	15.9	4.1	17.6	4.3	16.8	4.8	16.5	3.7	18.8	4.3	17.8	4.2
sweet	15.2	3.0	13.8	4.3	15.5	5.8	15.6	4.1	14.0	4.4	16.6	4.3
umami	13.1	4.6	12.2	4.6	10.4	6.4	12.3	6.6	13.9	4.0	13.7	4.7
Pleasantness												
water	14.1	4.4	14.3	3.1	13.8	2.4	13.2	4.6	14.4	2.2	11.9	4.6
bitter	-8.3	6.0	-7.6	5.5	-10.7	3.0	-6.8	5.7	-8.0	4.7	-8.8	5.1
salty	-8.3	6.8	-8.6	6.0	-8.1	3.5	-6.1	7.1	-8.3	5.4	-6.3	4.6
sour	-2.0	6.8	-4.2	6.8	-1.8	6.1	-0.9	7.9	-3.8	6.2	2.3	7.2
sweet	-0.3	6.3	0.7	5.0	3.8	3.0	1.1	7.2	2.0	4.5	5.8	6.4
umami	-7.8	7.1	-4.4	5.4	-3.9	5.4	-7.3	6.9	-5.7	5.9	-4.3	6.8
Mood												
water	17.9	3.1	16.3	2.8	17.6	3.4	16.6	2.8	14.9	3.3	16.0	3.0
bitter	-4.6	3.3	-3.4	5.4	-8.2	5.9	-2.7	4.3	-2.3	3.1	-5.5	5.9
salty	-4.1	3.9	-2.8	4.1	-4.6	4.3	-3.4	4.6	-1.6	2.2	-2.6	3.2
sour	-2.7	3.3	-1.0	4.8	-1.8	3.7	-0.6	2.4	-0.4	3.9	0.8	3.6
sweet	-0.7	2.7	-0.8	3.9	0.5	3.2	0.4	3.3	0.3	2.2	1.2	2.5
umami	-3.8	5.3	-3.0	5.0	-3.1	3.5	-3.8	5.0	-1.3	4.6	-2.9	4.1

Figure C04 Odor stimuli profile

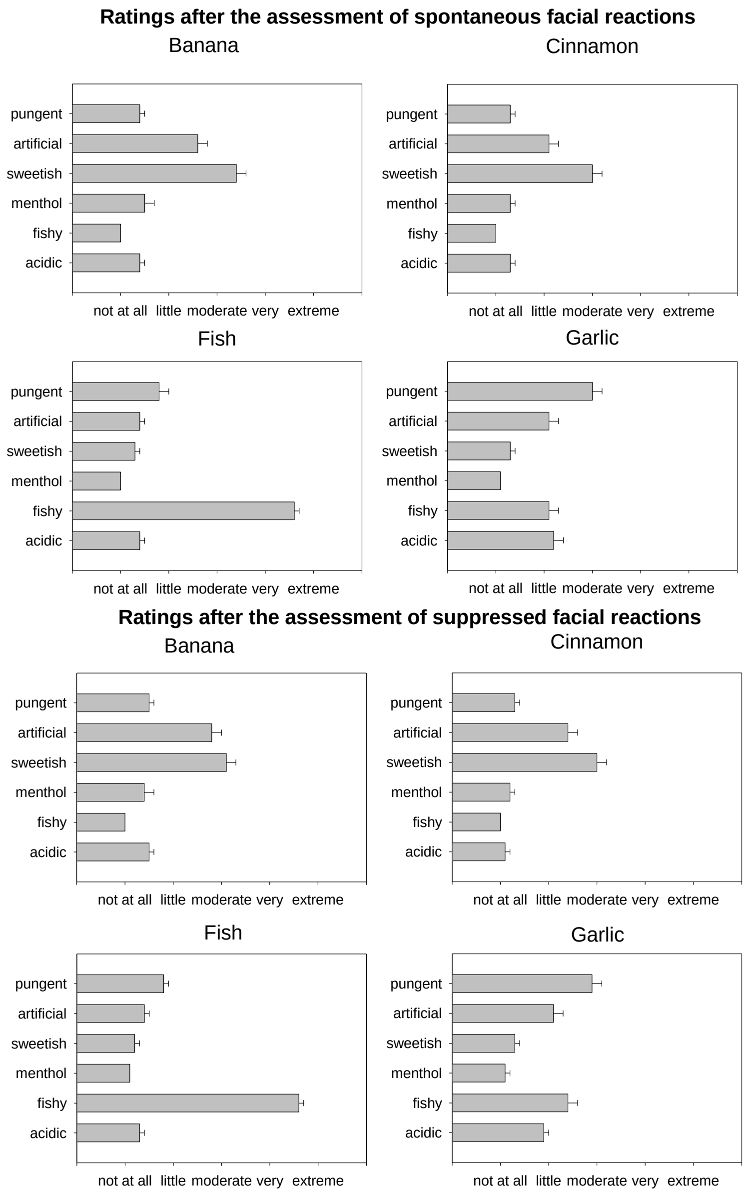


Table C42 Intensity, pleasantness, and mood ratings (Mean ± *SD*) in response to banana, cinnamon, fish, and garlic in healthy controls, patients with Bulimia, or Attention-Deficit Hyperactivity Disorder.

	Spontaneous reactions						Suppressed reactions					
	Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)		Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Intensity												
banana	19.3	3.5	17.2	3.2	16.7	3.7	18.6	3.6	18.8	2.5	17.6	3.6
cinnamon	15.9	3.3	15.8	2.6	15.8	3.2	16.3	2.6	17.3	3.7	18.9	3.7
fish	20.3	3.7	18.0	3.6	18.5	4.2	21.5	2.2	19.3	4.2	20.1	3.7
garlic	20.8	3.9	19.9	3.0	19.4	3.6	20.6	2.1	21.8	2.2	20.1	3.6
Pleasantness												
banana	18.0	4.2	16.9	4.2	17.8	3.2	15.3	4.8	14.8	6.5	18.2	3.4
cinnamon	16.3	5.3	19.7	4.6	17.3	3.7	16.0	5.2	18.5	6.2	17.0	4.5
fish	8.8	3.6	8.9	5.7	7.8	3.3	7.4	4.2	9.8	8.3	7.7	5.2
garlic	9.0	4.7	12.9	7.4	8.9	3.9	7.3	5.4	12.2	7.9	6.7	3.7
Mood												
banana	18.1	2.8	16.1	3.8	18.2	2.6	16.6	3.2	15.6	3.5	17.6	2.9
cinnamon	17.9	2.2	17.5	4.8	17.9	2.3	16.3	2.4	16.1	4.0	16.3	5.0
fish	15.7	3.7	13.9	3.4	14.0	4.0	15.2	2.9	14.2	4.2	14.4	5.3
garlic	14.6	4.5	15.8	3.8	14.8	2.9	14.6	4.4	14.9	4.3	13.5	5.9

Table C43 Task difficulty rating and task performance rating in response to tastes and odors in healthy controls, patients with Bulimia, or Attention-Deficit Hyperactivity Disorder.

		Controls (n = 12)		Bulimia Nervosa (n = 12)		ADHD (n = 12)	
		M	*SD*	*M*	*SD*	*M*	*SD*
How difficult?							
Tastes	water	1.3	0.5	2.2	0.7	1.6	0.7
	bitter	3.7	1.4	2.9	1.3	3.8	1.3
	salty	3.4	1.3	3.5	1.0	3.0	1.0
	sour	3.2	1.2	3.6	1.2	2.9	0.7
	sweet	1.9	1.0	2.3	0.8	1.8	0.5
	umami	3.3	0.9	3.1	1.2	2.8	1.2
Odors	banana	2.1	1.0	2.3	0.9	1.8	0.8
	cinnamon	1.9	1.0	2.4	1.1	2.2	1.1
	fish	2.4	1.3	2.8	1.2	2.8	1.3
	garlic	2.8	1.2	2.4	1.1	2.8	1.2
How good?							
Tastes	water	1.8	1.2	2.2	0.8	1.8	0.8
	bitter	3.4	1.3	2.8	1.2	3.5	1.2
	salty	3.1	1.3	2.8	0.8	2.5	1.0
	sour	2.6	1.0	2.9	0.9	2.5	0.9
	sweet	1.9	0.9	2.2	0.8	1.9	0.8
	umami	2.8	0.8	2.6	0.9	3.0	1.1
Odors	banana	2.0	0.9	2.4	1.0	2.3	1.1
	cinnamon	2.0	1.0	2.3	0.9	2.3	1.2
	fish	1.8	0.7	2.3	0.9	2.2	0.9
	garlic	2.4	1.2	2.2	1.0	2.8	1.1

Table C44 Frequency of **Action Units (AUs)** during **spontaneous facial reactions** in response to the bitter, salty, sour, sweet, umami **tastes**, and water before and after swallowing (pre and post), and for both periods combined (total) in healthy controls (*n* = 12), patients with Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

Action Unit		water			bitter			salty			sour			sweet			umami		
		C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS
AU 1 Inner Brow Raise	pre	0	0	0	1	1	2	3	1	3	4	4	3	1	0	0	0	0	0
	post	0	2	0	2	2	4	3	6	1	3	7	3	0	2	1	2	1	0
	total	0	2	0	3	3	6	6	7	4	7	11	6	1	2	1	2	1	0
AU 2 Outer Brow Raise	pre	0	0	0	1	0	0	3	2	1	4	3	1	0	0	0	0	0	0
	post	0	1	0	2	3	1	3	5	1	4	2	2	1	3	1	0	2	0
	total	0	1	0	3	3	1	6	7	2	8	5	3	1	3	1	0	2	0
AU 4 Brow Lower	pre	3	4	1	5	7	13	8	10	18	8	11	12	5	6	2	8	9	7
	post	2	4	3	8	9	12	7	14	12	7	9	11	5	7	3	8	8	7
	total	5	8	4	13	16	25	15	24	30	15	20	23	10	13	5	16	17	14
AU 5 Lid Raise	pre	1	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0
	post	0	0	0	0	1	0	2	1	0	1	0	0	0	1	0	0	0	0
	total	1	0	0	0	2	0	3	1	0	1	0	1	1	1	0	0	0	0
AU 6 Cheek Raise	pre	0	0	0	0	0	4	5	1	4	4	0	2	1	1	1	1	0	0
	post	0	0	0	0	1	3	5	1	6	1	1	1	2	1	1	1	0	2
	total	0	0	0	0	1	7	10	2	10	5	1	3	3	2	2	2	0	2
AU 7 Lids Tight	pre	1	0	1	1	3	8	4	7	7	6	6	6	1	1	2	4	4	4
	post	0	1	0	4	5	9	4	8	9	4	5	7	2	3	2	3	2	7
	total	1	1	1	5	8	17	8	15	16	10	11	13	3	4	4	7	6	11
AU 9 Nose Wrinkle	pre	0	0	0	0	0	3	1	0	2	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	4	0	0	1	1	0	2	0	1	0	0	0	1
	total	0	0	0	0	0	7	1	0	3	1	0	2	0	1	0	0	0	1
AU 10 Upper Lip Raise	pre	0	0	0	5	8	12	9	11	12	11	11	11	5	5	2	8	10	8
	post	0	0	0	11	10	12	9	12	13	9	10	12	5	6	3	7	11	8
	total	0	0	0	16	18	24	18	23	25	20	21	23	10	11	5	15	21	16

Table C44 Continued.

Action Unit		water			bitter			salty			sour			sweet			umami		
		C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS
AU 12 Lip Corner Pull	pre	0	0	2	0	2	4	8	1	3	3	1	3	3	4	1	1	2	0
	post	0	1	2	0	3	4	5	5	7	2	4	2	2	5	2	1	3	2
	total	0	1	4	0	5	8	13	6	10	5	5	5	5	9	3	2	5	2
AU 13 Sharp Lip Pull	pre	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	post	0	3	0	0	2	0	0	1	0	0	3	2	0	2	1	0	0	0
	total	0	3	0	0	2	0	0	1	0	0	3	3	0	2	1	0	0	0
AU 14 Dimpler	pre	4	12	9	5	12	3	2	14	4	5	10	6	2	14	7	1	16	9
	post	4	6	13	5	8	6	5	8	7	8	7	7	6	5	12	4	9	8
	total	8	18	22	10	20	9	7	22	11	13	17	13	8	19	19	5	25	17
AU 15 Lip Corner Depress	pre	0	0	0	4	3	8	5	4	4	3	2	5	1	2	1	3	1	4
	post	1	1	0	2	1	10	4	2	6	1	3	2	7	1	1	5	2	2
	total	1	1	0	6	4	18	9	6	10	4	5	7	8	3	2	8	3	6
AU 16 Lower Lip Depress	pre	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0
	post	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	1	0	1	2	0	0	0	1	1	0	1	0	0	0	0
AU 17 Chin Raise	pre	1	3	1	2	3	6	3	5	1	1	3	6	1	2	0	3	0	4
	post	1	1	0	1	3	2	4	6	3	5	3	2	0	4	3	4	5	1
	total	2	4	1	3	6	8	7	11	4	6	6	8	1	6	3	7	5	5
AU 18 Lip Pucker	pre	0	1	0	1	1	1	0	0	1	4	0	3	1	1	0	1	0	0
	post	1	0	2	0	1	0	1	0	0	1	0	1	0	0	4	0	1	0
	total	1	1	2	1	2	1	1	0	1	5	0	4	1	1	4	1	1	0
AU 19 Tongue Show	pre	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	1	1	0	0	3	1	0	0	0	0	0	0	0	0
	total	0	0	0	0	1	1	0	1	3	1	0	0	0	0	0	0	0	0
AU 20 Lip Stretch	pre	0	0	0	0	0	3	0	2	0	0	2	0	0	1	0	0	1	0
	post	0	0	0	1	2	3	2	2	2	1	1	1	0	0	0	0	1	1
	total	0	0	0	1	2	6	2	4	2	1	3	1	0	1	0	0	2	1

Table C44 Continued.

Action Unit		water C	water BN	water ADHS	bitter C	bitter BN	bitter ADHS	salty C	salty BN	salty ADHS	sour C	sour BN	sour ADHS	sweet C	sweet BN	sweet ADHS	umami C	umami BN	umami ADHS
AU 23 Lip Tight	pre	0	0	0	0	1	1	1	1	0	4	3	6	1	0	2	1	0	0
	post	0	2	1	0	3	1	3	6	2	6	5	11	0	3	4	1	4	0
	total	0	2	1	0	4	2	4	7	2	10	8	17	1	3	6	2	4	0
AU 24 Lip Press	pre	9	8	9	7	10	10	4	13	12	6	10	14	8	12	13	7	16	14
	post	9	14	12	9	12	12	8	15	15	12	17	27	13	18	21	13	21	14
	total	18	22	21	16	22	22	12	28	27	18	27	41	21	30	34	20	37	28
AU 25 Lips Part	pre	0	0	0	0	0	2	1	0	2	3	3	3	1	0	2	0	0	2
	post	15	12	19	20	19	14	20	16	20	23	17	25	19	20	27	23	19	25
	total	15	12	19	20	19	16	21	16	22	26	20	28	20	20	29	23	19	27
AU 26 Jaw Drop	pre	5	1	2	1	1	6	2	1	1	3	3	2	0	1	1	1	1	0
	post	12	15	16	15	19	13	19	17	19	19	24	26	18	19	28	19	17	21
	total	17	16	18	16	20	19	21	18	20	22	27	28	18	20	29	20	18	21
AU 28 Lip Suck	pre	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	post	0	1	0	1	1	0	0	2	0	0	5	1	0	2	0	0	2	0
	total	0	1	0	1	1	0	0	3	0	0	5	1	0	2	0	0	2	0
AU 29 Jaw Thrust	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
AU 30 Jaw to Sideways	pre	0	1	1	0	2	0	1	2	1	1	5	0	1	1	0	0	4	0
	post	0	0	0	0	0	0	0	0	0	0	1	2	1	0	3	2	1	0
	total	0	1	1	0	2	0	1	2	1	1	6	2	2	1	3	2	5	0
AU 34 Puff	pre	3	4	1	5	1	0	1	5	0	0	2	0	1	1	2	2	2	1
	post	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	total	3	4	1	5	1	0	1	6	0	0	2	0	1	1	2	2	2	1
AU 35 Cheek Suck	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
	total	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0

Table C44 Continued.

Action Unit		water			bitter			salty			sour			sweet			umami		
		C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS
AU 36 Tongue Bulge	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	total	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
AU 37 Lip Wipe	pre	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0
	post	0	0	0	1	0	0	1	0	0	0	1	1	1	2	1	0	0	0
	total	1	0	0	1	0	0	1	0	0	0	1	1	3	2	1	1	0	0
AU 38 Nostril Dilate	pre	1	1	0	0	3	0	0	3	2	0	2	0	3	2	0	1	2	0
	post	1	2	0	1	2	1	0	2	0	0	3	0	1	3	1	1	4	0
	total	2	3	0	1	5	1	0	5	2	0	5	0	4	5	1	2	6	0
AU 39 Nostril Compress	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
	total	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
AU 43 Eyes Closed	pre	0	0	0	1	1	2	3	3	3	1	0	1	0	0	0	0	0	1
	post	0	0	0	0	1	0	0	2	1	1	1	1	0	0	0	0	1	1
	total	0	0	0	1	2	2	3	5	4	2	1	2	0	0	0	0	1	2
AU 50 Speech	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	2	1	0	4	0	0	2	1	0	0	0	0	1
	total	0	0	0	0	0	2	1	0	4	0	0	2	1	0	0	0	0	1

Table C45 Frequency of **Action Units (AUs)** during **suppressed facial reactions** in response to the bitter, salty, sour, sweet, umami **tastes**, and water before and after swallowing (pre and post), and for both periods combined (total) in healthy controls (*n* = 12), patients with Bulimia (*n* =12), and Attention-Deficit Hyperactivity Disorder (*n* = 12). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

		water			bitter			salty			sour			sweet			umami		
Action Unit		C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS
AU 1 Inner Brow Raise	pre	0	1	0	0	1	0	0	1	1	0	1	1	0	2	0	1	0	0
	post	0	1	1	0	0	3	0	0	1	0	2	0	0	1	0	0	1	1
	total	0	2	1	0	1	3	0	1	2	0	3	1	0	3	0	1	1	1
AU 2 Outer Brow Raise	pre	1	3	0	0	1	3	0	1	0	1	1	2	0	1	0	1	0	0
	post	0	1	1	1	1	1	0	1	0	0	3	0	0	1	0	1	0	1
	total	1	4	1	1	2	4	0	2	0	1	4	2	0	2	0	2	0	1
AU 4 Brow Lower	pre	0	0	2	0	1	5	3	3	5	1	3	6	0	0	1	2	4	5
	post	0	1	2	2	4	9	3	2	5	3	2	4	4	1	4	1	4	3
	total	0	1	4	2	5	14	6	5	10	4	5	10	4	1	5	3	8	8
AU 5 Lid Raise	pre	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
	total	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0
AU 6 Cheek Raise	pre	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
AU 7 Lids Tight	pre	0	0	1	0	1	2	2	0	3	0	0	1	0	0	0	0	0	2
	post	1	1	1	1	0	3	0	0	2	0	2	3	0	1	2	1	2	2
	total	1	1	2	1	1	5	2	0	5	0	2	4	0	1	2	1	2	4
AU 10 Upper Lip Raise	pre	0	0	1	5	6	9	7	6	8	7	7	9	3	5	2	8	9	8
	post	0	0	1	5	10	8	5	6	5	5	6	6	3	2	3	6	5	6
	total	0	0	2	10	16	17	12	12	13	12	13	15	6	7	5	14	14	14
AU 12 Lip Corner Pull	pre	1	0	1	3	0	1	2	1	1	0	0	1	3	1	1	4	0	0
	post	2	4	0	1	0	2	3	3	0	2	0	0	4	7	3	1	3	1
	total	3	4	1	4	0	3	5	4	1	2	0	1	7	8	4	5	3	1

Table C45 Continued.

Action Unit		water C	water BN	water ADHS	bitter C	bitter BN	bitter ADHS	salty C	salty BN	salty ADHS	sour C	sour BN	sour ADHS	sweet C	sweet BN	sweet ADHS	umami C	umami BN	umami ADHS
AU 13 Sharp Lip Pull	pre	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
	total	0	1	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0
AU 14 Dimpler	pre	5	9	13	3	7	3	1	15	5	2	4	6	1	8	7	1	7	8
	post	4	3	5	7	5	6	3	5	4	4	5	12	2	3	6	4	6	10
	total	9	12	18	10	12	9	4	20	9	6	9	18	3	11	13	5	13	18
AU 15 Lip Corner Depress	pre	0	0	0	0	2	3	1	1	2	2	0	0	0	0	2	2	0	1
	post	0	2	0	1	0	1	2	0	0	3	0	2	1	1	0	1	2	0
	total	0	2	0	1	2	4	3	1	2	5	0	2	1	1	2	3	2	1
AU 16 Lower Lip Depress	pre	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	post	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	total	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
AU 17 Chin Raise	pre	0	1	0	1	0	2	1	1	1	2	2	2	1	1	1	1	1	5
	post	3	1	2	3	4	0	0	0	1	0	3	2	0	0	0	1	2	1
	total	3	2	2	4	4	2	1	1	2	2	5	4	1	1	1	2	3	6
AU 18 Lip Pucker	pre	1	0	1	0	0	0	0	1	2	1	1	1	1	0	1	0	0	0
	post	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0
	total	1	0	1	0	0	0	0	3	2	1	1	1	1	2	1	0	0	0
AU 20 Lip Stretch	pre	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0
	post	0	0	1	1	2	0	0	0	1	0	1	0	2	0	0	1	0	1
	total	0	0	1	2	2	0	1	1	1	0	1	0	3	0	0	1	0	1
AU 23 Lip Tight	pre	0	0	1	0	0	1	1	1	2	1	3	4	2	0	1	0	0	2
	post	0	1	0	0	1	1	0	1	2	2	1	1	0	2	1	0	3	0
	total	0	1	1	0	1	2	1	2	4	3	4	5	2	2	2	0	3	2
AU 24 Lip Press	pre	8	13	11	4	10	13	4	8	15	4	9	13	3	11	15	2	10	9
	post	9	10	11	6	8	6	7	10	11	7	13	20	9	15	31	5	13	12
	total	17	23	22	10	18	19	11	18	26	11	22	33	12	26	46	7	23	21

Table C45 Continued.

Action Unit		water			bitter			salty			sour			sweet			umami		
		C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS
AU 25 Lips Part	pre	0	1	1	0	0	2	1	0	2	1	0	2	3	0	1	0	2	1
	post	12	8	12	8	8	10	11	11	13	10	9	21	12	13	14	9	12	14
	total	12	9	13	8	8	12	12	11	15	11	9	23	15	13	15	9	14	15
AU 26 Jaw Drop	pre	0	3	2	1	0	2	1	0	3	1	0	1	2	0	1	0	0	1
	post	11	9	11	9	7	9	8	12	12	9	8	19	13	14	13	8	13	13
	total	11	12	13	10	7	11	9	12	15	10	8	20	15	14	14	8	13	14
AU 28 Lip Suck	pre	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	post	1	2	0	3	0	0	1	1	0	1	1	0	1	3	0	1	2	0
	total	1	3	0	3	0	0	1	1	0	1	1	0	1	3	1	1	2	0
AU 30 Jaw to Sideways	pre	0	0	0	0	1	0	1	3	5	0	4	1	0	2	0	1	2	0
	post	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	total	1	0	1	0	1	0	1	5	5	0	4	1	0	2	0	1	2	0
AU 31 Jaw Clench	pre	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	post	1	0	0	2	1	0	4	1	1	1	0	0	1	0	1	2	0	1
	total	1	0	0	3	1	0	5	1	1	2	0	0	2	0	1	2	0	1
AU 34 Puff	pre	1	2	1	0	1	1	0	2	1	0	2	1	0	0	1	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	1	2	1	0	1	1	0	2	1	0	2	1	0	0	1	0	0	0
AU 35 Cheek Suck	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
	total	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
AU 36 Tongue Bulge	pre	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	post	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 37 Lip Wipe	pre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	post	1	1	0	1	0	0	1	2	1	1	0	0	0	1	0	1	0	0
	total	1	1	0	1	0	0	1	2	1	1	0	0	0	1	0	1	1	0

Table C45 Continued.

Action Unit		water			bitter			salty			sour			sweet			umami		
		C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS	C	BN	ADHS
AU 38 Nostril Dilate	pre	2	2	0	3	4	1	3	2	0	1	1	0	6	1	1	4	2	0
	post	1	0	1	2	3	2	1	3	0	2	3	3	0	1	0	2	2	1
	total	3	2	1	5	7	3	4	5	0	3	4	3	6	2	1	6	4	1
AU 43 Eyes Closed	pre	0	0	0	0	1	0	1	1	0	1	2	0	0	0	0	0	0	0
	post	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	total	0	0	0	0	2	0	1	1	0	2	2	0	0	0	0	0	0	0

Table C46 Frequency of **Action Units (AUs)** during **spontaneous and suppressed facial reactions** in response to different **odors** (banana, cinnamon, fish, and garlic) in healthy controls (*n* = 12), patients with Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

	spontaneous												suppressed											
Action Unit	banana			cinnamon			fish			garlic			banana			cinnamon			fish			garlic		
	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD
AU 1 Inner Brow Raise	3	0	0	2	0	0	0	0	2	1	3	0	1	1	0	0	0	0	0	1	0	0	0	0
AU 2 Outer Brow Raise	3	0	1	3	0	0	1	0	2	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
AU 4 Brow Lower	2	5	3	4	4	5	6	4	4	8	10	10	0	0	0	0	0	3	0	2	3	0	2	4
AU 6 Cheek Raise	1	0	2	0	0	0	3	1	1	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
AU 7 Lids Tight	2	2	6	2	1	3	2	1	5	5	4	8	0	0	0	1	0	1	0	1	1	0	0	1
AU 9 Nose Wrinkle	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 10 Upper Lip Raise	1	2	2	0	2	0	6	2	5	6	7	6	0	0	0	0	1	0	1	2	1	1	3	3
AU 12 Lip Corner Pull	1	2	2	0	2	0	6	2	1	3	1	3	0	1	0	0	1	1	0	0	0	1	1	0
AU 14 Dimpler	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
AU 15 Lip CornerDepress	0	0	0	0	1	0	1	0	1	2	0	2	0	0	1	0	0	0	0	1	0	0	0	2
AU 16 Lower Lip Depress	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 17 Chin Raise	0	0	0	0	1	0	0	0	1	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0
AU 20 Lip Stretch	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 24 Lip Press	0	1	0	0	1	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 25 Lips Part	0	0	0	0	0	0	2	0	1	4	1	1	0	0	1	0	0	0	0	0	0	0	0	0

Table C46 Continued.

Action Unit	spontaneous												suppressed											
	banana			cinnamon			fish			garlic			banana			cinnamon			fish			garlic		
	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD
AU 26 Jaw Drop	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 31 Jaw Clench	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
AU 33 Blow	0	0	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
AU 38 Nostril Dilate	0	2	1	0	4	0	0	1	2	0	0	5	1	1	0	1	2	3	2	2	3	1	0	2
AU 39 Nostril Compress	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 43 Wink	1	0	0	1	2	0	3	2	2	2	2	1	0	0	0	0	0	0	0	1	1	0	1	0
AU 45 Blink	18	23	26	25	25	33	24	22	23	37	22	33	19	21	21	15	16	27	16	13	20	15	15	27
AU 50 Speech	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C47 Frequency of **Action Units (AUs)** during **spontaneous facial reactions** in response to different **cartoons** in healthy controls (*n* = 6), patients with Bulimia (*n* = 6), and Attention-Deficit Hyperactivity Disorder (*n* = 6). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

Action Unit	spontaneous																	
	isle			marriage			plant			beaver			kangaroo			fish fingers		
	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD
AU 1 Inner Brow Raise	0	0	0	1	1	0	3	0	1	0	0	1	0	0	1	1	1	1
AU 2 Outer Brow Raise	0	0	0	1	2	0	3	0	1	0	0	1	0	0	0	1	1	2
AU 4 Brow Lower	1	2	1	0	0	1	1	2	0	0	0	0	1	1	1	0	4	0
AU 6 Cheek Raise	5	5	4	4	6	4	4	5	3	4	4	5	2	3	4	2	4	5
AU 7 Lids Tight	0	0	1	0	0	0	0	0	1	0	7	0	0	3	0	0	0	0
AU 10 Upper Lip Raise	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0
AU 12 Lip Corner Pull	5	7	7	5	10	6	7	8	4	8	6	8	3	9	6	3	11	5
AU 14 Dimpler	0	0	4	0	0	0	2	0	3	0	0	0	1	0	5	0	1	0
AU 15 Lip CornerDepress	4	3	1	0	3	2	1	4	3	2	0	4	1	1	4	3	1	3
AU 17 Chin Raise	1	0	1	0	2	2	1	4	2	0	2	2	1	2	3	2	1	2
AU 18 Lip Pucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
AU 24 Lip Press	1	2	2	0	2	3	0	1	1	1	0	0	2	0	3	1	0	2
AU 25 Lips Part	2	1	1	1	2	1	1	0	1	0	0	1	0	0	0	0	1	0
AU 26 Jaw Drop	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
AU 31 Jaw Clench	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 37 Lip Wipe	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
AU 38 Nostril Dilate	0	0	1	0	0	3	1	0	1	0	0	0	0	0	1	0	0	0
AU 39 Nostril Compress	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C48 Frequency of **Action Units (AUs)** during **suppressed facial reactions** in response to different **cartoons** in healthy controls (*n* = 6), patients with Bulimia (*n* = 6), and Attention-Deficit Hyperactivity Disorder (*n* = 6). All AUs were counted, thus persons might have shown each AU more than once (AUs not listed were not observed).

Action Unit	suppressed																	
	isle			marriage			plant			beaver			kangaroo			fish fingers		
	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD	C	BN	ADHD
AU 1 Inner Brow Raise	0	0	4	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
AU 2 Outer Brow Raise	0	0	5	0	1	0	0	0	0	0	0	2	0	2	0	0	0	0
AU 4 Brow Lower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
AU 6 Cheek Raise	0	1	1	1	1	2	1	1	2	0	5	1	0	0	2	0	2	2
AU 7 Lids Tight	0	2	0	0	4	0	0	1	0	0	0	1	0	0	0	0	0	1
AU 12 Lip Corner Pull	0	3	3	1	2	2	4	3	2	1	7	0	1	0	2	0	2	3
AU 14 Dimpler	1	0	1	0	0	0	0	0	2	0	0	1	0	0	0	1	0	2
AU 15 Lip CornerDepress	0	0	3	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
AU 17 Chin Raise	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
AU 18 Lip Pucker	0	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0
AU 24 Lip Press	0	2	3	0	1	0	1	0	0	0	4	3	0	1	1	1	0	2
AU 25 Lips Part	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
AU 26 Jaw Drop	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0
AU 28 Lip Suck	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AU 31 Jaw Clench	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0
AU 38 Nostril Dilate	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
AU 50 Speech	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table C49 Corrugator activity (mV) during **spontaneous facial reactions** in response to the **tastes** over the first 5 seconds before swallowing and over the first 4 seconds after swallowing (Mean ± *SD*) in healthy controls (*n* = 11, before swallowing; *n* = 12, after swallowing), Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Tastes	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	-0.5	2.4	1.0	1.6	0.4	1.3	-0.7	3.5	1.1	1.5	2.3	7.5
	2	-1.2	4.6	2.1	4.8	-0.6	2.5	-1.0	4.1	0.6	1.3	-0.1	1.3
	3	-1.9	5.9	0.4	4.6	-0.3	5.5	-1.3	4.3	1.1	2.1	-1.3	4.3
	4	-3.0	7.6	-0.1	3.9	-1.8	5.0	-1.3	4.2	2.2	5.8	-1.4	5.1
	5	-3.8	7.3	-0.3	3.9	-1.9	4.2	-1.0	4.6	1.5	3.6	-1.7	4.9
	6	-3.3	7.4	0.1	4.6	-2.2	5.0	-1.2	3.7	1.5	3.4	-1.6	4.9
	7	-2.6	7.0	0.1	4.6	-2.4	5.0	-1.4	4.0	0.1	1.2	-1.7	4.6
	8	-2.3	7.6	0.0	4.3	-2.5	5.5	-1.4	3.9	0.2	1.4	-1.9	5.5
	9	-2.6	8.0	-0.6	3.7	-3.0	6.3						
	10	-2.7	8.0	-0.2	4.1	-2.3	7.2						
Bitter	1	1.6	2.0	2.1	2.9	0.2	1.9	3.0	3.5	-2.0	4.0	1.7	14.6
	2	3.3	4.9	2.8	5.7	1.8	5.0	2.4	7.7	-2.8	11.4	3.9	15.6
	3	2.4	8.8	3.6	6.6	5.5	10.2	2.1	8.4	-2.7	22.5	1.2	20.2
	4	2.9	13.2	6.4	14.1	12.6	16.6	3.2	7.7	-3.3	29.7	1.6	25.5
	5	4.3	15.3	9.8	17.5	21.0	20.3	3.8	8.8	-5.0	28.1	-1.4	20.1
	6	4.3	15.4	12.1	21.3	24.4	26.2	3.0	10.5	-7.7	24.2	-2.5	20.3
	7	3.5	13.7	9.1	14.6	22.2	23.1	0.8	6.7	-7.0	23.1	-1.9	23.3
	8	4.3	14.4	9.8	17.0	27.4	34.1	2.4	9.8	-7.0	20.5	-3.9	21.3
	9	2.6	12.5	6.7	12.8	17.5	21.1						
	10	1.1	11.6	4.1	7.9	13.2	19.2						
Salty	1	4.0	6.0	1.5	1.9	3.5	5.1	4.2	8.0	3.5	6.4	8.3	15.8
	2	9.7	9.9	12.3	16.7	7.2	13.7	4.1	8.8	3.5	4.7	10.0	23.8
	3	12.7	18.9	16.8	22.7	15.7	22.3	4.5	10.1	7.3	24.5	0.9	18.3
	4	11.0	21.2	19.2	27.7	13.6	18.8	-1.4	11.2	-2.1	12.5	0.4	20.8
	5	6.0	13.9	15.1	25.3	14.5	17.0	-1.8	10.6	-1.8	11.7	0.8	25.1
	6	4.1	13.9	11.5	18.4	10.7	14.4	-3.1	10.0	-2.9	11.2	0.1	27.4
	7	1.8	11.5	9.9	16.0	11.3	17.3	-4.1	10.1	-2.0	10.5	-2.2	22.5
	8	1.1	10.4	8.7	12.8	13.6	19.6	-3.2	11.5	-0.3	11.3	-4.8	17.6
	9	1.7	11.8	9.9	13.5	13.6	21.1						
	10	0.5	9.4	9.9	12.2	16.4	33.2						
Sour	1	3.1	4.1	2.0	3.6	2.8	5.8	1.0	10.4	-0.8	7.4	0.0	3.7
	2	12.3	12.1	4.1	4.3	6.0	9.4	-3.2	15.0	-3.4	9.0	-0.2	8.0
	3	11.3	13.6	4.0	7.0	7.4	12.4	-4.6	15.3	-3.7	10.4	-1.0	15.0
	4	9.8	12.9	8.4	13.1	8.5	12.3	-5.7	12.8	-3.1	15.2	1.4	24.2
	5	3.9	7.8	7.8	8.8	9.6	13.3	-5.4	14.2	-6.4	23.6	3.0	25.2
	6	3.4	8.7	10.0	13.2	8.8	12.8	-6.0	14.3	-4.6	35.1	1.1	19.3
	7	4.8	10.7	7.1	8.1	10.7	16.7	-6.5	13.2	-4.3	30.0	-1.1	17.8
	8	5.5	10.2	7.6	9.0	7.8	19.9	-6.5	14.6	-8.1	26.7	-2.8	16.5
	9	2.9	8.0	10.1	12.3	5.9	15.3						
	10	3.5	8.1	13.9	27.3	6.8	13.7						
Sweet	1	1.5	3.9	0.0	2.6	1.6	1.6	0.0	3.8	1.2	3.7	-1.9	5.6
	2	3.6	7.1	2.2	5.6	0.7	3.2	-1.1	5.3	2.3	5.9	-5.5	14.9

Table C49 Continued.

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Tastes	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sweet	3	5.4	13.9	1.2	6.8	-0.4	5.3	-2.0	7.2	2.0	5.4	-5.8	14.9
	4	1.6	14.3	1.5	7.2	-1.1	5.0	-3.2	8.5	0.6	6.8	-6.1	15.1
	5	-0.1	12.3	3.7	11.9	-1.4	5.3	-4.1	8.8	0.3	6.1	-6.1	15.7
	6	0.5	13.3	3.1	11.1	-1.2	4.9	-5.3	9.4	0.4	6.8	-6.4	15.8
	7	0.4	12.6	2.5	10.2	-2.1	5.2	-6.2	10.6	2.3	8.2	-6.2	15.1
	8	-0.7	10.4	3.1	12.2	-2.1	4.9	-6.1	10.8	0.8	12.9	-6.3	15.1
	9	-1.6	9.9	3.0	11.9	-1.9	5.0						
	10	-2.6	8.6	2.9	11.8	-1.9	5.1						
Umami	1	1.1	2.2	1.3	2.8	0.7	2.2	3.2	10.5	0.5	3.0	1.7	4.5
	2	4.7	7.6	1.4	4.4	0.6	3.8	2.9	17.6	1.9	7.5	1.7	12.8
	3	6.8	15.0	5.3	10.3	1.2	6.8	0.3	17.3	4.3	11.1	-3.6	19.3
	4	4.9	15.0	3.1	6.2	2.8	6.9	3.1	12.5	2.1	5.8	-7.7	30.8
	5	0.8	10.5	0.3	4.1	7.4	22.7	-0.8	13.5	1.4	6.0	-8.0	32.0
	6	2.4	16.0	2.5	8.7	4.2	12.3	-2.3	12.2	1.6	7.1	-7.6	31.3
	7	2.0	13.8	5.7	18.0	2.0	4.1	-0.8	6.8	1.8	8.4	-6.5	29.5
	8	2.7	10.9	6.5	15.6	1.7	5.6	0.3	7.7	4.1	13.0	-7.3	31.3
	9	3.6	11.3	6.4	14.9	1.3	5.8						
	10	2.9	10.7	8.1	14.6	2.0	7.0						

Table C50 Levator activity (mV) during **spontaneous facial reactions** in response to the **tastes** over the first 5 seconds before swallowing and over the first 4 seconds after swallowing (Mean ± *SD*) in healthy controls (*n* = 11, before swallowing; *n* = 12, after swallowing), Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	2.7	5.4	2.0	4.2	3.0	4.9	1.5	3.3	0.6	6.5	-0.7	10.4
	2	3.4	7.1	4.1	8.4	5.5	17.0	0.7	5.4	-0.6	9.1	2.6	13.4
	3	-15.0	17.3	-4.0	17.6	-15.4	29.1	0.1	4.8	-0.6	11.1	-3.1	15.6
	4	-21.4	13.7	-9.0	15.2	-26.7	23.5	-0.9	3.1	-3.1	8.1	-1.5	17.8
	5	-25.2	10.7	-9.4	18.7	-28.0	24.3	-1.7	3.1	-2.5	11.6	-4.3	15.4
	6	-27.0	10.7	-13.8	14.7	-29.2	24.0	-2.0	1.9	-2.2	13.0	-2.5	14.0
	7	-25.6	11.5	-12.7	16.2	-30.1	25.5	-2.1	1.8	-4.7	8.6	-2.6	12.6
	8	-27.9	11.6	-10.9	19.7	-29.7	27.2	0.1	7.6	-3.2	7.9	-4.3	15.8
	9	-27.0	10.9	-11.1	18.6	-29.7	27.6						
	10	-26.5	10.9	-13.4	15.5	-30.2	29.0						
Bitter	1	1.3	6.5	5.0	7.4	7.3	8.4	2.2	5.5	-2.6	11.6	-2.2	8.2
	2	2.1	8.7	7.6	16.9	1.0	20.1	2.4	6.8	-0.9	15.8	1.3	15.3
	3	-12.6	12.9	-1.9	14.0	-19.9	25.0	1.3	6.6	-0.2	25.1	4.3	17.0
	4	-20.5	13.2	-8.6	12.2	-21.2	25.0	2.7	9.7	6.7	39.3	8.3	21.5
	5	-24.4	15.9	-9.9	14.4	-19.1	29.7	5.2	15.3	5.7	39.1	9.6	21.5
	6	-23.4	18.4	-9.1	17.8	-8.9	39.2	4.1	12.8	-1.0	25.5	11.2	18.8
	7	-22.8	18.0	-9.6	16.4	-5.1	38.8	1.8	10.2	-0.9	20.6	4.7	19.4

Table C50 Continued.

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Bitter	8	-24.2	16.3	-8.9	15.3	-10.3	31.6	1.6	12.9	-2.9	22.3	3.2	19.3
	9	-24.7	17.6	-10.1	8.2	-12.2	33.1						
	10	-25.1	17.1	-8.0	9.2	-18.6	28.0						
Salty	1	3.2	5.6	2.1	6.0	3.1	9.8	-0.6	9.2	3.8	12.1	0.2	10.6
	2	11.1	15.3	6.3	28.0	2.2	24.9	6.2	9.5	3.8	7.5	0.1	17.2
	3	0.3	19.0	0.1	31.3	-16.4	28.8	5.0	11.2	7.0	18.0	3.0	24.8
	4	-5.1	26.2	-6.7	24.5	-22.7	34.5	12.7	25.9	6.5	15.7	5.3	27.2
	5	-6.5	25.2	-12.4	24.8	-26.5	40.4	7.7	22.3	6.9	14.3	10.8	28.3
	6	-6.2	30.2	-11.4	23.5	-25.0	38.5	3.4	18.0	1.9	13.5	10.5	29.0
	7	-8.6	23.3	-12.6	31.3	-25.9	34.9	-0.8	17.3	-5.2	8.0	13.9	29.5
	8	-8.6	25.0	-11.0	29.4	-26.2	36.0	-5.3	14.9	-1.9	8.9	11.5	27.2
	9	-12.3	18.4	-14.1	30.5	-35.3	32.8						
	10	-16.8	18.3	-13.7	32.9	-29.2	40.1						
Sour	1	4.4	11.0	6.2	9.2	5.2	9.9	2.0	4.3	-2.8	14.0	7.6	16.8
	2	6.1	10.7	7.7	17.6	4.4	16.4	4.4	12.1	-4.8	32.5	7.1	24.2
	3	-4.4	15.4	3.8	24.1	-13.4	25.2	1.5	14.4	-3.4	30.3	9.9	22.9
	4	-5.4	22.0	-3.1	17.6	-21.1	33.5	1.4	12.4	-8.1	28.2	3.3	25.6
	5	-6.7	20.1	-2.9	17.7	-21.4	28.0	5.8	15.3	-10.8	37.5	-2.6	24.8
	6	-9.0	19.0	-2.6	19.9	-14.5	26.0	1.9	15.2	-14.9	33.9	-1.1	24.6
	7	-13.1	17.4	-6.8	18.9	-17.7	26.6	-2.4	10.1	-15.5	37.0	1.2	27.1
	8	-12.5	16.7	-11.0	16.1	-27.5	30.1	-3.0	9.3	-14.6	38.8	14.5	33.8
	9	-13.1	15.2	-9.2	12.8	-24.9	25.5						
	10	-15.5	14.7	-7.9	19.7	-24.3	30.0						
Sweet	1	0.8	5.3	1.8	5.7	4.7	12.1	0.8	6.9	0.0	8.3	2.6	7.0
	2	-0.7	14.9	1.6	18.8	-2.3	16.9	4.5	11.8	0.5	11.7	4.4	12.8
	3	-7.2	13.7	-2.2	18.8	-21.0	27.3	6.5	16.4	5.0	22.1	4.3	8.1
	4	-16.2	17.9	-4.4	15.0	-25.1	28.3	12.5	26.5	6.3	21.6	2.0	6.7
	5	-22.9	16.1	-7.1	11.2	-29.6	26.4	4.7	11.8	2.1	17.5	2.2	11.3
	6	-24.3	17.2	-8.1	11.8	-30.0	26.1	0.4	7.3	-2.9	17.4	3.0	11.5
	7	-25.8	15.8	-9.3	9.9	-31.3	23.4	-0.2	8.4	0.5	16.6	5.2	11.8
	8	-28.4	16.0	-10.1	14.4	-33.1	20.6	0.8	11.3	-3.1	16.8	0.8	6.0
	9	-27.1	17.8	-8.6	13.6	-29.6	28.8						
	10	-26.7	20.8	-9.1	15.5	-30.0	31.1						
Umami	1	1.6	6.0	2.4	8.3	3.0	10.5	5.9	6.9	0.6	8.3	-1.8	8.0
	2	1.8	10.2	3.0	15.0	-7.1	22.0	4.7	8.2	5.6	14.5	-2.2	15.0
	3	-11.4	16.1	-2.7	22.1	-32.2	26.6	1.7	7.4	5.6	16.4	-3.0	21.0
	4	-17.2	15.5	-11.9	22.2	-34.8	29.8	1.2	6.0	2.6	8.4	-6.9	12.8
	5	-19.2	15.7	-13.7	19.0	-33.3	30.4	1.3	6.9	-0.6	13.2	-5.9	11.1
	6	-22.4	15.2	-14.9	17.5	-35.1	30.7	2.4	9.3	-0.4	12.8	-8.8	17.0
	7	-22.3	14.1	-13.5	16.4	-33.1	32.3	3.9	11.4	1.2	10.6	-9.6	17.3
	8	-21.2	14.4	-12.5	13.4	-33.9	33.8	4.4	16.7	2.8	10.3	-9.3	16.0
	9	-21.5	14.7	-11.7	15.4	-37.6	33.7						
	10	-23.0	15.8	-10.0	18.0	-38.6	32.7						

Table C51 Zygomaticus activity (mV) during **spontaneous facial reactions** in response to the **tastes** over the first 5 seconds before swallowing and over the first 4 seconds after swallowing (Mean ± *SD*) in healthy controls (*n* = 11, before swallowing; *n* = 12, after swallowing), Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	1.2	0.8	0.7	0.9	2.0	3.4	-1.0	1.7	0.7	2.2	-0.8	2.1
	2	3.8	3.5	3.6	5.0	3.7	3.2	-1.2	2.1	0.2	3.1	0.2	2.8
	3	1.2	2.8	1.6	3.5	1.9	5.7	-1.6	2.4	0.0	2.3	-1.3	2.5
	4	0.3	3.8	0.0	3.2	-0.7	2.6	-2.3	2.4	-0.5	1.6	-0.6	3.9
	5	-1.2	2.2	-0.6	3.2	-1.4	2.4	-2.3	2.5	-0.9	1.8	-1.5	2.6
	6	-1.4	2.3	-1.6	1.7	-1.7	2.1	-2.3	2.6	-0.8	1.8	-0.9	2.9
	7	-0.4	3.9	-0.6	2.5	-2.2	2.2	-2.4	2.5	-0.8	2.1	-0.9	2.3
	8	-1.2	3.4	-0.7	4.4	-2.0	2.5	-1.9	3.2	-0.6	2.4	-1.5	2.7
	9	-1.2	3.8	-0.3	4.1	-1.8	3.0						
	10	-1.1	3.1	-1.0	2.5	-2.3	2.6						
Bitter	1	0.4	0.5	1.1	2.9	1.3	1.2	-2.2	4.1	-0.9	3.0	-0.4	2.3
	2	2.4	3.0	3.3	4.2	3.9	3.9	-2.4	4.0	0.8	6.2	0.2	3.7
	3	0.4	2.3	-0.2	3.0	0.3	3.5	-1.1	2.5	1.7	7.3	1.9	5.2
	4	-0.7	2.8	-2.2	3.2	0.3	4.7	-1.1	2.5	3.7	18.4	3.0	5.8
	5	-2.0	2.7	-2.2	3.6	0.2	6.1	-2.0	3.8	3.0	15.3	3.6	7.1
	6	-1.9	3.6	-1.7	4.5	1.6	7.2	-1.8	4.3	2.1	13.5	3.6	7.1
	7	-1.0	3.8	-1.3	6.0	1.7	5.4	-3.4	5.3	0.5	8.1	1.6	5.2
	8	-1.2	4.2	-1.7	4.5	1.8	5.5	-3.1	6.9	0.3	7.8	1.0	5.2
	9	-2.4	3.3	-2.5	3.1	1.7	5.9						
	10	-2.1	3.4	-2.4	2.8	0.5	4.9						
Salty	1	1.1	2.2	1.8	2.0	1.0	1.7	-2.1	2.4	-0.2	3.4	-1.8	7.3
	2	4.2	5.2	5.2	5.9	4.1	4.3	-0.7	4.4	1.8	8.4	-0.8	10.5
	3	6.2	8.8	2.6	5.0	3.0	7.1	1.3	10.2	2.2	7.0	1.4	16.4
	4	3.5	9.3	0.4	3.3	1.5	5.5	2.1	8.3	2.3	8.3	0.5	14.1
	5	4.0	9.0	-0.8	2.0	0.1	5.8	-0.4	4.5	2.3	9.0	-1.5	11.4
	6	3.4	8.4	-0.1	3.2	0.2	5.7	-2.5	4.9	1.5	9.7	-0.3	12.3
	7	2.5	7.5	0.1	4.3	0.1	5.0	-2.0	4.6	-2.0	5.9	0.1	10.6
	8	2.5	7.6	-0.2	4.5	-0.1	5.7	-2.7	3.9	0.1	7.1	-1.0	10.4
	9	1.4	6.6	0.9	7.6	-1.1	4.5						
	10	0.4	5.8	-1.1	4.6	-0.1	6.6						
Sour	1	1.1	2.0	1.4	1.7	2.2	2.2	-1.1	3.1	0.5	3.9	0.4	4.4
	2	3.6	2.6	4.3	4.9	4.2	4.3	1.0	4.6	0.1	7.2	1.4	7.0
	3	1.2	3.2	2.9	6.4	1.9	5.0	-1.4	3.5	3.3	5.9	2.9	8.1
	4	1.1	3.9	0.7	5.9	0.8	4.8	-0.8	3.9	1.6	3.2	2.3	7.1
	5	2.8	4.8	0.2	5.6	0.3	3.8	-0.5	4.9	-0.5	8.5	0.1	7.2
	6	3.1	6.8	0.9	6.2	0.4	3.6	-1.1	4.1	-0.9	7.2	-0.7	6.2
	7	1.7	5.0	-0.6	4.5	0.3	4.2	-2.1	4.2	-1.4	6.5	-0.4	7.0
	8	1.2	4.4	-1.7	3.5	-0.9	3.5	-1.2	3.6	-1.4	6.9	3.3	9.1
	9	1.2	3.8	-0.3	4.3	-1.1	2.9						
	10	0.0	3.8	0.7	6.3	-0.3	4.9						
Sweet	1	0.6	0.6	0.9	1.2	1.7	2.8	-2.9	4.4	-0.5	2.0	-0.1	2.0
	2	1.9	2.4	2.0	3.3	2.3	3.1	-1.1	6.0	0.4	2.4	-1.8	9.4

Table C51 Continued.

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sweet	3	3.3	5.0	1.5	3.8	0.1	3.7	-1.2	6.2	0.9	4.5	-2.2	9.3
	4	1.7	5.7	0.7	4.1	0.6	7.2	-0.8	6.4	1.0	5.5	-2.3	9.4
	5	0.6	4.6	-0.9	1.7	-1.4	4.7	-1.9	4.8	1.2	3.6	-2.8	10.7
	6	1.1	8.1	0.3	4.0	-1.2	6.3	-1.4	2.3	0.6	6.3	-2.5	10.8
	7	1.4	6.1	-0.6	2.8	-0.6	5.7	-2.3	4.5	-0.4	3.2	-1.8	8.2
	8	-0.6	4.5	-1.2	2.1	-2.5	3.3	-2.5	5.6	-1.2	2.3	-2.9	8.9
	9	0.4	5.3	-0.8	2.6	-1.4	6.2						
	10	-0.2	5.1	-0.6	2.6	-0.9	6.3						
Umami	1	0.9	0.8	0.6	1.3	1.8	2.1	-0.1	3.4	-0.8	1.6	-1.4	1.7
	2	3.4	4.1	3.1	4.8	4.5	3.3	-0.1	3.8	3.1	7.2	-1.6	4.9
	3	2.5	3.3	1.8	5.1	0.6	4.7	-0.6	5.9	1.0	3.6	-0.1	5.9
	4	1.9	4.8	-1.5	4.3	-1.2	3.2	-0.7	5.3	-1.1	2.2	-2.1	3.6
	5	1.4	5.6	-2.1	4.5	-1.7	2.3	-0.7	4.3	-0.7	4.6	-2.1	4.3
	6	1.4	6.3	-2.0	4.6	-1.6	2.7	-1.5	3.1	0.2	4.5	-3.8	5.8
	7	1.1	4.0	-1.6	4.3	-1.0	4.2	-1.1	4.6	-0.4	2.7	-3.9	5.5
	8	0.9	3.7	-1.6	4.3	-1.6	3.4	-0.8	6.2	-0.1	3.8	-3.6	4.7
	9	0.2	2.4	-0.9	4.5	-1.5	4.2						
	10	-0.2	2.6	-0.5	5.7	-2.1	3.1						

Table C52 Corrugator activity (mV) during **suppressed facial reactions** in response to the **tastes** over the first 5 seconds before swallowing and over the first 4 seconds after swallowing (Mean ± *SD*) in healthy controls (*n* = 12), patients with Bulimia (*n* = 11), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	0.4	2.6	1.3	2.8	0.1	1.1	0.2	0.9	1.1	1.6	0.1	1.3
	2	1.4	4.8	1.1	3.3	0.4	3.6	0.5	1.0	1.3	1.8	0.2	1.3
	3	-0.9	4.0	-0.2	3.2	-0.7	4.2	0.6	1.2	1.5	2.0	-0.2	1.5
	4	-1.2	4.3	-0.9	3.7	-0.7	3.8	0.4	1.4	2.0	2.8	-0.2	2.0
	5	-1.5	4.7	-1.0	3.2	-1.2	3.7	0.3	1.5	1.6	2.5	-0.6	2.0
	6	-1.6	5.0	-0.9	3.7	-1.6	3.7	0.3	1.5	1.4	2.2	-0.6	1.6
	7	-1.8	5.2	-1.3	3.8	-1.6	3.5	0.1	1.4	1.6	2.3	-0.7	1.5
	8	-2.0	5.3	-1.6	3.6	-1.7	3.6	0.1	1.2	1.5	2.1	-0.9	1.6
	9	-2.3	5.0	-1.7	4.1	-1.7	3.5						
	10	-2.3	4.9	-1.2	3.7	-2.1	3.5						
Bitter	1	1.4	2.2	-3.2	13.5	1.5	3.9	1.0	2.4	-2.0	6.0	-1.7	10.1
	2	2.2	4.4	-3.2	17.8	1.3	3.9	0.9	2.4	-1.6	6.1	-1.2	13.6
	3	2.6	4.5	-2.3	19.1	0.1	3.2	0.6	2.2	0.0	1.3	-1.6	12.8
	4	2.8	5.2	-2.2	19.3	0.2	3.4	-0.8	5.1	1.0	3.5	-1.7	12.3
	5	2.2	6.5	-1.3	18.9	-0.3	3.3	-1.9	6.8	-0.9	6.0	-2.6	13.2
	6	1.0	6.8	-2.6	17.9	0.2	3.3	-1.9	7.0	-0.8	8.9	-2.6	13.4
	7	0.7	5.8	-2.9	18.0	0.6	3.5	-1.5	6.5	-2.3	11.0	-3.8	12.6

Table C52 Continued.

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Bitter	8	0.7	5.0	-3.0	17.4	0.7	4.2	-0.4	6.1	-2.2	7.7	-3.0	13.2
	9	0.3	5.2	-2.9	18.0	0.5	3.5						
	10	0.2	4.9	-2.8	18.6	0.0	3.5						
Salty	1	2.3	3.4	3.1	5.5	2.2	2.5	0.8	4.9	0.8	1.4	-0.1	3.2
	2	3.5	5.1	4.4	9.9	1.9	2.5	1.1	6.2	0.4	2.5	-0.8	6.0
	3	1.8	4.9	2.2	4.7	1.7	4.4	0.4	5.3	0.0	2.6	-0.1	6.5
	4	1.1	4.8	1.2	3.4	1.1	3.5	-0.5	5.8	-0.1	1.9	-1.2	6.3
	5	-0.3	3.8	1.2	3.7	0.5	2.8	-1.7	5.4	-0.9	2.3	-0.9	5.7
	6	-0.3	4.5	0.4	3.3	1.3	4.4	-2.2	5.1	-0.7	3.0	-1.7	6.2
	7	-0.4	4.6	0.0	2.8	1.3	4.4	-2.0	4.9	0.0	2.0	-2.1	6.4
	8	-0.3	4.4	-0.3	2.5	0.5	3.7	-2.3	4.4	-0.4	2.2	-2.6	8.2
	9	-0.4	3.9	1.6	6.4	0.0	3.9						
	10	-0.8	3.8	0.1	3.1	0.0	3.1						
Sour	1	-0.2	2.8	3.7	5.6	0.5	3.0	0.6	2.2	-0.9	1.9	-1.0	3.4
	2	0.7	5.2	7.3	14.4	0.7	4.5	0.2	1.6	-2.1	3.0	-1.2	5.0
	3	-0.4	6.3	5.1	9.2	0.1	4.8	-0.5	2.4	-2.7	4.8	-2.0	6.0
	4	-2.1	6.3	5.7	9.1	0.1	5.9	-0.9	3.2	-2.2	3.4	-2.5	6.7
	5	-1.6	7.3	4.6	7.5	-0.7	6.3	-1.3	3.3	-2.7	3.4	-2.7	6.6
	6	-1.3	7.3	4.3	7.5	-0.5	6.4	-2.2	3.3	-2.4	3.5	-3.1	7.0
	7	-1.3	7.2	3.5	6.7	-1.2	5.8	-1.4	2.6	-3.3	4.4	-2.8	6.5
	8	-1.7	6.9	2.2	5.8	-1.9	5.2	-2.2	3.0	-3.5	5.0	-3.2	7.2
	9	-2.7	6.5	1.3	5.0	-2.2	5.1						
	10	-2.7	6.8	1.4	4.8	-1.7	5.0						
Sweet	1	0.8	2.0	1.5	1.6	-1.3	8.1	-0.9	4.6	0.0	1.0	-2.5	7.0
	2	0.7	5.3	2.0	4.5	-2.4	8.4	-0.8	4.9	0.1	2.3	-3.5	10.5
	3	-0.7	4.9	0.0	2.9	-3.4	8.0	-0.5	4.8	-0.5	1.7	-3.5	11.6
	4	-2.0	5.4	-0.5	3.1	-3.6	8.3	-1.3	5.3	-0.5	1.8	-4.0	11.8
	5	-2.0	5.6	-0.4	2.7	-3.7	8.3	-1.4	5.0	-0.8	2.4	-3.8	11.7
	6	-2.4	5.5	-0.5	2.2	-3.6	8.2	-1.8	4.8	-0.9	2.5	-4.1	11.4
	7	-2.9	5.1	-0.3	2.8	-4.1	8.0	-2.2	6.1	-0.3	2.3	-3.4	11.2
	8	-3.2	5.0	-0.5	2.5	-4.0	8.1	-2.1	5.7	0.0	1.2	-4.2	11.6
	9	-2.9	5.4	0.0	2.8	-4.0	8.1						
	10	-3.0	5.2	0.2	2.9	-4.1	8.1						
Umami	1	0.8	2.6	1.1	1.1	0.3	2.8	1.1	3.6	-0.2	1.2	-0.2	5.2
	2	2.2	4.5	2.9	4.4	1.5	5.0	2.1	6.9	0.2	2.0	1.1	10.4
	3	1.1	5.0	3.8	6.7	1.1	6.7	2.1	5.1	0.7	2.1	-0.5	7.6
	4	1.1	7.2	2.7	3.9	0.1	4.8	0.3	3.3	1.5	5.0	-1.4	7.0
	5	0.6	7.8	2.1	4.2	0.3	4.1	0.4	2.5	2.9	9.4	-1.7	7.2
	6	0.3	7.5	2.3	4.9	0.7	4.5	-0.7	2.1	1.9	6.9	-2.0	7.2
	7	-0.1	8.1	1.6	4.2	0.8	6.0	-1.2	2.6	0.1	4.6	-1.9	7.2
	8	0.0	8.4	1.5	3.8	0.1	4.4	-1.8	2.8	-0.2	5.3	-2.3	7.2
	9	-0.9	7.9	1.4	3.6	-0.2	4.6						
	10	-0.7	7.7	1.0	2.9	0.0	4.8						

Table C53 Levator activity during **suppressed facial reactions** in response to the **tastes** over the first 5 seconds before swallowing and over the first 4 seconds after swallowing (Mean ± *SD*) in healthy controls (*n* = 12), patients with Bulimia (*n* = 11), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	-1.4	8.0	2.9	7.4	2.0	10.3	2.8	5.7	-0.1	8.0	-2.8	8.6
	2	-1.3	11.4	5.8	11.2	-5.1	27.6	7.3	17.9	1.7	6.6	4.8	19.6
	3	-12.8	14.1	-6.6	11.1	-28.8	30.6	4.8	14.8	3.4	8.9	-1.8	14.6
	4	-24.2	13.0	-9.6	11.3	-32.8	27.3	3.2	10.6	-1.5	5.4	-3.4	12.8
	5	-25.9	14.1	-11.4	9.5	-41.2	34.8	3.5	7.9	-0.6	9.8	-4.9	11.6
	6	-25.1	13.5	-10.6	11.5	-42.0	34.0	3.7	8.4	-0.6	12.4	-3.3	15.1
	7	-24.8	12.7	-12.7	12.7	-40.6	36.0	3.3	8.3	-3.3	5.9	-6.5	11.5
	8	-25.9	14.3	-9.3	11.6	-38.5	39.4	-0.3	2.7	-3.1	5.8	-7.6	9.9
	9	-25.3	13.7	-12.6	10.7	-41.1	38.7						
	10	-23.6	17.6	-12.6	10.8	-43.1	36.3						
Bitter	1	-3.5	7.4	0.7	7.2	3.5	6.6	2.6	7.3	-0.1	3.0	-2.3	8.2
	2	-7.4	15.9	3.6	22.1	-3.3	18.5	4.8	14.4	-0.1	7.1	-2.9	9.4
	3	-16.1	19.1	-10.1	16.8	-30.2	22.9	6.4	15.3	1.1	9.2	-3.1	10.7
	4	-23.0	20.0	-14.8	16.0	-32.6	25.8	4.5	14.7	2.2	6.9	-1.6	11.0
	5	-26.9	20.4	-13.9	17.5	-40.3	26.1	1.3	10.8	-1.9	5.3	-3.7	10.6
	6	-31.5	21.7	-11.4	21.7	-37.6	24.0	-0.2	8.8	-0.2	7.4	-4.0	8.5
	7	-30.9	21.0	-14.0	19.3	-35.0	25.2	-0.2	9.8	-1.4	6.5	-4.6	8.3
	8	-32.0	20.2	-17.7	17.5	-37.0	26.9	0.3	9.0	-3.4	7.0	-4.0	8.3
	9	-30.2	19.0	-16.4	20.5	-34.0	30.3						
	10	-30.2	20.7	-17.6	20.6	-39.1	27.3						
Salty	1	-0.2	6.8	7.0	9.3	6.0	7.2	-0.8	2.6	-0.9	3.8	-0.6	7.9
	2	2.4	19.7	3.4	13.1	-2.5	15.8	0.3	7.0	-3.0	9.4	-4.2	12.3
	3	-16.5	22.4	-3.5	10.0	-18.5	23.7	1.8	9.4	0.7	7.8	-4.7	14.6
	4	-23.8	16.7	-6.8	13.3	-35.3	29.0	2.3	13.4	-2.5	7.3	-6.8	11.9
	5	-24.6	16.9	-7.3	17.2	-36.4	29.4	-0.7	13.7	-1.3	18.3	-2.0	14.3
	6	-25.5	19.6	-12.0	14.2	-35.0	27.9	-2.8	9.9	-3.3	9.0	-5.7	9.3
	7	-24.2	23.8	-13.4	10.6	-34.5	27.5	-3.4	9.9	-1.0	14.0	-3.6	9.5
	8	-25.2	21.4	-11.7	12.9	-36.9	29.5	-4.9	9.9	-1.4	14.7	-4.3	12.7
	9	-22.5	25.9	-14.1	11.1	-34.3	27.4						
	10	-22.2	29.4	-13.0	12.1	-33.2	26.9						
Sour	1	-1.5	10.0	7.4	9.8	0.3	14.1	1.7	8.6	-0.4	2.0	2.7	14.4
	2	-2.9	12.4	8.2	19.0	-7.9	28.3	1.4	11.6	10.1	19.6	4.3	24.1
	3	-14.4	17.6	-1.1	14.1	-18.5	40.9	1.4	12.1	3.3	8.2	5.5	19.4
	4	-23.6	17.6	-6.0	16.1	-31.9	37.4	1.0	9.8	-1.2	5.2	-0.5	12.8
	5	-25.9	15.8	-3.8	19.5	-43.4	38.5	-1.4	8.2	1.4	9.1	0.7	15.5
	6	-26.8	15.4	-7.1	18.7	-46.8	34.4	-0.5	8.2	-0.1	6.8	0.4	11.5
	7	-27.8	15.9	-4.8	18.4	-47.5	30.1	-1.3	8.0	-3.3	6.0	5.1	27.5
	8	-27.6	15.8	-8.7	14.4	-47.4	31.9	-2.1	7.8	3.3	11.3	2.4	18.2
	9	-26.4	16.9	-9.6	10.5	-45.3	31.7						
	10	-25.1	16.5	-8.1	13.9	-40.2	30.8						
Sweet	1	-0.7	8.2	4.0	6.9	-0.4	13.3	-1.1	3.5	5.0	8.8	-2.0	7.8
	2	-1.3	10.7	5.9	17.3	-11.5	33.5	0.1	4.5	12.3	21.8	-3.4	13.0

Table C53 Continued.

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sweet	3	-15.3	17.8	-0.3	16.8	-36.4	38.3	1.5	10.2	7.3	15.1	5.7	14.8
	4	-21.4	19.4	-10.4	11.0	-42.0	34.9	-1.8	6.2	2.1	5.7	1.8	18.2
	5	-22.8	18.9	-13.8	9.5	-40.8	28.3	-2.4	6.7	2.8	4.2	-3.1	15.2
	6	-28.5	18.5	-14.7	12.8	-40.0	32.2	-2.7	6.0	3.2	6.0	-7.0	13.5
	7	-29.2	18.0	-10.7	23.0	-42.9	32.8	-1.4	6.6	2.6	7.4	-6.3	16.0
	8	-28.8	17.5	-10.2	18.8	-42.7	33.9	-0.4	7.2	2.0	10.2	-6.6	14.5
	9	-27.2	17.6	-11.1	19.9	-43.3	38.1						
	10	-27.4	16.8	-10.1	15.5	-46.0	38.1						
Umami	1	2.3	4.3	4.6	6.0	2.1	9.1	2.3	10.1	0.8	2.8	-2.8	11.2
	2	2.1	12.6	8.1	18.7	-7.8	20.6	3.0	13.7	3.0	5.4	0.0	8.4
	3	-15.8	13.5	-1.8	14.6	-29.9	27.1	4.0	15.5	3.2	5.8	-1.4	10.0
	4	-23.1	14.7	-7.6	12.0	-38.3	28.4	3.0	15.0	3.7	8.8	-5.4	16.2
	5	-26.6	13.6	-8.3	14.4	-40.6	30.4	1.8	9.9	6.7	14.7	-5.7	14.4
	6	-27.2	11.6	-8.3	15.3	-43.7	28.6	-1.2	6.4	7.8	21.7	-5.3	12.1
	7	-27.2	12.9	-4.5	25.3	-42.7	30.1	-1.8	5.2	2.9	11.9	-6.4	15.7
	8	-25.0	12.9	-8.2	22.0	-48.5	29.4	-2.5	4.5	2.1	9.9	-4.5	13.4
	9	-24.2	12.1	-10.5	16.2	-47.0	29.0						
	10	-26.1	13.7	-11.2	14.6	-46.8	28.6						

Table C54 Zygomaticus activity during **suppressed facial reactions** in response to the **tastes** over the first 5 seconds before swallowing and over the first 4 seconds after swallowing (Mean ± *SD*) in healthy controls (*n* = 12), patients with Bulimia (*n* = 11), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Water	1	0.7	1.2	0.8	1.0	1.6	2.5	0.1	2.3	0.1	2.1	-1.8	2.3
	2	2.6	2.4	2.9	3.7	2.4	1.6	0.6	4.3	0.0	2.3	-0.8	5.2
	3	2.2	4.5	-0.7	2.7	-0.2	2.9	0.0	4.2	0.1	2.6	-1.5	5.3
	4	-0.8	1.1	-1.6	2.9	-1.0	2.2	-0.9	2.4	-1.2	1.7	-2.0	5.1
	5	-1.5	1.9	-2.1	2.6	-1.6	3.6	-0.9	2.2	-1.0	2.2	-1.8	5.5
	6	-1.3	3.8	-2.2	2.5	-2.0	3.7	-1.3	2.9	-0.3	5.3	-1.9	6.2
	7	-1.3	3.2	-2.1	2.7	-2.3	2.9	-1.0	3.1	-1.0	2.7	-2.3	5.8
	8	-1.4	2.7	-1.6	3.4	-2.0	3.7	-1.2	1.9	-1.0	1.7	-3.4	4.4
	9	-2.2	3.6	-1.8	2.5	-1.9	4.8						
	10	-1.8	4.0	-2.6	2.3	-2.1	2.5						
Bitter	1	0.5	0.8	0.2	1.2	1.2	2.1	0.2	4.2	-0.7	1.7	-3.9	7.4
	2	1.5	3.2	2.0	3.2	2.9	3.6	0.4	3.4	-0.7	2.4	-4.1	8.6
	3	-0.5	5.0	-1.9	2.5	-0.8	2.6	1.2	4.3	-0.5	2.5	-4.7	7.6
	4	-0.9	3.6	-2.6	3.8	-1.1	5.0	1.6	4.3	0.0	3.3	-4.3	8.7
	5	-2.0	2.2	-3.0	2.5	-2.6	2.6	0.6	3.1	-0.8	2.3	-5.0	8.6
	6	-2.5	3.1	-2.6	4.3	-2.4	1.7	0.0	3.1	-1.0	2.0	-4.8	8.3
	7	-1.5	2.4	-2.6	3.3	-2.2	2.0	0.5	3.7	-0.5	2.5	-4.8	8.5

Table C54 Continued.

		Before swallowing						After swallowing					
		C		BN		ADHD		C		BN		ADHD	
Taste	time	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Bitter	8	-2.4	2.7	-3.4	2.9	-1.7	3.8	0.4	3.9	-0.7	2.3	-0.7	16.5
	9	-2.4	4.2	-2.0	6.5	-1.0	4.6						
	10	-2.3	5.4	-2.8	4.0	-2.6	2.4						
Salty	1	0.9	1.6	1.5	1.9	1.5	2.4	-1.3	1.6	-0.2	2.3	-1.5	3.4
	2	5.0	5.3	2.5	2.8	2.9	3.4	0.6	4.9	0.5	4.9	-0.5	7.0
	3	2.3	6.0	0.3	3.8	0.4	3.5	1.1	3.7	0.5	2.8	0.5	8.4
	4	0.0	3.2	0.6	4.8	-2.4	4.3	0.9	4.7	0.0	2.5	-2.1	5.2
	5	0.5	4.3	-1.0	3.1	-2.6	4.4	0.4	5.2	0.5	5.7	-2.4	4.0
	6	0.7	6.0	-1.9	3.7	-2.5	4.0	0.8	6.2	-0.4	3.8	-2.6	3.7
	7	1.5	7.9	-1.4	4.0	-2.9	3.7	-0.4	5.0	-0.5	2.6	-2.6	3.6
	8	1.1	6.8	-2.1	2.0	-2.9	4.2	-0.5	4.0	0.4	4.1	-1.1	4.0
	9	1.1	5.7	-2.1	2.0	-2.7	3.7						
	10	1.2	6.3	-2.2	1.8	-2.4	3.8						
Sour	1	0.3	2.1	0.8	1.8	1.0	1.6	-1.3	2.8	-0.7	1.9	-0.7	2.7
	2	2.5	3.5	3.7	4.2	4.1	4.6	-0.2	3.3	1.8	7.1	0.6	4.8
	3	2.2	3.3	1.2	3.3	1.5	4.9	-0.1	4.3	1.0	4.1	1.7	4.4
	4	0.0	4.3	-0.6	3.5	-0.9	5.1	-0.8	4.0	-1.4	2.3	-0.8	2.4
	5	-0.6	3.2	-1.1	3.0	-2.9	4.6	-1.6	3.3	-1.5	3.5	0.5	5.7
	6	-2.4	2.6	-1.9	2.2	-2.9	4.5	-0.9	2.5	-1.8	3.3	-0.8	2.9
	7	-2.0	2.1	-1.8	2.8	-2.8	3.5	-1.6	3.0	-2.4	3.6	0.3	6.2
	8	-1.6	3.8	-1.7	3.1	-2.9	3.7	-1.4	4.0	-1.0	5.0	0.7	5.6
	9	-1.1	3.6	-1.9	2.9	-2.1	4.7						
	10	-1.5	3.8	-1.5	2.2	-0.7	6.1						
Sweet	1	-0.1	2.2	1.1	1.4	0.7	1.9	-0.6	2.5	0.9	3.1	-4.1	8.4
	2	2.2	2.9	2.9	3.8	1.5	4.8	-0.5	2.0	3.8	6.8	-4.6	10.0
	3	1.4	4.0	0.7	1.9	-0.5	5.7	1.6	4.3	1.1	4.0	-2.9	7.7
	4	-0.8	2.6	-1.6	2.6	-2.1	4.4	0.2	2.8	0.2	2.8	-2.3	6.7
	5	-0.9	3.5	-2.4	2.2	-2.9	3.2	-0.6	1.9	0.6	3.3	-2.6	4.0
	6	-2.8	4.4	-2.8	2.2	-2.9	3.4	0.4	3.4	1.2	4.2	-3.7	5.5
	7	-2.4	4.1	-2.1	4.5	-3.2	3.6	0.2	2.5	0.2	3.0	-4.6	10.3
	8	-3.0	3.2	-1.4	4.3	-3.0	3.7	0.6	3.5	-0.2	2.3	-3.7	11.3
	9	-1.9	4.9	-1.7	5.0	-2.7	4.8						
	10	-1.9	3.8	-1.6	4.6	-3.5	3.3						
Umami	1	0.9	.9	1.7	2.7	1.5	1.5	0.4	1.8	-0.7	2.3	-1.2	2.8
	2	3.9	3.3	3.0	4.7	4.1	3.7	-0.5	2.7	0.0	4.4	0.3	4.0
	3	1.5	3.9	-0.1	2.3	-0.1	5.5	0.2	4.4	0.6	3.9	0.4	3.8
	4	0.6	5.1	-1.5	2.0	-1.5	4.5	0.2	5.1	0.1	3.8	-0.4	4.2
	5	-1.4	3.5	-0.8	3.3	-2.0	4.3	-0.6	4.1	0.6	6.6	-1.7	3.8
	6	-1.3	3.3	-0.9	3.7	-2.5	3.2	-1.3	3.9	0.8	6.9	-1.3	3.7
	7	-0.8	4.3	-0.3	5.1	-1.7	5.4	-1.3	2.9	-0.3	5.2	-2.0	3.3
	8	0.1	5.5	-1.1	3.7	-3.7	2.6	-2.0	2.7	-0.4	5.2	-0.6	4.9
	9	0.7	7.1	-1.6	2.4	-3.4	2.7						
	10	-1.3	2.3	-2.0	2.2	-3.3	2.4						

Table C55 Corrugator activity (mV) during spontaneous and suppressed facial reactions in response to different odors, i.e. banana, cinnamon, fish, and garlic over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 12), patients with Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Spontaneous						Suppressed					
		C		BN		ADHD		C		BN		ADHD	
Odors	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Banana	1	0.7	1.0	-0.2	1.4	0.0	1.0	0.1	0.3	0.1	0.6	0.0	0.7
	2	0.5	1.1	0.0	1.9	-0.2	1.4	0.3	0.8	0.5	0.5	-0.1	1.0
	3	0.2	1.5	0.0	1.7	-0.2	1.3	0.2	1.0	1.0	1.3	-0.2	1.1
	4	1.1	4.5	2.2	7.6	-0.2	1.5	0.4	0.9	1.0	1.7	-0.1	1.3
	5	0.1	1.5	1.0	2.9	0.3	1.9	0.4	0.6	1.1	1.3	0.2	1.3
	6	-0.1	1.2	1.3	4.6	-0.3	2.0	0.5	0.8	1.0	1.5	0.0	1.3
	7	0.9	4.3	1.5	4.4	-0.3	2.0	1.1	1.6	0.9	1.7	-0.1	1.1
	8	1.1	5.1	1.8	4.5	-0.3	2.1	0.7	1.0	1.0	1.5	-0.1	1.2
Cinnamon	1	1.1	2.5	0.2	1.5	0.0	0.9	-0.1	0.5	0.1	0.8	-0.1	0.9
	2	4.7	13.8	1.0	2.7	-0.4	0.7	0.0	0.7	0.2	0.8	-0.2	0.8
	3	2.7	7.4	1.8	2.9	-0.4	1.2	0.3	0.8	0.6	1.4	0.8	3.1
	4	1.8	5.4	2.5	6.2	-0.2	1.8	0.4	1.2	0.4	1.2	0.1	0.8
	5	1.7	5.4	2.5	6.6	-0.5	1.5	0.2	0.8	0.5	1.2	0.2	1.2
	6	1.5	4.0	2.1	5.6	-0.5	1.7	0.3	0.8	0.5	2.0	0.2	1.2
	7	1.7	4.0	3.0	7.1	-0.4	1.7	0.3	0.8	0.8	2.4	0.3	1.1
	8	1.1	2.6	0.9	2.3	1.8	8.7	0.2	0.9	0.8	1.7	0.2	1.0
Fish	1	2.3	3.2	0.4	1.1	-0.1	0.8	0.0	0.6	0.1	0.9	0.0	0.9
	2	11.7	15.1	2.5	4.7	7.0	15.8	0.4	0.8	1.5	3.1	0.7	1.6
	3	8.5	11.3	6.3	14.3	10.7	24.2	0.4	0.8	0.8	1.7	0.3	1.5
	4	3.5	5.8	7.1	14.3	3.8	8.4	0.4	0.9	0.9	2.1	0.2	1.2
	5	3.2	5.3	6.0	11.5	0.6	3.0	0.3	0.8	1.1	2.2	0.4	1.4
	6	3.5	7.2	5.3	8.9	0.6	2.3	0.3	0.8	1.3	2.1	0.2	1.3
	7	3.9	7.7	4.2	6.2	0.7	2.2	0.3	0.9	1.0	1.9	0.1	1.4
	8	3.2	7.0	3.0	4.2	0.9	2.1	0.7	0.9	0.9	1.7	0.1	1.5
Garlic	1	3.2	7.4	0.4	0.9	2.9	7.6	0.1	0.4	0.0	0.8	0.6	0.7
	2	9.5	14.7	5.5	9.7	9.0	25.6	0.6	0.9	0.7	1.7	1.0	2.7
	3	7.3	11.9	8.7	17.7	8.4	20.7	0.7	0.6	1.0	1.5	1.1	2.1
	4	6.5	8.5	5.3	10.1	6.7	16.2	0.8	0.8	0.6	1.1	1.6	2.9
	5	5.4	7.3	3.2	5.6	2.4	2.9	0.9	0.8	0.7	1.3	1.7	3.4
	6	3.3	5.2	3.8	8.2	2.7	3.7	1.0	1.0	0.8	1.5	2.0	3.2
	7	3.5	5.6	4.0	8.5	5.0	10.6	0.9	0.8	0.9	1.7	1.9	3.5
	8	4.5	7.1	2.5	6.3	7.8	19.8	0.7	0.7	1.3	2.3	1.7	3.7

Table C56 Levator activity (mV) during spontaneous and suppressed facial reactions in response to different odors, i.e. banana, cinnamon, fish, and garlic over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 12), patients with Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Spontaneous						Suppressed					
		C		BN		ADHD		C		BN		ADHD	
Odors	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Banana	1	-0.6	1.1	0.0	3.3	-0.8	1.2	-0.4	0.8	0.2	0.7	-0.3	0.6
	2	-0.6	1.7	-0.3	3.0	-0.9	1.6	-0.1	1.0	0.1	0.8	-0.3	0.5
	3	-0.3	1.1	-0.1	2.4	-0.6	1.7	0.0	0.8	0.2	0.8	-0.5	1.0
	4	-0.4	1.1	0.2	3.0	-0.4	1.9	-0.2	1.2	0.3	1.1	-0.5	1.1
	5	-0.3	1.1	0.5	3.1	-0.2	1.6	-0.3	1.9	0.2	0.7	-0.6	1.2
	6	-0.3	1.1	-0.4	3.2	-0.2	1.8	-0.4	2.1	0.2	0.7	-0.4	1.4
	7	-0.4	1.4	-1.0	3.9	-0.3	1.5	-0.8	2.2	0.3	1.0	-0.7	1.4
	8	-0.2	1.1	-1.1	3.7	0.7	2.7	-0.6	1.9	0.4	1.0	-0.5	1.6
Cinnamon	1	-0.1	0.5	0.4	1.1	0.4	1.2	0.0	0.5	-0.4	1.0	-0.3	1.0
	2	-0.3	1.1	0.0	1.0	-0.3	1.6	0.3	1.2	-0.3	1.2	-0.5	1.9
	3	-0.2	0.6	0.1	1.4	-0.5	1.9	0.1	1.0	-0.3	1.5	-0.2	2.5
	4	-0.2	1.3	2.1	5.5	-0.6	2.0	0.1	0.9	-0.2	1.8	-0.1	2.6
	5	-0.3	1.6	1.4	4.2	-0.3	2.3	-0.1	0.6	-0.4	1.6	0.5	3.4
	6	-0.4	1.0	0.0	2.1	-0.3	2.2	-0.1	0.7	-0.4	1.5	0.2	3.3
	7	-0.4	1.2	1.1	4.2	0.0	2.3	-0.1	0.8	-0.4	1.4	0.0	3.1
	8	-0.4	1.2	1.3	3.9	-0.2	2.4	0.0	1.2	-0.2	1.5	1.5	7.0
Fish	1	0.0	1.1	0.3	1.1	-0.3	1.2	-0.1	0.7	-0.3	0.4	-0.5	0.9
	2	3.9	6.8	0.7	1.4	1.0	2.9	-0.2	1.2	0.5	1.6	-0.3	2.0
	3	7.4	13.8	0.8	1.6	1.5	4.8	0.0	1.2	0.1	0.9	-0.4	2.3
	4	14.4	33.7	1.3	2.5	1.8	4.6	-0.2	1.3	0.2	1.0	-0.6	1.9
	5	19.6	52.2	2.5	5.1	1.0	2.4	0.3	2.5	0.6	2.1	-0.9	1.7
	6	19.6	55.5	1.3	2.4	1.3	3.3	-0.2	1.4	0.0	1.1	-1.0	1.8
	7	17.5	53.1	1.9	3.8	1.3	3.5	-0.2	1.7	0.2	1.0	-0.8	2.1
	8	16.8	50.4	2.2	4.5	0.4	2.3	-0.1	1.5	0.3	1.0	-0.7	2.4
Garlic	1	0.1	1.4	0.9	2.9	0.6	1.9	-0.5	1.3	-0.2	0.7	-0.2	1.5
	2	2.5	5.2	1.0	2.6	2.9	9.9	-0.3	2.2	0.0	1.3	-0.2	1.7
	3	4.0	9.5	0.7	2.4	1.7	6.9	-0.5	2.5	-0.1	1.5	0.2	1.9
	4	5.8	12.8	0.4	2.4	2.5	9.4	-0.7	2.2	0.1	1.7	0.7	2.3
	5	6.1	14.5	-0.2	2.0	2.5	10.0	-0.8	2.6	-0.1	1.6	0.4	2.1
	6	6.2	16.9	0.4	2.2	2.9	10.5	-0.4	2.4	0.6	2.5	0.5	2.2
	7	8.4	24.5	1.1	3.8	2.1	8.0	-0.6	2.4	0.6	2.7	0.8	2.6
	8	9.6	28.8	2.8	7.7	1.8	6.5	-0.8	2.3	0.3	2.0	0.6	2.4

Table C57 Zygomaticus activity (mV) during spontaneous and suppressed facial reactions in response to different odors, i.e. banana, cinnamon, fish, and garlic, over the first 4 seconds, i.e. 8 periods (Mean ± *SD*), in healthy controls (*n* = 12), patients with Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

		Spontaneous						Suppressed					
		C		BN		ADHD		C		BN		ADHD	
Odors	period	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Banana	1	-0.4	1.3	0.1	0.7	-0.1	1.0	0.2	0.7	0.0	0.1	-0.2	0.4
	2	-0.2	2.1	0.1	0.7	-0.1	1.2	0.1	0.3	0.2	0.8	0.0	0.8
	3	-0.2	2.1	0.5	1.1	0.1	1.6	0.0	0.3	0.5	1.2	-0.4	0.8
	4	-0.4	1.6	0.3	0.6	0.0	1.3	0.0	0.3	0.3	0.9	-0.5	1.2
	5	-0.5	1.7	0.2	0.5	0.0	1.1	-0.4	1.3	0.1	0.4	-0.6	1.6
	6	-0.6	1.7	0.0	0.5	0.0	0.9	-0.3	1.0	0.0	0.2	-0.6	1.5
	7	-0.6	1.8	0.0	0.4	0.2	1.2	-0.2	0.6	0.1	0.3	-0.6	1.4
	8	-0.6	1.8	-0.2	0.8	0.4	1.9	0.0	0.3	0.0	0.3	-0.6	1.4
Cinnamon	1	0.0	0.1	0.1	0.3	0.0	0.8	0.0	0.3	0.0	0.2	-0.1	0.3
	2	0.0	0.2	-0.1	0.1	0.0	0.6	0.0	0.3	0.1	0.3	-0.2	0.5
	3	-0.1	0.3	-0.1	0.3	0.1	0.5	0.1	0.2	0.1	0.4	-0.2	0.5
	4	-0.1	0.3	0.7	1.3	0.0	0.4	-0.2	0.8	0.3	0.8	0.4	1.6
	5	-0.1	0.3	0.3	0.8	0.0	0.4	0.0	0.3	0.3	0.8	1.8	6.3
	6	-0.1	0.3	0.2	0.5	0.1	0.3	-0.1	0.2	0.5	1.3	1.9	6.6
	7	-0.1	0.3	0.3	1.1	0.1	0.5	0.2	0.8	0.3	1.0	1.8	6.3
	8	-0.1	0.3	0.1	0.8	0.1	0.6	-0.4	1.0	0.2	0.7	1.1	3.9
Fish	1	0.2	0.5	0.1	0.2	-0.3	2.4	-0.3	1.2	0.0	0.1	0.1	0.5
	2	1.6	2.1	0.1	0.4	-0.2	2.5	0.1	0.4	0.1	0.4	1.1	3.9
	3	3.2	5.6	0.8	2.5	-0.2	2.5	-0.2	1.1	0.1	0.3	1.8	6.4
	4	4.8	10.4	0.6	1.9	-0.3	2.4	-0.3	1.3	0.1	0.4	1.2	4.3
	5	6.3	17.1	1.0	2.6	-0.2	2.5	-0.3	1.4	0.9	3.1	0.7	2.9
	6	6.5	17.9	0.7	2.4	-0.4	2.4	-0.3	1.5	0.1	0.5	0.3	1.3
	7	5.3	15.0	0.8	2.8	0.7	4.3	-0.4	2.0	0.3	1.0	-0.3	0.8
	8	4.5	11.9	1.0	3.4	0.1	3.0	-0.1	0.7	0.1	0.6	-0.2	0.5
Garlic	1	0.2	0.3	0.4	1.3	0.2	1.0	-0.2	0.7	0.0	0.3	0.6	2.3
	2	1.5	2.9	1.1	2.2	-0.2	0.8	-0.1	0.6	0.3	1.8	0.2	0.8
	3	1.3	3.0	1.1	2.9	-0.1	1.1	-0.3	0.8	0.3	1.8	1.2	4.0
	4	1.6	3.2	0.3	1.2	0.9	3.3	-0.2	0.6	0.3	1.6	1.7	5.0
	5	1.4	3.2	0.1	0.8	0.9	3.6	-0.2	0.6	0.2	1.3	1.6	5.0
	6	1.9	5.2	0.3	0.8	0.7	2.7	-0.1	0.6	1.5	3.7	1.5	4.6
	7	2.6	7.5	0.3	0.7	0.8	2.9	-0.6	1.6	1.2	3.2	1.4	4.2
	8	2.7	8.5	0.5	1.1	0.8	2.6	-0.5	1.5	0.5	1.6	1.0	2.7

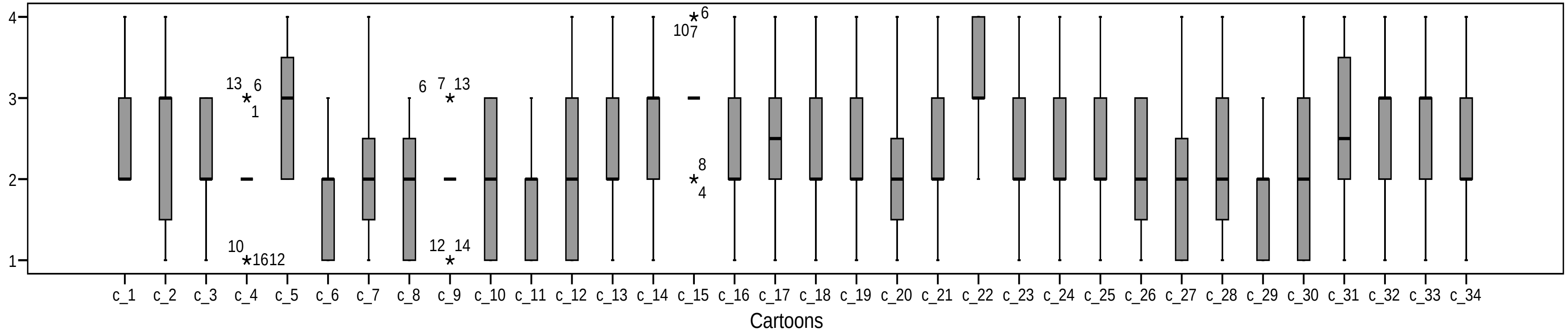
Table C58 Funniness rating of 34 cartoons in the pre-study and in study 3.

Cartoon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
M	2.5	2.5	2.3	2.0	2.8	1.8	2.1	1.9	2.1	2.1	1.8	2.3	2.5	2.6	3.1	2.4	2.5
SD	0.6	1.0	0.6	0.6	0.8	0.7	1.0	0.8	0.6	0.9	0.7	1.1	0.8	0.8	0.6	1.0	0.9

Cartoon	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
M	2.3	2.3	2.1	2.2	3.2	2.3	2.3	2.4	2.1	1.9	2.3	1.7	2.0	2.6	2.8	2.8	2.4
SD	1.0	0.8	0.9	0.8	0.8	1.0	0.9	1.0	0.8	0.9	1.1	0.7	1.0	1.0	0.8	0.8	0.7

Cartoon	marriage		isle		plant		kangaroo		beaver		fish fingers	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Controls	2.1	0.9	2.7	0.9	2.1	0.9	2.3	0.9	2.2	0.7	2.8	1.1
Bulimics	2.1	0.8	1.8	0.8	2.2	0.7	2.1	0.8	2.1	1.0	2.4	0.5
ADHD	1.8	0.6	2.4	1.0	2.4	0.8	2.3	1.1	2.2	1.0	2.5	0.9

Table C59 Box Plots of the funniness rating of 34 cartoons in the pre-study.



1- very funny, 4 - not funny

Table C60 Correlations (Pearson) between specific facial reactions (smiling, AU 6 + 12, and negative reactions) and funniness rating of each cartoon in the total sample (N = 36).

Cartoon	Smiling (AU 6 + 12)	Negative reactions
marriage	.30 (.077) (*)	-.47 (.003)**
isle	.48 (.003)**	-.17 (.315)
plant	.13 (.464)	-.35 (.037)*
kangaroo	.44 (.007)**	-.24 (.155)
beaver	.62 (.000)***	-.41 (.014)*
fish fingers	.57 (.000)***	-.18 (.298)

(*) $p \leq .10$, * $p < .05$, ** $p < .01$, *** $p \leq .001$.

Table C61 Correlations (Pearson) between specific spontaneous and suppressed facial reactions (smiling, AU 6 + 12, and negative reactions) and funniness rating of each cartoon.

Cartoon	Smiling (AU 6 + 12)		Negative reactions	
	spontaneous n = 18	suppressed n = 18	spontaneous n = 18	suppressed n = 18
marriage	.07 (.790)	.44 (.065)	-.37 (.136)	-.54 (.021)*
isle	.40 (.100)	.39 (.107)	-.50 (.035)*	.03 (.908)
plant	.38 (.124)	.19 (.444)	-.25 (.326)	-.39 (.106)
kangaroo	.62 (.006)**	.43 (.074)(*)	-.53 (.025)*	.08 (.759)
beaver	.73 (.001)***	.52 (.028)*	-.73 (.001)***	-.03 (.903)
fish fingers	.57 (.013)*	.61 (.007)**	-.35 (.160)	.05 (.838)

(*) $p \leq .10$, * $p < .05$, ** $p < .01$, *** $p \leq .001$.

Table C62 SIAB-S subscales for the present and past state (Mean ± *SD*) in healthy controls (*n* = 12), patients with Bulimia (*n* = 12), and Attention-Deficit Hyperactivity Disorder (*n* = 12).

	Controls (*n* = 12)			Bulimia Nervosa (*n* = 12)			ADHD (*n* = 12)		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
SIAB-S present									
1. General Psychopathology and Social Integration	11	0.4	0.4	12	1.0	0.4	12	0.5	0.4
2. Bulimic Symptoms	11	0.1	0.1	12	2.4	0.8	12	0.5	0.8
3. Body Image and Slimness Ideal	11	0.8	0.3	12	1.9	0.7	12	0.9	0.4
4. Sexuality and Body Weight	12	0.4	0.4	12	0.8	0.8	12	0.3	0.4
5. Methods to counteract Weight Gain. Substance Abuse. Fasting	11	0.1	0.1	12	0.3	0.3	12	0.2	0.2
6. Atypical Binges	11	0.3	0.4	12	1.2	0.4	12	0.7	0.9
Total Score	12	0.3	0.2	12	1.2	0.4	12	0.5	0.3
SIAB-S past									
1. Bulimic Symptoms	11	0.7	1.1	12	3.1	0.6	12	0.5	0.8
2. General Psychopathology	11	0.9	0.8	12	2.1	0.7	12	1.2	0.8
3. Slimness Ideal	11	1.5	1.0	12	3.0	0.6	12	1.4	0.8
4. Sexuality and Social Integration	11	1.2	0.8	12	2.0	1.0	12	1.1	0.8
5. Body Image	11	0.5	0.4	12	1.5	0.9	12	0.3	0.3
6. Methods to counteract Weight Gain. Substance Abuse. Fasting. Autoaggression	11	0.3	0.2	12	0.6	0.4	12	0.4	0.3
7. Atypical Binges	11	0.7	0.6	12	1.4	0.7	12	0.9	0.9
Total Score	11	0.8	0.6	12	2.0	0.5	12	0.8	0.4

Table C63 Comparisons across groups of the SIAB-S present state.

Present state	General Psychopathology and Social Integration	Bulimic Symptoms	Body Image and Slimness Ideal	Sexuality and Body Weight	Methods to counteract Weight Gain. Substance Abuse. Fasting	Atypical Binges	Total Score
C vs. BN	BN > C***	BN > C***	BN > C***	*ns*	BN > C*	BN > C***	BN > C***
C vs. ADHD	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
BN vs. ADHD	BN > ADHD*	BN > ADHD***	BN > ADHD***	*ns*	*ns*	*ns*	BN > ADHD***

***$p \leq .001$, *$p < .05$, Cronbach`s alpha (.87, .41, .68, .31, 61, .04).

Table C64 Comparisons across groups of the SIAB-S past state.

Past state	Bulimic Symptoms	General Psychopathology	Slimness Ideal	Sexuality and Social Integration	Body Image	Methods to counteract Weight Gain. Substance Abuse. Fasting. Autoaggression	Atypical Binges	Total Score
C vs. BN	BN > C***	BN > C*	BN > C***	*ns*	BN > C*	BN > C*	*ns*	BN > C***
C vs. ADHD	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
BN vs. ADHD	BN > ADHD***	BN > ADHD*	BN > ADHD***	*ns*	BN > ADHD*	*ns*	*ns*	BN > ADHD***

***$p \leq .001$, *$p < .05$,Cronbach`s alpha (.69, .91, .91, .76, .29, .68, -.39).

Table C65 Results of the debriefing questionnaire.

		Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)		Total sample (*N* = 36)	
		n	%	*n*	%	*n*	%	*n*	%
Did you know/guess that I was watching you during the experiment?	No	4	33.3	4	33.3	7	58.3	15	41.7
	Yes	8	66.7	8	66.7	5	41.7	21	58.3
Did this knowledge have an influence on your behavior?	No	7	58.3	6	50.0	5	41.7	18	50.0
	Yes	1	8.3	2	16.7	0	0.0	3	8.3
Did this knowledge have an influence on your facial expressions?	No	5	41.7	7	58.3	5	41.7	17	47.2
	Yes	3	25.0	1	8.3	0	0.0	4	11.1
Did your facial expressivity increase or decrease?	Increase	2	16.7	0	0.0	0	0.0	2	5.6
	Decrease	1	8.3	1	8.3	0	0.0	2	5.6

Table C66 Identification rates of the taste quality of the taste strips in total and in % in healthy controls, patients with Bulimia, and Attention-Deficit Hyperactivity Disorder.

		Controls (*n* = 12)		Bulimia Nervosa (*n* = 12)		ADHD (*n* = 12)	
	Strip number	*n*	%	*n*	%	*n*	%
sweet	A1	12	100.0	12	100.0	12	100.0
	A2	12	100.0	12	100.0	12	100.0
	A3	12	100.0	10	83.3	9	75.0
	A4	5	41.7	4	33.3	6	50.0
sour	B1	12	100.0	12	100.0	11	91.7
	B2	9	75.0	11	91.7	9	75.0
	B3	8	66.7	4	33.3	4	33.3
	B4	2	16.7	0	0.0	1	8.3
salty	C1	12	100.0	12	100.0	11	91.7
	C2	10	83.3	8	66.7	12	100.0
	C3	9	75.0	10	83.3	9	75.0
	C4	5	41.7	5	41.7	5	41.7
bitter	D1	12	100.0	11	91.7	12	100.0
	D2	12	100.0	12	100.0	9	75.0
	D3	9	75.0	8	66.7	9	75.0
	D4	3	25.0	2	16.7	2	16.7

C2 (salty): BN < ADHD, p =.032.

Table C67 Subscales (Mean ± *SD*) of the ADHS-SR questionnaire in healthy controls (*n* = 10) and patients with Bulimia (*n* = 11).

Item	Item number	Controls (*n* = 10) *M*	*SD*	Bulimics (*n* = 11) *M*	*SD*
Inattention					
unattentive to details	1	1.0	0.9	1.3	0.9
unconcentrated	2	1.0	1.1	1.1	0.9
not listening in conversations	3	0.8	0.6	0.7	0.7
problems to perform tasks at work	4	0.2	0.4	0.4	0.5
problems with organization	5	0.5	0.5	1.0	1.0
avoid mentally demanding tasks	6	0.5	0.5	0.8	1.0
loss of things	7	0.9	1.0	0.8	0.8
easily distracted	8	1.3	1.2	1.7	0.8
forget meetings and recalls	9	0.5	1.0	0.4	0.5
Overactivity	10				
fidgety		0.5	1.0	0.8	0.4
problems to sit for longer periods	11	0.3	0.7	1.0	0.9
feeling restless	12	0.6	0.8	1.5	0.5
being loudly	13	0.2	0.6	0.1	0.3
always on the move	14	0.5	0.7	0.8	0.9
Impulsitivity					
interrupt somebody during speech	15	0.8	0.8	0.8	0.6
impatience	16	0.7	0.7	1.2	0.8
interrupt somebody during activities	17	0.3	0.5	0.5	0.5
talk a lot	18	0.3	0.7	0.3	0.5

Table C68

	Controls						Bulimia Nervosa							ADHD						
	spontaneous			suppressed			spontaneous				suppressed			spontaneous				suppressed		
	Order			Order			Order				Order			Order				Order		
Ss	Taste	Odor	Cartoons	Taste	Odor	Cartoons	Ss	Taste	Odor	Cartoons	Taste	Odor	Cartoons	Ss	Taste	Odor	Cartoons	Taste	Odor	Cartoons
1	1	2	A1	2	3	R10	**29**	1	2	A1	2	3	R10	**26**	1	2	A1	2	3	R10
3	2	1	A2	3	4	R60	**28**	2	1	A2	3	4	R60	**16**	2	1	A2	3	4	R60
4	3	3	R4	4	*2*	A20	**30**	3	3	R4	4	*2*	A20	**15**	3	3	R4	4	2	A20
5	4	4	R3	1	1	A50	**17**	4	4	R3	1	1	A50	**31**	4	4	R3	1	1	A50
6	1	3	R6	3	4	A30	**34**	1	3	**R2**	3	4	**A10**	**40**	1	3	**R5**	3	4	**A20**
9	4	1	A6	2	*2*	R20	**35**	4	1	A6	2	*2*	R20	**21**	4	1	A6	2	*2*	R20
11	4	2	R1	3	1	A60	**36**	4	2	R1	3	1	A60	**22**	4	2	R1	3	1	A60
13	3	1	R5	2	4	A40	**38**	3	1	R5	2	4	A40	**24**	3	1	R5	2	4	A40
14	2	4	A4	1	1	R50	**39**	2	4	A4	1	1	R50	**25**	2	4	A4	1	1	R50
27	3	2	A5	1	3	R30	**37**	3	2	A5	1	3	R30	**23**	3	2	A5	1	3	R30
41	2	3	R2	2	2	A10	**32**	2	3	**R6**	2	2	**A30**	**20**	2	3	R2	2	2	A10
42	1	4	A3	4	3	R40	**33**	1	4	A3	4	3	R40	**19**	1	4	A3	4	3	R40

Cartoons: **Order A (A1-A6):** 1 marriage, 2 isle**,** 3 plant **Order R (R1-R6):** 1 beaver**,** 2 fish fingers**,** 3 kangaroo

Variation: 6 different order within spontaneous and suppressed part

1	1	2	2	3	3
2	3	1	3	1	2
3	2	3	1	2	1

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Affidavit
(*Eidesstattliche Erklärung*)

I hereby declare that my thesis entitled "Facial Reactions in Response to Gustatory and Olfactory Stimuli in Healthy Adults, Patients with Eating Disorders, and Patients with Attention-Deficit Hyperactivity Disorder" is the result of my own work.
I did not receive any help or support from commercial consultants.
All sources and/or materials applied are listed and specified in the thesis.

Furthermore, I verify that this thesis has not yet been submitted as part of another examination process neither in identical nor in similar form.

Mainz, 14.04.2010