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EXTENDED ESSAY

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**Changes in Gustatory Performance. The Effects of Smoking on
Sensing the Five Primary Taste Qualities and Water**

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MAKUAISITIN TOIMINNAN MUUTOKSET. TUPAKAN VAIKUTUS VIIDEN PERUSMAUN JA VEDEN TUNNISTAMISEEN

Tutkimuksen tavoitteena oli selvittää ja testata tupakoinnin vaikutusta makuaistiin. Tutkimus keskittyi erityisesti osoittamaan yhteyden nuorten epäterveellisten elämäntapojen ja makuaistin heikentymisen välillä. Henkilökohtaisena pontimena tutkimukselle oli havainto, että tupakoinnin vaikutusta makuaistiin ei ole laajemmin tutkittu sekä se, että aiheesta ei yleisesti keskustella.

Tutkimuksen empiirinen osa muodostui testisarjoista, jotka toteutettiin 17 – 19 -vuotiaille nuorille. Tutkittavat nuoret jaettiin kahteen ryhmään sen perusteella, tupakoivatko he: toisessa ryhmässä oli nuoria, jotka olivat tupakoineet pitkäkestoisesti tai vaihtelevan mittaisia kausia, toisen ryhmän nuoret eivät olleet tupakoineet. Testisarja muodostui lukuisista makutesteistä, joilla tutkittiin testattavien kykyä tunnistaa viittä perusmakua: hapanta, karvasta, suolaista, makeaa ja umamia sekä kuudentena näytteenä vettä.

Tutkimuksen tuloksena havaittiin, että tupakoivien nuorten kyky tunnistaa perusmakuja on heikompi kuin vertailuryhmän. Tutkimuksen perusteella voidaan myös päätellä, että tupakointi vaikuttaa erityisesti tiettyjen makujen tunnistamiseen; tupakoivilla nuorilla oli vaikeuksia tunnistaa hapanta, karvasta sekä suolaista, kun taas vertailuryhmällä ei ollut vaikeuksia tunnistaa näitä perusmakuja.

Tehdyn tutkimuksen merkittävyyttä kasvattaa osoitus siitä, että lyhytaikainenkin tupakointi voi vaikuttaa makuaistiin. Keskustelua tästä aiheesta tulisi lisätä erityisesti sen vuoksi, että se on yksi tupakoinnin haittoja, jotka vaikuttavat tupakoitsijaan nopeasti. Makujen herkkä tunnistaminen on olennainen elämänlaatua lisäävä tekijä, erityisesti tärkeässä kehitysvaiheessa oleville nuorille.

CHANGES IN GUSTATORY PERFORMANCE. THE EFFECTS OF SMOKING ON SENSING THE FIVE PRIMARY TASTE QUALITIES AND WATER

The purpose of this research was to investigate and test how the gustatory performance is influenced by smoking cigarettes. The objective was to focus on young people's gustatory functioning and the potential damage that may be caused by unhealthy life style. The basis for the study was the observation that the effects of tobacco consumption on gustation have not been generally discussed and therefore became a topic of personal interest.

An empirical series of tests were carried out among 17 to 19-year-old adolescents. The examinees were divided into two groups according to their smoking status: one group was composed of smokers and the other group of non-smokers. The tests consisted of recognition experiment of the five primary taste qualities, i.e. sour, bitter, sweet, salty and umami, in addition to water.

As a result of this investigation smoking adolescents' ability of to recognize different primary taste qualities seems to be reduced in comparison with the non-smoking adolescents. It could be pointed out that according to the results the variation in gustatory performance between the two groups was taste-specific; it is obvious that the sensitivity of smokers to identify sour, bitter and salty tastes was impaired compared to non-smokers who, in most of the cases, did not show any difficulties in recognizing these tastes.

The study was important because it provided an interesting aspect on how the functioning of the sense of taste can easily be impaired by smoking cigarettes already in the early stages of tobacco consumption. Discussion on this topic should be encouraged among adolescents because the sense of taste is obviously an imperative constituent of quality of life that is especially important for young people.

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1. Introduction

Cigarette is one of the deadliest industrial products that can be found in the worldwide markets and it is obvious that nowadays it would not gain access to the open markets as a new product. It has been estimated that smoking annually causes nearly five million deaths in the world (Vierola 2004) and that if the present trend will continue, by 2030 it will result in 10 million deaths per year. Globally altogether 47 % of men and 12 % of women smoke (Murray CJL, Lopez AD 1996). That means a total of 1.2 billion smokers in the world 800 million of which live in the developing countries (The World Bank, 1999). While the topic is well studied and its dangers rightly realized, it remains to a great extent actual, since the consumption of tobacco is increasing especially in adolescents.

As recently as in 1996 over 60 % of Chinese people thought that smoking has few or no harmful effects on health (Vierola 2004). Yet, the ideas and conceptions of smoking cigarettes have started to change during the past decades. The previous assumptions that tobacco is a sign of power and intelligence and that it is unrelated to health problems have gradually been replaced by information from recent studies. Active education on the damaging effects of tobacco has succeeded in affecting general attitudes towards smoking. The number of smokers in developed countries has decreased due to effective campaigning against tobacco, whereas in the developing world their number is still increasing (WHO, 1997).

Besides its many unpleasant consequences, such as bad smell, prematurely ageing skin and yellow teeth, smoking is the primary cause of a great number of diseases. It causes a wide range of different cancers, cardiovascular diseases, lung diseases, cerebral thrombosis (Huovinen 2004) and gustation and olfaction disorders (Vierola 2004).

Disorders related to gustation have a significant effect on the process of flavour perception and may therefore have a negative impact on an individual's health and food preferences. In this research I attempt thus to determine whether the assumption of smoking being an impairing factor for the sense of taste can be shown to be valid. So, the research question of this essay is: **How does smoking cigarettes affect the recognition of the five primary taste qualities and water?** The hypothesis of this research is that gustatory performance is impaired by smoking cigarettes.

Initially, the aim of this investigation was to perform a research on how olfaction affects the sense of taste and what other significant factors decrease the sensitivity for tasting. Yet, the relation between olfaction and gustation seemed to be too complicated to be investigated and was therefore omitted from the study. Other possibilities for topic appeared to be numerous including the effect of age, sex and smoking. Since I had had various discussions with one of my acquaintances concerning her experience of impaired gustation probably due to her smoking habits, I decided to concentrate on the effects of smoking on the gustatory performance, which seemed to be very significant and highly actual as a health hazard.

2. Literature Review

2.1 Smoking

Tobacco is classified as a substance that stimulates and relaxes the central nervous system (Wallinheimo 2004). It has an overall negative impact on the human body causing several diseases ranging from decreased physical performance to various highly dangerous cancers. WHO (1997) has characterized tobacco as one of the most significant health hazards in the world.

2.1.1 Health Hazards Related to Smoking

Cigarettes are constituted of about 4000 substances many of which cause very dangerous diseases. The most common toxic substances are nicotine, tar and carbon monoxide, which increase the chance of getting cardiovascular diseases, respiratory diseases and cancers. Every third cancer disease and cardiovascular disease is caused by smoking. (Vierola 2004)

The nicotine in cigarettes also results in physical and mental dependency (Cigarettes and Other Nicotine Products, 2005). During smoking the nicotine moves immediately to the blood circulation system after which it takes seven seconds for it to reach the brain. This leads to a dependency similar to cocaine and heroin.

2.2 Chemical Senses and Smoking

2.2.1 Chemical Senses

Whether an organism is able to survive in the nature depends on its ability to adapt itself into the changes that constantly take place in its surroundings. Even the most primitive unicellular organisms have this capability of collecting essential information for the changes in their own activities. Multicellular organisms have specific sense organs to control the environmental signals and to respond to the stimuli in an appropriate way. Humans have five basic senses, namely vision, touch, hearing, olfaction and gustation. The organs responsible for these senses to function are eyes,

skin, ears, nose and mouth respectfully. All the senses are divided into subcategories according to the stimulus they respond to¹. (Hiltunen et al. 2003)

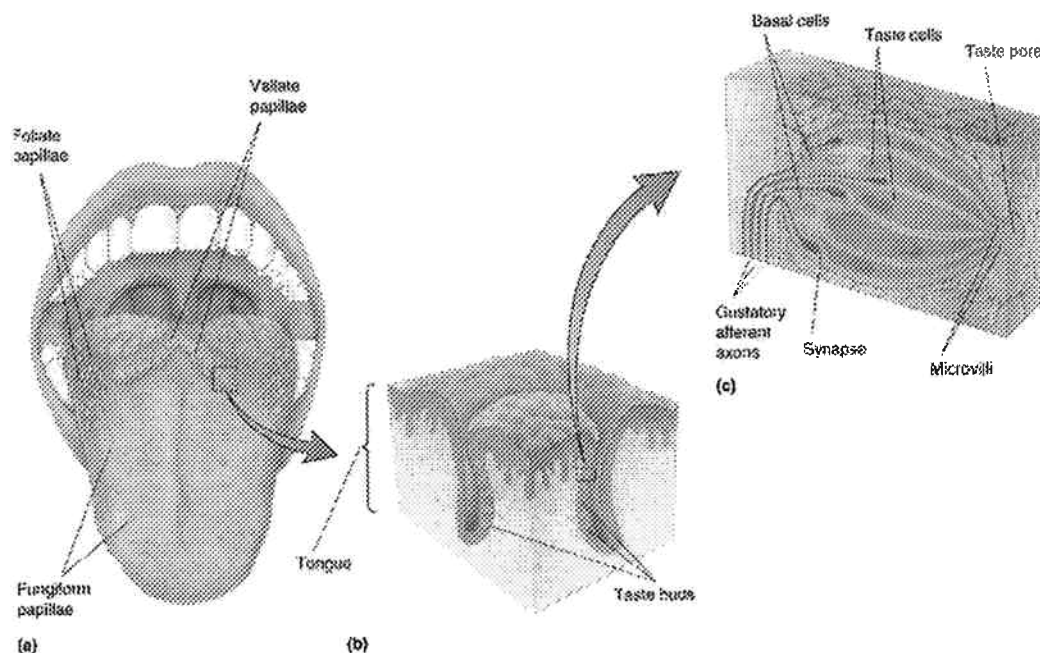
The greatest biological significance of the chemical senses, i.e. particularly olfaction and gustation, is to warn of spoiled or otherwise harmful substances for the organism (Hiltunen et al. 2003). Unlike other senses, their receptors react to direct stimulus from the surroundings, so that the substances dissolved in the saliva or the mucus of the nasal cavity will stimulate the specialised receptors to produce electrochemical signals that can then be transmitted to the brain (Hiltunen et al. 2003). This specific process is called the sensory transduction and consists of sensitivity, vigour, speed and versatility of the sensory system (Connors 2003).

2.2.2 Gustation

Tasting is predominantly a function of taste buds that are found in the mouth (Guyton 1991). The mouth is lined with receptor cells that are situated in the taste buds and are responsible for the sensation of tasting. Yet, most of the taste receptors and hence tasting happens essentially on the dorsal surface of the tongue (Connors 2003). The taste buds are composed of sensory cells, supporting cells and basal cells. Because of the degeneration of taste receptors approximately every ten days, Beidler and Smallman (1965) concluded that there must be a continuous replacing of the dying receptor cells by mitotic divisions, in which according to Guyton (1991) the new receptor cells are formed from the surrounding epithelial cells. The part of the receptor cell that is exposed to chemical stimuli is the small apical-membrane region that is found close to the surface of the tongue. These receptor sites containing apical-regions extend their microvilli into the taste pores where they are in a direct contact with the chemical stimuli. The chemical stimulus is processed in the taste buds and channelled to the nerve fibres to which the receptor cell is synapsed near the bottom of the taste bud (Connors 2003).

The standard amount of taste buds varies from 2,000 to 5,000 and the number of receptor cells in each taste bud varies between 50 and 150 besides the numerous supporting and basal cells (Connors 2003). The illustration of the structure of the sense of taste is shown in Picture 2.1.

¹ Vision responds to electromagnetic energy; touch, pressure and sound to mechanical energy; taste and smell to chemical energy and change in temperature to the heat energy (Hiltunen et al. 2003).



Picture 2.1 The structure of the sense of taste. a. Surface of the tongue, which is covered with four different types of papillae. b. Cross section of a papilla with taste buds. c. A taste bud containing the taste receptors, which form synapses with the nerve fibres. (The tongue, its papillae, and its taste buds 2004)

2.2.3 Impaired Gustation as a Result of Smoking

According to Dr. Andrew Spielman (2005) the reasons for impaired gustation as a result of smoking can be variable. He suggests that inhaled hot air has a negative thermal effect on the integrity of the papillae on the tongue and thus impairs the sense of taste.

A high level of nicotine in blood also has an effect on the acetylcholine receptors, i.e. specific neurotransmitters, of taste receptors and thus may indirectly affect the neurotransmittance so that the taste stimulus and coding of the nerve impulses in the brain becomes suppressed. In the same way the blood nicotine has apparently a direct effect on the acetylcholine receptors in the brain and consequently affects the central nervous system in the process of tasting. (Spielman 2005)

2.3 Primary Taste Qualities

An individual can identify hundreds of different tastes. All the tastes are combinations of the five primary taste qualities: sweet, salty, sour, bitter and umami². The taste buds on the dorsal surface of the tongue are specialised to respond from one to five different primary taste stimuli, though usually one or two basic tastes are dominant. (Guyton 1991)

The pure salty taste is best detected in NaCl. The taste is primarily the taste of Na⁺ cation, however, also other salts contribute to the salty taste together with other taste sensations. Threshold for sensing the NaCl in salt is 0.001 mol/dm³. (Guyton 1991)

The sour taste is caused by H⁺ ions in different acids. The more the acid contains protons (H⁺ ions), the greater is the concentration of H⁺, leading to a stronger taste sensation. The threshold for tasting sour taste's hydrochloric acid is on average 0.0009 mol/dm³.³ (Guyton 1991)

The sweet taste is not elicited by any specific group of chemicals but is present in various substances such as sugars, alcohols and artificial sweeteners. With sugars the connection between the chemical structure and the taste is not always self evident. Some artificial sweeteners made of two amino acids can have taste intensity 10,000 to 100,000 times greater than in the case of some sugars. The threshold to sense the sweet taste of sucrose is 0.01 mol/dm³ (Guyton 1991; Connors 2003).

Also bitter taste is evoked by several classes of chemicals and is present in various organic substances (e.g. alkaloids and long organic chains containing nitrogen). The significance of bitter taste is especially in warning of poisonous and harmful substances. Because of the potential harmful effects, the threshold for tasting bitter substances is considerably lower compared to other primary tastes, 0.000008 mol/dm³.

² Until recently umami has not been accounted as a primary quality taste, but presently an increasing number of gustation researchers classify it as the fifth one. According to Hiltunen et al. (2004) it has been shown to possess its own representatives in the cerebral cortex and taste receptors on the tongue that respond explicitly to its stimulus.

³ The low threshold for acids can be explained by concentration; the more acidic the substance is the lower is the threshold for sensation

The fifth basic taste is umami and is caused by the amino acid glutamate. The taste of umami can best be found from bouillon and other stocks. Glutamate is often added to foods, e.g. meat, fish and poultry, to strengthen its original good taste. (Glutamate and taste 2005)

2.3.1 Combinations of Primary Taste Qualities

The five primary taste qualities combine to yield a huge number of different flavours. Studies on the taste discrimination of the taste buds show that they can make a distinction between 4,000 to 10,000 chemicals. This suggests the need of taste buds to identify the different concentrations of each primary taste quality. The specificity of each taste bud for their appropriate primary taste quality stimuli affects the process: taste buds reflect the distinct proportions of their dominant taste categories and the information is brought together to discriminate among different flavours. (Connors 2003)

3. Materials and Methods

3.1 Objective of the Study and General Description of the Experiments

The aim of the present study was to examine whether smoking has an effect on the functioning of the sense of taste. The investigation consisted of two parts. The first part was in the form of a questionnaire to collect the essential background information of the examinees (Appendix 1) and the second part was the experimentation. Altogether three experiments were conducted, all of them being primary taste quality tests. The first experiment was a preliminary test aim of which was to make the examinees acquainted with the five primary taste qualities, while the second and third were the actual tests that gave the data for the conclusions of cigarette's effects on gustation to be based on.

The preliminary test was performed with the five primary taste qualities besides with water. The subjects' task was to taste each of the six samples⁴ at a time and to write down the names of the tastes in the right order on the given form (Appendix 2). The preliminary test is described in more detail in section 3.4.1.

⁴ The samples used were bitter, sour, salty, sweet, umami and water.

The procedure in the second and third test was uniform to that of the first test. The subjects had eleven samples to evaluate, two of each primary taste quality and water as the eleventh. The examinees were provided with another form (Appendix 3) for the eleven samples to be named in the right order. The test is explained in the section 3.4.2.

3.2 Subjects

The objective was to recruit pupils of the ages between 16 and 20 evenly from both sexes. Both boys and girls were equally interested in the experiment and therefore also the participation was almost equal (4 boys, 6 girls) giving a total of 10 test subjects. The average age for the whole group was calculated as 17.6 years. The group of ten was then divided into two: the smoking group (5 smokers) and the control group, i.e. non-smokers (5 non-smokers). Both of the groups were composed of two boys and three girls. The main concepts of the experiment were described and the short time needed to perform the test emphasized. All the subjects took part in all three tests.

3.3 Experiment Conditions

Before the actual experiment, the examinees filled Form 1 for background information. Thereafter the subjects were asked to continue with their own pace with the experiment. All the needed instructions for the experiment were found on the Form 2 but as a precaution, they were gone through with the examinees prior to the test and the basic idea of the experiment was clarified. Also the five primary taste qualities were named and explained in order to avoid any ambiguity. Besides the Forms 1 and 2 also the samples were placed for the examinees beforehand so as to minimize any possibility of errors.

3.4 Experimentation

3.4.1 Samples

Altogether six different substances were used that comprised of all the five primary taste qualities (i.e. sour, bitter, salty, sweet, umami) and water. Each of the samples had a fixed concentration value that was maintained throughout the whole experimentation. The water used was regular tap water⁵. Table 1 represents all the primary taste qualities, the compounds they are made of and the amount of the substance per one gram.

Table 3.1 The compounds, molecular formulae, concentrations and amounts of the primary taste quality samples.

Taste	Compound	Molecular formula	Concentration in aqueous solution %	Amount in aqueous solution g/l
Sweet	Saccharose	$C_{12}H_{22}O_{11}$	0.800	8,00
Salty	Sodium chloride	NaCl	0.200	2,00
Sour	Tartaric acid	$HOOC(CH_2O)_2COOH$	0.025	0.25
Bitter	Caffeine	$C_8H_{10}N_4O_2$	0.050	0.50
Umami	Monosodium glutamate ⁶	$NaC_5NH_8O_4$	0.018	0.18

The preparation of the samples was done one day ahead of each of the test⁷. The powdered substances were added into one litre of water each. This gave directly the right concentrations for the experimentation. This implies that all the examinees were provided the same sample concentrations and therefore it ought not to have an effect on the results.

3.4.2 Preliminary Test

The preliminary test was performed to make the examinees acquainted with the six samples, i.e. the five primary taste qualities and water (Picture 3.1), and to find out an approximated outcome of final results. The testing provided also an insight of whether the concentrations of the samples were

⁵ Although tap water is known to be slightly alkaline, its effect was considered to be negligible as water was basically used only as a reference point for concentrations.

⁶ As the table states, umami is made principally of monosodium glutamate. Yet, monosodium glutamate accounts for only 50 % of the compound, while the rest of the taste is caused by 5'- guanylic acid (25%) and inosinic acid (25%).

⁷ The ready powder samples were prepared by mixing with water according to the instructions provided by Valio Oyj.

appropriate. The concept for the six-sample test was provided by Valio Oyj, which also supplied the substances with their detail specification information and other materials⁸.

At first the examinees were asked start with the background information sheets (Appendix 1) that were placed on tables beforehand. After having handed in the information sheet the examinees were allowed to continue with the taste test that was placed in front of each candidate following their own speed. According to the instructions the examinees were permitted to taste each of the sample more than once.

Some verbal instructions were given to the candidates prior to the test. They consisted of recommendations for no beverage or food consumption and no smoking 30 minutes before the test. Also the importance of rinsing the mouth with water between each sample was emphasized⁹. The examinees were also introduced to the idea of the preliminary test being only an indication for the actual tests.



Picture 3.1 On the left are the samples for the actual tests and on the right the samples for Preliminary test.

3.4.3 Primary Taste Quality Test

The aim of Tests 2 and 3 was to identify the relation between cigarette smoking and the accuracy of tasting. The method used in the preliminary test was slightly modified in order to increase the

⁸ The samples provided by Valio Oyj are being frequently used in taste tests in the department of Research and Development, Sensory analysis, Valio Oyj.

⁹ The rinsing of mouth was done in order to eliminate the possibility of previous sample affecting the performance in the sample in hand.

reliability of results in Tests 2 and 3. Although in principal the three tests were similar, yet, second and third test were somewhat harder for the subjects.

Applying the same method acquired from the preliminary test the testees were introduced this time to eleven samples that were placed in advance on each table together with the answer sheet (Appendix 3). The samples contained two of each primary taste qualities and one water sample. Hence, the examinees were required to mark the samples in the right order on the paper and were encouraged to rinse their mouths between each sample. As the number of samples was greater in Tests 2 and 3, also the time used for them was longer. The concept for the Tests 2 and 3 was also provided by Valio Oyj.

4. Results

4.1 Subjects

The information collected on the test subjects was assembled from the background information form to illustrate the age distribution and smoking status of each male and female subject. (Table 4.1)

Table 4.1 Number of subjects in age categories by sex and smoking status

Age (years)	Non-smokers		Smokers	
	Males	Females	Males	Females
17	1	3	0	2
18	0	0	1	0
19	1	0	1	1
Totals	2	3	2	3

4.2 Performance in the primary taste quality test of the smokers and non-smokers

Gustatory function was measured with an eleven-sample taste test that consisted of taste sample identification. The gustatory performance of the smokers was shown to be considerably lower than the performance of non-smokers. Because of the high concentrations of samples the subjects with a

normally functioning sense of taste should have recognized most of the primary taste qualities. However, especially smokers did not meet these expectancies. (Graph 4.1 and 4.2)

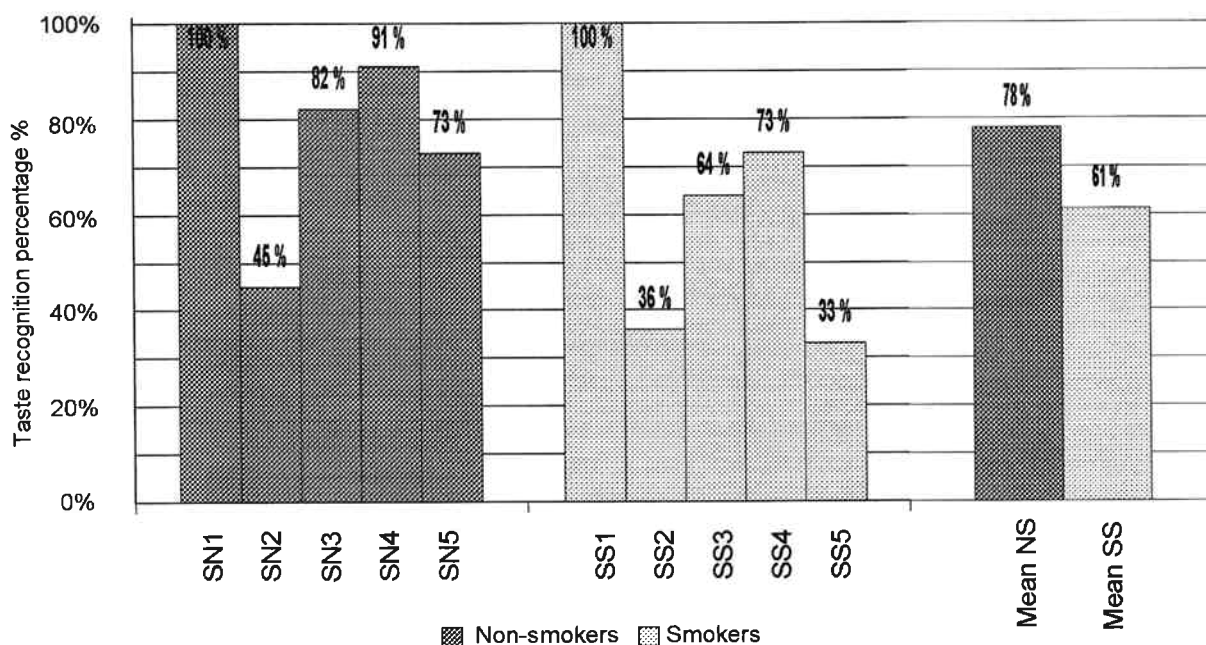
According to the preliminary test, all the test subjects sensed each of the different tastes though might not have been able to distinguish between them. Because of the obvious deviation of performance between subjects the concentrations of the samples were decided to be kept constant throughout the study to facilitate the interpretation of results.

Table 4.2 Average recognition percentage of the subjects in different tests

Test	Mean of taste recognition / %	
	Non-smokers	Smokers
Preliminary test	73.4	60.0
Test 1	76.4	67.6
Test 2	78.2	63.6

The average recognition percentage was discovered to illustrate variance in conformity with the smoking status. Smokers' gustatory function indicated a distinct decrease in performance leaving no ambiguity for analysis. Non-smokers superiority in gustatory performance was evident in each test. (Table 4.2)

Graph 4.2 Results for Test 1 for each subject according to smoking status. SN indicates a subjects who does not smoke and SS indicates a subject who smokes.



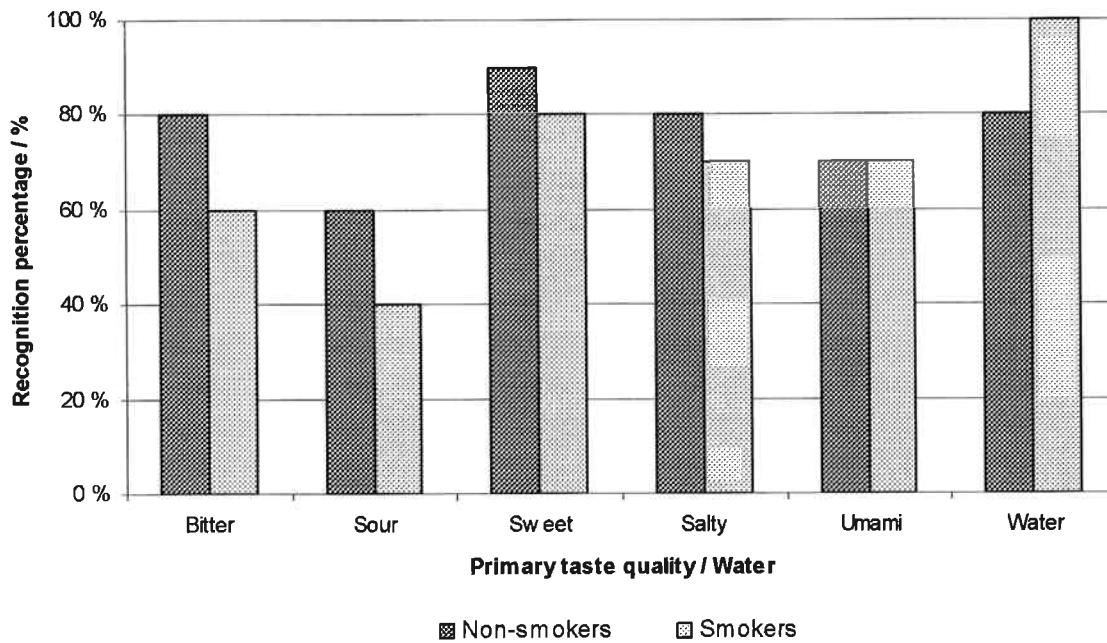
Test 2 revealed that the results followed the same trend of previous tests, non-smokers being more sensitive to different tastes. Results for Test 2 were still clearer than in Test 1 providing justified indications on smokers' impaired functioning of gustation. The deviation in the average percentage of recognition was greater than in Test 1. (Graph 4.2)

4.3 Differences in Tasting Performance Between Each Primary Taste Quality

The recognition percentages varied greatly between different taste samples. Especially sour, bitter and umami were recognized poorly by the two groups. Overall, smokers performed significantly poorer than non-smokers when tasting bitter, sour and salty. Also, smokers' ability to recognize sweet was somewhat lower. However, no difference in identification was found for umami. In

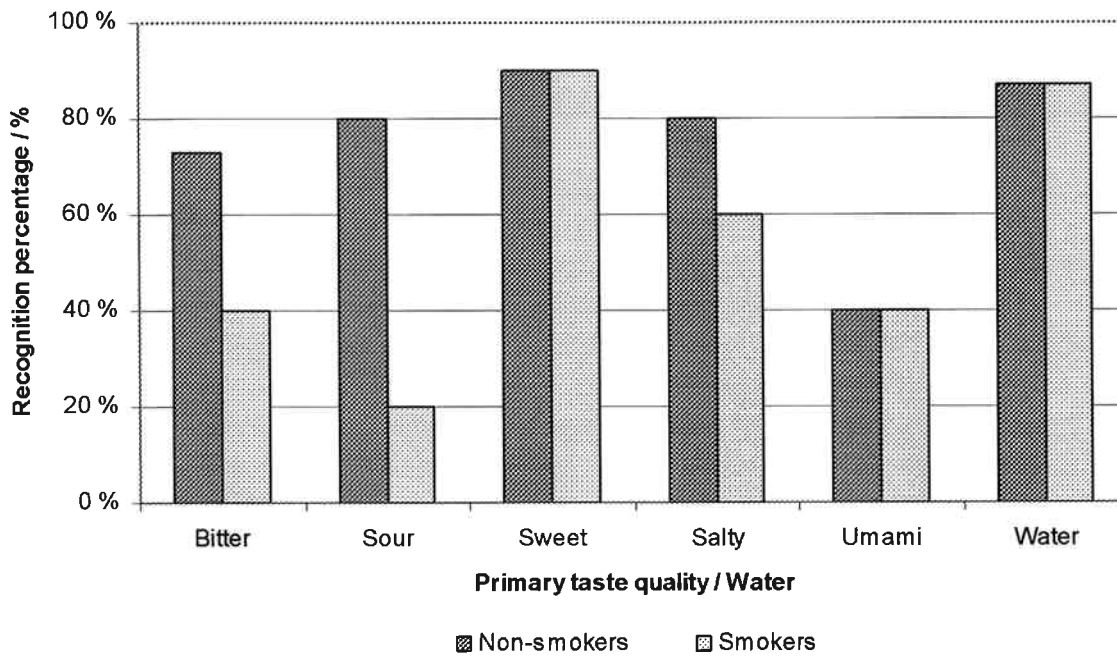
contrast the smoking group outperformed the control group for water sample in Test 1. (Graph 4.3 and 4.4)

Graph 4.3 Comparison of the recognition percentage of different primary taste qualities and water according to smoking status in Test 1.



The recognition of samples varied in the same manner for both of the groups. Bitter, sour and umami were recognized the least followed by the salt sample. Water appeared to be easier to recognize by smokers whereas non-smokers outperformed smokers in all the rest except for umami. Sweet and water samples were both well recognized by each of the groups. (Graph 4.3)

Graph 4.4 Comparison of the recognition percentage of different primary taste qualities and water according to smoking status in Test 2.



Test 2 gave evidence to the assumption that some of the samples were recognized better than others. Bitter, sour and umami were again the samples least recognized. Also recognition of salt was noticed to drop slightly. The deviation for bitter and sour samples in Test 2 for the two groups was significantly higher than in Test 1 non-smoking group attaining a lot higher scores. Sweet and water were still most recognized samples. The poor recognition of umami may have been caused by the unfamiliarity of the examinees with the sample. (Graph 4.4)

5. Discussion

5.1 Subjects

The subjects for the study were recruited among highly educated pupils in Ressu upper secondary school. The knowledge of the pupils of smoking and its harmful effects was thought to be appreciable and was found to result in a low percentage of pupils smoking. This aspect also set limits to the standard of the smoking group seeing that the initial idea was to take only smokers who

consumed at least 10 cigarettes per day. Given that only few pupils did actually fulfil the criteria, the investigation could not be performed as previously planned and hence all the regular smokers were accepted into the experimentation.

The selection of subjects should have included the consultation of possible passive smoking. It has been shown to cause identical though milder effects on an individual as direct smoking (Vierola 2004) and would therefore influence the reliability of the control group. Also the fact that the time span of cigarette consumption between different smoking individuals varied and that it has a potential effect on the ability to taste, the smoking group could have been restricted to such individuals who had smoked for at least one year.

5.2 Performance in the Gustatory Test

Overall, the smoking group's ability to recognise primary taste qualities was clearly outperformed by non-smokers. However, the test was found out to be taste-specific; non-smokers recognized bitter, sour, sweet and salty better than smokers whereas smokers were better able to identify water sample. The recognition of umami did not show any difference between the groups.

Although the present investigation gave clear indication of impaired gustatory function of smokers, another recent study concluded that smoking seems to have no correlation with judgement of taste intensity (Niskanen 2000). The possible inaccuracies in the results may arise from smokers' short intervals of tobacco consumption or from too low concentrations of samples, which allowed only few subjects to recognize the samples. This implies the need for revising the method used and possibly modifying it so that different concentrations of samples would be utilized. Also, the investigation ought to be repeated in a greater scale by choosing the subjects outside the school community.

However, the simplicity of the study allows estimations to be drawn. The smokers' performance was evidently poorer and therefore it may be rightly stated that the functioning of gustation may be altered by tobacco consumption. Yet, the topic remains to be little investigated and further studies are required for conclusions to be drawn of the reasons for these particular effects of smoking.

6. Conclusions

The objective of the research was to investigate and test the changes in gustatory performance as a result of smoking cigarettes. The investigation was based on collecting sufficient background information and especially performing three taste tests that were carried out among 17 to 19-year-old adolescents.

The hypothesis of the investigation regarding the impairing effects of smoking on gustatory performance was proved to be correct. The empirical study substantiated the assumptions; in all of the three tests smokers showed a reduced ability to discriminate between the five primary taste qualities whereas non-smokers' performance in the gustatory test was significantly better. The comparison of different tastes revealed that the functioning of the gustatory system is not necessarily consistent between different tastes but on the contrary sour, bitter and salty samples were recognized more poorly than other tastes. Non-smoking group were more sensitive to all of these three tastes. However, the recognition of water was not shown to differ between the two groups.

It could be pointed out that the research on the effects of smoking on gustation was necessary and actual. Though adolescents are continuously being informed of the harmful effects of smoking, yet it remains to be common among them. The investigation provided a concrete example of how the sense of taste – an imperative constituent of quality of life – could be damaged by smoking cigarettes. The study attempts to awaken discussion on the implications of tobacco consumption concerning the youth and to consult ever more adolescents themselves giving more value to their insights about the topic. It also could increase the contributions of different parties to mutual understanding of the issue so that the adolescents would have the possibility to take the matter under a serious consideration.

The present research aroused several new questions. Potential further studies could investigate the correlation between poor eating habits and the changes in gustatory performance caused by smoking cigarettes. Other interesting research questions could also be the significance of passive smoking related to gustatory performance as well as the effect of impaired gustation on gaining weight.

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Picture 3.1 by Thomas Eskolin. At Valio Oyj, Department of Research and Development, Sensory analysis.

Appendices

Appendix 1. The background information questionnaire.

Form 1

Background information form

1. Name: _____

2. Test subject number (examiner fills): _____

3. Class: _____

4. Age: _____

5. Sex male
 female

6. Which of the following describes best my smoking habits:

1 I don't smoke

2 I smoke

3 If yes, how many cigarettes per day _____
and how long have I smoked (months) _____

7. Estimate your own sense of taste. It functions

1 a lot worse

2 a bit worse

3 not worse nor better

4 a bit better

5 a lot better

than the sense of taste of other people of my age.

Appendix 3. Primary taste quality test form.

Form 3

Preliminary primary taste quality test

Test subject number (examiner fills): _____

Class: _____

Date: _____

Taste each of the samples starting from the left and name whether the taste is **sour, salty, sweet, bitter, umami or water**. You are allowed to taste the samples more than once. Between every sample, wash your mouth with the water provided.

Code of the sample	Taste
32	
17	
68	
41	
26	
54	
19	
56	
34	
47	
11	