Influence of different musical styles, keys, and instruments on the gustatory perception

Wettbewerbsarbeit 2016 im Fach Biologie
Kantonsschule Sursee

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Abstract

The question, whether music can have an influence on the gustatory perception, will be answered in this paper. More specifically, it will be shown, what difference a change in key (major/minor), in musical style (jazz/rock) and in pitch and instrument (high-pitched piano/low-pitched French horn) can make. In order to outline the study, the basic senses taste and hearing and their connection, the crossmodal correspondences, are introduced. As a preliminary experiment, the participants listened to six song extracts and ticked adjectives that they thought would suit the song. These results made up a part of the main experiment, in which other participants divided into two groups have tasted orange marmalade while listening to "The Love Theme" in either major or minor, salt and vinegar crisps to "Feeling Good" in either jazz or rock, and "The Rohan Theme" played by either a high-pitched piano or a low-pitched French horn. They had to rate the foodstuff on taste (sweet, salty, bitter, sour) and the suitability of the adjectives from the preliminary experiment. Firstly, the goal of this study was to demonstrate a possible change in the gustatory perception by solely changing the background music. Secondly, it was to show whether adjectives that suit the music could also be matched to the foodstuff itself. As the results have shown, music in major reduces while minor enhances bitter flavours. Jazz leads to a more intense flavour sensation whereas the piano and horn songs did not show any significant influence. Adjectives that suit the music do not necessarily have to be matched to the foodstuff presented with it as well. It will be discussed, what mechanisms might be responsible for the change (or for the lack of change) of the gustatory perception.

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1 Introduction

1.1 Basic senses

1.1.1 Gustatory perception

The gustatory perception is a complex system, involving almost all of the human senses. When eating or drinking something, the latter focus on what is going inside the mouth to prevent swallowing poisonous or harmful substances, which can eventually damage the guts. [1]

Before food can be tasted, it needs to be broken down by chewing it. This does not only make it easier to swallow and digest, it, too, speeds up dissolving the molecules in saliva. This mix of saliva and food molecules then hit the tongue, where papillae are found. They are the biggest structures on a human tongue. One type (*filiform papillae*) is responsible for the bumpy and rough appearance on the tongue, which allows it to clean the mouth and direct food to the back of the mouth. However, they do not have any taste function. The other three types (*fungiform papillae, foliate papillae* and *circumvallate papillae*) all contain taste buds. These are clusters of taste receptor cells, arranged like segments of an orange. Some of the latter connect to nerve fibres, which lead to cranial nerves and later on to the brain. How and if the ones not synapsing with nerve fibres convey their information to the brain is yet to discover. [1, 2, 3]

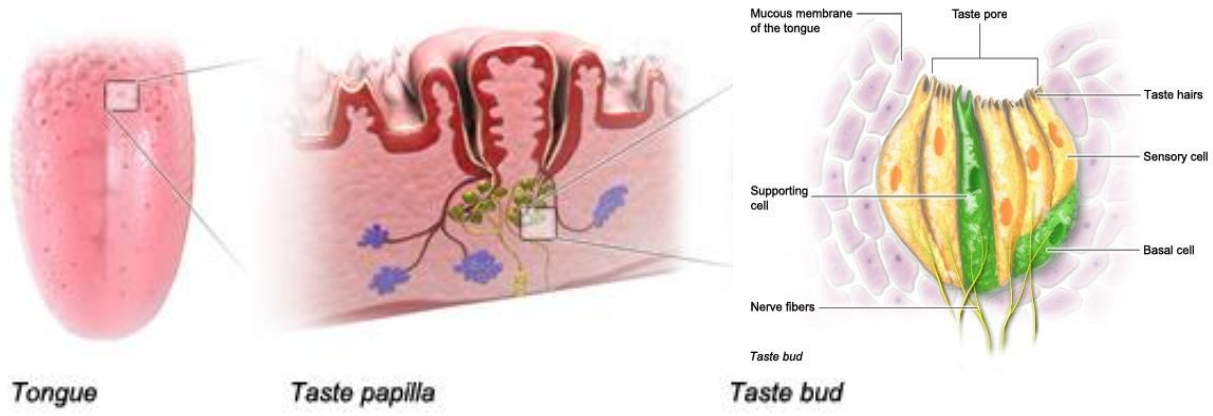

Figure 1: Close up of the human tongue, showing in detail where papillae and taste buds are located. [4]

Taste receptor cells can interact either with charged particles such as ions found in sodium and acids, or with specific chemical structures such as glucose. Through several steps, both substances cause a perception of taste. This process is complex, as it involves many different factors. It will not be discussed in the present study. However, the perceived taste is either sour, salty, sweet or bitter since they are the four basic tastes. Umami – often described as "savoury" – is evoked by glutamate and constitutes a special case concerning the basic tastes. While it has been accepted as one of the latter due to having its own receptors, some scientists are still undecided, whether it truly is a taste or simply functions as signal for protein intake. [1, 5]

As mentioned before, almost all senses take part in creating the gustatory perception. "You eat with your eyes" is not only a popular saying when it comes to plating dishes in a pleasing way but also refers to actual scientific statements. The fact that artificial colourings exist to modify the look of food or beverages alone shows that humans respond to different colours in diverse manners. Several studies have dealt with this topic. Joseph A. Maga's study on the influence of colour on taste thresholds is regarded as a classic on this field. He presented each basic taste (salty, sweet, bitter or sour) as aqueous liquids in four forms: coloured red, yellow and green

and one time left colourless. The results have shown that people are more sensitive to sweetness in a green coloured beverage than in a yellow coloured one, whereas red decreases bitter sensations. [1, 6].

The somatosensory system contributes to the gustatory perception by sensing temperature and texture. Evaluating this information makes it easier to describe and talk about the nature of foodstuff. It also functions as protection from, for example, acidic substances, which will etch and damage the stomach when swallowed. [1]

Even though hearing used to be considered as least important sense in terms of gustatory perception, studies have shown that not only the sound that the foodstuff itself makes, but also the sound of the surroundings can influence the flavour. A crisp, for example, is rated significantly staler when its crunching sound has been modified to be quieter than a crisp whose sound level had been increased. An Ig-Nobel-prize winning study by Zampini and Spence came to this conclusion. The participants had to taste many identical potato crisps while they received real-time auditory feedback through headphones. The sounds were altered to sound more or less crunchy. As mentioned above, this had an effect on the crisp's taste, even though it never changed. [7]

Latest researches by Crisinel and Spence ("As Bitter as a Trombone")) have also shown that the pitch of a tone can be corresponded to a taste. The participants were asked to match a gustatory stimulus, presented as a solution, to a sound of varying pitch. Accordingly, high-pitched sounds played by a piano were associated with sweet tastes, whereas low-pitched sounds coming from a brass instrument corresponded to bitter tastes. The study also showed that it is even possible to influence the pleasantness of food by playing the right pitched sound. Bitter tastes are associated with poisonous food and therefore seen as less pleasant. When low-pitched brass tones were played, the foodstuff was often marked unpleasant as well. [8]

Another study by Crisinel et al. called "a bittersweet symphony" seems to share similar results. In this study however, the focus was on bitter and sweet tastes. A cinder toffee containing sweet sugar and bitter treacle was handed out while soundtracks were played in the background. Based on the findings of the previously mentioned study, the soundtracks were composed in advance to sound bitter or sweet. The "bitter" track contained low, grumble-like noises, whereas the "sweet" one was made of high and clear notes. As expected, the toffee was perceived sweeter when listening to the "sweet" track and vice versa. [8, 9]

Apart from taste itself, the olfaction is the most important sense, when it comes to gustatory perception. That is because the mouth cavity and the nasal cavity are directly connected through the retronasal passage behind the palate. Molecules, which are being released into the air when chewing and swallowing, find their way into this passage to stimulate the olfactory receptors. These so-called retronasal olfactory sensations are thought to originate from the mouth, which is why they are not perceived as "regular" olfactory sensations. The brain connects them and the gustatory sensations into what is called flavour. [1]

When now talking about pure taste, the retronasal olfactory sensation is left away. The airflow responsible for transmitting the molecules to the nasal cavity needs to be suppressed. When having a stuffy nose, this is achieved naturally and flavour decreases. However, just holding one's nose serves the purpose as well, of which will be made use in the following experiment for illustrating purposes: Before putting a bit of cinnamon on the tongue, the nose is being pinched, not allowing the airflow to reach the nasal cavity. The cinnamon tastes rather bland and has slightly sweet notes. That is its pure taste. Now letting go of the nose, the whole flavour is experienced: a mix of spicy and sweet with hints of bitter. However, in the present study, the difference between taste and flavour will not be discussed any further and the experiments rely on a foodstuff's whole flavour. "Taste" will be mentioned nonetheless, referring to the basic tastes sweet, sour, salty and bitter. [1, 10]

1.1.2 Auditory perception

Vibrations of objects and sound waves build the base of the perception of sounds. Hearing someone's voice, for example, begins by their vocal cords vibrating as they speak. These vibrations cause fluctuations in air pressure, which then reach the ear as sound waves. They are defined by frequency and intensity. [11]

After surpassing the auditory canal of the external ear, the sound waves set the eardrum in vibrations to transmit the caused amplitudes to the ossicles (hammer, anvil and stirrup) before reaching the cochlea in the inner ear. As a result, the hair cells in the cochlear duct bend. This creates a mechanical stimulus, which then triggers the sensory cell. Once it reaches the brain through the auditory nerve, an aural impression is perceived. [11]

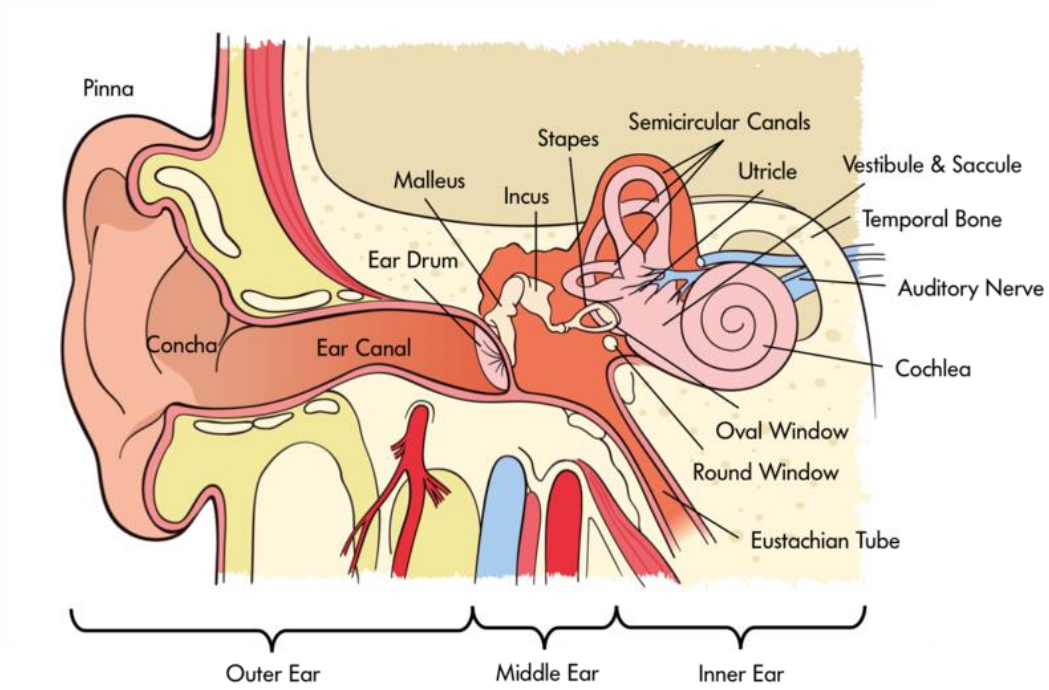

Figure 2: Image showing the auditory system in detail. Not every labelled part is mentioned in the precedent paragraph. [12]

There have been many studies and researches on the auditory perception, some of which dealing with music. Especially one strikes out in relevance to this present study. Bruno Mesz et al. examined if and how music can have taste. In the study called "the taste of music", they let professional musicians improvise based on a given modality (melody, chord or no restrictions) and a target word (salty, sweet, sour and bitter). The improvisations provided reliable results and showed that it was possible for the musicians to link tastes and music. The study has shown that the word "sour" resulted in sounding high-pitched and dissonant and the word "bitter" in sounding low-pitched and legato (smooth). Improvisations based on "sweet" were consonant and soft, while being based on "salty", they were staccato (short and abrupt). In a second experiment, the improvisations were played back to non-musicians. They were able to match the auditory stimuli to the word they were meant to represent, which enhances the significance of the previous experiment. [13]

1.2 Crossmodal correspondence

According to Charles Spence and Cesare Parise, crossmodal correspondences could be defined as "the 'natural' mapping of features or dimensions of experience across sensory modalities" [9]. Different sensory inputs and modalities interfere with each other and are combined to break down the complexity of the environment. The brain tries to make sense out of it by crossing borders of sensory modalities and thus matching different inputs. [14, 15]

The crossmodal correspondence between colour and gustatory perception, for example, has a comprehensible aim: the colour red indicates sweetness and both of these attributes are often found in foodstuff with a high nutritional value. The purpose and evolutionary background of the crossmodal correspondence between the auditory and gustatory perception has not yet been confirmed. [16]

Crossmodal correspondences also play part in language, where they are often used in a metaphorical way. Both "sharp" and "creamy" are adjectives used to describe the taste of a foodstuff, in terms of either intensity or pleasantness. However, neither of them can actually be evoked solely by taste since they are tactile sensations. [17]

The same goes for music, which can be described with tastes. The musical style pop is often associated with sweet and sticky, since, usually, there are rather high notes and the songs are catchy. They figuratively stick to the listener. That is why "bubble-gum pop" has become a common saying.

In the discussion of crossmodal correspondences, the question of what mechanisms could be responsible for the mapping of auditory and gustatory sensations arises. One possible explanation is based on the so-called "intensity matching". It claims that an attribute of one stimulus can be transferred onto or seen in another. For example, if the present song is loud and therefore more intense, the foodstuff is expected to live up to that. The gustatory stimulus will have a stronger taste. [18]

The study „as bitter as a trombone" provides another explanation for a possible mechanism involved in crossmodal correspondences. The theory of hedonic matching claims that if one stimulus is liked, the other will more likely be seen as pleasant as well. According to the mentioned study, a pleasant pair would be piano sounds matched with sweet tastes, an unpleasant combination would be trombone tones and bitter tastes. For further information on this study, see chapter 1.1.1. [8]

A third explanation suggests the presence of a statistical co-occurrence. It relies on innate orofacial gestures that even babies make as a response to basic tastes. They naturally put their tongue out and downwards when experiencing bitter tastes - probably because they are associated with poisonous food - and out and upwards when experiencing sweet tastes. These gestures cause a low resp. high vowel when air is exhaled. The taste evoking the gesture and the consequence of this tongue position are naturally co-occurring, leaving one to learn this association from an early age. [19, 20]

There are multiple studies dealing with the differences and similarities between crossmodal correspondences and synaesthesia. The latter is a neurological condition caused by cross wiring in the brain. Senses appear to be mixed up, i.e. people concerned report tasting words or seeing colours when being told numbers. As mentioned above, crossmodal correspondences are about the involvement of different senses at once. Recent studies now discuss, where crossmodal correspondences end and synaesthesia begins. This controversial question will not be discussed in the present study. [21]

1.3 Hypotheses

The present study tries to find answers to the following questions:

How do different musical keys influence the gustatory perception?

1. Songs in major are associated with sweet tastes.
2. Songs in minor are associated with bitter tastes.

The last two hypotheses (1 and 2) do not have a scientific background. Intentionally, minor songs are often seen as dull or bitter, whereas songs in major sound sweeter. Most pop songs are written in major and - as mentioned above – they appear to be sweeter than other musical keys.

How do different musical styles influence the gustatory perception?

3. Jazz songs (particularly in vocal/easy listening style) could be described as rather round-sounding. Therefore, they may evoke sweet and bitter notes since these two tastes are not necessarily sharp.
4. Rock songs (particularly in alternative style) are rather harsh. They could be put in relation with salty and sour flavours since they are both on the dominant and sharp side.

How do different pitches and instruments influence the gustatory perception?

5. Low-pitched notes played by brass instruments trigger associations with bitter and less pleasant tastes.
6. High-pitched notes played by piano trigger associations with sweet and more pleasant tastes.

These hypotheses are based on the findings of "as bitter as a trombone" and "a bittersweet symphony" by Crisinel et al. Both studies seem to confirm the stated hypotheses. [8, 9]

Can varying styles, keys or instruments manipulate the pleasantness of a foodstuff?

7. Sweet tasting foodstuff (either "manipulated" by the background music or on its own) is more pleasant than bitter tasting food.

This hypothesis relies on the findings of "as bitter as a trombone" by Crisinel and Spence. Their results showed that when a gustatory stimulus was perceived sweet, it was automatically liked more. [8]

Do present adjectives play a role in the gustatory perception when listening to music?

8. If certain adjectives were already picked when listening to the music on its own, they would be recognised again in the foodstuff when presented with it, even if it does not necessarily suit the description by given adjective.

This hypothesis relies on the findings of "Wine and Song: The Effect of Background Music on the Taste of Wine" by A. North. In this study, he let the participants taste the same red and white wine with different background music. They were given four different descriptions that were previously chosen to suit the auditory stimulus. The study showed that the participants mostly chose to describe the wine accordingly to the background music. [22]

2 Methods

2.1 Preliminary Experiment

The preliminary experiment was inspired by the previously mentioned study by North on the effect of background music on the taste of wine. In a pilot study, he let a test group decide on whether given adjectives were matching to a certain piece of music. These adjectives were later on used in the main study. North concluded that the background music did indeed influence the perception of the wine. Critics argue that this method could have potentially manipulated the participants since their range of possible answers was drastically decreased. [22]

2.1.1 Participants

Eighty-three participants (aged 13-17 years, 55 female, 28 male) took part in the experiment. They were students of the Kantonsschule Sursee. The experiment lasted approximately ten minutes and was held in their respective classrooms.

2.1.2 Apparatus and stimuli

2.1.2.1 Auditory stimuli

To match the hypotheses, always two songs with one varying factor were chosen to build a pair: Major's counterpart was minor, jazz's was rock and high-pitched piano's was low-pitched French horn. This was in order to justify a possible variation in perception as it was claimed in the hypotheses.

For the major and minor pair "The Love Theme" from the movie "The Godfather" was chosen. Both variations were instrumentals played by an orchestra. The song in major lasted from 0:00 – 0:32, the one in minor from 0:04 – 0:48. [23, 24]

For the jazz and rock pair "Feeling Good", originally sung by Nina Simone, was used. The jazz variation was by Michael Bublé, the rock version by a band called Muse. The jazz version lasted from 1:06 – 1:40, the rock version from 0:49 – 1:20. [25, 26]

For the piano and brass pair, a part of "The Rohan Theme" namely "Eowyn's Theme" from the "The Lord of the Rings: The Two Towers" soundtrack was chosen. One version was played by a piano, the other one by a French horn. To enhance the impact, the pitches of the variations have been changed to match the results of Crisinel and Spence, in which it is said that high-pitched notes sounded sweeter, low-pitched ones on the other hand were more bitter (see chapter 1.1.1). The piano version was sharpened by six semitones; the brass version was lowered by six semitones. The piano version lasted from 0:00 – 0.41, the French horn version from 0:00 – 0.40. [8, 9, 27, 28, 29]

The extracts were cut into length that both songs displayed the exact same part of the song. This explains why they differ in length.

Both the full songs and the extracts used in the experiment can be found on the CD on the bound copy's last page of the cover or here: http://bit.ly/2e3XNDS

2.1.2.2 Questionnaire

The questionnaire was a sheet of paper with six columns, each being titled with "extract" and a number from 1-6. All of them contained the same fifteen adjectives, two lines for associations and the question, whether they liked the extract. To that it included stating age and sex.

The adjectives were chosen on intuition by the researcher in a way that they can describe both food and music. They were listed as the following:

mächtig (mighty) – **frisch** (fresh) – **lebhaft** (vivid) – **fein** (delicate) – **luftig** (airy) – **weich** (soft) – **hart** (hard) – **süss** (sweet) – **bitter** – **langweilig** (boring) – **familiär/heimelig** (familial) – **angenehm** (enjoyable) - **fruchtig** (fruity) – **modern** – **intensiv** (intense)

2.1.3 Procedure

The participants were handed the questionnaire and given the instruction to tick the adjectives that, in their opinion, matched the played song. Multiple adjectives could be ticked. They were told to write down associations if present.

The six extracts were played one after another through amplifier. To avoid influence of the previously played song, the order was changed in every test group. The groups were four classes consisting of 20-24 students.

2.1.4 Results

Table 1: Results of the preliminary experiment with 83 participants. The numbers indicate how many times a certain adjective has been ticked or how many people liked the extract. The last two rows are answers to the question "Do you like the extract?" The experiment was held in German, the words in brackets are translations of the words used.

	The Godfather Theme		**Feeling Good**		**Rohan Theme**	
	minor	**major**	**jazz**	**rock**	**piano**	**horn**
mächtig (mighty)	34	3	14	27	11	59
frisch (fresh)	6	35	26	14	12	6
lebhaft (vivid)	38	26	37	56	4	9
fein (delicate)	23	20	13	0	20	1
luftig (airy)	16	35	16	3	8	10
weich (soft)	34	34	24	1	36	14
hart (hard)	5	2	8	49	12	27
süss (sweet)	10	42	10	1	13	0
bitter	5	2	1	5	6	19
langweilig (boring)	5	20	5	2	36	26
familiär (familiar)	3	26	5	0	9	9
angenehm (enjoyable)	23	29	38	10	36	10
fruchtig (fruity)	4	24	6	0	3	0
modern	0	0	51	56	4	3
intensiv (intense)	36	2	18	44	12	18
yes	46	34	60	54	40	14
no	35	47	23	27	40	68

The results showed how changing just one factor of a song (key, style, instrument + pitch) could influence the perception. Because of the high number of participants, the results were clear for the most part. Only the both variations of "Feeling Good" have the same adjective as most ticked one.

The associations did not conform in a way that they could be significant, which is why they were left out of editing.

2.2 Main Experiment

2.2.1 Participants

Seventy participants took part in this experiment. The first group consisted of fifty-five students from the Kantonsschule Sursee (none of which took part in the preliminary experiment), aged 12-17 years and of which 28 were female. Four students reported a minor impairment of their olfactory senses due to a cold or hay fever. Twenty have eaten more than half an hour prior to the experiment. They were split up into nine groups. The experiment lasted approximately fifteen minutes for each group.

As part of further researches, a second group consisting of 40 students, aged 12-13 and of which 25 were female, took part of the experiment as well. However, they were asked to just rate the marmalade listening to either major or minor. The chocolate and crisps were left away. None of the participants reported an impairment of senses and no one has eaten prior to the experiment. They were split up into two groups and the experiment lasted approximately fifteen minutes for each group.

The third group consisted of fifteen adults, aged 22-63 years and of which ten were female. No one reported any impairment of senses and no one has eaten prior to the experiment. They were split up into four groups and the experiment lasted approximately fifteen minutes for each group.

Each group was informed that they were going to evaluate foodstuff.

2.2.2 Apparatus and stimuli

2.2.2.1 Auditory stimuli

The auditory stimuli used in the main experiment were the same as in the preliminary experiment (see chapter 2.1.2.1). They were played via amplifier.

2.2.2.2 Gustatory stimuli

Much like the auditory stimuli, the gustatory stimuli had to be chosen to match both elements of a pair and to possibly evoke multiple perceptions.

Therefore, the foodstuff going with major and minor had to be bitter and sweet at once. Orange marmalade was chosen due to its bitter aroma from the orange and the sweet notes from the sugar. The store-bought marmalade had orange peel cut into strips added. To ensure that every sample was the same, the strips had to be removed. The marmalade was slightly warmed up to facilitate straining it through a sieve. It was at room temperature when being handed out to the participants. [30]

The jazz and rock pair was to possibly evoke an either salty or sour taste. Therefore, the foodstuff going with it had to contain both at once. Salt and vinegar crisps were chosen, since the acidity of the vinegar and the saltiness of the seasoning were what was looked for. Due to irregular shape, the crisps were crushed into chunks that were more or less equal in size. [31]

Referring to Crisinel and Spence, the piano and brass pair had to evoke bitter and sweet tastes. The preliminary experiment has shown that in this pair the mightiness was also a factor worthy of taking in consideration. In order to match the hypotheses, the foodstuff had to be bitter and sweet at the same time but also provide room to perceive it in an either delicate or mighty way. Dark chocolate was chosen. Depending on the circumstances, the chocolate can either be perceived as delightful and sweet or the complete opposite. The chocolate was broken up into equally sized, individual pieces following the lines on the bar. [8, 9, 32]

2.2.2.3 Questionnaire

The questionnaire was printed on three pages to enable changing the order. Each page had eight 10-point scales on them. Four were for the basic tastes sweet, salty, bitter and sour. The other

four scales were titled with four adjectives from the preliminary experiment. Two of them were the most ticked ones for each element in a pair. The other two were adjectives, which were often ticked for one element but hardly for the other one. For example, “fruity” was not even the second most picked adjective in major with 24 ticks, but in minor it was only ticked 4 times. The difference expresses a rather low association in one and a high association in the other case. The questionnaire also contained the questions, whether the product is liked, if there were more suitable words to describe the foodstuff, what associations were evoked, if the participant had an impairment of senses of smell and taste and if they had eaten something shortly before the experiment. To that it included stating age and sex.

2.2.3 Procedure

The participants were split up into 13 groups. Four student and two adult groups evaluated the products listening to the songs that were expected to sound bitter and harsh (minor, rock and French horn), the other four student and two adult groups were listening to the songs that were rather sweet and soft sounding (major, jazz and piano). The order was varied in each group. One group functioned as control group without listening to any music.

All experiments were held in the same room, apart from the one with the adults. The participants were handed the questionnaire and a plastic cup filled with water for rinsing the mouth after each product. They were instructed to close their eyes while being handed out a plastic spoon with the product on it. When being told to do so, they could put the spoon in their mouth and open their eyes afterwards. They were instructed to rate the product simultaneously to tasting it. The music started playing via amplifier once the participants had put the spoon in their mouth. It was played twice to provide a longer sensation.

3 Results

It has to be noted that the standard deviations are high in most cases since there often were rogue results. That is why some deviations are higher than the actual mean and therefore, the error bar reaches under zero. It could be discussed, whether the median would have been a better option, since it disregards rogue results. However, for this study the mean has been seen as more suitable as it considers every aspect. Furthermore, rogue results point out the fact that the gustatory perception is versatile.

Another fact worth pointing out is that the control group consisted of only four people, making the validity of their results questionable. Nonetheless, they are still present in the diagram for comparison reasons.

3.1 Basic tastes and pleasantness

3.1.1 Major and minor

The students' results show that the marmalade is perceived sweeter and saltier but less bitter and sour when listening to the song in major (figure 3). The difference between the both averages of sweetness amounts to 1.13, the difference between the both averages of bitterness to 1.56.

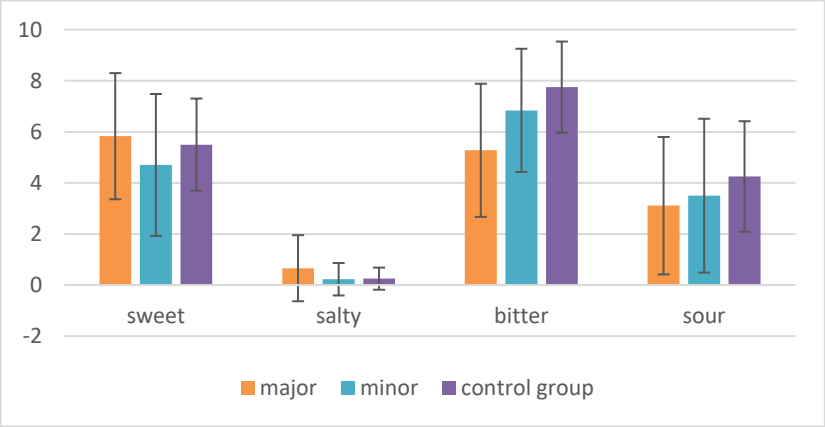

Figure 3: Chart showing the average of the perceived tastes as calculated by 95 students' answers. Ninety-one of them were listening to "The Love Theme" in either major or minor while tasting orange marmalade. The control group consisting of four students tasted the marmalade without listening to music. The error bars represent the SEM.

The adults' results surprisingly show the exact opposite (figure 4). The song in major has as an effect that the marmalade is perceived less sweet and salty but sourer. It is also slightly bitterer but the difference between the averages amounts to only 0.07.

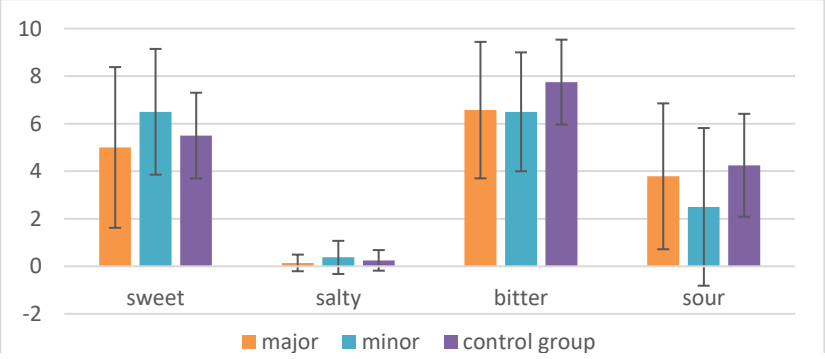

Figure 4: Chart showing the average of the perceived tastes as calculated by 15 adults' answers. They were listening to "The Love Theme" in either major or minor while tasting orange marmalade. The control group consisting of four students tasted the marmalade without listening to music. The error bars represent the SEM.

The two groups have different ratings of the pleasantness (figure 5). The students like the marmalade more while listening to the song in major, while the adults enjoyed it more when minor was playing.

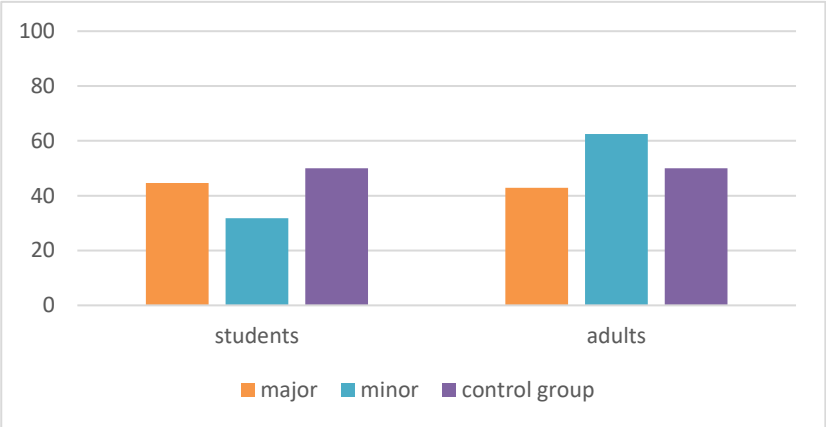

Figure 5: Chart displaying the pleasantness of orange marmalade while listening to "The Love Theme" in either major or minor. The bar shows the percentage of people who liked it. The control group of four students tasted the chocolate without listening to music. There was only one control group, which is why both of their columns are the same. There were 95 students and 15 adults in this experiment.

3.1.2 Jazz and rock

Overall, the crisps are perceived sweeter, bitterer and sourer but less salty when students were listening to "Feeling Good" in the style of jazz (figure 6). The differences in both the salty and sour taste are small with only 0.48 resp. 0.5. The average of the perceived sweetness is 1.35 higher when listening to jazz than when listening to rock. The same goes for bitter. In that case, the difference between the averages is 1.96.

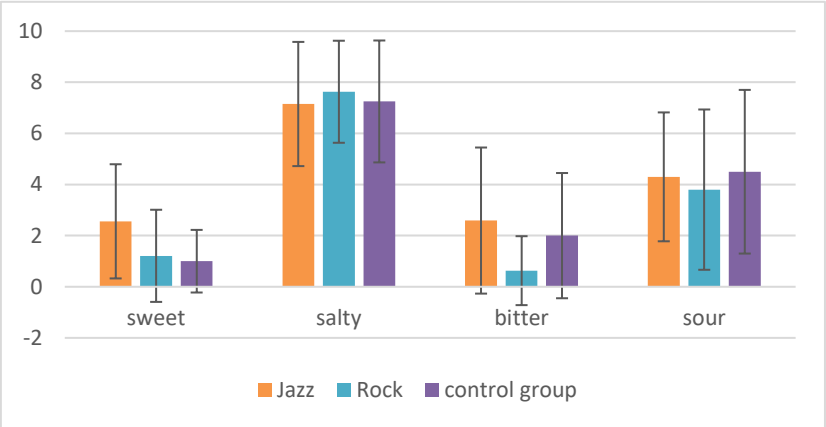

Figure 6: Chart showing the average of the perceived tastes as calculated by 55 students' answers. Fifty-one of them were listening to "Feeling Good" in the style of either jazz or rock while tasting salt and vinegar crisps. The control group consisting of four students tasted the crisps without listening to music. The error bars represent the SEM.

According to the adults' answers, listening to jazz evokes a saltier and bitterer but less sweet and sour perception of the crisps (figure 7). The bitterness is hardly noticed, both averages are smaller than 1.

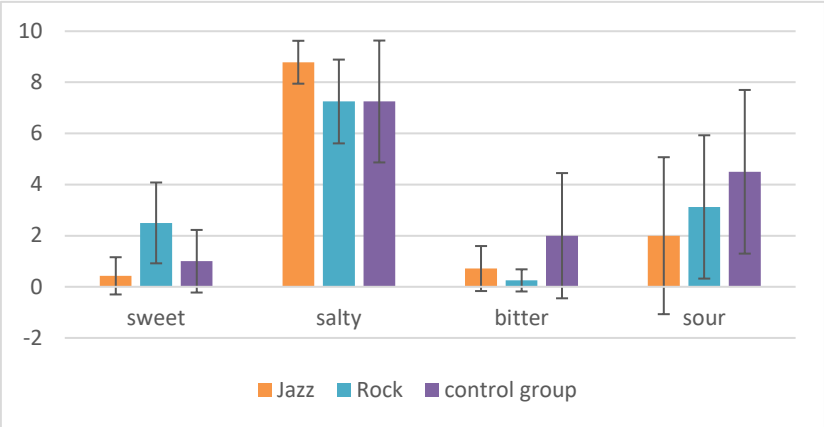

Figure 7: Chart showing the average of the perceived tastes as calculated by 15 adults' answers. They were listening to "Feeling Good" in the style of either jazz or rock while tasting salt and vinegar crisps. The control group consisting of four students tasted the crisps without listening to music. The error bars represent the SEM.

In both groups, the crisps are liked more when being presented with rock music. The students generally like the crisps more with both percentages being over 80% while the adults have percentages of 57-75% (figure 8).

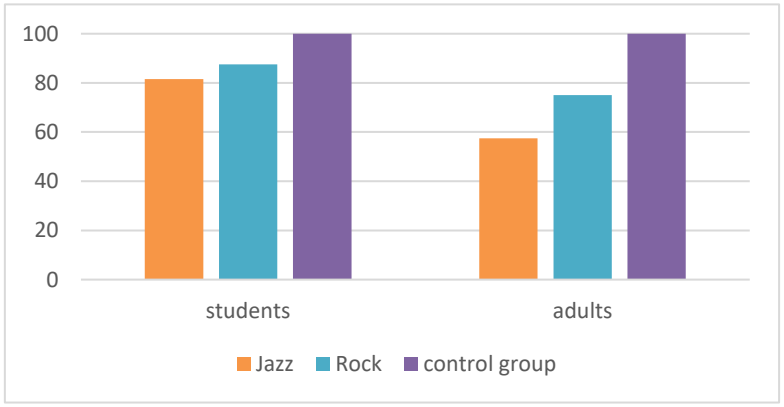

Figure 8: Chart displaying the pleasantness of salt and vinegar crisps while listening to "Feeling Good" in either the style of jazz or rock. The bar shows the percentage of people who liked it. The control group of four students tasted the crisps without listening to music. There was only one control group, which is why both of their columns are the same. There were 55 students and 15 adults in this experiment.

3.1.3 High-pitched piano and low-pitched French horn

The chocolate appears to be overall more intense in taste when listening to high-pitched piano tones since its averages dominate in each taste according to the students' results (figure 9). The significantly more prevalent tastes were sweet and bitter. When listening to low-pitched French horn sounds, the tastes salty and sour reach an average of only 0.13 resp. 0.08. The same tastes receive higher averages when listening to high-pitched piano sounds but they are still very low with only 0.48 resp. 0.96.

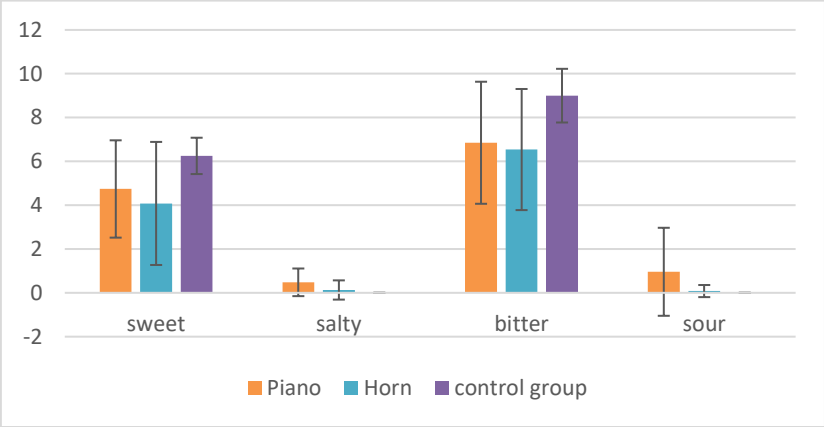

Figure 9: Chart showing the average of the perceived tastes as calculated by 55 students' answers. Fifty-one of them were listening to "The Rohan Theme" played by either a high-pitched piano or a low-pitched French horn while tasting dark chocolate. The control group consisting of four students tasted the chocolate without listening to music. The error bars represent the SEM.

The chocolate is perceived bitterer and saltier but less sweet and sour when listening to the song played by piano. Overall and according to the adults' results, the differences between the averages are low (figure 10). They are never higher than 0.5. The prevalent tastes are once again sweet and bitter.

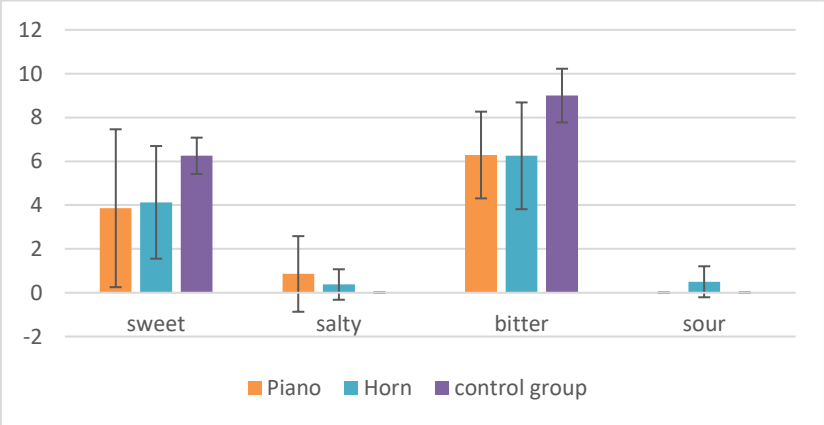

Figure 10: Chart showing the average of the perceived tastes as calculated by 15 adults' answers. They were listening to "The Rohan Theme" played by either a high-pitched piano or a low-pitched French horn while tasting dark chocolate. The control group consisting of four students tasted the chocolate without listening to music. The error bars represent the SEM.

The chocolate is liked more when listening to the track played by French horn in both groups (figure 11). The students' results show a higher difference between the percentages while the adults' results are only slightly different from each other (~ 4%)

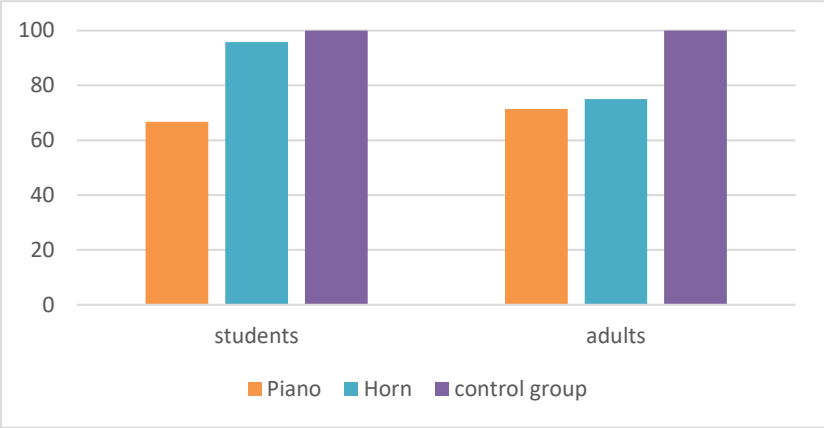

Figure 11: Chart displaying the pleasantness of dark chocolate while listening to "The Rohan Theme" played by either a high-pitched piano or a low-pitched French horn. The bar shows the percentage of people who liked it. The control group of four students tasted the chocolate without listening to music. There was only one control group, which is why both of their columns are the same. There were 55 students and 15 adults in this experiment.

3.2 Adjectives

The varying number of participants mentioned in the captions is due to sometimes mistaken orders of the questionnaire. This means that some participants have received false adjectives, which were not meant to be paired with the present foodstuff.

3.2.1 Major and minor

According to the students, the marmalade is seen as fresher and more vivid but less intense and fruity when presented with "The Love Theme" in major than when presented with the same song in minor (figure 12). Most differences are low with values between 0.05 and 0.59. "Fresh" is an exception with a rather high difference of 1.25.

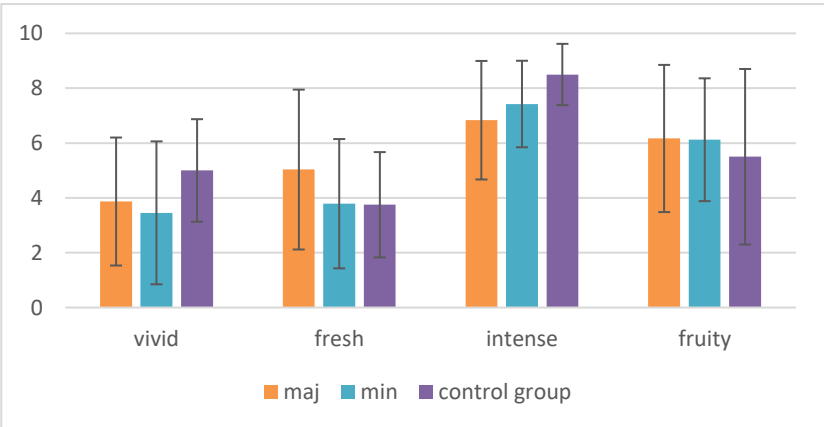

Figure 12: Chart showing the average of the pre-selected adjectives as calculated by 67 students' answers. Twenty-three of them were listening to "The Love Theme" in either major or minor while tasting orange marmalade. The control group consisting of four students tasted the marmalade without listening to music. The error bars represent the SEM.

In the case of the adults, the marmalade tastes fresher, fruitier, more intense and more vivid when listening to the song in major (figure 13). The averages of "fresh" have a low difference of only 0.33, while the averages of "fruity" have a rather high difference of 2.17.

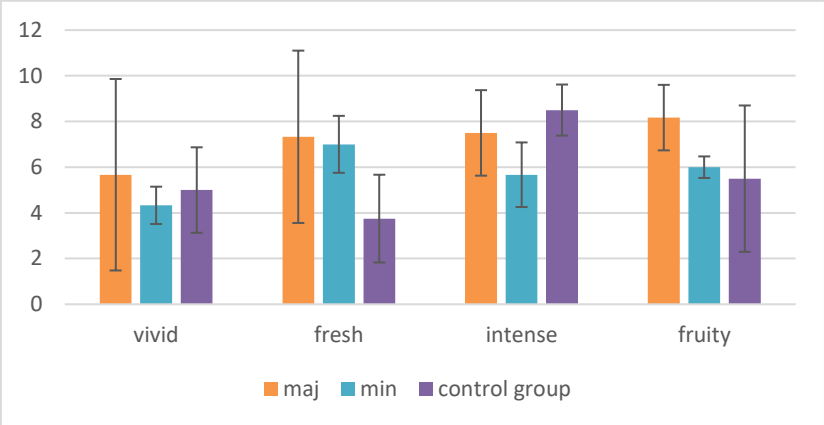

Figure 13: Chart showing the average of the pre-selected adjectives as calculated by six adults' answers. They were listening to "The Love Theme" in either major or minor while tasting orange marmalade. The control group consisting of four students tasted the marmalade without listening to music. The error bars represent the SEM.

3.2.2 Jazz and rock

When listening to rock, the crisps are perceived more modern, vivid and enjoyable but less hard than when listening to jazz according to the students' results (figure 14). The differences in average do not exceed 1.3 (difference in the case of "hard"), leaving them rather low.

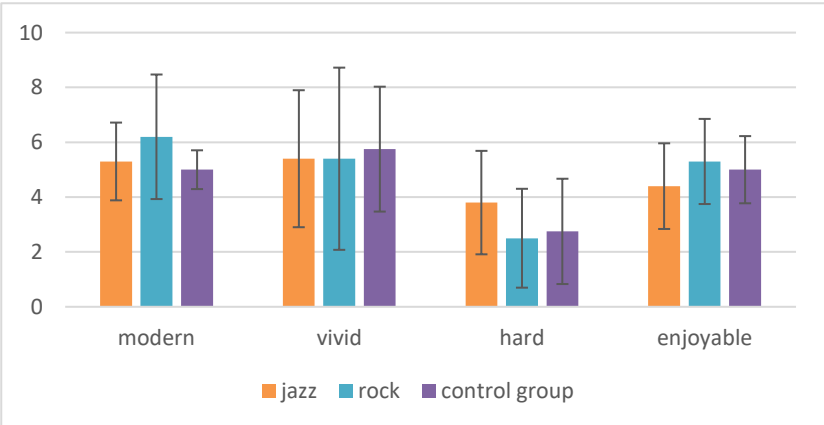

Figure 14: Chart showing the average of the pre-selected adjectives as calculated by 24 students' answers. Twenty of them were listening to "Feeling Good" in the style of either jazz or rock while tasting salt and vinegar crisps. The control group consisting of four students tasted the crisps without listening to music. The error bars represent the SEM.

The adults' results show that the crisps are seen as harder and more vivid but less modern and enjoyable when listening to rock than when listening to jazz (figure 15). Just like the students' results, the adults' results have low differences with "vivid" being the highest with 1.32.

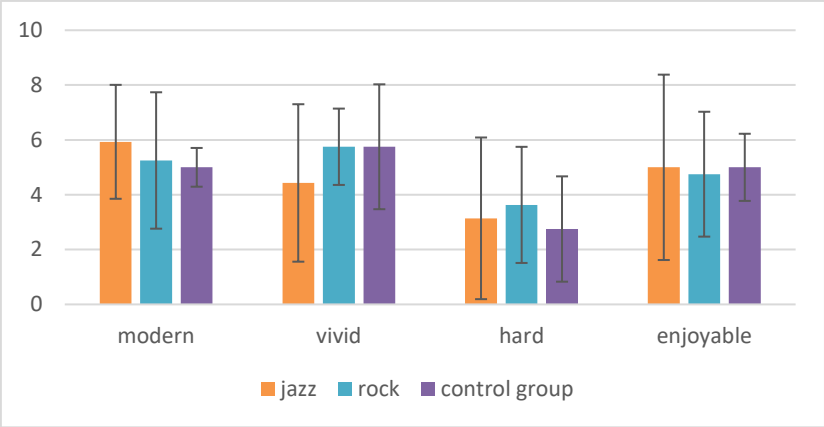

Figure 15: Chart showing the average of the pre-selected adjectives as calculated by 15 adults' answers. They were listening to "Feeling Good" in the style of either jazz or rock while tasting salt and vinegar crisps. The control group consisting of four students tasted the crisps without listening to music. The error bars represent the SEM.

3.2.3 High-pitched piano and low-pitched French horn

The students' results suggested that the chocolate is perceived mightier but less soft and fruity when listening to the piano tones (figure 16). The perception of a delicate attribute is the same in both cases.

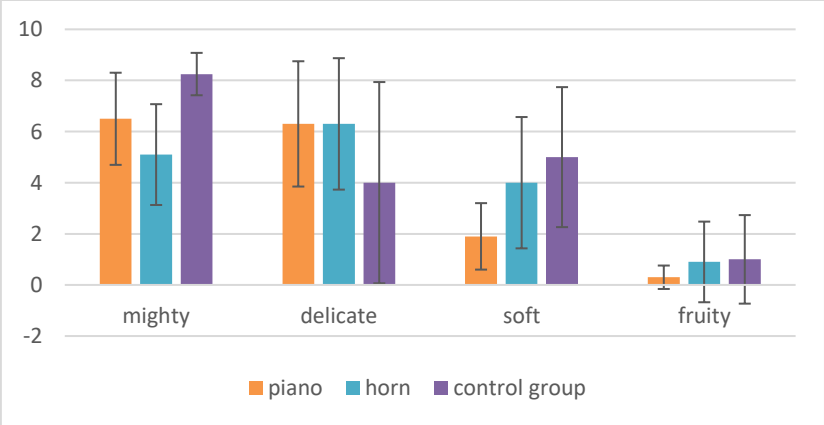

Figure 16: Chart showing the average of the pre-selected adjectives as calculated by 24 students' answers. Twenty of them were listening to "The Rohan Theme" played by either a high-pitched piano or a low-pitched French horn while tasting dark chocolate. The control group consisting of four students tasted the chocolate without listening to music. The error bars represent the SEM.

The adults see the chocolate as mightier, softer and more delicate when listening to a low-pitched French horn than to a high-pitched piano (figure 17). The rating of the fruitiness is low in both cases but the French horn has not evoked any fruity sensation at all, leaving this bar at zero.

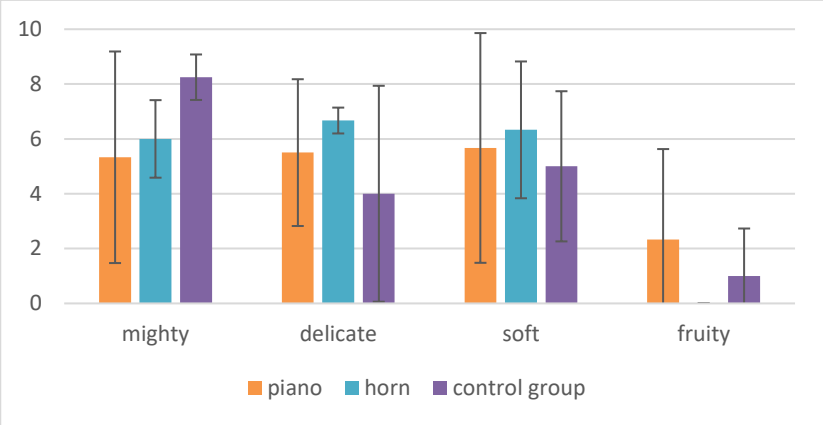

Figure 17: Chart showing the average of the pre-selected adjectives as calculated by six adults' answers. They were listening to "The Rohan Theme" played by either a high-pitched piano or a low-pitched French horn while tasting dark chocolate. The control group consisting of four students tasted the chocolate without listening to music. The error bars represent the SEM.

4 Discussion

4.1 Basic tastes and pleasantness

4.1.1 Major and minor

The marmalade was perceived sweeter and saltier, but also less bitter and sour when listening to the song in major. However, the standard deviation is high and the difference between the average in major and minor is small in the case of sour and salty, which leads to the conclusion that the different key could not influence these two tastes to a convincing extent. Supported by the control group's results, one argument is that salty can hardly be tasted in marmalade and therefore, it is difficult to note a possible influence. Sour, however, is a present taste, which is why there should be another explanation. Nevertheless, the high p-value (statistical measure to show significance calculated by the t-test) of 0.52 indicates insignificance, which makes the results unreliable. Further discussion is therefore left away.

The difference between the two sweetness averages is rather high with 1.12 and the p-value of 0.046 shows that these results are significant. Hypothesis 1 can therefore be confirmed. The preliminary experiment has already shown that the music itself is perceived sweet, which leads to the conclusion that major and sweetness are naturally associated. They seem to share certain attributes such as being a mood-booster or evoking round sensations, which could be why they are put in relation.

The results for the bitterness, on the other hand, have a p-value of only 0.004 and are therefore significant. Hypothesis 2 appears to be true. It could be said that one reason for experiencing a bitterer sensation is the dull feeling that comes with a soundtrack in minor. As the study "the taste of music" has shown (see chapter 1.1.2), an often played interval in improvisations to the target word "bitter" was a semitone, also known as *minor* second. It is odd sounding and can – as the name suggests – often be found in compositions in minor. The word "bitter" itself naturally animates trained musicians to play something in minor. [13]

The marmalade was more pleasant when listening to major. This speaks in favour for hypothesis 7 as the sweeter version was liked more. However, it goes against the hedonic matching mentioned in the study "as bitter as a trombone" since the preliminary experiment showed that the extract in minor was liked more. [8]

With a p-value ranging from 0.39 to 0.96, none of the adults' results is significant. Maybe if there had been more than 15 participants, these values would look differently. Nonetheless, the adults had a different perception than the students in every taste, leaving the results inverted. As this study was not intended to focus on the development of the gustatory perception, it remains unanswered whether this change in perception is based on personal taste or age difference. Besides, the adults were tested in a different room than the other groups since they were not able to come to the classroom at desired times. This different setting might have contributed to their perception as well.

However, in this group the tastes salty and sour, too, remain almost uninfluenced by the change of the key. For further discussion on the topic of these two tastes, see chapter 4.1.3. Surprisingly, there has been almost no difference between the two averages of bitter, but due to both of them being lower than the control group's average, it can be said that the music did have an influence, just not the assumed one. The biggest difference is in sweetness, where minor assumingly evoked a sweeter taste than major. Any reason other than personal taste has not been found. Hypotheses 1 and 2 cannot be confirmed.

4.1.2 Jazz and rock

Hypotheses 3 and 4 call for varying results in salty and sour, but they have to be denied since both tastes have a low difference in average and a p-value of over 0.45. Once again, the background music could not influence these two tastes. For a further discussion on this topic, see chapter 4.1.3.

Both the "sweet" and "bitter" results are significant with a p-value of 0.02 resp. 0.004. Listening to jazz resulted in both a higher sweetness and bitterness, which could lead to the conclusion that this musical style did not enhance specific tastes but the overall intensity. Adding up all results from the tastes when listening to jazz leaves an intensity average of 16.6 per person, when listening to rock it is only 13.3. The varying intensity could be justified with jazz being generally more associated with a relaxed environment. The listener could then possibly focus on other things like the taste. Students associated TV-commercials and picnics, which are rather relaxing, with jazz, whereas they associated rock with parties and aperitifs. This assumption does speak against the intensity matching, though. However, it could be argued that the theory of intensity matching focuses mainly on loudness and volume rather than the intensity itself and what atmosphere it evokes. [18]

Neither hypothesis 3 nor 4 can be confirmed. The musical styles used in this study do influence the tastes bitter and sweet but supposedly, it does not have to do with them sounding round and balanced or harsh and sharp.

The crisps were slightly liked more when listening to rock. The preliminary experiment's results speak against this as they show a higher pleasantness of the jazz track. Hypothesis 7 cannot be confirmed because the crisps were perceived sweeter when listening to jazz but liked less. This could rely on the fact that crisps are meant to be a salty snack and the appearance of sweetness could be off-putting to some people.

Apart from the ones in sweetness, no results provided by the adults are significant in the crisps' case. Only when it comes to bitterness do the two test groups agree, since both rated the crisps tasting bitterer when listening to jazz. The high average in saltiness when listening to jazz implies a clear dominance of this taste. That is maybe the reason why the other tastes have been rated so low. The crisp's intensity when rock is playing is about the same as the students have

rated it (adults: 13.125, students: 13.25), whereas it dropped from 16.6 to 12 when listening to jazz. As the associations were similar to what the students said, the explanation given earlier does not apply here. Taking the focus on loudness in the intensity matching in mind, it might be the fact that the volume of the music was different of necessity, since it was played via amplifier on the laptop rather than an external one (as used with the students), that decided this divergent result. This assumption is not proven, though. Once again, hypotheses 3 and 4 cannot be confirmed. [18]

4.1.3 High-pitched piano and low-pitched French horn

Even though the p-values of the salty and sour perception of 0.03 and 0.04 indicate the significance of the results, the low differences in average (0.35 and 0.88) show once more that these two tastes remain almost unaffected by changing the background music. One reason could be that the association between these tastes and music is not as natural as with the other tastes. Sweet and bitter are often used to describe music or the emotional state, in which the artist performing the song is. Sour and salty, on the other hand, mainly function as taste description. Surely, they could also be used to describe people, but finding a piece of music that would be defined as clearly sounding sour or salty is rather difficult.

Since hypotheses 5 and 6 actually relied on precedent scientific studies, the results for bitter and sweet were surprising. As it was already stated in the study "a bittersweet symphony" (see chapter 1.1.1), high-pitched piano tones did make the foodstuff taste sweeter than when listening to low-pitched brass tones. Nonetheless, the p-value of 0.21 and the low difference in average indicates that these results are nonsignificant. The differences in average of the bitter taste is hardly noticeable (0.31) and with a p-value of almost 0.4, these results, too, are nonsignificant. They spoke against hypothesis 5 to begin with, since the high-pitched piano tones seemingly evoke a bitterer taste. According to the results from the previously mentioned studies "as bitter as a trombone" and "a bittersweet symphony" (see chapter 1.1.1), this effect should be inverted. Hypotheses 5 and 6 cannot be confirmed, even though the piano did make the chocolate taste slightly sweeter overall. [8, 9]

One reason for the results being so different could be that the dark chocolate may have been too bitter. The cocoa content was 72%, which means that the bitter side clearly dominated, making it hard to experience sweet in a convincing way. Another reason might be the quality difference between the auditory stimuli. The brass notes had a lower quality due to pitching and that may have made it difficult to hear it properly in order to influence the gustatory perception. This assumption could be put in relation with the higher intensity (13 when listening to piano, 10.2 when listening to French horn) and since the brass track was duller, the chocolate might have been perceived duller as well (see chapter 4.4).

The pleasantness of the chocolate was higher when listening to the soundtrack played by the French horn but the chocolate was perceived sweeter when listening to the track played by the piano. Besides, in the preliminary experiment, the horn soundtrack was disliked the most of all extracts. Once again, hypothesis 7 is assumingly wrong. If anything, the contrary might be the case: in two of three cases, the foodstuff was liked more when it was perceived bitterer. In order to prove this statement, further researches would have to be made (see chapter 4.5).

The adults seem to agree with the students that high-pitched piano tones resulted in the foodstuff tasting both saltier and slightly bitterer. The differences in all averages are very low and the p-values range from 0.11 to 0.98, making the results unsound. The hypotheses 5 and 6 cannot be confirmed once again. The explanations given earlier that the chocolate was too bitter to begin with and the low quality of the horn track could apply here as well. The overall intensity is inverted from the students' rating, i.e. the adults perceived the chocolate to have a more intense

flavour when listening to low-pitched French horn tones (piano: 11, horn: 12.8). As it was already the case before with the crisps, the different intensity ratings could have been caused by the difference in volume.

4.2 Adjectives

It has to be noted that apart from one result (soft in the students' results), none of the following results is significant. All of their p-values range from 0.13 up to 1. This discussion is therefore based on unreliable results.

There was no adult test group in the preliminary experiment but because of comparison reasons, these results will come into consideration nonetheless.

4.2.1 Major and minor

It could be said that to evoke a fruitier, fresher and more vivid sensation in food, songs in major seem to match, whereas songs in minor trigger a slightly more intense sensation. Apart from the results from vivid, the results are in accord with the ones from the preliminary experiment. Therefore, it can be added that the music was somehow responsible for the difference. It does not become clear, whether it was solely the music or also the adjectives providing the manipulating effect when influencing the perception. The results also resemble the findings of "The Effect of Background Music on the Taste of Wine" as the adjectives that matched the music also could be used to describe the foodstuff. It has to be noted that the differences in average are low and the p-values high, though. Moreover, the lack of congruence for vividness makes the music's effect questionable. Hypothesis 8 cannot be confirmed, but it can be said that the music did influence the matching of adjectives and the foodstuff slightly. [22]

The adults' results in the main experiment are the same as in the preliminary experiment concerning the adjectives "fresh" and "fruity". Contrary to the results of the first experiment, the marmalade was perceived more vivid and intense when listening to major. This is also different from the students' results. Due to the fact that there was no adult group participating in the preliminary group, it could also be that the adults would have perceived the music itself differently. This assumption is in need of proof through performing the preliminary experiment with the adults, though. Another reason for the change in perception of a "vivid" attribute could be that the adults might have known the movie "The Godfather" better, in which this song is played. Therefore, they would not necessarily associate this rather sad, thought-provoking and reverent movie with "vivid".

4.2.2 Jazz and rock

Jazz made the crisps taste harder but less modern and enjoyable than when listening to rock. There is no difference between the averages of "vivid". Only the results from "modern" matched the results from the preliminary experiment whereas "hard" and "enjoyable" appeared in inverted form. One reason for the difference in the case of "hard" might be the comparison of the crisp's firm texture with the music. As the preliminary experiment has shown, the rock song was often associated with a hard attribute and therefore, the texture of the crisp appeared less hard compared to the rock music. One reason for the inverted results when speaking of "enjoyable" could be the generally higher pleasantness of the crisp when listening to rock music. That there is no difference between the averages of "vivid" (one when listening to jazz, the other when listening to rock), is supported by them being almost identical to the control group's one, i.e. the music had almost no influence on the vivid sensation of the crisp.

All results by the adults are the different way around in comparison to the students' results. However, they match the results from the preliminary experiment in the case of "hard" and

"enjoyable". The explanation given above concerning "hard" does consequently not apply here. It can be said that the change of musical style did have a slight influence on the way the crisps would be described but considering the fact that these results are nonsignificant and do not resonate with them above, hypothesis 8 cannot be confirmed.

4.2.3 High-pitched piano and low-pitched French horn

When listening to piano, the chocolate appeared to be mightier but less soft and fruity than when listening to the song played by a French horn. The varying instrument and pitch did not affect the perception of a "delicate" attribute, thus the averages are the same.

These results are the inverted version of what the preliminary experiment has shown. This can either be justified by the lack of "manipulating" elements in the auditory stimulus or the dominance of the traits the chocolate provides. However, a reason speaking against this assumption is that the control group has clearly different results. That means that the music did have an influence, but the adjectives that were matched to the music do not necessarily match the chocolate.

The adults' results agree with the ones from the students on the fact that chocolate seems to be softer when brass tracks are playing. However, they perceived it to be mightier, more delicate and less fruity, which is different from the students. These results match with the preliminary experiment in the case of "mighty" and "fruity". This would speak against the assumption mentioned above that these adjectives do not match chocolate. It could be argued that the adults have paid more attention to the music and have therefore seen more attributes as suitable. As there were no changes apart from the setting and the amplifier, this assumption is rather vague and does not rely on anything other than intuition. Since these results were compiled from only six people, it is unclear how adaptable these results are.

4.3 Conclusion

Students and adults have different perceptions, which makes it difficult to argument in a convincing way. What can be said is that music does have an influence on the gustatory perception to a certain extent. None of the hypotheses were confirmed due to either insignificance, false assumptions or the fact that the contrary might have happened.

As a summary, everything of significance found out in this study is listed here:

- Songs in major enhance sweet and reduce bitter flavours according to teens' gustatory perception.
- Songs in minor have the opposite effect, i.e. they enhance bitter flavours.
- Jazz – particularly in vocal/easy listening style – enhances the foodstuff's intensity, making it taste both sweeter and bitterer.
- Neither high-pitched piano tunes nor low-pitched French horn sounds have a huge influence on the gustatory perception.
- Attributes of the music do not necessarily have to be found in the foodstuff presented with it.
- Overall, music has an influence on the gustatory perception, since the control group had diverse results in almost every case.

It could be made use of these results in restaurants, bars or possibly even stores (see chapter 4.5). Music could be used to enhance or reduce certain tastes, much like a seasoning. It could function as trigger for certain sensations and/or it could be used to play with the guests' mind. "The Fat Duck", a restaurant by three Michelin-star chef Heston Blumenthal, already makes use of previous findings by providing a multisensory dining experience. One of its signature

dishes is “the sound of the sea”. The guests receive their seafood meal and a shell with headphones in it, through which noises from the sea are played to enhance the feeling of being at the beach. It should supposedly taste more pleasant that way. Based on the present study, a similar approach could be made but with music rather than just noises. [33]

4.4 Methodological critique

One problem with the method was that this study was not intended to deal with the difference in perception between teens and adults. Nonetheless, this was a major aspect in the discussion and it would have been helpful to know more about it. If the intention of analysing different age groups had been stated from the beginning, the scientific knowledge on this topic could have been acquired. However, this study covered an already large variety of topics to begin with. This leads to the next point, which is the fact that probably too many variables were taken into consideration. This may have led to inaccuracy in the discussion, which possibly could have been avoided.

Another point of criticism is the false order in which the questionnaire has been distributed, leaving less results than needed for the significance of the adjectives. This is not necessarily the method’s fault but constructing the questionnaire to ensure a right order would have prevented this.

The results from the preliminary experiment and the main experiment could have been discussed better, if the same assessment was used. The numbers in the first experiment represented how many people have ticked a certain adjective. The numbers in the second experiment stood for a number on a scale from one to ten in order to find out how much the certain adjective would be recognised. Due to this difference, the relation between these results could not be put into numbers.

As mentioned in chapter 4.1.3, the chocolate was probably too bitter, since it contained 72% cocoa. That was most likely responsible for the dominance of the bitterness. A chocolate with only 50% might have provided better results.

Another factor on this topic was the lower quality of the brass track compared to the piano track. It is normal that quality changes with pitching it manually but maybe it could have been prevented of dropping this far by choosing another conversion tool or pitching it less.

4.5 Suggestions for further researches

It would be interesting to see, whether musical styles other than rock and jazz could have an influence on the gustatory perception as well. Especially after mentioning the almost natural association between sweetness and pop music, having results to underlie this assumption would make a difference.

As this study has shown, music can sometimes act as some sort of “seasoning” for a foodstuff. An idea for further research could therefore be, whether it is possible to substitute or at least reduce sugar or salt. The foodstuff “seasoned with music” could provide a healthier alternative.

Another suggestion is based on hedonic matching. If the participants were to rate the foodstuff listening to their favourite song or genre, would they automatically like the foodstuff better as well and vice-versa? However, it would call for a previous clarification, whether the participants already liked the foodstuff without listening to music.

A fourth idea is more on the marketing-based side and parts of it have already been researched. For further information on this topic, see [34] in the references. Could the background music in a store or restaurant tempt people to buy a sweeter or bitterer product as the association is rather present that way?

Lastly, the assumption given in chapter 4.1.3 could provide an idea for further researches: Does music that evokes bitterness make food taste better? As a result, is bitter-tasting food liked more than sweet-tasting food?

5 Reflection

Generally, I am content with how this paper has turned out. At first, I slightly doubted my decision on what to write this study about after I had seen how little this field had been researched. This meant that I would not have a lot of room for comparisons. Nonetheless, I enjoyed getting into the topic and watching my paper fall into place. In the end, all this work seemed to pay off judging of what I have achieved.

In the beginning, I have set myself a tight schedule in order to work on my discipline and to get things done in time. I was yet to realise that this would not work. I still procrastinated a lot and found ways to put off the parts that were not that interesting to me. Moreover, school was demanding and it was difficult for me to stay focused after it with everything else piling up. Luckily, I could at least stay on the schedule provided by my supervisor. This is something I would have to work on for another time.

Organising and scheduling the experiments with the classes required a lot of back and forth between the responsible teachers and me, but everything ran smoothly and I am glad that the classes participated that well.

Writing this study in English has offered me an insight in another area of this language I was not exactly familiar with. I had to look up most technical terms and idioms that are not in the everyday language. Surely, I am still not completely fluent in scientific English and do have to look up certain words but through this paper, I have gained a lot of understanding and I have learnt to express myself on a technical level.

When I got to the part of statistically evaluating my data, I became aware of the fact that I have never had statistics in school. It would have come in handy to know the basics but luckily, I figured out most of it. For another time, I would ask my supervisor more questions in advance.

As I have mentioned a couple of times, I have not intended to perform my experiments with adults. I was not aware of the fact that still doing so would mean that I would possibly have to evaluate the age difference as well. Whenever I thought that I had a reasonable explanation for a phenomenon in the students' results, the adults' results made it invalid. Next time I would thoroughly think my process and the consequences through before deciding to do something that I have not intended to do.

6 References

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[30] Marmelade Bitterorangen, Migros, Migros Sursee.

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7 Acknowledgement

I would like to thank my family for enduring all of my test experiments, helping me out with any questions I had and supporting me throughout.

Many thanks to my supervisor Mister Lussi for answering every ever so trivial question and to my SJF-expert Bernhard Sollberger for supporting me with his expertise.

Lastly, I would like to thank all my participants and the responsible teachers for letting me perform my experiment with them.

8 Annex

A1: Questionnaire for the preliminary experiment. For translations, see chapter 2.1.2.2.

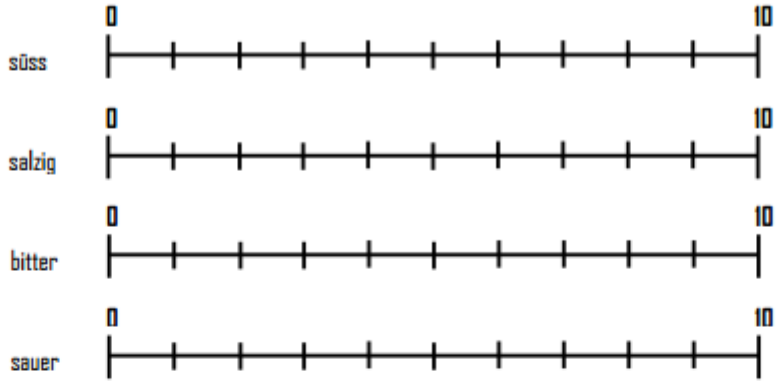
Geschlecht: m/f Alter: ___

Auszug 1	Auszug 2	Auszug 3	Auszug 4	Auszug 5	Auszug 6
☐ mächtig	☐ mächtig	☐ mächtig	☐ mächtig	☐ mächtig	☐ mächtig
☐ frisch	☐ frisch	☐ frisch	☐ frisch	☐ frisch	☐ frisch
☐ lebhaft	☐ lebhaft	☐ lebhaft	☐ lebhaft	☐ lebhaft	☐ lebhaft
☐ fein	☐ fein	☐ fein	☐ fein	☐ fein	☐ fein
☐ luftig	☐ luftig	☐ luftig	☐ luftig	☐ luftig	☐ luftig
☐ weich	☐ weich	☐ weich	☐ weich	☐ weich	☐ weich
☐ hart	☐ hart	☐ hart	☐ hart	☐ hart	☐ hart
☐ süss	☐ süss	☐ süss	☐ süss	☐ süss	☐ süss
☐ bitter	☐ bitter	☐ bitter	☐ bitter	☐ bitter	☐ bitter
☐ langweilig	☐ langweilig	☐ langweilig	☐ langweilig	☐ langweilig	☐ langweilig
☐ familiär/heimelig	☐ familiär/heimelig	☐ familiär/heimelig	☐ familiär/heimelig	☐ familiär/heimelig	☐ familiär/heimelig
☐ angenehm	☐ angenehm	☐ angenehm	☐ angenehm	☐ angenehm	☐ angenehm
☐ fruchtig	☐ fruchtig	☐ fruchtig	☐ fruchtig	☐ fruchtig	☐ fruchtig
☐ modern	☐ modern	☐ modern	☐ modern	☐ modern	☐ modern
☐ intensiv	☐ intensiv	☐ intensiv	☐ intensiv	☐ intensiv	☐ intensiv
Assoziationen:	Assoziationen:	Assoziationen:	Assoziationen:	Assoziationen:	Assoziationen:
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

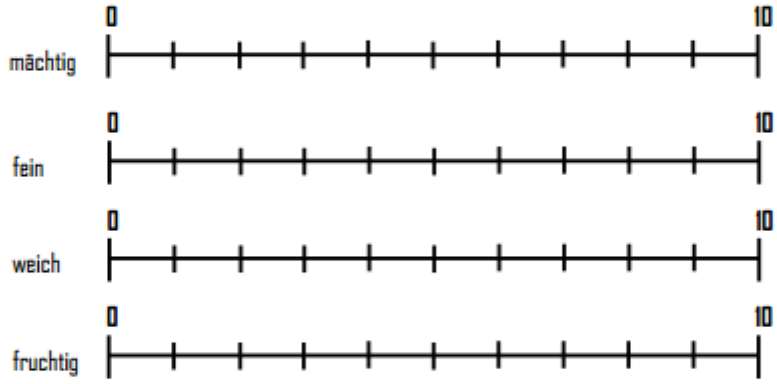
A2: Questionnaire for the main experiment. See chapter 2.2.2.3 for translations

Fragebogen Maturaarbeit Alter: Geschlecht:

Wie empfindest du das Lebensmittel? Bitte kreuze auf jeder Skala an, wie stark die Geschmacksrichtung ausgeprägt ist. 0 bedeutet „überhaupt nicht ausgeprägt", 10 bedeutet „sehr stark ausgeprägt".



Bitte kreuze auf jeder Skala an, wie stark die Adjektive auf das Lebensmittel zutreffen. 0 bedeutet „trifft überhaupt nicht zu", 10 bedeutet „trifft sehr stark zu".



Magst du das Produkt? Bitte kreuze an. ja/nein

Fallen dir zutreffendere Beschreibungen ein als die oben genannten? Bitte notiere diese.

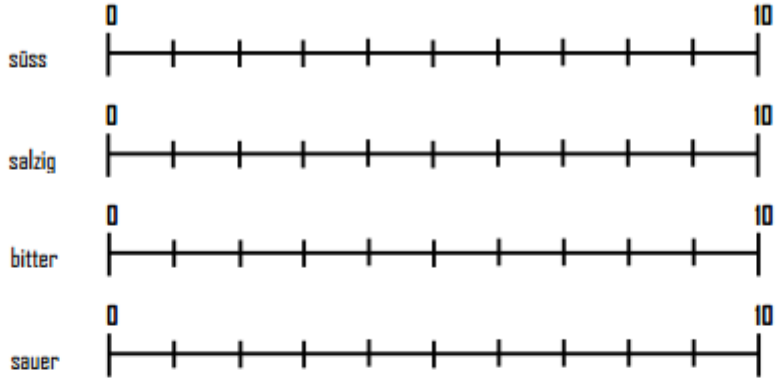
Welche Assoziationen (Bilder, Erlebnisse, Gefühle...) hat das Produkt beim Probieren hervorgerufen? Bitte notiere diese.

Bist du erkältet oder ist dein Geschmacks- und Geruchssinn sonst eingeschränkt? Bitte kreuze an und notiere bei einem „Ja" kurz die Art der Einschränkung. ja/nein

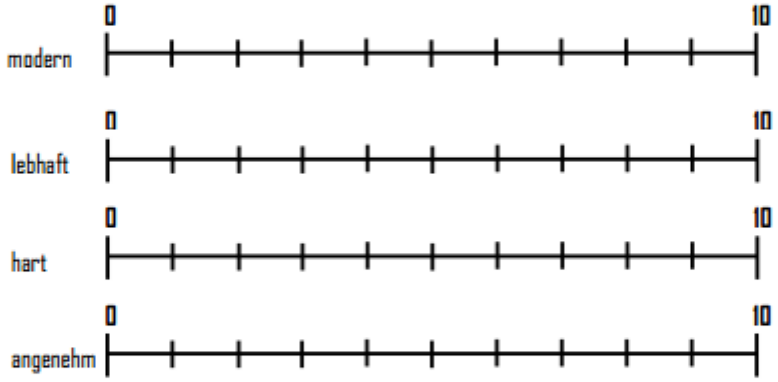
Hast du kurz vorher etwas gegessen? Bitte kreuze an und gib bei einem „Ja" kurz an, was du gegessen hast. ja/nein

Fragebogen Maturaarbeit Alter: Geschlecht:

Wie empfindest du das Lebensmittel? Bitte kreuze auf jeder Skala an, wie stark die Geschmacksrichtung ausgeprägt ist. 0 bedeutet „überhaupt nicht ausgeprägt", 10 bedeutet „sehr stark ausgeprägt".



Bitte kreuze auf jeder Skala an, wie stark die Adjektive auf das Lebensmittel zutreffen. 0 bedeutet „trifft überhaupt nicht zu", 10 bedeutet „trifft sehr stark zu".



Magst du das Produkt? Bitte kreuze an. ja/nein

Fallen dir zutreffendere Beschreibungen ein als die oben genannten? Bitte notiere diese.

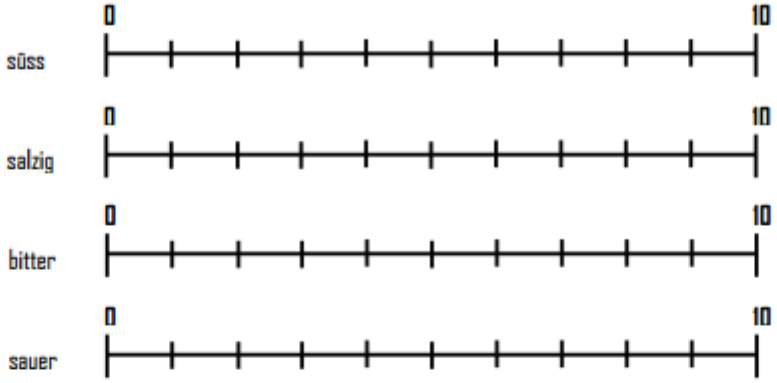
Welche Assoziationen (Bilder, Erlebnisse, Gefühle...) hat das Produkt beim Probieren hervorgerufen? Bitte notiere diese.

Bist du erkältet oder ist dein Geschmacks- und Geruchssinn sonst eingeschränkt? Bitte kreuze an und notiere bei einem „Ja" kurz die Art der Einschränkung. ja/nein

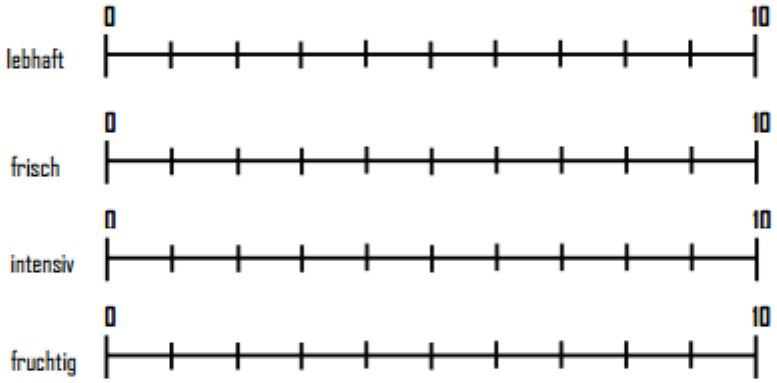
Hast du kurz vorher etwas gegessen? Bitte kreuze an und gib bei einem „Ja" kurz an, was du gegessen hast. ja/nein

Fragehngen Maturaarbeit Alter: Geschlecht:

Wie empfindest du das Lebensmittel? Bitte kreuze auf jeder Skala an, wie stark die Geschmacksrichtung ausgeprägt ist. 0 bedeutet „überhaupt nicht ausgeprägt", 10 bedeutet „sehr stark ausgeprägt"



Bitte kreuze auf jeder Skala an, wie stark die Adjektive auf das Lebensmittel zutreffen. 0 bedeutet „trifft überhaupt nicht zu", 10 bedeutet „trifft sehr stark zu".



Magst du das Produkt? Bitte kreuze an. ja/nein

Fallen dir zutreffendere Beschreibungen ein als die oben genannten? Bitte notiere diese.

Welche Assoziationen (Bilder, Erlebnisse, Gefühle...) hat das Produkt beim Probieren hervorgerufen? Bitte notiere diese.

Bist du erkältet oder ist dein Geschmacks- und Geruchssinn sonst eingeschränkt? Bitte kreuze an und notiere bei einem „Ja" kurz die Art der Einschränkung. ja/nein

Hast du kurz vorher etwas gegessen? Bitte kreuze an und gib bei einem „Ja" kurz an, was du gegessen hast. ja/nein

A3: Table with the results from the main experiment for major and minor. See figures 3-5 for charts. The numbers in the respective first row stand for the age of the participant, the letter for the sex (m: männlich/male, w: weiblich/female). When they are coloured blue, the participant reported a minor impairment of senses. Green stands for "having eaten half an hour before the experiment". The grey coloured segments are the adults' results. CG stands for control group.

		13m	13m	14m	14m	14m	14m	12m	13m	13m	13m	12w	13w	13w	13w	14w	13w	12w	13w	13w	13w	13w	12w	13w	13w	12m	13m	13w	12w	13w	12w	13w	12w	12w	12w	13w	12w	12w	12w	13w	12m	12m	12m	13m	average	standard deviation	t-test
maj	sweet	9	8	7	6	9	3	6	7	8	3	6	2	3	7	1	6	10	8	7	7	7	10	10	9	5	1	1	3	3	4	6	4	5	3	4	4	5	8	8	8	6	8	5	3	6	7	8	5,83	2,47	0,05
	salty	1	6	0	0	0	0	0	3	4	0	0	3	1	0	1	0	0	0	0	0	3	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	2	0	0	3	0,66	1,29	0,05
	bitter	3	1	3	6	8	9	3	4	7	10	5	7	6	7	8	8	0	0	4	5	4	2	0	3	3	5	9	7	8	8	8	3	8	8	5	7	5	5	5	8	3	6	5	8	7	2	2	5,28	2,61	0,00
	sour	1	9	1	2	5	1	0	4	1	5	7	8	2	5	6	7	4	3	0	0	1	1	1	7	0	1	9	4	0	2	5	2	8	1	2	1	2	2	1	2	4	4	0	6	2	0	7	3,11	2,69	0,52
	like?	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0	0	1	1	1	1	1	1	0	1	1	1		44,68		

		13w	14w	13w	13w	12w	12w	14m	13m	13m	13m	13m	14m	13w	13m	13m	13m	14m	13w	13m	13m	12m	12m	13m	13m	12w	13w	12w	13w	12w	12w	12m	14m	13m	13m	12m	12m	12w	13m	12w	13w	12w	average	standard deviation	t-test
min	sweet	7	8	9	6	10	7	7	1	7	3	6	4	7	5	7	3	1	3	1	0	3	7	0	7	3	2	0	5	5	6	3	2	6	3	10	3	3	6	6	6	6	10	1	2				4,70	2,78	
	salty	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2	0	0	0	0	3					0,23	0,63	
	bitter	7	7	0	6	7	8	9	9	2	8	2	2	4	8	10	4	8	10	4	8	10	8	9	8	5	8	8	3	7	7	9	8	7	10	8	8	4	10	7	6	6	7	7	8				6,84	2,41	
	sour	6	1	0	1	1	2	1	7	2	0	7	2	2	4	5	9	8	8	9	6	8	0	7	0	4	1	10	4	4	2	3	0	4	0	0	0	0	8	3	2	2	2	5	4				3,50	3,01	
	like?	1	0	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0				31,82		

		35w	22w	52w	58w	63w	29w	32m			
maj	sweet	0	6	9	7	8	5	0	5.00	3.38	0.39
	salty	0	0	1	0	0	0	0	0.14	0.35	0.47
	bitter	0	6	7	7	9	8	9	6.57	2.87	0.96
	sour	8.5	2	0	1	7	2	6	3.79	3.07	0.48
	like?	0	1	1	1	0	0	0	42.86	0.49	

		36m	29m	50m	57m	50w	50w	26w	26w		
min	sweet	8	6	0	8	7	6	9	8	6.50	2.65
	salty	0	0	0	0	1	2	0	0	0.38	0.70
	bitter	8	1	10	7	5	8	6	7	6.50	2.50
	sour	2	0	10	0	3	5	0	0	2.50	3.32
	like?	1	1	0	1	1	1	0	0	62.50	0.48

		17w	16w	17w	17w		
CG	sweet	8	6	3	5	5.50	1.80
	salty	0	0	1	0	0.25	0.43
	bitter	10	8	5	8	7.75	1.79
	sour	5	1	7	4	4.25	2.17
	like?	0	1	0	1	50.00	0.50

A4: Table with the results from the main experiment for jazz and rock. See figures 6-8 for charts. The numbers in the respective first row stand for the age of the participant, the letter for the sex (m: männlich/male, w: weiblich/female). When they are coloured blue, the participant reported a minor impairment of senses. Green stands for "having eaten half an hour before the experiment". The grey coloured segments are the adults' results. CG stands for control group.

		12w	13w	13w	13w	14w	13w	12w	13w	13w	13w	13w	12w	13w	13w	13w	12w	13w	13m	13m	14m	14m	14m	14m	12m	13m	13m	13m	average	standard deviation	t-test
jazz	sweet	1	3	4	0	1	1	4	4	5	2	7	3	3	0	0	3	0	6	7	2	0	4	2	0	1	6	0	2.56	2.23	0.03
	salty	7	5	7	10	4	4	6	7	8	8	7	9	8	10	9	8	4	8	10	4	5	10	9	7	9	0	10	7.15	2.43	0.46
	bitter	0	0	3	6	0	0	0	1	3	5	0	6	2	0	10	1	7	2	0	6	2	6	1	1	1	0	7	2.59	2.86	0.00
	sour	3	5	5	2	3	5	5	6	1	3	2	7	3	7	10	2	6	3	9	5	0	5	3	0	7	2	7	4.30	2.52	0.54
	like?	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	81.48	0.39	

		13w	14w	13w	13w	12w	12w	14m	14m	13m	14m	13m	13m	13m	14m	13m	13m	13m	12m	12m	13m	13m	13m	14m	14m			
rock	sweet	2	2	0	4	1	6	3	6	0	0	0	0	0	1	0	0	1	0	2	0	0	0	1	0			
	salty	8	9	8	9	9	9	7	10	7	9	8	8	8	8	8	4	9	8	2	3	10	7	9	6			
	bitter	0	0	0	0	0	3	0	0	1	0	0	0	0	1	0	2	1	0	0	6	0	0	1	0			
	sour	8	7	0	0	4	8	0	0	4	4	7	9	3	3	7	3	2	6	5	9	0	0	2	0			
	like?	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1			

		35w	22w	52w	58w	63w	29w	32m			
jazz	sweet	0	0	0	2	0	1	0	0.43	0.73	
	salty	8.5	9	9	9	10	9	7	8.79	0.84	0.01
	bitter	0	0	2	0	1	0	2	0.71	0.88	0.06
	sour	0	0	9	3	2	0	0	2.00	3.07	0.24
	like?	1	1	0	0	0	1	1	57.14	0.49	0.50

		36m	29m	50m	50w	50w	26w	57m	26w		
rock	sweet	3	3	1	3	1	6	1	2	2.50	1.58
	salty	8	6	10	6	5	8	6	9	7.25	1.64
	bitter	0	0	1	1	0	0	0	0	0.25	0.43
	sour	2	2	2	4	7	0	8	0	3.13	2.80
	like?	1	1	1	1	0	1	0	1	75.00	0.43

		17w	16w	17w	17w		
CG	sweet	3	1	0	0	1.00	1.22
	salty	10	6	9	4	7.25	2.38
	bitter	0	0	2	6	2.00	2.45
	sour	0	5	4	9	4.50	3.20
	like?	1	1	1	1	100.00	0.00

A5: Table with the results from the main experiment for piano and horn. See figures 9-11 for charts. The numbers in the respective first row stand for the age of the participant, the letter for the sex (m: männlich/male, w: weiblich/female). When they are coloured blue, the participant reported a minor impairment of senses. Green stands for "having eaten half an hour before the experiment". The grey coloured segments are the adults' results. CG stands for control group.

																																average	standard deviation	t-test
		13m	13m	14m	14m	14m	14m	12m	13m	13m	13m	12w	13w	13w	13w	13w	13w	12w	13w	14w	13w	12w	13w	13w	13w	13w	12w	13w						
Piano	sweet	9	6	3	2	6	4	6	8	2	5	4	6	7	5	8	7	5	5	3	6	0	1	6	1	4	5	4				4.74	2.22	0.21
	salty	1	2	1	0	0	2	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0				0.48	0.63	0.03
	bitter	4	10	5	7	4	8	3	6	8	10	6	7	4	7	0	10	8	4	6	10	10	8	10	10	2	10	8				6.85	2.78	0.39
	sour	2	5	1	0	0	0	0	1	0	0	0	0	0	6	0	1	0	0	0	0	0	0	8	1	0	1	0				0.96	2.01	0.04
	like	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	0	1	1	0	1	0	1				66.67	0.47	
		13w	14w	13w	13w	12w	12w	14m	14m	13m	14m	13m	13m	13m	14m	13m	13m	13m	12m	12m	13m	13m	13m	14m	14m									
Horn	sweet	2	1	2	2	8	6	7	3	10	5	4	6	9	1	4	3	0	3	2	0	7	4	0	3							4.08	2.81	
	salty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0							0.13	0.44	
	bitter	8	8	1	6	5	9	4	7	0	5	5	10	2	5	4	9	10	4	9	10	7	8	5	7							6.54	2.76	
	sour	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0							0.08	0.28	
	like	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1							95.83	0.28	
		35w	22w	52w	58w	63w	29w	32m																										
Piano	sweet	0	0	5	8	9	5	0																								3.86	3.60	0.88
	salty	0	0	1	0	0	5	0																								0.86	1.73	0.51
	bitter	7	7	8	8	2	5	7																								6.29	1.98	0.98
	sour	0	0	0	0	0	0	0																								0.00	0.00	0.11
	like	1	1	1	1	1	0	0																								71.43	0.45	
		36m	29m	50m	57m	26w	50w	50w	26w																									
Horn	sweet	7	7	1	2	6	5	5	0																							4.13	2.57	
	salty	0	0	1	0	0	2	0	0																							0.38	0.70	
	bitter	4	2	9	7	8	4	7	9																							6.25	2.44	
	sour	1	0	2	0	0	1	0	0																							0.50	0.71	
	like	1	1	0	1	1	1	1	0																							75.00	0.43	
		17w	16w	17w	17w																													
CG	sweet	5	6	7	7																											6.25	0.83	
	salty	0	0	0	0																											0.00	0.00	
	bitter	7	9	10	10																											9.00	1.22	
	sour	0	0	0	0																											0.00	0.00	
	like	1	1	1	1																											100.00	0.00	

A6: Table with the results from the main experiment concerning the adjectives for major and minor. See figures 12 and 13 for charts. The numbers in the respective first row stand for the age of the participant, the letter for the sex (m: männlich/male, w: weiblich/female). When they are coloured blue, the participant reported a minor impairment of senses. The grey coloured segments are the adults' results. CG stands for control group.

																																	average	standard deviation	t-test
		12m	13m	13w	12w	13w	12w	13w	12w	12w	12w	12w	13w	12w	12w	12w	13w	12m	12m	13m	12w	13w	13m	13w	13w	13m	14m	14m	14m					
maj	lebhaft	5	4	2	7	1	3	5	1	1	5	7	1	3	2	1	0	3	4	4	8	3	2	9	7	5	6	4	3	7	3		3,87	2,33	0,52
	frisch	1	2	6	7	5	9	7	3	0	7	8	6	6	5	1	0	4	3	9	9	2	2	7	7	8	10	2	4	8	3		5,03	2,92	0,07
	intensiv	4	7	7	10	3	9	6	5	7	7	8	8	8	5	2	10	9	6	3	9	8	7	3	7	6	10	7	8	9	7		6,83	2,16	0,22
	fruchtig	1	3	5	10	3	8	9	2	1	6	7	8	6	4	3	10	6	8	2	9	9	6	7	6	9	10	8	6	7	6		6,17	2,68	0,94
		12w	13w	13w	12w	13w	12w	13w	12w	12w	12m	14m	13m	13m	12m	12m	12m	12w	12w	13m	12m	13w	14w	13w	13w	12w	12w	14m	14m	13m	14m	13m	14m	
min	lebhaft	0	0	0	1	1	2	7	1	0	4	0	5	5	4	5	5	4	0	1	2	6	5	0	7	3	5	7	3	7	3	6	8	7	3,45	2,61	
	frisch	3	2	3	8	8	1	3	3	3	4	4	6	4	1	3	3	3	3	1	2	10	6	6	3	6	1	6	0	0	3	4	7	5	3,79	2,36	
	intensiv	5	6	6	4	4	7	9	8	7	10	9	10	6	10	8	8	9	7	9	6	9	6	7	9	9	7	7	7	8	7	7	6	8	7,42	1,58	
	fruchtig	10	7	6	4	5	6	3	9	8	2	2	3	3	7	6	6	8	3	6	3	8	7	9	10	6	6	8	4	7	7	8	7	8	6,12	2,24	
		17w	16w	17w	17w																													
CG	vivid	8	4	5	3																												5,00	1,87	
	fresh	3	5	1	6																												3,75	1,92	
	intense	10	8	9	7																												8,50	1,12	
	fruity	3	7	2	10																												5,50	3,20	

					average	standard deviation	t-test
		35w	22w	52w			
maj	vivid	0	7	10	5.67	4.19	0.33
	fresh	2	10	10	7.33	3.77	0.58
	intense	5.5	7	10	7.50	1.87	0.78
	fruity	6.5	8	10	8.17	1.43	0.66
		36m	29m	50m			
min	vivid	10	9	8	4.33	0.82	
	fresh	7	6	4	7.00	1.25	
	intense	9	6	9	5.67	1.41	
	fruity	8	9	9	6.00	0.47	

A7: Table with the results from the main experiment concerning the adjectives for jazz and rock. See figures 14 and 15 for charts. The numbers in the respective first row stand for the age of the participant, the letter for the sex (m: männlich/male, w: weiblich/female). When they are coloured blue, the participant reported a minor impairment of senses. The grey coloured segments are the adults' results. CG stands for control group.

		35w	22w	52w	58w	63w	29w	32m	12w	13w	13m	13w	13w	13m	14m	14m	14m	14m	average	average	standard deviation	standard deviation	t-test	t-test
jazz	modern	5.5	5	4	8	5	10	4	2	5	6	4	6	5	6	7	5	7	5.98	5.30	2.08	1.42	0.61	0.97
	vivid	0	8	1	5	5	8	4	1	6	6	9	7	9	4	3	6	3	4.43	5.40	2.87	2.50	0.30	0.60
	hard	0	5	0	1	8	2	6	5	1	3	1	4	3	3	7	6	5	3.14	3.80	2.95	1.89	0.74	0.67
	enjoyable	7	10	1	2	1	6	8	3	6	5	6	1	4	6	5	5	3	5.00	4.40	3.38	1.56	0.88	0.54

		36m	29m	50m	50w	50w	26w	57m	26w	13w	14w	13w	13w	12w	12w	14m	14m	13m	14m	average	average	standard deviation	standard deviation	t-test	t-test
rock	modern	9	5	5	4	5	0	7	7	7	6	4	3	4	4	8	10	9	7	5.25	6.20	2.49	2.27		
	vivid	7	7	4	7	4	6	4	7	10	3	1	10	3	7	6	9	1	4	5.75	5.40	1.39	3.32		
	hard	5	0	3	5	2	5	2	7	2	2	0	2	5	0	4	5	1	4	3.68	2.50	2.12	1.80		
	enjoyable	7	5	7	7	3	4	0	5	3	6	7	6	6	2	6	7	5	5	4.75	5.30	2.28	1.55		

		17w	16w	17w	17w	average	standard deviation
CG	modern	6	5	5	4	5	0.71
	vivid	8	6	7	2	5.75	2.28
	hard	5	4	2	0	2.75	1.92
	enjoyable	5	7	4	4	5	1.22

A8: Table with the results from the main experiment concerning the adjectives for piano and horn. See figures 16 and 17 for charts. The numbers in the respective first row stand for the age of the participant, the letter for the sex (m: männlich/male, w: weiblich/female). When they are coloured blue, the participant reported a minor impairment of senses. The grey coloured segments are the adults' results. CG stands for control group.

		35w	22w	52w	12w	[illegible]	13m	[illegible]	13w	13m	14m	14m	14m	14m	average	average	standard deviation	standard deviation	t-test	t-test
Piano	mighty	0	9	7	7	3	7	7	6	10	5	5	7	8	5.33	6.50	3.86	1.80	0.83	0.13
	delicate	8.5	6	2	10	5	9	3	3	10	6	6	6	5	5.50	6.30	2.68	2.45	0.58	1.00
	soft	0	10	7	3	4	2	1	0	1	2	0	3	3	5.67	1.90	4.19	1.30	0.86	0.04
	fruity	0	0	7	0	0	1	0	0	1	1	0	0	0	2.33	0.30	3.30	0.46	0.37	0.29

		36m	29m	50m	13w	14w	13w	13w	12w	12w	14m	14m	13m	14m	average	average	standard deviation	standard deviation	t-test	t-test
Horn	mighty	7	7	4	5	7	6	4	6	6	7	6	0	4	6.00	5.10	1.41	1.97		
	delicate	7	7	6	4	7	6	8	8	7	6	0	10	7	6.67	6.30	0.47	2.57		
	soft	9	7	3	5	3	5	6	3	2	3	0	10	3	6.33	4.00	2.49	2.57		
	fruity	0	0	0	0	0	0	2	0	0	2	0	5	0	0.00	0.90	0.00	1.58		

		17w	16w	17w	17w	average	standard deviation
CG	mighty	8	7	9	9	8.25	0.83
	delicate	10	0	1	5	4.00	3.94
	soft	8	7	1	4	5.00	2.74
	fruity	0	0	4	0	1.00	1.73

9 Declaration

Ich erkläre hiermit,

- dass ich die vorliegende Arbeit selbständig und nur unter Benutzung der angegebenen Quellen verfasst habe,
- dass ich auf eine eventuelle Mithilfe Dritter in der Arbeit ausdrücklich hinweise,
- dass ich vorgängig die Schulleitung und die betreuende Lehrperson informiere, wenn ich diese Maturaarbeit, bzw. Teile oder Zusammenfassungen davon veröffentlichen werde, oder Kopien dieser Arbeit zur weiteren Verbreitung an Dritte aushändigen werde.

Ort und Datum: _____

Unterschrift: _____