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Measuring facial expressions and autonomic nervous system reactions elicited by the flavor of juices, using an implicit and an explicit measurement approach

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„Dankbarkeit ist das Gedächtnis des Herzens.“

Jean-Baptiste Massillon (1663 - 1742)

1. Introduction and objectives

Food choice is a seemingly simple, but in fact very complicated behavior that is influenced by many interaction factors [KÖSTER, 2009]. Thus finding out about consumers' preferences is still a challenge, because in marketing and consumer research a lot of products do not show the success predicted by previous conventional sensory tests. Thereby nobody would imply that consumers give intentionally false answers in sensory tests, but there are unconscious motivated drivers in the consumers' decision making process, which cannot be captured by rationally worded research questions like in hedonic acceptance tests. These rationally worded research questions tend to elicit only rational based answers. But in the marketplace the consumers take their buying decision for many irrational or emotional reasons in addition to the rational motivations. [LABARBERA and TUCCIARONE, 1995]

To capture these unconscious processes involved in decision making within preference tests or sensory tests, nonverbal or physiological responses can be used. Physiological testing methods go beyond consumer self-report data, because physiological reactions are controlled by the autonomic nervous system and therefore reflect involuntary, emotional and/or unconscious processes. In the case of conventional product liking tests the consumer has to remember the hedonic impression and think rationally about how to quantify this impression using the given scale type. Automatic and physiological measures in contrast are not biased by conscious cognitive processing, but give an implicit involuntary reaction to the stimuli. [LABARBERA and TUCCIARONE, 1995]

In the following study facial expressions and autonomic nervous system reactions (ANS reactions) elicited by the flavor of different juices were examined in an implicit and explicit testing situation. For measuring ANS reactions electrodermal activity (EDA) or skin conductance (SC), finger temperature (FT) and pulse with its derived parameters blood volume pulse (BVP) and pulse volume amplitude (PVA) were used. These physiological parameters are not under our conscious control, because they are influenced by the autonomic nervous system and therefore are suggested to be indicators in the domains of stress, arousal and emotion.

It was investigated if (a) tasting different flavors of juices elicits different facial expressions and ANS responses; (b) there is a correlation between liking or conventional rating and ANS responses and/or facial expressions and (c) there are differences in facial expressions between implicit and explicit measurement. So it was investigated if facial expressions and ANS measurements could give new insights into consumer behavior and if they could be used to determine product acceptance. Little work regarding these study objectives was published until now and this work should allow better insights in consumer's product acceptance by using facial expressions and ANS responses.

The following hypotheses have been tested:

(a) H0: Different juices do not elicit different facial expressions and ANS responses. We expected the H0 to be disproved.
(b) H0: ANS responses and/or facial expressions do not correlate with liking rating. We expected the H0 to be disproved.
(c) H0: Facial expressions do not differ between implicit and explicit approach. We expected the H0 to be disproved.

In the next chapters the relationship between emotions, food, self-report measurements, facial expressions and autonomic nervous system reactions is discussed.

"Men, as well as women, are much oftener led by their hearts than by their understandings."

Lord Chesterfield (1694–1773)

2. Scientific background

2.1. Emotions

The history of emotion research is defined of varying opinions of specificity or association between different emotions with different patterns of autonomic nervous system activity. From JAMES'S hypothesis (1884) that physiological responses form the basis of emotional experience and that feeling followed the physiological response elicited by an emotional stimulus over LANG'S theory (1994b) with suggesting the physiological responses to be the emotion, over CANNON'S (1928) and BARD'S theory (1934) that different emotions produce different autonomic patterns to SCHACHTER'S and SINGER'S theory (1962) which was an alternative to both James's and Cannon's theory. Modern emotion theories are often based on the Cannon-Bard theory [BRADLEY, 2000].

There is a dimensional and a discrete perspective in emotion research. The most commonly assumed dimensions are valence, arousal (activation) and approach-avoidance [DAVIDSON, 1999; SCHNEIRLA, 1959]. The valence dimension distinguishes pleasure and displeasure, the arousal dimension low and high arousal and the approach-avoidance dimension approach and avoid stimuli. The direction, intensity and the hedonic valence and the degree of arousal or activation are seen to be central in emotions. Emotions are associated with physiological reactions of the body. According to the activation theory, increase in arousal is linked with increase in the strength of responding in numerous systems like cortical, sympathetic (i.e. heart rate, skin conductance) and somatic (i.e. muscle tension). [BRADLEY, 2000]

DAVIDSON et al. (1990) suggested that a simple biphasic organization of emotion exists and that emotions stem from two underlying neural systems: the appetitive (for positive affective states) and the defensive (for negative affective states) motivational system and both vary in arousal. In contrast, the discrete emotions perspective suggested that each emotion corresponds to a unique profile in behavior, experience and physiology [EKMAN, 1999]. SMITH and ELLSWORTH (1985) combine both perspectives.

In general different methods exist which are suggested to be linked with emotional responses such as self-report measures, autonomic measures with electrodermal activity, heart rate and skin temperature (which are discussed in more detail in the next chapters), startle response magnitude, brain states with electroencephalography and neuroimaging, behavior measures with facial behavior and electromyography. Still, there is no gold standard to measuring emotional responding. [MAUSS and ROBINSON, 2009]

2.1.1. Emotions and food

Sensory properties like visual, olfactory, taste and tactile qualities of food can have direct emotional impact on the body [DESMET and SCHFFERSTEIN, 2008]. The taste and olfactory senses allow humans to select appropriate items for ingestion from among the multitude of nutritive, nonnutritive and toxic foods encountered in their natural habitat [GALEF, 1981].

A gustatory stimulus evokes a two-dimensional response, discriminative and affective (emotional) [NORGREN, 1985]. The first mentioned level corresponds to the qualitative characteristics of the stimulus like chemical and physical attributes of tastes. The affective or hedonic dimension with degree of pleasure or displeasure elicited by a stimulus is important in the control of many taste-mediated responses related to food intake and rejection [SMITH and VOGT, 1997]. Pleasant stimuli elicit approach and acceptance, unpleasant stimuli induce avoidance and rejection and so taste preferences and aversions are determined [ROUSMANS et al., 2000].

Most of evaluative reactions toward foods are not fixed and innate, but largely produced by learning. Therefore flavor evaluations are generally acquired through experience and shaped by individual learning within socio-cultural structures. [BAYENS et al., 1996]

According to ROZIN and FALLON (1987), the expression of disgust is an emotion that is clearly food related. The authors defined it as revulsion at the prospect of oral incorporation of offensive objects. Surprise can be elicited by certain food combinations or novel food. Liked stimuli can lead to a smiling face (especially in infants), which is a sign for happiness. Eating and therefore food in general is basically a positive experience related to positive emotions.

2.2. Self-report measurement

Hedonic acceptance tests are an important interface between marketing research, product development and food sensory research reflecting the subjective perception by consumers.

These self-report measures reflect how the consumer perceives a product within a product acceptance test. These measures can only capture the consumers' statements and decisions, which are influenced by higher cognitive processes. On the contrary, autonomic nervous system reactions reflect the spontaneous and uncontrollable emotional reactions without distortion by higher cognitive processes. [POELS and DEWITTE, 2006]

Self-reports are often used in consumer behavior research because of simply handling, cheap equipment and the possibility for group assessment. On the one hand self-report measures are the easiest way to test the acceptance of new products; on the other hand there is a big disadvantage: these measures can only reflect the cognitive processes, but not the unconscious reactions and lower-order emotions, which are often biased by cognitive or social desirability constraints. [POELS and DEWITTE, 2006]

Additionally the lack of language to describe taste experiences limits the validity of methods directly asking test subjects by using questionnaires [KÖSTER, 1990]. But there is a movement away from the explicit, conscious orientation of many food preference tests to a focus on implicit memory, unconscious processes and behavioral aspects. This is a general trend in psychology and focus on an "adaptive unconscious", which is responsible for most of our behavior [KHILSTROM, 1999].

2.3. Facial expressions

The association of facial expressions and emotional states goes back to DARWIN (1872). He demonstrated the universality of facial expressions, that there are specific inborn emotions and that facial expressions occur in combination with other bodily responses such as physiological responses. EKMAN and FRIESEN postulated 1971 six primary emotions with unique facial expressions. These so called “basic emotions” comprised “anger”, ”disgust”, “fear”, “happiness”, “sadness” and “surprise” and were regarded to be universal across ethnicity groups and cultures. In table 1 these basic emotions and their related facial expressions are described in detail.

basic emotion	description of facial muscles
anger	nostrils raised, mouth compressed, furrowed brow, eyes wide open, head erect
disgust	lower lip turned down, upper lip raised, expiration, mouth open, spitting, blowing out, protruding lips, throat-clearing sound, lower lip and tongue protruding
fear	eyes open, mouth open, lips retracted, eyebrows raised
happiness	eyes sparkling, skin under eyes wrinkled, mouth drawn back at corners
sadness	corners of mouth depressed, inner corner eyebrows raised
surprise	eyebrows raised, mouth open, eyes open, lips protruding

Table 1: description of facial muscles in the today’s basic emotions by Darwin [DARWIN, 1872]

Facial expressions are generated by contractions of facial muscles, which deform temporally facial features like eye lids, eye brows, nose, lips and skin texture by wrinkles and bulges. Muscular activity changes briefly and lasts for a few seconds, mostly between 250 ms and 5 seconds. [FASEL and LUETTIN, 2003]

Most automatic facial expression analysis approaches in the literature attempt to link facial expressions to one of the basic emotion classes according to EKMAN and FRIESEN (1971). Another measurement method is the facial action coding system

(FACS) developed as well by EKMAN and FRIESEN (1978). FACS uses 44 action units for the description of facial actions together with additional information about their location and their intensity. With adequate database emotional related FACS scores can be translated into affective meanings (EKMAN et al., 1998). But this method is very time consuming and needs specially trained coders and therefore limits this method in terms of applicability. Another method to classify and analyze facial expressions is electromyography (EMG). This method can detect subtle changes in the activity of facial muscles, which are unlikely to be recognized with observational techniques [HU et al., 1999]. But the application of electrodes in the face can be regarded as rather intrusive, especially when participants have to eat or to drink in an experimental session. Non-intrusive and quick ways to measure facial expressions are automated facial expression recognition systems like nViso (nViso SA, Lausanne, Switzerland), Affdex (Affectiva Inc., Waltham, USA) and FaceReader (Noldus Information Technology, Wageningen, The Netherlands). The disadvantage of these methods is that they are not as sensitive as EMG and highly reliant on good quality video recordings of the observed face. But the continuous improvement with each version of the software over the past few years and more affordable computing power for real-time analysis or higher throughput in batch analysis make these methods increasingly interesting.

In this study a model-based approach to analyze facial expressions was used. The software FaceReader uses the Active Appearance Model (AAM) [COOTES and TAYLOR, 2000] to create an artificial face model, which reflects key points in the face, and detects and interprets faces within the six basic emotions by learning processes with pictures of different faces.

Most researchers agree that facial expressions function as a communication signal to species members or at the environment [GREIMEL et al. 2006; ROSENSTEIN and OSTER, 1988]. They are important to both basic survival and social interaction. Communication of fear, disgust and threat by facial expressions to others is important [ERICKSON and SCHULKIN, 2003] to prevent them from threats [ROSENSTEIN and OSTER, 1988].
In general, facial expressions of aversions and preferences seem to be innate due to the ability of babies to differentiate without prior taste experience between the basic tastes by showing typical facial expressions [GREIMEL et al., 2006; ROSENSTEIN and

OSTER, 1988]. Bitter stimuli elicit facial expressions of disgust in neonates and sweet stimuli elicit expressions of satisfaction and of smiling [STEINER et al., 2001].

There are changes in facial reactions related to pleasantness [GREIMEL et al., 2006; ZEINSTRA et al., 2009]. The previous study of DANNER et al. (2013) also showed that measuring facial expressions is a sufficiently accurate method to differentiate between samples varying in flavor. Additionally ZEINSTRA et al. (2009) showed that facial expressions in children are a good indicator of “dislikes”, but not of “likes” matching DANNER et al. (2013). HORIO (2003) found out that the facial muscles of adults showed greater response to disliked tastes than to liked tastes. So it seems that food does not evoke strong positive reactions. Maybe accepted and commonly consumed foods just show mild positive reactions [DE GRAAF et al., 2005].

But the objectivity of facial expressions as a tool for measuring food preferences can be influenced by masking and controlling facial expressions [ZEINSTRA et al., 2009]. Humans learn to control their facial expressions during childhood as a socializing and cultural effect [CAMRAS and FATANI, 2008]. Therefore the measurement of ANS parameters was included in this study. These parameters can’t be changed or controlled by the organism voluntarily except for people who are familiar with certain techniques like relaxation or mediation with a long learning process. Most ANS responses are not visible compared to facial expressions and therefore physiological reactions are not or not easy to suppress or to influence.

2.4. Autonomic nervous system reactions

Many existing studies investigate physiological parameters in the context of stress situations, psychological disorders like anxiety or schizophrenia, but even in marketing research and consumer behavior [BOUCSEIN, 2012]. Just a few studies examined physiological parameters with focus on influences of food, most of them with pictures [e.g. DROBES et al., 2001; OVERDUIN et al., 1997] but with other intentions, some of them with appearance or smelling of food [DE WIJK et al., 2012] or even tasting food [NEDERKOORN et al., 2000] but with other intentions. To our knowledge there is only one study by DE WIJK (2012) working with this combination of analysis of facial expressions and ANS responses in food context.

In general there is still no scientific consensus how emotion and the organization of the autonomic nervous system are related or if they are related at all [KREIBIG, 2010]. Therefore the few findings involving food tasting or hedonic food acceptance are hard to interpret and the question if there is a relationship between ANS responses and product acceptance still exists.

2.4.1. The nervous system

The nervous system is divided into two broad components: the central nervous system and the peripheral nervous system, which comprises the autonomic and somatic nervous system [LARSEN et al., 2008]. Psychophysiological study of emotion has traditionally focused on autonomic and somatic output (i.e. heart rate, blood pressure or electrodermal activity) [BRADLEY, 2000].

The somatic nervous system innervates skeletal muscles, including those of the face. The vegetative nervous system regulates and coordinates the functions of the inner organs in the human organism to adapt their functions to different situations. It innervates the smooth muscular system of all organs and organ systems, heart and glands. Its functions can only be little influenced voluntarily or are completely uninfluenceable – so it is also called involuntary or autonomic nervous system. [THEWS et al., 1999]

The peripheral vegetative nervous system consists of three parts: sympathetic nervous system, parasympathetic nervous system and intestinal nervous system. The former is responsible for activity and adjusting the organism to external overloading and the second is responsible for relaxation and regeneration. Most organs are innervated by nerves from both and they act antagonistically. The hypothalamus in the brain has the role of control center for all vegetative functions but also other brain regions like medulla oblongata or amygdala influence the physiological phenomena like skin conductance and heart rate. [THEWS et al., 1999]

In early days it was presumed, that pleasure is related to the parasympathetic system, because appetitive situations do not involve stress, and aversive events are related to sympathetic activity. But today these systems are seen as to be coactive. [BRADLEY, 2000]

2.4.2. Measurement of physiological parameters

The direct measurement of the most physiological parameters like the activity of sweat glands is not possible, therefore correlations are measured. But not every measured value has to be transformed into another signal. For example, a transformation for the heart frequency is unnecessary. Therefore it is enough to measure the signal by electrodes and to intensify the signal.

<u>Measuring arrangement</u>

- transducer: derivation of the signal
- intensification: adaption and intensification of the signal
- registration unit: recording of the measured signal

Disturbing factors can influence the measurement of the physiological parameters. Modulating influences of other body functions can also influence the measured parameters. For example, heart frequency fluctuations occur due to changing breathing rhythm like taking a deep breath. Movements of the whole body or especially of the parts with the applied electrodes can disturb the measurement and may lead to faulty or useless measurement results. Also daily variations of physiological parameters should be considered. Some substances like nicotine, alcohol, drugs or medication influence physiological functions in the body. Electrical noise sources can also influence the measured signals. The ambient temperature should be kept constantly between 22-24 °C. It is important to include a sufficient measurement at rest before starting the actual measurement.
[ÖBFP, 2006]

2.4.2.1. Electrodermal activity

The first empirical study to examine electrodermal activity in human skin dates back to 1879. The beginning of the modern era of eletrodermal activity research was in the early 1970s. [DAWSON et al., 2000]

The application of electrodermal activity is widespread in use in different fields like clinical psychophysiology for anxiety, psychomatic disorders and depression research, in schizophrenia illness, detection of deception or "lie detection", neurology, dermatology, therapeutic use of biofeedback, marketing and product acceptance and many more. But even today the electrodermal phenomenon is not fully understood. [BOUCSEIN, 2012]

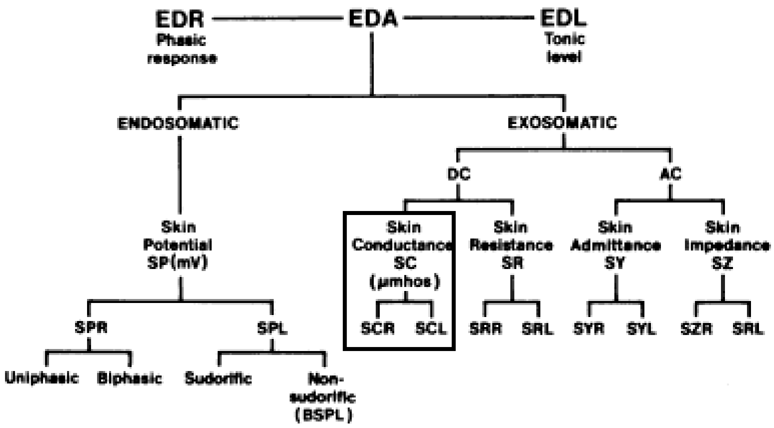

Figure 1: labeling of electrodermal activity
[CHRISTIE, 1981]

Figure 1 shows an overview of the electrodermal system. The electrodermal activity can be measured with endosomatic or exosomatic method. Former is an invasive direct measurement of electrical activity and latter is measured by electrodes on the skin's surface. Recordings with direct current (DC) or with alternating current (AC) are possible. With direct current skin conductance or skin resistance can be measured. Here in this work the exosomatic method with direct current to measure skin conductance was used.

Anatomy and physiology of skin and sweat glands

The human skin consists of a complex set of organs and protects the body from environmental threats and has sensory functions. Its role in the regulation of the perspiration is twofold, because the skin prevents from drying out and produces with special glands sweat for thermoregulation of the body. [BOUCSEIN, 2012]

The human skin consists of three layers:

1. **Epidermis**
   high resistance, low conductance
2. **Dermis**
   high conductance
3. **Subcutis**
   secretory component of the sweat gland, high conductance

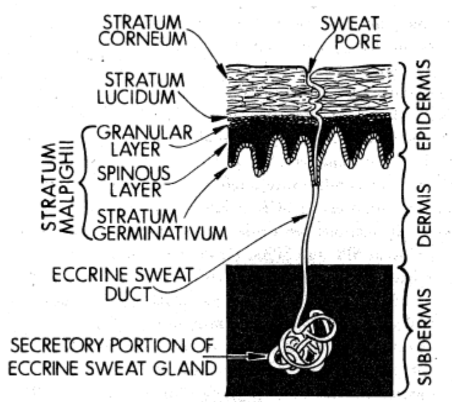

Figure 2: ecccrine sweat gland in various layers of skin
[Dawson et al., 2000; adapted with permission from HASSETT, 1978]

The eccrine glands are a certain type of sweat glands and are spread over the entire body surface. Their secretory segment is located in the Subdermis, the duct runs through the Dermis and the Epidermis and ends as sweat pore on the skin surface (see figure 2), where they excrete sweat. A high density of eccrine sweat glands are located on the palmar and plantar surfaces with about 2000 glands/cm^2 skin area. The secretory segments of the eccrine sweat glands are innervated by the sympathetic nervous system. [ÖBFP, 2006]

The primary function of most eccrine sweat glands is thermoregulation. But those on the palmar and plantar surfaces seem to have more grasping behavior functions than evaporative cooling functions (EDELBERG, 1972a). It has also been suggested that they are more responsive to significant or emotional stimuli than to thermal stimuli. [DAWSON et al., 2000]

Emotional sweating is caused by increased sweat gland activity and can occur in emotional states like in situations of high arousal or under stress [BOUCSEIN, 2012]. DARROW (1927) supported the theory that phasic electrodermal responses begin about one second before moisture appears on the surface of skin. So he concluded that not the sweat on the skin per se, but the activity of the sweat glands influences electrodermal responses. He also proposed that the function of the secretory activity of the palms is primarily for tactile tasks and to grip on objects. [DARROW, 1937]
The real function is still discussed today.

Measuring background

Skin conductance can only be measured indirectly. Applying an electrical potential over two electrodes leads to measureable changes in current. The sweat ducts of the sweat glands can be imagined as a set of variable resistors, which are connected in parallel. A moist skin has a higher conductance than a dry one always depending on the ionic concentration of ductal sweat.

According to **Ohm's law**:

$$\mathbf{I}\ \textit{(current in amperes)} = \frac{\mathbf{V}\ \textit{(voltage in volts)}}{\mathbf{R}\ \textit{(resistance in ohms)}}$$

$$\mathbf{C}\ \textit{(conductance in ohms)} = \frac{\mathbf{I}\ \textit{(current in amperes)}}{\mathbf{V}\ \textit{(voltage in volts)}} = \frac{1}{\mathbf{R}\ \textit{(resistance in ohms)}}$$

There are different useable methods like a constant voltage source with d.c. voltage or with alternating voltage and a constant current method for measuring skin resistance. The latter method is not used anymore. The use of constant voltage methodology for exosomatic EDA recording is preferred, but all methods have advantages and disadvantages. [BOUCSEIN et al., 2012]

A constant voltage source with alternating voltage is used by radio module MULTI (Schuhfried GmbH, Mödling, Austria) in this study. This method avoids skin or electrode polarization.

The unit of skin conductance is Siemens (S) with 1 S = 1 Ohm $^{-1}$. In practice there are measured values in microsiemens range (µS). In English-speaking regions the term micromho (µmho) is used. [ÖBFP, 2006]

Electrodes

Silver-silver chloride electrodes are the most used electrode type for recording skin conductance, because they minimize bias potentials and polarization. In figure 3 the three common electrode placements on the palms for recording skin conductance are illustrated. Using the non-dominant hand is preferred because it is less likely to have cuts or horny skin and the dominant hand is free to perform manual tasks.
[DAWSON et al., 2000]

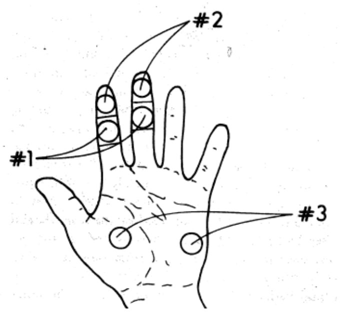

Figure 3: electrode placements

1: volar surfaces on medial phalanges
2: volar surfaces of distal phalanges
3: thenar and hypothenar eminences of palms

[DAWSON et al., 2000]

EDA terms

Table 2 shows important abbreviations and terms related to electrodermal activity.

term	definition	unit / common values
EDA (**e**lectro**d**ermal **a**ctivity)	generic term for all electrical skin phenomena	
EDR (**e**lectro**d**ermal **r**eaction)	term for stimulation-induced electrical skin phenomena	
GSR (**g**alvanic **s**kin **r**esponse)	older term for EDR	
SCL (**s**kin **c**onductance **l**evel)	tonic level of electrical conductance of skin	0.5-15 µS (depending on level of activation)
NS-SCR (**n**on-**s**pecific **s**kin **c**onductance **r**esponse)	spontaneous fluctuations of skin conductance without stimulation	1-3 per minutes (depending on level of activation)
ER-SCR (**e**vent **r**elated – **s**kin **c**onductance **r**eaction	fluctuations of skin conductance after stimulus, consists of amplitude, latency, rise time and half recovery time	
ER-SCR *amplitude*	phasic increase in conductance shortly following stimulus onset	0.2-1 µS
ER-SCR *latency*	temporal interval between stimulus onset and SCR initiation	1-3 sec.
ER-SCR *rise time*	temporal interval between SCR initiation and SCR peak	1-3 sec.
ER-SCR *half recovery time*	temporal interval between SCR peak and point of 50% recovery of SCR amplitude	2-10 sec.
SR (**s**kin **r**esistance)	electrical resistance of the skin, reciprocal of conductance	(kilo)- ohm
SP (**s**kin **p**otential)	electrical voltage of skin	µV

Table 2: important terms of the electrodermal system
modified:[ÖBFP, 2006; DAWSON et al., 2000]

Response to stimuli

Figure 4 shows a typical response to a stimulus. SCR consists of the latency time followed by the rise time with the increasing amplitude as response to the stimulus. After rising time recovery time decreases the amplitude again. For identification of a response a minimum of 0.05 µS change in amplitude is widely used and accepted [BOUCSEIN, 2012; VENABLES and MITCHELL, 1996]. Also non-specific skin conductance responses can occur, which are spontaneous fluctuations of skin conductance without stimulation and which should be differentiated with true responses [BOUCSEIN, 2012].

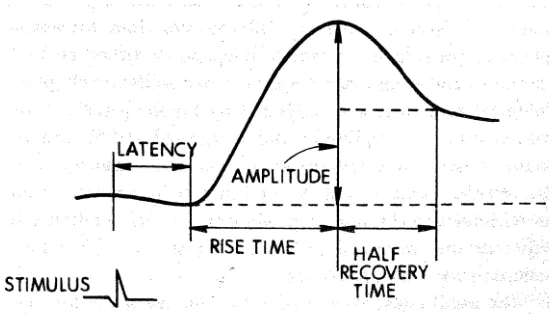

Figure 4: components of ER-SCR [DAWSON et al., 2000]

Skin conductance consists of a phasic and a tonic component. The tonic level is the absolute level of conductance at a given moment in the absence of a measurable phasic response, and it is referred to as skin conductance level (SCL). Superimposed on the tonic level are phasic increases in conductance, referred to as skin conductance responses (SCRs). [DAWSON et al., 2000]

A large variability of SCL values exist because every person has an individual level (e.g. thickness of the corneum) [DAWSON et al., 2000]. KATKIN (1975) concluded that electrodermal activity is a personality variable that reflects individual differences in higher central processes like attending to and processing information. There are persons with stable and labile electrodermal activity or responders and non-responders. Certain abnormalities in electrodermal lability are associated with diagnosable psychopathology like schizophrenia [ZAHN, 1986].

Among ANS measurements tonic EDA parameters have been the most frequently used indicator of arousal in psychophysiological research for a long time [DUFFY, 1972]. In general stronger stimulation elicits larger responses and repetition of the same stimuli leads to habituation. SCL gradually decreases during resting phase, rapidly increases

when novel stimulation occurs and gradually decreases when the stimulus is repeated. [DAWSON et al., 2000]
Stimuli which have the effect of increasing SCL would be expected to increase heart rate level and blood pressure and to decrease finger pulse volume [ENGEL, 1960; GRINGS and DAWSON, 1978].

2.4.2.2. Finger temperature

Blood vessels in the hands are important for skin temperature regulation. The activity of adrenergic vessels constricting fibers controlled by the sympathetic nervous system influence the blood circulation in the skin. With decreasing outdoor temperature the above-described activity increases and so the body's heat emission gets reduced. Otherwise, if the outdoor temperature increases, the activity is inhibited and vasodilatation for supporting heat emission is induced. Changes in blood circulation lead to changes in skin temperature with a delay of 5-15 seconds. Arousal leads to vasoconstriction and so finger temperature decreases, while relaxation leads to vasodilatation and finger temperature increases. [ÖFBP, 2006]

Measuring

For measuring skin temperature a thermistor, a temperature dependent electrical resistance, can be used. Endogenous changes in skin temperature occur only slowly with about 0.1 °C per minute and so a waiting period of 5-10 minutes should be considered. Finger temperature measuring can be influenced by several factors like ambient temperature, surface under the hand, humidity, season, medication, stimulants like alcohol and nicotine, daytime and breathing. The average hand temperature at rest and with ambient temperature of 21 °C is about 28 °C – 33 °C. [ÖFBP, 2006]
Vasoconstriction with a resulting decrease in skin temperature can be caused by different factors like cold, arousal or activation. Vasodilatation with a resulting increase in skin temperature can be caused by heat or relaxation. [THEWS et al., 1999]

2.4.2.3. Pulse and pulse amplitude

The heart is dually innervated by the sympathetic and parasympathetic nervous system [THEWS et al., 1999]. The pulse describes the pulse rate, which is defined as number of impulses per minutes, and the quality of this impulse. The heart frequency describes the number of heart beats per minute (bpm) and at rest it is about 60 – 80 bpm, depending on the individual level. [ÖBFP, 2006]
HR can be an indicator of various phenomena like attention, arousal and cognitive or physical efforts [POELS and DEWITTE, 2006].

The rhythmic contraction of the heart muscle is controlled by the sinus node. The sympathetic and parasympathetic nervous system has only modulating influence. The heart frequency is increased by activation of the sympathetic nervous system and is decreased by activation of the parasympathetic nervous system. The pulsation is a result of ventricle contraction during systole and of heart relaxation during diastole. This pressure is visible and palpable on the skin surface. The increased pressure during systole increases the elasticity of the vessels, which are able to convert pressure energy into strain energy, what is called “windkessel function”. Due to that function a volume pulse additional to the pulse wave exists. The volume change depends on the pressure change and so on the blood pressure amplitude and on the elasticity of the vessels. The blood pressure amplitude is the difference between systolic and diastolic blood pressure.

$$\Delta V = E^* \Delta P$$

ΔV = volume change or pulse volume amplitude (PVA)
E = elasticity
ΔP = pressure change or blood pressure amplitude

The elasticity of the vessels is not constant, because it depends on the activity of the smooth muscular system of the vascular wall and on the intravascular pressure. If the muscular system of the vascular wall gets activated by the sympathetic nervous system, elasticity and PVA decrease but blood pressure amplitude increases. On the other hand a decrease in the activity of the sympathetic nervous system or relaxation leads to relaxation of the muscular system of the vascular wall and so the elasticity of the vessels and PVA increase. [ÖBFP, 2006]

Measuring

The above mentioned processes can be observed by photoplethysmography (PPG). This measuring method includes an infrared light source and a photoelectrical converter. In most cases the reflecting light is measured, but it is also possible to measure the passing light. Tissues have different blood supply and are varying in permeability or reflection of red light. For example, if the finger has a good blood supply more light is reflected. Otherwise, if the finger has a poor blood supply, less light is reflected.

A positive relationship between finger temperature and finger PVA exists. Relaxed vessels due to vasodilatation lead to more blood amount and so to increased skin temperature. But they also enhance elasticity of vessels with accompanying increased PVA. The skin temperature responds with some delay after PVA changes. Variations of the position of the hand relative to the heart cause effects on skin temperature and PVA. If the hand is raised above the head, the finger temperature decreases and PVA increases. In the contrary case with hand down the blood amount increases and so skin temperature also increases, but PVA decreases.

PVA responds like skin conductance to changes in the activity of the sympathetic nervous system. The advantage over measuring skin conductance is that PVA values return faster to their base level because sweat always has to evaporate first. The cardiac response can be influenced by factors like posture, respiration, ambient temperature and physical differences such as body weight or fitness.
[ÖBFP, 2006]

2.4.3. Physiological reactions and arousal

General arousal is suggested to be an organic overall excitation. EDA parameters are the most used ANS indicators of arousal in psychophysiological research. [DUFFY, 1972] HAIDER (1969, 1970) stated in his hierarchical arousal model that different parameters indicate different levels of generality of arousal. According to him, EDRs indicate localized phasic arousal processes and EDL stands for measuring more generalized arousal.

EDA is regarded as a sensitive and valid indicator for the lower arousal range and reflects small and mostly cognitively determined variations in arousal state. HR is suggested to be better an indicator for the higher arousal range and for somatically determined arousal processes. [EPSTEIN et al., 1975; MIEZEJESKI, 1978; WALSCHBURGER, 1986] But HR can become insensitive during low arousal processes and does not respond to small variations like the EDA parameter (SILVERMAN et al., 1959]. In a review of FOWLES (1980) with a series of studies, EDA and HR seem to respond in different ways. He concluded HR is responding to positive hedonic motivational states but not to aversive stimuli and EDA does not increase during appetitive motivational activation. This would be in agreement with the study of VERNET-MAURY et al. (1999) where autonomic responses elicited by pleasant odors were shorter and weaker than by unpleasant odors.

In another context, BOUCSEIN et al. (1999) showed that the most favorably rated product (cosmetic foam products) elicited the lowest SCL value. So skin conductance can be seen as a specific indicator for negative emotions and dislike in product acceptance processes. According to BENSAFI et al. (2002), HR increased for unpleasant odors during smelling task compared to non-odor conditions. Due to other studies with similar results, HR is suggested to accelerate in a context of rejection. Finger temperature increased for liked compared to disliked foods during first sight in the study of DE WIJK et al. (2012). So liked food may lead to relaxation and increases FT by decreased activity of sympathetic nervous system.

In investigations of the relationship between facial expressions and changes in ANS parameters, LEVENSON, EKMAN and FRIESEN (1983, 1990) examined voluntary facial reactions and their connection to the autonomic nervous system activity. Among negative emotions, anger, fear and sadness produced larger heart rate acceleration than disgust and anger produced larger finger temperature increase than fear. Also differences between negative and positive emotions were visible: anger and fear produced larger rate acceleration than happiness, while fear and disgust produced larger skin conductance increase than happiness.

Suggestions about EDA being a better predictor of market performance and consumer acceptance compared to self-reported measures (LaBarbera and Tucciarone, 1995) and about getting additional information by measurement of the physiological parameters pulse and finger temperature, support the intention of our investigation.

3. Materials and methods

To implement the study several measurement instruments (hardware) and software programs were used. All necessary details are given in the following pages with focus on more detailed description about the used hard- and software for measuring facial reactions and ANS parameters and about data collection program. This chapter also contains all information about the used samples, the participating test subjects, the detailed experimental design, the preparation of the data and the used statistical analysis.

3.1. Hardware

The following hardware was used:

- Biofeedback 2000 $^{x\text{-}pert}$ radio module MULTI (measure of automatic nervous system reactions) and Bluetooth radio pyramid (Schuhfried GmbH, Mödling, Austria)
- Logitech HD Pro C910 webcam
- Logitech C600 webcam
- 3 laptops (Lenovo X220 Tablet, Dell Precision, HP compaq)

3.2. Software

The following software was used:

- Compusense® five software Version 5.2 (Compusense Inc., Guelph, Canada)
- Senstools software Version 3.3.2 (OP&P Product Research BV © 1994-2002)
- Biofeedback 2000 $^{x\text{-}pert}$ software Version 4.0 (Schuhfried GmbH, Mödling, Austria)
- Media Recorder 2.0 (Noldus Information Technology, Wageningen, The Netherlands)
- FaceReader™ Version 5 (Noldus Information Technology, Wageningen, The Netherlands)
- The Observer XT® Version 11 (Noldus Information Technology, Wageningen, The Netherlands)
- Microsoft Excel 2007
- IBM SPSS Statistics 21 (IBM Corporation, Armonk, USA)

3.3. Measurement of facial reactions

3.3.1. FaceReader 5

FaceReader is a program for facial analysis and can detect emotional expressions in the face. It can identify six basic emotions: “angry”, “disgusted”, “happy”, “sad”, “scared”, and “surprised” and a neutral state. The measured values for facial expressions are between 0 and 1. FaceReader technology can also detect facial states like left and right eye open or closed, mouth open or closed, eyebrows raised, neutral or lowered, the test participant’s global gaze direction and tracks the head orientation. The program is also able to identify the person’s gender, age, ethnicity, the amount of facial hair (beard and/or moustache) and whether the person is wearing glasses or not.

FaceReader works in three steps: face finding, face modeling and face classification. In the face modeling step a model-based method is used, called the Active Appearance Model (AAM) [COOTES and TAYLOR, 2000], to create an artificial face model, which reflects the location of 500 key points in the face and the associated facial texture. Face classification is done by training an artificial neural network [BISHOP, 1995]. The program uses over 10,000 manually annotated images as training materials. FaceReader can recognize facial expressions with an accuracy of 90%. The accuracy is slightly varying between the different emotions. [VAN KUILENBURG et al, 2005; DEN UYL and VAN KUILENBURG, 2008; BIJLSTRA and DOTSCH, 2011; LANGNER et al., 2010]

FaceReader 5 works with projects. There can be multiple participants in a project and multiple videos per participant. Videos can be analyzed after video recording or per live recording.

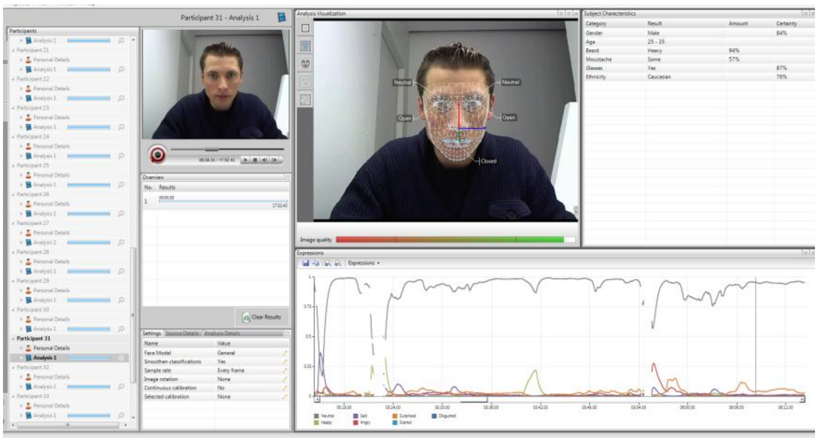

Figure 5: user interface of FaceReader 5: facial expressions with the six basic emotions and the neutral state with values between 0 and 1; white grid with the 500 key points on the participants' face

The software has also some limitations. In general FaceReader is not trained to work with very young children (<3 years) and with children from East Asia and South-East Asia. Glasses with thick and dark frames and light conditions can influence the performance. The participant should sit or stand and look frontally into the camera, so the pose and the movement of the participant is limited. The participant's face should not be partially hidden for example by hairs, hat or hands in the face.

[User manual FaceReader™ Version 5, Noldus Information Technology, Wageningen, The Netherlands, 2012]

3.3.2. Media Recorder 2.0

Media Recorder 2.0 was used as software to create video files of the participant's face. The generated video files are AVI-format and can be used in FaceReader 5 and in The Observer XT 11. The videos were recorded with a resolution of 640 x 480 and 25fps (frames per second) with a Logitech HD Pro C910 webcam mounted on the screen of the presenting laptop.

[User manual Media Recorder 2.0, Noldus Information Technology, Wageningen, The Netherlands, 2011]

3.4. Measurement of ANS parameters

3.4.1. Biofeedback 2000 x-pert radio module MULTI

The Biofeedback 2000 x-pert radio module MULTI is able to measure different physiological parameters through a multi sensor, which is applied on the volar surface of the medial phalange of the forefinger of the left hand (non-dominant hand) by using Velcro strap.

Figure 6: radio module MULTI:
- yellow = EDA
- red = temperature
- violet = BVP (pulse)

Following four parameters can be recorded simultaneously:

Parameter	Measurement range	Resolution	Accuracy	Sample rate	Common values
1. EDA (**e**lectro**d**ermal **a**ctivity)					
-SCL (**s**kin **c**onductance **l**evel)	0-50 µS	1 nS		2 kHz	1-10 µS
-SCR (**s**kin **c**onductance **r**esponse)	0-50 µS	1 nS			
2. finger temperature	10-40 °C	0.01 °C	0.5 °C	4 values/ second	
3. pulse	30-200 bpm	0.004 bpm			
-BVP (**b**lood **v**olume **p**ulse)	0-100 %	0.025 %		500 Hz	
-PVA (**p**ulse **v**olume **a**mplitude)	0-100 %	0.025 %			
4. motility	0-20 m/s^2	0.05 m/s^2		200 Hz	

Table 3: measureable ANS parameters

The radio module MULTI communicates through Bluetooth technology with the radio pyramid, which is connected with the laptop. The measured data are transferred from the radio module via the radio pyramid to the software Biofeedback 2000 $^{x\text{-}pert}$ on the laptop.

Bluetooth data of the radio module MULTI:

- transmit and receive frequency: 2.402 - 2.480 GHz
- sensitivity of the receiver: -84 to -74 dBm
- Bluetooth transmission power: Class 2
- transmission power: -2 to 3 dBm
- Bluetooth range: ~10 m

Bluetooth data of the radio pyramid:

- transmit and receive frequency: 2.000 - 2.4835 GHz
- signal modulation: FSK
- Bluetooth transmission power: Class 1
- transmission power: -0 dBm

[User manual Biofeedback 2000 $^{x\text{-}pert}$, hardware, Schuhfried GmbH, Mödling, Austria]

3.4.1.1. Electrodes

The electrodes should be correctly applied to the skin to avoid voltage fluctuations. It can be useful to clean the skin with alcohol. An electrode gel is not required.

[User manual Biofeedback 2000 $^{x\text{-}pert}$, hardware, Schuhfried GmbH, Mödling, Austria]

Skin conductance

EDA1 sensor with gold electrodes integrated in the Velcro strap for one-finger-measurement was used. EDA1 represents the influences from the limbic system via hypothalamic thermoregulatory areas on the electrodermal activity [BOUCSEIN, 2012]. Skin conductance was measured by current/voltage measurement. A square wave signal with a frequency of 20 Hz and amplitude with +/- 1.42 V was applied to the skin. Skin conductance level was measured through the current flow over the skin and skin conductance response was measured through subtraction between the actual value and past mean values. The usage of alternating voltage avoided polarization of the skin.

[User manual Biofeedback 2000 x-pert, hardware, Schuhfried GmbH, Mödling, Austria]

Finger temperature

The digital sensor for temperature measurement is integrated in the finger Velcro.

[User manual Biofeedback 2000 x-pert, hardware, Schuhfried GmbH, Mödling, Austria]

Pulse and derived parameters (BVP, PVA)

BVP is the blood volume pulse and is the measurement of the average blood circulation of the near skin surface through photoplethysmography relative to the maximum display area. The BVP parameter is smoothed by sliding averaging to correct imbalances.

PVA is the pulse volume amplitude and is the measurement of the peak-peak value of BVP relative to the maximum value. PVA results from subtraction between maximum and minimum of the BVP parameter during one heartbeat cycle.

The parameter **pulse** is the number of heart beats per minute (bpm) and is determined by cycle time measurement of the BVP parameter.

The principle of this measurement is the infrared light absorption of the red blood cells. If a good circulated tissue is irradiated by infrared light, the intensity of the reflected or transmitted light varies because of the flow of red blood cells. The sensor consists of an infrared light source and an infrared receiver and is integrated in the finger Velcro.

[User manual Biofeedback 2000 $^{x\text{-}pert}$, hardware, Schuhfried GmbH, Mödling, Austria]

Motility

The sensor is integrated in the radio module MULTI and measures acceleration in all three motion axes (c_x, c_y, c_z). For motility measurement the difference between the sum of the three axes and the sliding averaging of the past values are used.

[User manual Biofeedback 2000 $^{x\text{-}pert}$, hardware, Schuhfried GmbH, Mödling, Austria]

3.4.2. Biofeedback 2000 $^{\text{x-pert}}$ software

Different software modules are acquirable. In this case only the basic software module “lines (multi-feedback)” was available, in which one or more physiological parameters were measured and displayed as lines: skin conductance level, skin conductance response, finger temperature, pulse, blood volume pulse, pulse volume amplitude and/or motility. The lines (one line for every parameter) on the display were automatically scaled. The measured data were transferred from the radio module MULTI via the radio pyramid to the software Biofeedback 2000 $^{\text{x-pert}}$.

Figure 7: user interface of Biofeedback 2000 $^{\text{x-pert}}$ software with visualization of the parameters in lines (orange: SCL, yellow: SCR, red: finger temperature, blue: BVP, violet: PVA, brown: pulse, pink: motility)

The base setting for the mains frequency is 50 Hz and a Notch Filter is integrated. Following settings are adaptable and were used in the experimental session:

<u>Data storage rate (1/sec):</u>

SCL: **40** *(10-40)*   BVP: **40** *(10-100)*   Mot: **10** *(2-10)*

<u>Smoothing (intensity of averaging) with range of 1-20:</u>

SCL: 3   SCR: 5   finger temperature: 10   BVP: 1   PVA: 1   pulse: 1   motility: 1

The measured data can be exported into Microsoft Excel or SPSS.

[User manual Biofeedback 2000 $^{\text{x-pert}}$, software, Schuhfried GmbH, Mödling, Austria]

3.5. Data collection with The Observer XT

The Observer XT is an event recorder for the collection, management, analysis and presentation of observational data. Observations of behavior can be entered in form of codes by a coding scheme. External data like physiological one can also be entered in The Observer XT through a synchronization signal. Details of observations can be translated in “Time” (how long), “Subject” (which person), “Behavior” (e.g. walking) and “Behavior Modifier” (describes “Behavior” more detailed) with nominal or numerical modifiers. The Observer XT works in three main steps: “Setup”, “Observe” and “Analyze”. In the “Setup” step a coding scheme can be created and the independent variables get defined. In the “Observe” step observations are carried out. The observational data are collected in an “Event Log”. FaceReader data can be imported into The Observer XT. If required, physiological data can be acquired simultaneously with an external Data AcQuisition (DAQ) system. Observational and physiological data can be synchronized automatically or manually.

In this study FaceReader and Biofeedback data were synchronized manually and sections of interest were selected for every sample by hand: “baseline”, “spontaneous/implicit responses” and “intentional/explicit facial expressions”. More details for data collection and preparation are given in chapter 3.9. Data preparation on page 44.

In the “Analyze” step, data of interest can be selected and put in a box. The “start box” contains all the data in the project and the “result box” represents the data set of interest for visualization and analysis. There are different filters usable for selecting data. Observational and physiological data can be visualized and analyzed. Analysis results can be exported to ASCII or Excel for further processing or analysis with other statistical software.

[User manual The Observer XT® Version 11, Noldus Information Technology, Wageningen, The Netherlands, 2012]

3.6. Test stimuli

3.6.1. Description of test stimuli

Five commercially available fruit or vegetable juices on the Austrian market were used as test stimuli. The juices included “Happy Day” banana juice, “Happy Day” grapefruit juice, “Spitz” orange juice, “Ja natürlich” sauerkraut juice and “Ja natürlich” mixed vegetable juice. A sixth juice (“Happy Day” orange juice) was always used as a first, a warm-up, sample at the beginning of an experimental session to familiarize the participants with the testing procedure. This sample was not used for statistical evaluation. Juices were chosen because eating and chewing movements would disturb the measurement of facial expressions. These samples were chosen with a broad spectrum of flavors and we expected them to have large variations in liking and familiarity. These variations might result in clear differences in facial expressions and ANS responses. The different flavors reflected to some degree the basic flavors: banana juice for sweetness, grapefruit juice for bitterness, sauerkraut juice for saltiness and sourness and additionally orange juice as a common drink and vegetable juice as uncommon drink.

Orange juice (warm-up sample)

Ingredients: 100% orange juice from orange juice concentrate.

No sugar added.

nutritional values per 100 g/ 100 ml	
energy	45 kcal/192 kJ
protein	0.7 g
carbohydrates	9.5 g
thereof sugar	9.4 g
fat	0.2 g
thereof saturated fat	<0.1 g
fibers	<0.1 g
sodium	0.001 g

RAUCH Fruchtsäfte GmbH & Co OG
Langgasse 1
6830 Rankweil
Austria

Banana juice

Banana nectar. Fruit content: minimum 30% from banana purée.

Ingredients: water, banana purée, sugar, acid: citric acid, antioxidant: ascorbic acid.

No nutritional value table available!

RAUCH Fruchtsäfte GmbH & Co OG
Langgasse 1
6830 Rankweil
Austria

Grapefruit juice

Ingredients: 100% grapefruit juice from grapefruit juice concentrate. No sugar added.

nutritional values per 100 g/ 100 ml	
energy	42 kcal / 180 kJ
protein	0.5 g
carbohydrates	9 g
thereof sugar	9 g
fat	0.1 g
thereof saturated fat	<0.1 g
fibers	<0.1 g
sodium	0.001 g

RAUCH Fruchtsäfte GmbH & Co OG
Langgasse 1
6830 Rankweil
Austria

Mixed vegetable juice

Ingredients: 55% organic red beet juice, 18% organic carrot juice, 18% organic celery juice, 7% organic potato juice, 2% organic radish juice.

nutritional values per 100 g/ 100 ml	
energy	32 kcal / 136 kJ
protein	0.9 g
carbohydrates	6.7 g
thereof sugar	6.7 g
fat	0 g
thereof saturated fat	0 g
fibers	0.2 g
sodium	0.1 g

Ja! Natürlich Naturprodukte Ges.m.b.H.
IZ Nö-Süd, Straße 3, Objekt 16
2355 Wr. Neudorf
Austria

Orange juice

<u>Ingredients</u>: 100% orange juice from orange juice concentrate.

No sugar added.

nutritional values per 100 g/ 100 ml	
energy	42 kcal / 182 kJ
protein	0.7 g
carbohydrates	8.8 g
thereof sugar	8.8 g
fat	0.2 g
thereof saturated fat	<0.1 g
fibers	0.2 g
sodium	<0.01 g

S. Spitz GmbH
Gmundnerstraße 27
4800 Attnang-Puchheim
Austria

Sauerkraut juice

<u>Ingredients</u>: organic sauerkraut juice 99.4%, not iodized sea salt 0.60%.

nutritional values per 100 g/ 100 ml	
energy	12 kcal/50 kJ
protein	1 g
carbohydrates	1.5 g
thereof sugar	0 g
fat	0.2 g
thereof saturated fat	0 g
fiber	0.2 g
sodium	0.2 g

Ja! Natürlich Naturprodukte Ges.m.b.H.
IZ Nö-Süd, Straße 3, Objekt 16
A-2355 Wr. Neudorf
Austria

3.6.2. Free choice profiling of test stimuli

Free choice profiling method with 41 participants, who didn't participate in the main study, was used to see how good consumers can differentiate the samples. 46% of the participants were female, 90% of them were between 20 and 29 years old and all of them were students at the University of Natural Resources and Life Sciences in Vienna. The samples were coded and randomized and about 100 ml were served in 250 ml glasses to the participants. The participants had to taste all five samples and were free to find attributes for differentiating the samples in categories of "visual appearance", "taste", "smell" and "texture". The intensity of every found attribute had to be marked for all five samples on a 100 mm scale. For evaluation the given markings on the scales were measured with the ruler. Senstools software (OP&P Product Research BV © 1994-2002, Version 3.3.2) was used to analyze given attributes and the data of measured intensities. For details of the used choice profiling test see Annex II "Free Choice Profile".

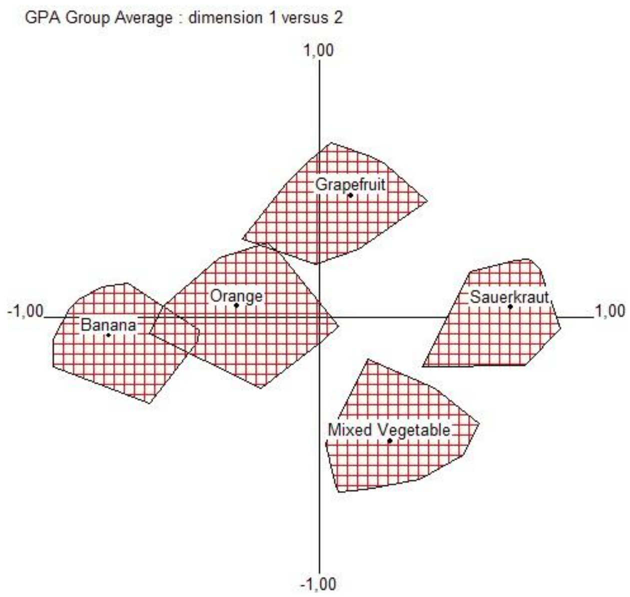

Figure 8: biplot of generalized Procrustes Analysis of the Freechoice Profiling of the five samples

Three dimensions were defined and screeplot showed that dimension 1 explained 54.3% and dimension 2 21.5% of the variability. Figure 8 shows the group average of the relevant dimensions. The red areas represent the individual factor. In general all samples could be clearly differentiated by the participants. The worked out descriptive attributes for banana and orange juice were sometimes similar. Sauerkraut and vegetable juice clearly varied from all other samples. The flavor of grapefruit juice was described sometimes similar to the flavor of orange juice. Maybe this result can reflect the related fruit acid content.

3.7. Participants

The participants were recruited at the University of Natural Resources and Life Sciences in Vienna. 99 students participated in the study. The data of 18 participants couldn't be used for statistical analysis because they didn't exactly follow the instructions during the experimental session or the quality of the measured data wasn't good enough (e.g. big glasses, permanent motion during session, hair or hands in the face). For statistical analysis 81 participants were used with an average age of 22.9 years (SD= 4.1 years) and with 43.2% females.

The participants read and signed an informed consent form at the beginning of the experimental session. All of them agreed that they are being video-recorded during the task and that these data together with the questionnaire data will be used anonymously for further analysis within this study. After the experimental session the participants received a reward for taking part in this study in form of sweets.

3.8. Experimental design

In the next chapters the experimental design used in this study is described to give an impression of the experimental set-up and the procedure of the experimental sessions.

3.8.1. Experimental set-up

The experiment took place in the sensory lab at the University of Natural Resources and Life Sciences in Vienna on every workday from 5th to 15th March 2013. In one testing booth the experiment was set up (see figure 9 and 10).
Streetlight and sunlight were avoided and artificial room lighting was used to ensure good illumination of the participant's face, which is an important requirement for FaceRader 5 (Noldus Information Technology, Wageningen, The Netherlands) to produce reliable results. The room temperature was about 21°C. A comfortable chair to avoid movement like "sliding around on the chair" was provided for the participants. A laptop (*Lenovo X220 Tablet*) guided the participant through questions and instructions, which were created with Compusense® *five* software (Compusense Inc., Guelph, Canada). The testing session was recorded continuously with a resolution of 640 x 480 at 25fps (frames per second) with a Logitech HD Pro C910 webcam mounted on the screen of the presenting laptop.

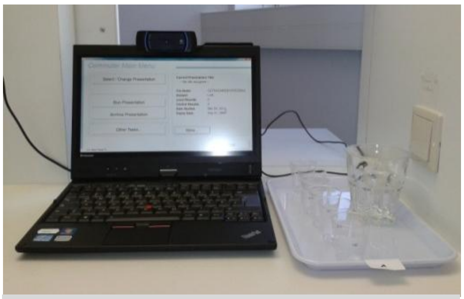

Figure 9:
laptop (*Lenovo X220 Tablet*) provided instructions and questions for the participant with webcam Logitech HD Pro C910

Figure 10:
1. laptop (*Dell precision*) with Media Recorder® software
2. laptop (*HP compaq*) with Biofeedback 2000 x-pert software and webcam Logitech C600

Outside the booth a laptop *(Dell precision*) with Media Recorder 2.0 (Noldus Information Technology, Wageningen, The Netherlands) software was used to video record the participant during the whole session. Another webcam Logitech C600 was used for video-recording the graphical output on the laptop (*HP compaq*) running Biofeedback 2000 $^{x\text{-}pert}$ software (Schuhfried GmbH, Mödling, Austria) to synchronize the data afterwards. Both webcams were checked for synchronization before starting the experiment. There was a difference of 1 frame (0.04 seconds).

3.8.2. Session procedure

The procedure of a session is outlined in figure 13. The participants always had to start with the warm-up sample to familiarize with the procedure. They were asked to taste the whole presented sample (2 cl) at once and take 20 seconds (integrated timer) to experience the sample with its flavor impression. Facial expressions can begin in a matter of milliseconds after an emotion-provoking stimulus, and usually are brief in duration (several seconds) [EKMAN and FRIESEN, 1978; EKMAN, 1984]. The measured ANS parameters have a slightly slower onset (in the range of a few seconds) [DAWSON et al., 2000; VENABLES and MITCHELL, 1996; BOUCSEIN, 2012]. Preliminary tests showed that allowing the participants 20 seconds to consider the taste offered a good compromise wherein participants had enough time to make up their minds regarding the taste without feeling forced to wait.

After experiencing the sample the participants had to give a signal by raising the right hand and visualize the taste experience of the sample with an intentional facial expression best presenting the liking of the sample. Afterwards, the participants had to rate the liking or disliking of the sample on a 9-point hedonic scale in German language [LILL and KÖHN, 2007] ranging from 1 (like extremely) to 9 (dislike extremely), and the familiarity on a 5-point scale, ranging from 1 (very familiar) to 5 (completely unfamiliar). After answering the questions participants were instructed to take a sip of water to rinse the mouth. Before continuing with the next sample the participants had to sit and wait for about 70 seconds (integrated timer) to level-off the physiological signals .The above described procedure was the same for all samples. At the end of the experimental session demographic questions and consumer behavior related questions had to be answered. For the exactly instructions and questions see Annex I "Questionnaire". In total one session took about 20 minutes.

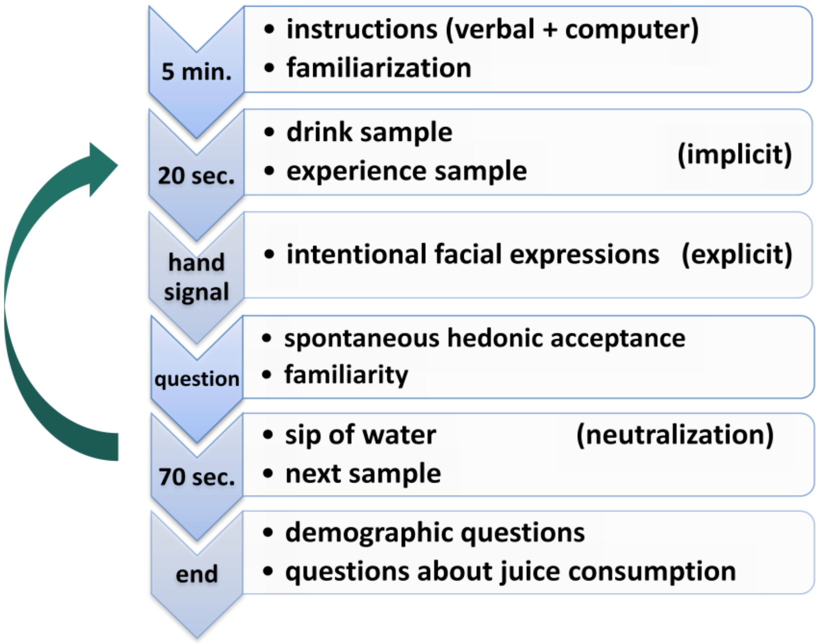

Figure 11: schematic trial procedure

3.8.3. Introduction and start of the experimental session

Figure 12:
electrode placement

The experimental leader instructed the participant to sit down on the chair and attached the Velcro strap with the integrated electrodes of the radio module MULTI (Biofeedback 2000 $^{x\text{-}pert}$, Schuhfried GmbH, Mödling, Austria) on the participant's volar surface of the medial phalanges of the forefinger of the left hand (see figure 11), which was cleaned before with ethyl alcohol. EDELBERG (1967) and VENABLES and CHRISTIE (1980) recommend the medial phalanges of the index or middle finger, because these medial phalanges tend to have less scarring, are less sensitive to movement effects and provide more areas for electrode fixing. The sender unit of radio module MULTI was strapped on forearm near the wrist (see figure 12) and transmitted the signals via Bluetooth to the analyzing laptop. The left hand was used because most of the people are right-hander and the electrodes should be placed on the non-dominant hand [DAWSON et al., 2000] and there was more space on the left side near the laptop to put the hand relaxed on the desk in the booth. The hand with the attached electrodes was put on a soft cotton cloth to avoid the influence of the cold desk on the finger temperature. After putting the electrodes on the finger, Media Recorder 2.0 and Biofeedback 2000 $^{x\text{-}pert}$ software recording with 40 Hz were started manually and synchronously as possible from outside the booth.

Figure 13:
radio module MULTI placement

The experiment leader gave each participant the same instructions for the experimental session orally:

- “Sit comfortable.”
- “Don’t move too much during the whole session; especially the left hand and arm with the attached electrodes and radio module MULTI. The left hand should be relaxed and restful.”
- “Do not be scared. No current flows in the module; it just measures parameters like the skin conductance.”
- If the participant wore glasses, he/she was asked, if it would be possible to do the session without glasses.
- “The physiological parameters need about five minutes to be stabilized. During this time you can try to find your most comfortable sitting position and I will prepare the samples. The samples are different juices and they will be put right beside the laptop. They are all marked with numbers. The laptop gives you all instructions you need for the session.”
- “Please taste a sample once only and drink the sample in one sip.”
- “After the first flavor impressions of the sample the laptop will give you the instruction to lift up your right hand. Please, lift up your right hand and show your facial expression, which would describe and present the liking of the sample best, for some seconds to the webcam. Then you have to rate your liking of the sample on a scale. After that take a sip of water and go to the next sample.”

3.8.4. Sample preparation

During the five minutes waiting for stabilization of physiological parameters the samples were prepared. 2 cl of every sample were put into 4cl shot cups. The six samples (including one warm-up sample) and a 250 ml glass of water were served on a tablet to the participant. The samples were randomized, number- and color-coded (color code was attached on the bottom of the cup and not visible for the participant but for easier identification during video analysis). The sauerkraut juice was always prepared 2 hours before testing to decrease the intensity of its strong smell, which could influence the participant's taste perception.

3.9. Data preparation

All recorded videos in AVI format were analyzed frame by frame using FaceReader 5 software and were imported to The Observer XT 11 (Noldus Information Technology, Wageningen, The Netherlands). In FaceReader 5 the settings "Face Model - general" and "Sample Rate - every frame" were used. The software feature "individual calibration" for standardization was not used, because a baseline before sample tasting was used for data correction. The physiological data were imported as a text format to The Observer XT 11 program. FaceReader and Biofeedback data were synchronized manually in The Observer XT and sections of interest were selected for every sample by hand: "baseline", "spontaneous/implicit responses" and "intentional/explicit facial expressions" (see figure 14).

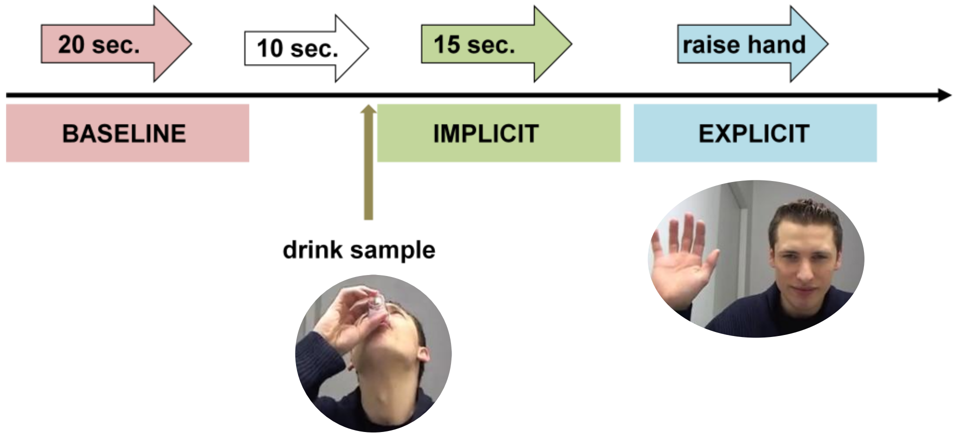

Figure 14: coding scheme for one sample

The baseline was always set 20 seconds before the participant continued with the presentation slide with instructions to taste the sample. The implicit section with the spontaneous facial expressions and ANS responses lasted for 15 seconds, started exactly when the participant swallowed the sample and lasted shortly before continuing with the slide to give the hand signal. The chosen time interval is within the indicated required time for changes in SCL [BOUCSEIN, 2012]. The explicit section with intentional facial expressions started when the participant raised the right hand and ended when the participant lowered the hand. The duration of the implicit and explicit section varied slightly between the participants depending on the individual time for sample handling and the individual duration of showing their intentional facial expressions.

People who didn't follow exactly the instructions or people who moved too much during the session (limit was 0.5 m/s^2 "motility") were excluded from statistical analysis. The analysis in The Observer XT 11 was conducted with the option "select intervals", which created a data table with maximum and mean values of all measured parameters of the baseline, implicit and explicit section.

The data were imported to Microsoft Excel and a baseline-correction was obtained by subtracting the mean values of the baseline from the mean value of the implicit section for the ANS parameters and by subtracting the maximum values of the baseline from the maximum values of the implicit or explicit section for the seven facial expressions ("angry", "disgusted", "happy", "sad", "scared", "surprised" and "neutral").

To correct the interindividual variance, LYKKEN and colleagues (1966) suggested expressing SCL as a proportion of one person's individualized range referred to as "range correction" with following formula: SCL corrected = (SCL – SCLmin) / (SCLmax – SCL min). SCLmin (according to SCR correction by LYKKEN and VENABLES, 1971) was taken as zero and each baseline corrected mean value per sample was divided by the maximum baseline corrected mean value out of all samples to create corrected individual or relative SCL. Before this correction SCL data underwent a subsequent square root transformation to normalize the distribution [GRINGS, 1974]. The same procedure was performed for the pulse parameter.

Due to the shorter duration of the facial reactions compared to ANS responses the use of the maximum values is more appropriate. Preliminary experiments showed that using the baseline corrected maximal values allowed a better differentiation between samples. Additionally two cumulative parameters: a) the baseline corrected "valence" as a measure of relative emotion calculated with a predetermined algorithm in which the ration between positive ("happy") and negative ("angry", "disgusted", "sad" and "scared") facial expressions was calculated within the section of interest and b) the baseline corrected sum of all negative emotions was included in the statistical analysis.

3.10. Statistical analysis

All analyses were performed with IBM SPSS Statistics 21 (IBM Corporation, Armonk, USA). For the statistical analysis the baseline corrected maximum values of the facial expression patterns (“angry”, “disgusted”, “happy”, “sad”, “scared”, “surprised” and “neutral”), the baseline corrected mean values of “valence” (a measure of relative emotion based on the ratio between positive and negative facial expressions) and the baseline corrected maximum values of “sum of all negative emotions” of the implicit and explicit section were used.

For the analysis of the physiological parameters (SCL, finger temperature, BVP, PVA and pulse) the baseline corrected mean values of the implicit section were used and additionally the individual or relative values of SCL and pulse. Due to available hardware for skin conductance recording it was just able to investigate the decrease or increase of SCL with its superimposed changes by mean values. It was not able to include SCR mean values for statistical analysis, because these values were always around zero due to alternating positive and negative SCR value changes. For an exact SCR analysis with its typical parameters like amplitude or recovery time, specialized software has to be used.

Repeated Measures ANOVA was conducted with the presented samples as within-subject factors and the facial expressions and the ANS parameters as measures. To assess differences between experiment conditions and gender differences, experimental condition and gender were added as additional factors. Greenhouse-Geisser correction was used in case of violation of the assumption of sphericity. For the post-hoc comparisons Bonferroni alpha correction was used. To examine the correlation between facial expressions or ANS reactions and the hedonic liking, a stepwise linear regression with backward elimination and Spearman correlation were used.

4. Results

In all results the term significant is taken to mean significant at α= 0.05 level. Following categories were used: < 0.05 = *, < 0.01 = ** and < 0.001 = ***.

4.1. Participants

In total there were 81 participants with 35 females and 46 males. 43.2% of the study participants were female. The participants were on average 22.9 years (SD= 4.1) old. With 79 people most of the participants were students (97.5%), the others were university staff or other staff.

Most of the participants stated that they drink fruit juice several times a week or several times a month (see figure 15).

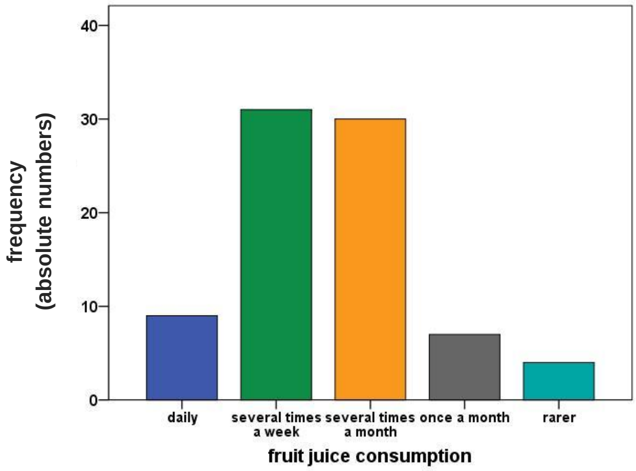

Figure 15: fruit juice consumption of the study population

No participant stated to drink vegetable juice every day. Most of the participants consume it rarer than once a month (see figure 16).

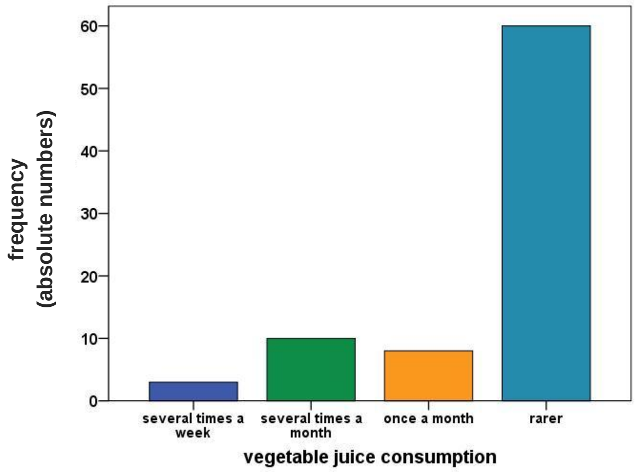

Figure 16: vegetable juice consumption of the study population

The average reported BMI of the female participants with 24.9 (SD= 4.0) was higher than the average BMI of the men with 22.9 (SD= 4.5). Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution indicated that the BMI data of all samples were not normally distributed (see figure 17).

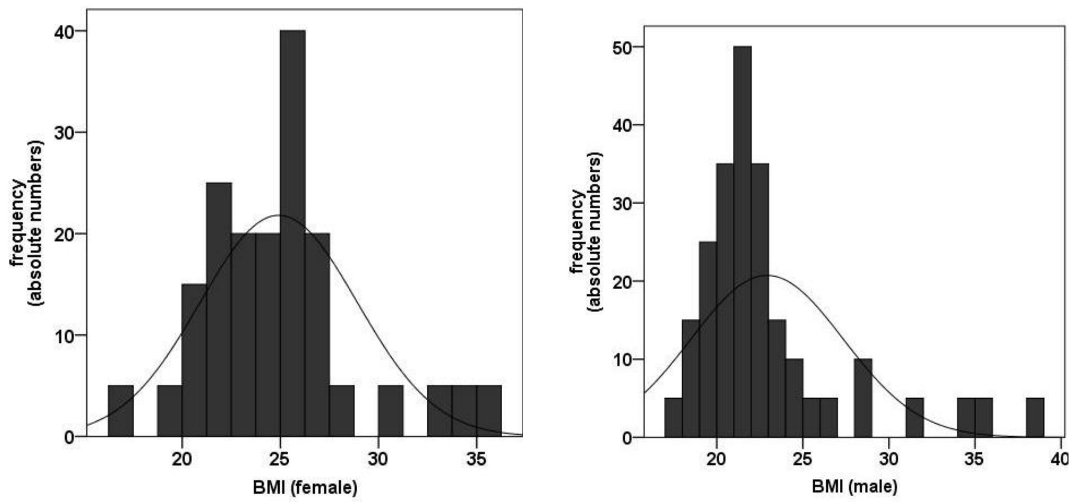

Figure 17: BMI distribution of the study population by gender

The participants rated the familiarity of the samples as follows: grapefruit juice as the sample with the lowest familiarity ("moderate familiar") and banana as the sample with the highest familiarity ("quite familiar"). But in general all samples were rated with almost equal familiarity.

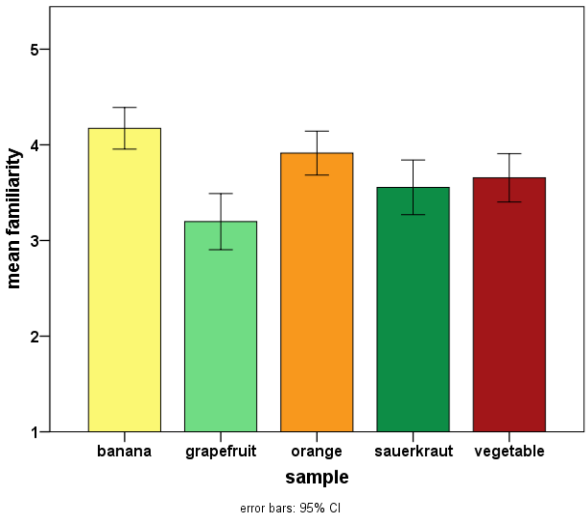

Figure 18: self-reported spontaneous familiarity with 1 (completely unfamiliar) to 5 (very familiar), Errorbars indicate SE

There were significant differences in self-reported familiarity between the different samples ($p < 0.001$). The means, the standard errors and the results of the post-hoc comparisons are summarized in table 4.

sample	mean	SE	SD	sig. diff.
banana	4.173	0.9848	0.1094	C
grapefruit	3.198	1.3268	0.1474	A
mixed vegetable	3.654	1.1419	0.1269	B
orange	3.914	1.0392	0.1155	BC
sauerkraut	3.556	1.2942	0.1438	AB

SE = standard error, SD = standard deviation, sig. diff. = significant differences

Table 4: reported familiarity: for post-hoc comparison Bonferroni correction and significance level p=0.05 were used

Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution indicated that the familiarity data of all samples were not normally distributed. The familiarity data of the samples banana and orange juice, which were the most liked samples, showed a left-skewed distribution. The grapefruit juice sample showed nearly a uniform distribution.

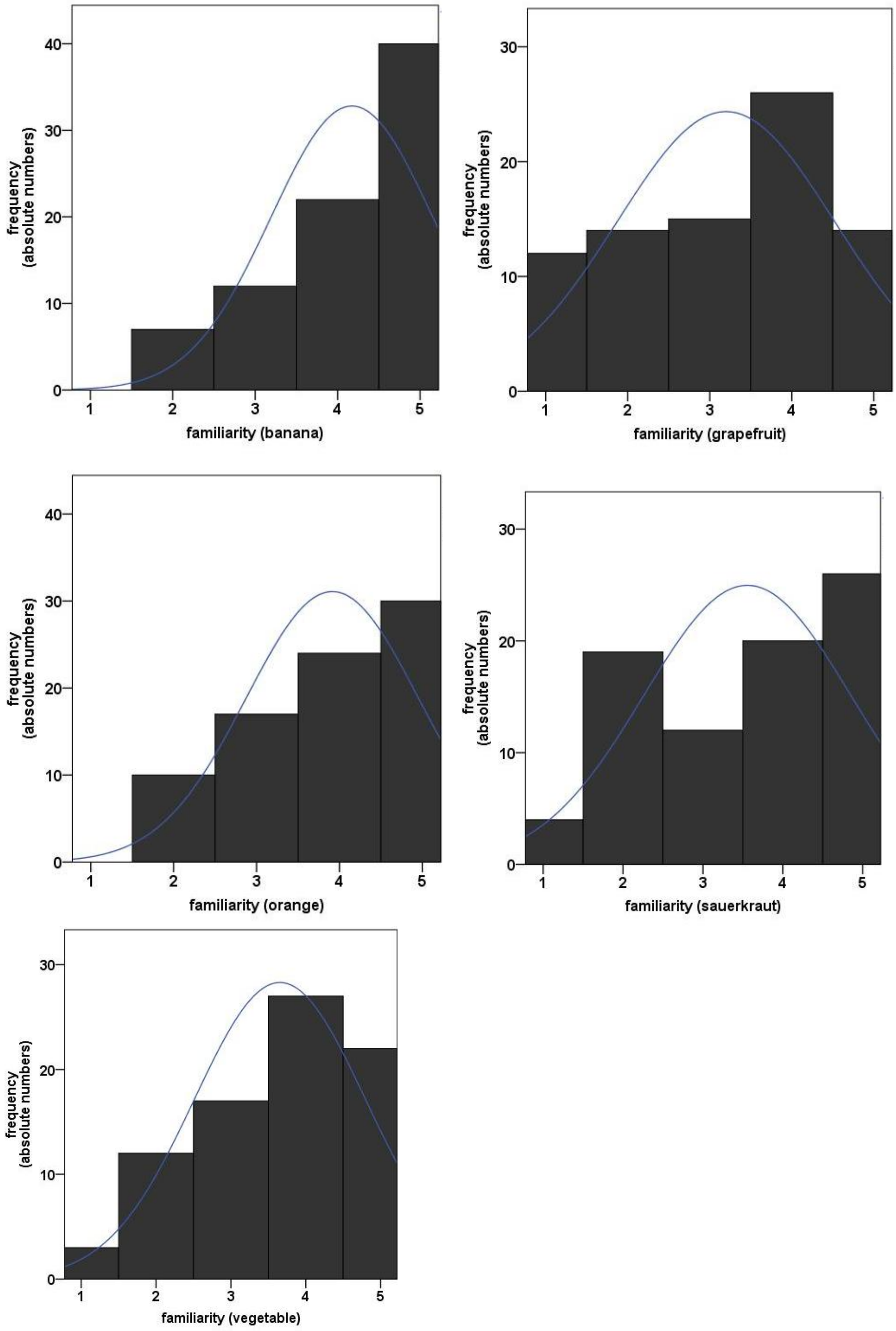

Figure 19: distribution of familiarity data

4.2. Self-reported spontaneous liking

There were significant differences in self-reported spontaneous liking between the different samples ($p < 0.001$). Pairwise comparisons showed (see table 5) that the sample banana juice ($\bar{x}$= 7.41) was rated significantly better than all other samples. The liking of orange juice ($\bar{x}$= 6.43) was rated significantly lower than banana juice but higher than vegetable ($\bar{x}$= 3.32), grapefruit ($\bar{x}$= 3.19) and sauerkraut juice ($\bar{x}$= 2.62). There were no significant differences between the liking of vegetable, grapefruit and sauerkraut juice, but they were rated as the least liked samples of all. There were no significant gender differences between the likings of the samples ($p > 0.05$). The means, the standard errors and the results of the post-hoc comparisons are summarized in table 5.

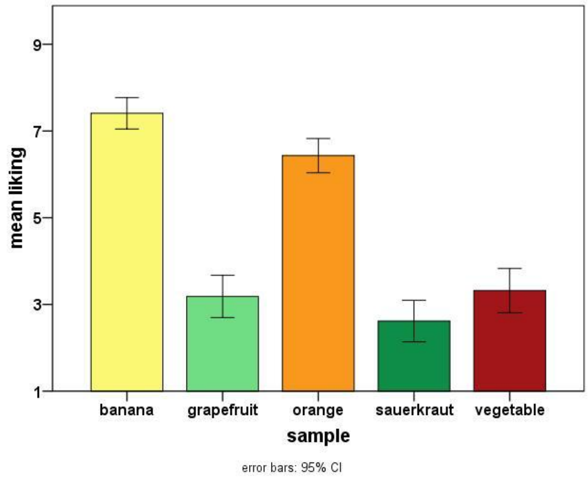

Figure 20: self-reported spontaneous hedonic acceptance with 1 (dislike extremely) to 9 (like extremely), Errorbars indicate SE

sample	mean	SE	SD	sig. diff.
banana	7.407	0.1815	1.6338	C
grapefruit	3.185	0.2448	2.2029	A
mixed vegetable	3.321	0.2569	2.3121	A
orange	6.432	0.1987	1.7884	B
sauerkraut	2.617	0.2406	2.1655	A

SE = standard error, CI = confidence interval, sig. diff. = significant differences, SD = standard deviation

Table 5: introspective liking: for post-hoc comparison Bonferroni correction and significance level p=0.05 were used

Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution indicated that the liking data of all samples were not normally distributed. The liking data of the samples banana and orange juice, which were the most liked samples, showed a left-skewed distribution. The other samples showed a right-skewed distribution. But we decided to use the mean values of the liking data due to the assumption that using a more robust location estimator like the median for statistical tests would not lead to different conclusion from results.

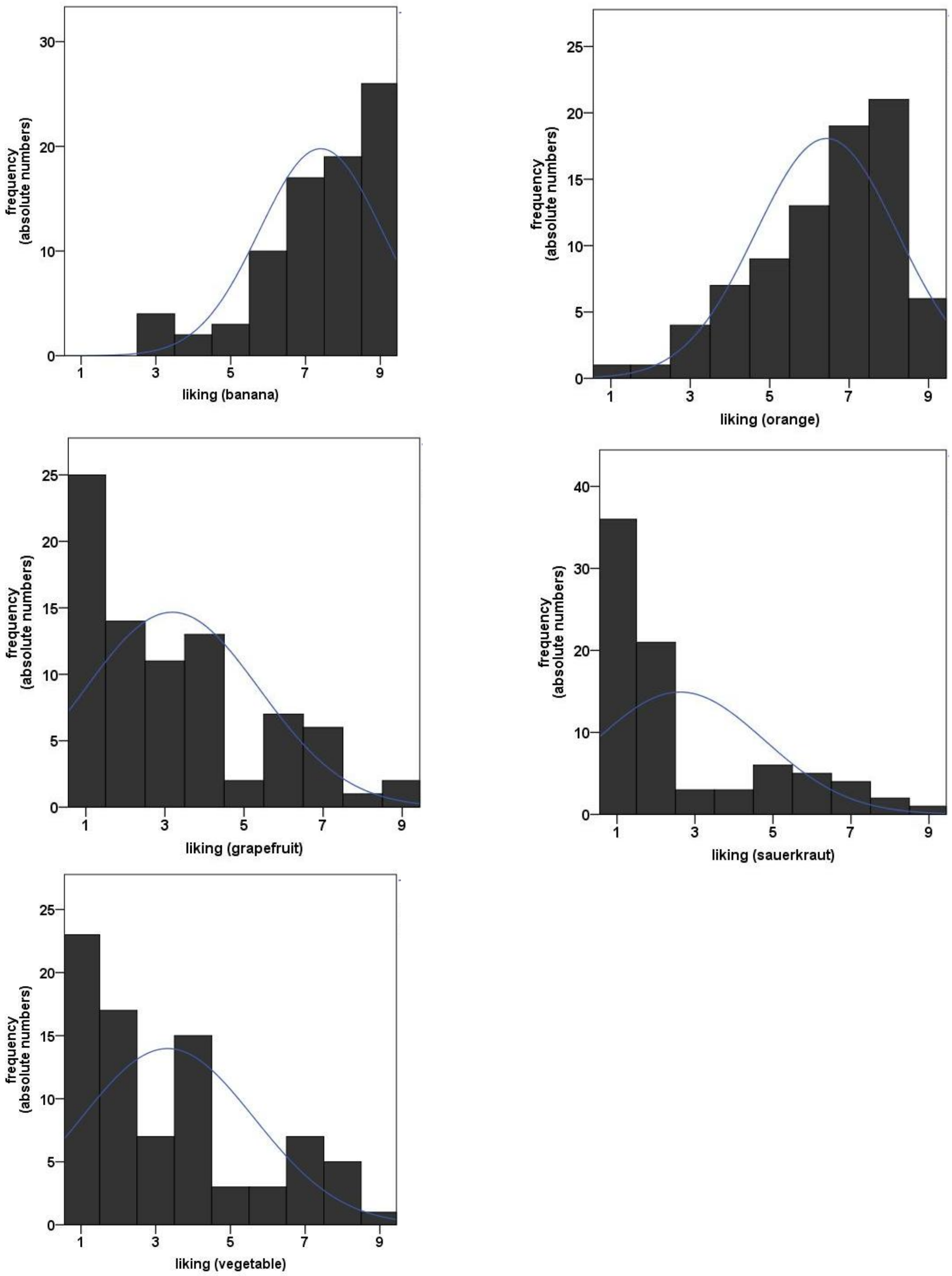

Figure 21: distribution of liking data

4.3. Changes in ANS parameters

Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution indicated that the data of ANS parameters were not normally distributed except for relative SCL for the sample banana juice (tested with Kolmogorov-Smirnov test). The changes in relative SCL showed normal distribution for banana juice, a left-skewed distribution for grapefruit, orange, sauerkraut and vegetable juice. The data of PVA change showed a distribution similar to normal distribution for all samples. But we decided to use the mean values of the ANS parameters due to the assumption that using a more robust location estimator like the median for statistical tests would not lead to different conclusion from results.

Repeated Measures ANOVA showed a significant difference ($p < 0.001$) in ANS parameters between the samples. No significant gender ($p > 0.05$) and interaction effects ($p > 0.05$) were observed.

The univariate test showed significant differences in the change of following ANS parameters during implicit situation: “SCL” ($p < 0.001$), “relative SCL” ($p < 0.001$) and “PVA” ($p = 0.036$). The other ANS parameters like “pulse”, “relative pulse”, “finger temperature” and “BVP” didn’t show significant differences in their change. The changes of the relative SCL is presented in figure 22. This parameter allowed a good differentiation between the samples. Sauerkraut juice elicited the highest and orange juice the lowest increase of relative SCL.

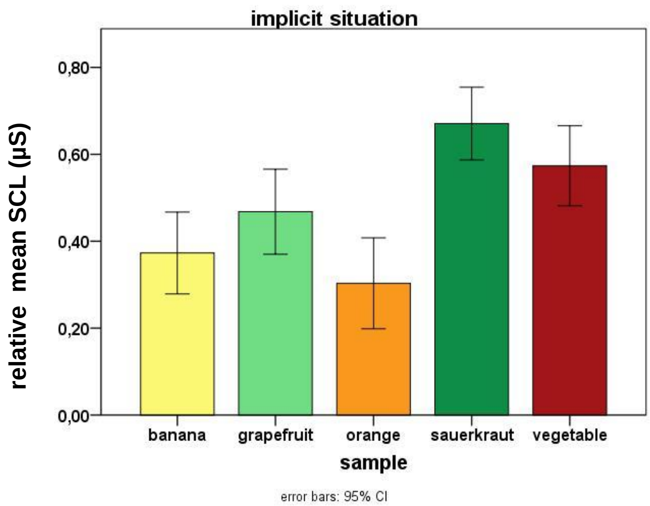

Figure 22: mean relative SCL in the implicit situation
Errorbars indicate SE

The means, the standard errors and the results of the post-hoc comparisons are summarized in table 6. Pairwise comparisons showed that mixed vegetable and sauerkraut juice caused significantly a stronger increase of SCL than banana and orange juice. Grapefruit juice elicited significantly higher SCL values than orange juice.
Similar association was observed for relative SCL. Mixed vegetable and sauerkraut juice significantly caused a stronger increase of relative SCL than banana and orange juice. Grapefruit juice elicited significantly higher relative SCL values than orange and sauerkraut juice.

If proofing the widely used and accepted minimum SCL change of 0.05 µS for identification of a response to a stimuli [BOUCSEIN, 2012; VENABLES and MITCHELL, 1996] only the less liked samples grapefruit (0.072 µS), vegetable (0.073 µS) and sauerkraut (0.087 µS) juice exceeded this minimum change level (see table 6).

Pairwise comparisons for PVA were not significant (p= 0.086), but indicated that vegetable juice elicited a slightly lower decrease in PVA than the other samples.

IMPLICIT									
	SCL *** (µS)			pulse (bpm)			PVA * (%)		
sample	mean	SE	sig. diff.	mean	SE	sig. diff.	mean	SE	sig. diff.
banana	0.046	0.006	AB	10.231	2.092	ns	-3.336	0.615	ns
grapefruit	0.072	0.011	BC	10.73	1.937	ns	-4.885	0.949	ns
mixed vegetable	0.073	0.008	C	9.989	1.804	ns	-2.322	0.650	ns
orange	0.043	0.006	A	10.110	2.096	ns	-4.504	0.898	ns
sauerkraut	0.087	0.009	C	10.578	1.924	ns	-4.370	0.896	ns

IMPLICIT									
	BVP (%)			relative SCL *** (µS)			temperature (°C)		
sample	mean	SE	sig. diff.	mean	SE	sig. diff.	mean	SE	sig. diff.
banana	0.081	0.048	ns	0.373	0.047	AB	-0.015	0.009	ns
grapefruit	0.110	0.056	ns	0.468	0.050	BC	-0.011	0.012	ns
mixed vegetable	0.032	0.062	ns	0.574	0.046	CD	-0.009	0.015	ns
orange	0.056	0.045	ns	0.303	0.053	A	-0.011	0.011	ns
sauerkraut	0.086	0.043	ns	0.671	0.042	D	-0.017	0.009	ns

IMPLICIT			
relative pulse (bpm)			
sample	mean	SE	sig. diff.
banana	0.421	0.061	ns
grapefruit	0.417	0.064	ns
vegetable	0.422	0.056	ns
orange	0.411	0.061	ns
sauerkraut	0.455	0.659	ns

ns = not significant

Table 6: ANS responses elicited by juices: significant differences are indicated with * $p< 0.05$ ** $p< 0.01$ *** $p< 0.001$. For post-hoc comparison Bonferroni correction and significance level $p=0.05$ were used.

4.3.1. Correlation between ANS parameters and self-reported liking

The stepwise backward linear regression showed a significant correlation between the spontaneous hedonic liking and the change of relative SCL ($p < 0.001$, $r = 0.203$). The other ANS parameters didn't show significant correlations with hedonic liking (see table 10 on page 66).

The correlation between baseline corrected relative mean SCL and hedonic liking ratings are represented in figure 23. The relative SCL is higher for disliked juices compared to lower values of liked samples.

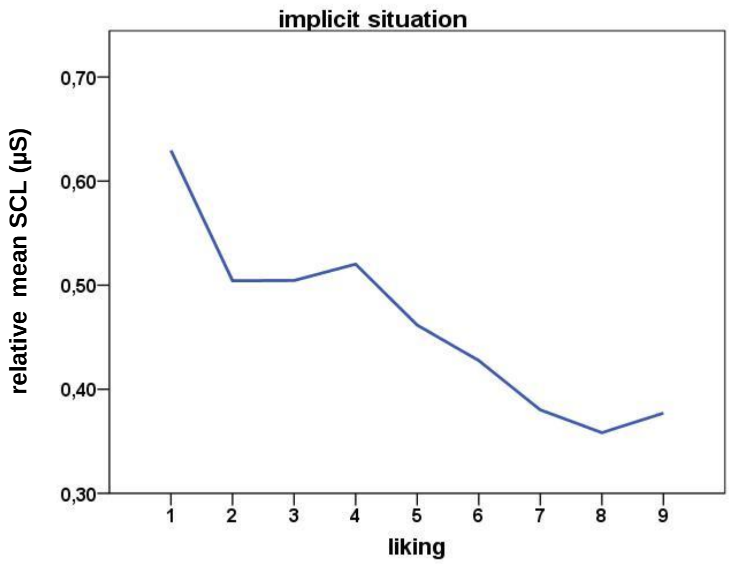

Figure 23: correlation between relative SCL and liking with 1 (dislike extremely) to 9 (like extremely)

Additionally individual liking ratings from the 9-point hedonic scale were classified in three categories with ratings 1-3 as "disliked", 4-6 as "neutral" and 7-9 as "liked". Post-hoc comparisons of performed ANOVA showed a significant differentiation ($p < 0.001$) between "liked" and "disliked" samples in relative SCL changes. Thus category 1 with the "disliked" samples had a significantly stronger increase in relative SCL than category 3 with the "liked" juices. No significant effects of "neutral" rated samples were observed.

4.4. Implicit measurement of spontaneous facial expressions

Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution indicated that the data of facial expressions in the implicit situation were not normally distributed except for “sad” for the sample sauerkraut juice (tested with Shapiro-Wilk and Kolmogorov-Smirnov test). The changes in “angry” showed a distribution similar to normal distribution for banana, sauerkraut and vegetable juice and a right-skewed distribution for grapefruit and orange juice. The changes in “disgusted” showed a distribution similar to normal distribution for banana and orange juice and a right-skewed distribution for grapefruit, sauerkraut and vegetable juice. The changes in “happy” showed a distribution similar to normal distribution for all samples. The changes in “neutral” showed a distribution similar to normal distribution for grapefruit, orange and vegetable juice, a right-skewed distribution for banana juice and a left-skewed distribution for sauerkraut juice. The changes in “sad” showed normal distribution for sauerkraut juice and the other samples showed a similar distribution. The changes in “negative emotions” showed a left-skewed distribution for banana juice and a distribution similar to normal distribution for all others. The changes in “valence” showed a distribution similar to normal distribution for all samples.

Repeated Measures ANOVA showed significant differences ($p = 0.004$) in the intensity of elicited spontaneous/implicit facial expressions between the samples. There were significant differences in gender ($p = 0.031$) observed but no interaction effects ($p > 0.05$) between samples and gender. The significant influence of gender showed that female participants had more intense facial reactions of “angry” ($p = 0.002$) than male participants. The facial expression “happy” ($p = 0.053$) was almost significant too. More significant differences between gender and facial expressions couldn’t be observed.

The univariate test showed significant differences in following facial expressions: “disgusted” ($p < 0.001$), “happy” ($p < 0.001$), “neutral” ($p < 0.001$), “sad” ($p = 0.004$) and “negative emotions” ($p < 0.001$). The facial expressions “angry” ($p = 0.436$), “scared” ($p = 0.232$), “surprised” ($p = 0.667$) and “valence” ($p = 0.345$) didn’t show significant effects.
Figure 24 shows that grapefruit, vegetable and sauerkraut juice elicited more intense the facial expression of “disgusted” than banana or orange juice. Sauerkraut juice had

the least “neutral” facial expression and showed the most intensity in “happy” compared to others.

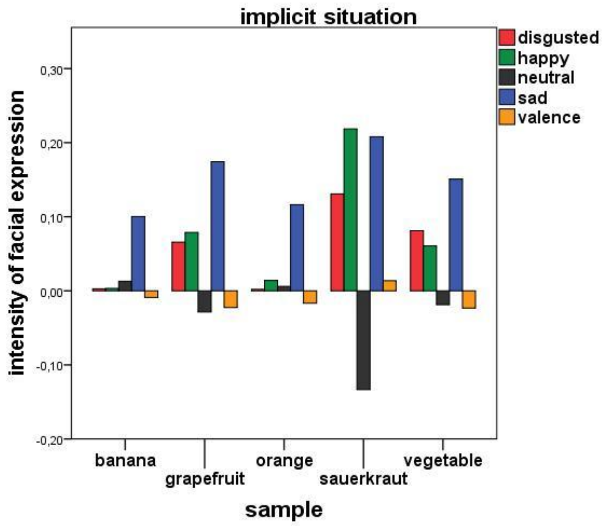

Figure 24: intensity of facial expressions in the implicit situation

The means, the standard errors and the results of the post-hoc comparisons are summarized in table 7. Pairwise comparisons showed that sauerkraut, grapefruit and vegetable juice elicited significantly more intense “overall negative” facial expressions and facial expressions of “disgusted” than banana and orange juice. Also “neutral” allowed a significant differentiation between samples. Sauerkraut juice caused the highest decline of “neutral” compared to the baseline, followed by grapefruit juice. Furthermore sauerkraut juice elicited the most intense facial reactions of “happy”. This phenomenon will be discussed in the next chapter.

IMPLICIT									
	ANGRY			DISGUSTED ***			HAPPY ***		
sample	mean	SE	sig. diff.	mean	SE	sig. diff.	mean	SE	sig. diff.
banana	0.039	0.009	ns	0.003	0.002	A	0.003	0.021	B
grapefruit	0.066	0.013	ns	0.066	0.022	B	0.079	0.026	B
mixed vegetable	0.053	0.014	ns	0.081	0.021	B	0.061	0.026	B
orange	0.053	0.011	ns	0.002	0.004	A	0.014	0.016	B
sauerkraut	0.061	0.015	ns	0.131	0.028	B	0.219	0.036	A

IMPLICIT									
	NEUTRAL ***			SAD **			SCARED		
sample	mean	SE	sig. diff.	mean	SE	sig. diff.	mean	SE	sig. diff.
banana	0.013	0.008	C	0.100	0.028	A	-0.005	0.006	ns
grapefruit	-0.029	0.012	B	0.174	0.022	AB	0.010	0.003	ns
mixed vegetable	-0.019	0.016	BC	0.151	0.027	AB	0.005	0.003	ns
orange	0.006	0.007	BC	0.116	0.022	AB	0.003	0.007	ns
sauerkraut	-0.133	0.021	A	0.208	0.026	B	0.011	0.004	ns

IMPLICIT									
	SURPRISED			NEGATIVE EMOTIONS ***			VALENCE		
sample	mean	SE	sig. diff.	mean	SE	sig. diff.	mean	SE	sig. diff.
banana	0.014	0.015	ns	0.136	0.034	A	-0.009	0.015	ns
grapefruit	0.021	0.015	ns	0.315	0.038	C	-0.023	0.014	ns
mixed vegetable	0.014	0.014	ns	0.300	0.040	BC	-0.023	0.019	ns
orange	0.009	0.019	ns	0.174	0.024	AB	-0.017	0.010	ns
sauerkraut	-0.006	0.017	ns	0.411	0.048	C	0.014	0.021	ns

ns=not significant

Table 7: intensity of facial expressions elicited by juices in the implicit situation. Significant differences are indicated with * $p< 0.05$ ** $p< 0.01$ *** $p< 0.001$. For post-hoc comparison Bonferroni correction and significance level $p= 0.05$ were used.

4.4.1. Correlation between implicit facial expressions and self-reported liking

Stepwise backward linear regression showed a significant correlation ($p < 0.001$, $r = 0.45$) between implicit facial expressions “disgusted”, “happy”, “neutral” and “sad”, “negative emotions” (all $p < 0.001$) and the spontaneous hedonic liking ratings. “Disgusted” and “neutral” had the strongest correlation with $r = -0.413$ and $r = 0.399$, respectively (see table 10 on page 66).

The means of facial expressions (see figure 25) indicated that disliked samples elicited more intense facial expressions of most negative emotions and less intense facial expressions of “neutral” than neutral rated or liked samples, with neutral and liked samples at almost the same level. Additionally individual liking ratings from the 9-point-hedonic scale were classified in three categories with ratings 1-3 as “disliked”, 4-6 as “neutral” and 7-9 as “liked”. The above mentioned assumption was strengthened for “disgusted” and “sad” as well as for “neutral” by an ANOVA (all $p < 0.001$) with the samples classified in the three categories.

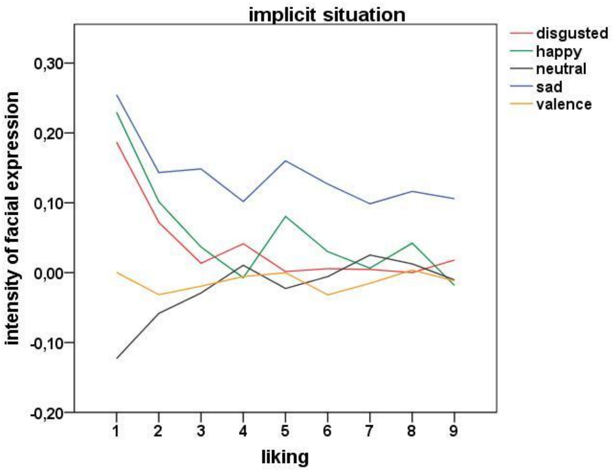

Figure 25: relations between the means of implicit facial expressions and introspective liking ratings with 1 (dislike extremely) to 9 (like extremely)

4.5. Explicit measurement of intentional facial expressions

Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution indicated that the data of facial expressions in the explicit situation were not normally distributed except for “sad” for the sample sauerkraut juice (tested with Shapiro-Wilk test). The changes in “angry” showed a right-skewed distribution for grapefruit juice and a distribution similar to normal distribution for all other juices. The changes in “disgusted” showed a left-skewed distribution for banana juice and a right-skewed distribution for all other ones. The changes in “happy” showed a distribution similar to normal distribution for all samples. The changes in “neutral” showed a distribution similar to normal distribution for banana juice and a left-skewed distribution for all other samples. The changes in “sad” showed normal distribution for sauerkraut juice and the other samples showed a similar distribution. The changes in “negative emotions” showed a right-skewed distribution for sauerkraut juice and a distribution similar to normal distribution for all others. The changes in “valence” showed a distribution similar to normal distribution for all samples.

Repeated Measures ANOVA showed a significant difference ($p = 0.004$) in explicit facial expressions between the samples. No significant gender ($p > 0.05$) and interaction effects ($p > 0.05$) were observed. The univariate test showed significant differences in following facial expressions: “angry” ($p = 0.008$), “disgusted” ($p < 0.001$), “happy” ($p = 0.003$), “neutral” ($p < 0.001$), “sad” ($p = 0.009$) and “negative emotions” ($p < 0.001$), “valence” ($p < 0.001$). The facial expressions “scared” ($p > 0.05$) and “surprised” ($p = 0.480$) didn’t show any significant effects. Figure 26 displays the explicit situation with banana juice elicited the most intense facial reaction of “happy” followed by orange juice compared to the other samples. Sauerkraut juice showed also in the explicit case the least neutral facial reactions. The valence was highest for banana juice and disgust was most intensive for sauerkraut juice.

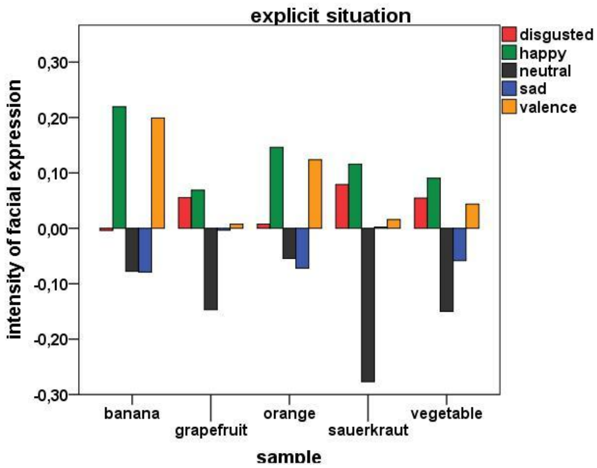

Figure 26: intensity of facial expressions in the explicit situation

Pairwise comparisons showed that sauerkraut, grapefruit and vegetable juice elicited significantly more intense facial expressions of “disgusted” and “negative emotions”, which is comparable to the findings in the implicit case. “Neutral” allowed differentiation in three homogeneous groups: sauerkraut juice with the highest decline in “neutral” facial expression followed by grapefruit and vegetable juice, forming the second group, and banana and orange juice with the lowest decrease in “neutral” forming the third group. “Happy” and “valence” showed that orange and banana juice significantly differed from sauerkraut, grapefruit and vegetable juice. The means, the standard errors and the results of the post-hoc comparisons are summarized in table 8.

EXPLICIT									
	ANGRY **			DISGUSTED ***			HAPPY **		
sample	**mean**	**SE**	**sig. diff.**	**mean**	**SE**	**sig. diff.**	**mean**	**SE**	**sig. diff.**
banana	-0.023	0.008	A	-0.004	0.001	A	0.220	0.380	B
grapefruit	0.023	0.015	B	0.055	0.019	BC	0.069	0.025	A
mixed vegetable	0.002	0.012	AB	0.054	0.018	BC	0.090	0.033	A
orange	-0.007	0.008	AB	0.008	0.011	AB	0.146	0.030	AB
sauerkraut	0.024	0.015	B	0.079	0.022	C	0.116	0.031	AB

EXPLICIT									
	NEUTRAL ***			SAD **			SCARED		
sample	**mean**	**SE**	**sig. diff.**	**mean**	**SE**	**sig. diff.**	**mean**	**SE**	**sig. diff.**
banana	-0.077	0.016	A	-0.079	0.024	ns	-0.006	0.006	ns
grapefruit	-0.147	0.024	B	-0.003	0.022	ns	0.006	0.003	ns
mixed vegetable	-0.150	0.025	B	-0.058	0.027	ns	-0.003	0.002	ns
orange	-0.054	0.013	A	-0.072	0.021	ns	-0.005	0.005	ns
sauerkraut	-0.277	0.036	C	0.002	0.023	ns	0.008	0.004	ns

EXPLICIT									
	SURPRISED			NEGATIVE EMOTIONS ***			VALENCE ***		
sample	**mean**	**SE**	**sig. diff.**	**mean**	**SE**	**sig. diff.**	**mean**	**SE**	**sig. diff.**
banana	-0.052	0.019	ns	-0.112	0.030	A	0.199	0.034	C
grapefruit	-0.018	0.019	ns	0.081	0.030	CD	0.007	0.024	A
mixed vegetable	-0.040	0.018	ns	-0.004	0.031	BCD	0.044	0.030	AB
orange	-0.047	0.015	ns	-0.076	0.029	AB	0.124	0.025	BC
sauerkraut	-0.048	0.017	ns	0.114	0.036	D	0.016	0.029	AB

ns= not significant

Table 8: intensity of facial expressions elicited by juices in the explicit situation. Significant differences are indicated with * $p< 0.05$ ** $p< 0.01$ *** $p< 0.001$. For post-hoc comparison Bonferroni correction and significance level $p= 0.05$ were used.

4.5.1. Correlation between explicit facial expressions and self-reported liking

Significant correlations between intentional facial expressions and self-reported liking were found for “angry”, “disgusted”, “happy”, “neutral”, “sad”, “negative emotions” and “valence”, at which “disgusted” (r= -0.510) and “valence” (r= 0.412) showed strongest correlations (see table 10 on page 66).

Similar as in the implicit case a linear or monotone model was not fully able to describe the relations between facial expressions and hedonic acceptance. Facial expressions of negative emotions like “disgusted” and “angry” were elicited only by disliked samples but not by neutral rated or liked samples. Whereas “happy” and increase in “valence” were elicited by liked but not by disliked and “neutral” samples. This was tested with an ANOVA with the samples classified in three categories as “liked” (rating 9-7 on 9-point hedonic scale), “neutral” (rating 6-4) and “disliked” (rating 3-1). The results showed that disliked samples elicited significantly more intense expressions of “angry” ($p= 0.024$) and “disgusted” ($p< 0.001$) and less intense “neutral” ($p< 0.001$) than neutral rated and liked samples. No significant differences between neutral rated and liked samples were observed. “Happy” and “valence” showed the opposite effect, significantly differentiating between liked and neutral rated samples, as well as between liked and disliked samples but not between neutral and disliked samples.

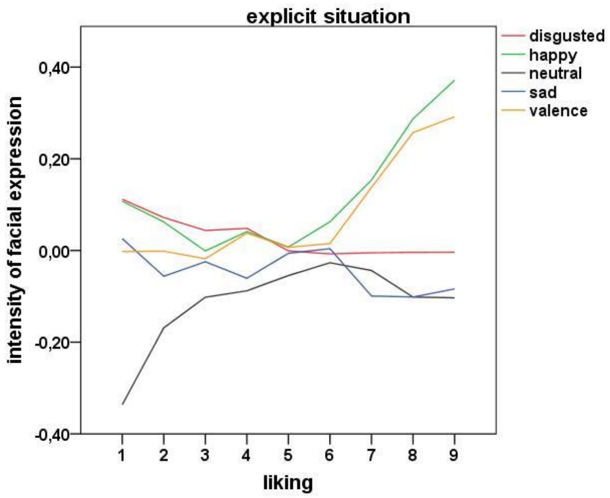

Figure 27: relations between the means of explicit facial expressions and introspective liking ratings with 1 (dislike extremely) to 9 (like extremely)

4.6. Comparison between the results of the implicit and explicit measurement of facial reactions

Repeated Measures ANOVA with experimental condition as additional factor showed significant differences between facial expressions elicited between implicit and explicit measurement ($p < 0.001$). In the implicit case the emotions “angry”, “neutral”, “sad”, “surprised” and “negative emotions” were elicited more intensively and “valence” less intensely. These differences were all significant at $p < 0.001$. Significant interaction effects between samples and experiment condition existed for “happy” and “valence” (see figures 24 and 26). The facial expression “happy” was elicited more intense in the implicit case for grapefruit and sauerkraut juice and less for the other samples ($p = 0.008$).

4.7. Correlation between ANS responses and implicit facial expressions

Significant correlations between relative SCL and the facial expressions in the implicit situation of “happy” ($p = 0.002$) and “neutral” ($p = 0.001$) and Spearman correlations of 0.151 and -0.165 respectively were found. No correlation effects between the other parameters were observed.

4.8. Summary of results

All in all there were significant differences in some ANS parameters and some facial expressions between the samples. Summary of the results are given in table 9 with all involved parameters. Significant differences are marked with * ($p < 0.05$), ** ($p < 0.01$) and *** ($p < 0.001$).

implicit facial expressions	**explicit facial expressions**	**implicit ANS responses**
angry	**angry ****	**relative SCL *****
disgusted ***	**disgusted *****	**PVA ***
happy ***	**happy ****	pulse
neutral ***	**neutral *****	BVP
sad **	**sad ****	finger temperature
scared	scared	
surprised	surprised	
valence	**valence *****	
negative emotions ***	**negative emotions *****	

Table 9: differences in elicited facial expressions and ANS responses between the samples (Repeated Measures ANOVA)
significant differences are marked with *** (p< 0.05), ** (p< 0.01) and *** (p< 0.001)**

Additionally there were significant correlations between introspective liking ratings and some facial expressions as well as relative SCL.

parameter	**explicit**		**implicit**	
	r	**p-value**	**r**	**p-value**
angry	-0.182	**<0.001**	-0.067	0.177
disgusted	-0.510	**<0.001**	-0.413	**<0.001**
happy	0. 281	**<0.001**	-0.256	**<0.001**
negative emotions	-0.359	**<0.001**	-0.306	**<0.001**
neutral	0.323	**<0.001**	0.399	**<0.001**
sad	-0.174	**<0.001**	-0.215	**<0.001**
scared	-0.035	0.484	-0.151	0.002
surprised	0.057	0.250	0.105	0.034
valence	0.412	**<0.001**	0.009	0.857
pulse			-0.009	0.854
PVA			-0.013	0.794
relative SCL			-0.222	**<0.001**
finger temperature			0.013	0.799

Table 10: Spearman correlation between introspective liking ratings and facial expressions as well as between introspective liking and ANS parameters (n = 405)

5. Suggestions and limitations

This study includes a huge study population compared to other studies in the field of ANS responses and facial expressions. But some suggestions for improvement and limitations of the used methods have to be mentioned.

5.1. Suggestions and limitations for measuring ANS reactions

The measurement of ANS parameters didn’t work well enough to have clear results for all used parameters. Unfortunately just SCL and PVA showed significant results. Measurement of skin temperature and the other pulse parameters failed. All in all the parameters SCL and SCR are less sensitive to movements (like drinking the sample or raising the hand). The parameter temperature showed always the same scheme with a rising curve at the beginning, which was then stable a certain time, before the curve declined continuously. This phenomenon can be explained by sensor-adaption to finger-temperature at the beginning and the cool down process due to unmoved hand during the whole session. Additionally change in skin temperature happens in general between 5 and 15 seconds and would require a longer waiting period (5-10 minutes) for sensor adaption to body temperature [ÖBFP, 2006]. The fact that skin temperature changes are relatively slow compared to e.g. EDA [BOUCSEIN, 2012] should also be considered. The sensor of the Biofeedback 2000 $^{x\text{-}pert}$ radio module MULTI was more sensitive to the measurement of the parameters BVP, pulse and PVA compared to EDA and skin temperature. Small movements of the body or of the hand like raising the dominant and free hand during sample tasting or intentional facial expression can influence the pulse parameters. Furthermore the pulse is determined by periodic time (RR-interval) of the BVP-curve and so it is important that the subject sits calm and relaxed without speaking or moving so that the BPV-curve can be stable and the pulse-curve can adapt correctly. For the next experimental session it can be useful to stop biofeedback measurement after the five minutes stabilizing phase and start it again before session starts. Additionally the attached radio module MULTI and electrodes were regarded as intrusive by some participants and so they could be distracted from the attached electrodes during testing procedure. Hand or arm movement was limited and therefore more complex tasting procedures like eating complete meals using cutlery could be problematic.

Compared to other studies we used in this study gold electrodes for EDA measurements. Today sintered silver/silver chloride (Ag/AgCl) electrodes are practically the only standard EDA electrodes in use. They are so-called "reversible electrodes" which are made from a metal in contact with a solution of its own ions (FOWLES et al., 1981; BOUCSEIN, 2012). Therefore silver electrodes should be used for the next experimental session.

5.2. Suggestions and limitations for measuring facial expressions

Due to the fact that FaceReader 5 software learns to detect and interpret facial expressions by learning processes with photographic examples, the software has certain weak points like the sensitive response to "happy". Unfortunately this problem occurs not just in smiling faces but even in faces showing "disgusted". Further limitations of FaceReader are analyzing problems of people wearing glasses and having hair or beard in their faces. The software is also very sensitive to light conditions. Additionally motor artefacts can be easily misinterpreted by FaceReader. Here in this study liquid samples were used and clear investigations to drink the sample at once to minimize motor artefacts in the face were given. Using food requiring chewing would elicit more motor artefacts in the face and would so influence the measurement results negatively.

In this study the people showed their intentional facial expressions in the explicit situation only one or two seconds. To get better evaluable data subjects should be instructed in the next experimental session to show their intentional facial expressions in the explicit situation for a fixed time with more than one or two seconds.

An important influential factor on the liking rating of the samples has to be mentioned here, because it might have biased results and conclusions. The so called "facial feedback hypothesis" suggests that facial expressions can influence the individual emotional experience/situation [KRAUT, 1982]. In the case of our study, participants had to show an intentional facial expression to describe the sample before they had to rate the liking on a scale. Therefore the participants' liking rating could have been influenced by showing intentional facial expressions. For future projects liking rating and showing intentional facial expressions should be separated by an appropriate experimental design.

6. Discussion of results

6.1. Self-reported familiarity and spontaneous liking

Due to the fact that most of the subjects stated that they are drinking fruit juice several times a week or several times a month compared to drinking vegetable juices rarer than once a month, it is not surprising that fruit juices were more liked than vegetable juices. Surprisingly the familiarity of all samples was rated almost equal with "quite familiar", although the juices vary huge in flavor. Orange juice, which was thought to be the most popular juice by us, even showed similar familiarity ratings like sauerkraut and vegetable juice. Possibly the wording of the question about familiarity wasn't sufficiently clear. So familiarity ratings didn't indicate the liking ratings of the samples. The liking ratings showed that banana juice as the sweetest juice was significantly better rated than all other samples. Orange juice was rated significantly lower than banana juice but higher than the rest. Vegetable, sauerkraut and grapefruit juice were the least liked samples of all, but there were no significant differences between them. These liking ratings reflected the known preferences for sweetness and aversion to bitterness, which are independent of culture and seem to be innate [REED et al., 2006]. The sensation of sweetness while tasting food is innately pleasant, whereas some other sensations are innately aversive such as bitterness and sourness [GIBSON, 2006].

6.2. Changes in ANS parameters

In general it should be pointed out that the testing situation under laboratory conditions can influence ANS responses and subjects may not be in a neutral state before starting testing. Additionally emotions evoked by food may depend on the internal state of the individual like the nutritional state (hungriness or thirstiness), mood and overall physical state [DESMET and SCHIFFERSTEIN, 2008].

Another important influencing factor to be mentioned is the Velcro strap with the integrated electrodes for measuring the ANS responses on the finger. The Velcro strap causes heat and sweat on the skin below after wearing for a longer period and so may influence skin conductance.

Pairwise comparisons showed that vegetable and sauerkraut juice caused significantly a stronger increase of SCL and relative SCL than banana and orange juice. The correlation between relative SCL and liking ratings also showed that the disliked samples had a stronger increase than liked samples. These results are in accordance with the results in the study of VERNET-MAURY et al. (1999) where autonomic responses elicited by pleasant odors were weaker than by unpleasant odors. In this study 15 subjects inhaled five odorants (lavender, ethyl aceto acetate, camphor, acetic acid and butyric acid) with different hedonic valence and then they rated pleasantness or unpleasantness on a 11-point hedonic scale (0= highly pleasant; 11= highly unpleasant). Six ANS parameters with skin potential, skin resistance, skin blood flow and skin temperature were measured. Very pleasant odors (lavender) and weakly pleasant odors (ethyl aceto acetate and camphor) showed weaker autonomic responses than unpleasant odors (butyric acid and acetic acid). But unfortunately values for exactly changes were missing.

In another context BOUCSEIN et al. (1999) showed that the most favorably rated cosmetic foam product elicited the lowest SCL value. The aims of this study was similar to our work, in particular to investigate how the psychophysiological test correlates with a linguistically based sensory assessment and to add so information on emotional and hedonistic foam qualities that could not be inferred from a linguistically based sensory assessment.

In the study of BENSAFI et al. (2002) 12 participants were exposed to 12 different food related odors (garlic, butter, coffee, caramel, chocolate, coconut, onion, fish, apple, Roquefort cheese, tomato and vanilla) while their facial and autonomic parameters (facial electromyographic and skin conductance) were recorded. Then they had to rate the odors on a pleasantness scale and they had to choose between seven words for emotions (fear, anger, sadness, surprise, neutral, joy or disgust) to describe their reaction to the odor. BENSAFI et al. (2002) couldn't find similar results to our study, because there were no significant differences for skin conductance evoked by unpleasant odors compared to pleasant ones. If considering the results of the relationship between skin conductance and specific emotions, which were associated by the subjects, as "disgust" described odors showed larger skin conductance compared to as "joy" described ones. Unfortunately these differences were not significant.

The study of ROUSMANS et al. (2000) with 45 participants investigated autonomic nervous system responses (skin potential, skin resistance, skin blood flow, skin temperature and heart rate) associated with primary tastes. Tasted samples had to be rated on an 11-point hedonic scale and three labels were indicated on this scale: 0= highly pleasant, 5= neutral and 10= highly unpleasant. The results showed similar to our study that the sweetest sample (here sucrose) was rated as the most pleasant, the sour, salty and bitter sample were rated as increasingly unpleasant with bitter as the most unpleasant. Furthermore the results showed that the pleasant and sweet taste stimuli induced only weak electrodermal responses whereas the unpleasant tastes (salty= NaCl solution, sour= citric acid solution and bitter= quinine sulfate solution) induced stronger ANS responses.

Due to the fact that no similar study to our study exists, it is not easy to compare the results exactly. But some possible general explanations could support the findings that SCL was larger for unpleasant than for pleasant juices. TAYLOR (1991) stated that negative (adverse or threatening) events evoke strong and rapid physiological, cognitive, emotional, and social responses. This mobilization appears to be greater for negative events than for neutral or positive events. Therefore, defensive (negative) responses seem to take precedence over appetitive (positive) responses. So the disliked samples reflect the aversive components compared to the liked samples for the appetitive system.
The most pleasant sample in our study was banana juice, which was the sweetest stimulus in the testing procedure and which induced the weakest electrodermal activity. This could be explained by the innate organic acceptance of sweet (STEINER, 1977) and the sensation of pleasure to take up needed nutrients which are important energy carriers for the human organism. Additionally sweetness is a familiar and usual flavor appreciated early in newborns. Therefore sweet food is frequent consumed and may lead to weak sympathetic activation due to the fact that electrodermal response decreases with repetition of the same stimulus [DAWSON et al., 2000].

The results of PVA measurement were not significant, but in general PVA decreased after tasting the samples. According to ÖBFP (2006), sympathetic nervous system activation leads to decrease in PVA. So tasting the samples activated unconscious physiological processes, but significant differences between the samples were not observable. But vegetable juice elicited a slightly lower decrease in PVA than the other samples. So there is activation due to flavor or tasting but no linkage to liking ratings.

The results of finger temperature were not significant, but in general sauerkraut juice elicited the highest decrease. The results do not support the findings of DE WIJK et al. (2012), who showed that the liked samples induced higher finger temperatures than disliked samples. However, the temperature differences in this study were very small within the range of 0.001 °C.

6.3. Changes in facial expressions

6.3.1. Implicit facial expressions measurement

There were significant differences in spontaneous/implicit facial expressions between the samples for “disgusted”, “happy”, “neutral”, “sad” and “negative emotions” and strongest correlation between implicit facial expressions and liking ratings for “disgust” and “neutral”.
The disliked juices (grapefruit, vegetable and sauerkraut juice) elicited significantly more intensely the facial expression “disgusted” than the liked ones (banana and orange juice). Surprisingly the disliked samples, especially sauerkraut juice, elicited significantly more intense facial reactions of “happy” compared to the liked samples. This phenomenon can be explained by two reasons. FaceReader reacts very sensitive to up moving mouth angles, so almost any kind of rise of the corners of the mouth is interpreted as “happy”. Additionally some participants were so surprised by the taste/flavor of sauerkraut juice that they started smiling or even laughing.

Furthermore the unliked samples showed significantly more intense “negative emotions” than the liked juices and the most unliked sauerkraut juice elicited significantly less intense “neutral” compared to the others. All in all unliked samples showed less neutral states and more negative facial reactions like disgusted compared to liked samples. The liked samples didn’t show much intense facial reactions even not intense positive ones. This is in accordance with the findings of ZEINSTRA et al. (2009), who found that facial expressions are a good indicator for dislike but not for liking. Six school-age children had to taste seven liquid samples (apple, sauerkraut, beetroot juice, skimmed milk, asparagus solution, bitter and sweet solution) - two of them were similar to the used juices in our study and they also differed huge in flavor like our used samples - while their faces were video recorded. Then they had to rate the liking of the samples on a 5-point smiley scale. Facial expressions were analyzed using the Facial Action Coding System (FACS) and not with FaceReader software like in our study. The samples were also categorized in three liking categories (liked, neutral, disliked). They found a correlation between rank order preference and the sum of negative facial

Action Units (the minimal distinguishable action of the facial muscle). The more the stimulus was disliked, the more negative Action Units were displayed. The relationship wasn't significant for positive or neutral Action Units.

We think positive stimuli (pleasant) or in our study the liked samples (banana and orange juice) elicited less responses (facial expressions and ANS), because positive associations may lead to relaxation. Negative stimuli (unpleasant) elicit increased responses due to the fact, that negative or in this case aversive reactions mobilize immediate action and are important for protection of the body. So in our study the unpleasant samples, which were rated as "unliked" and showed more intense facial expressions of "disgusted", might evoke these facial responses as a communication signal for others to avoid poison or contaminated food. The same explanation gave ERICKSON and SCHULKIN (2003) and ROSENSTEIN and OSTER (1988) regarding communication expressions of disgust as important signal to others for example to prevent the ingestion of potential poisoning (bitter) substances. The study of BAEYENS et al. (1996) observed conditioning of food valence in humans and showed negative expressions as a strong and important communication factor. In this study children consumed drinks, while simultaneously they watched a videotaped model synchronically drinking the identical drink and facially expressing his evaluation (neutral or dislike) of the drink. The result showed a clear observational evaluative learning effect, because the observing children decreased their liking for this drink when watching the negative facial expressions of the model. So, negative facial expressions seem to serve as a warning sign.

The experimental environment in the testing booth may suppress facial expressions in a certain extent. It is also possible that people had learned during their life to mask their facial expressions to a certain extent, so that in general facial expressions are less intensive. Therefore the objectivity of facial expressions as a tool for measuring food preferences can be influenced by masking and controlling facial expressions [ZEINSTRA et al., 2009]. Also personality traits can influence intensity of facial expressions. Outgoing personalities show more intense facial expressions whereas introverted people tend to show less intense facial expressions. JÄNCKE (1993) suggested that introverted people actively inhibit their facial expressions of positive emotions.

6.3.2. Explicit facial expressions measurement

There were significant differences in intentional facial expressions between the samples like in the implicit situation for “disgust”, “happy”, “neutral”, “sad”, “negative emotions” and additional for “angry” and “valence” and strongest correlation between explicit facial expressions and liking ratings for “disgust” and “valence”.

The unliked samples (sauerkraut, vegetable and grapefruit juice) elicited as in the implicit case significantly more intense facial expressions of “disgusted” and “negative emotions”. The facial expressions for “happy” was expressed more intensively for liked samples than for disliked ones in the explicit situation compared to the implicit situation. Therefore our results suggested that intentional facial expressions allowed a better discrimination between “liked”, “neutral” and “disliked” rated juices, whereas in the implicit measurement only “disliked” samples could be significantly discriminated from “liked” and “neutral, but no differentiation between “liked” and “neutral” rated samples was possible.

Correlations between facial expressions and introspective liking showed that in the explicit situation the facial expression for “happy” follows a linear increase with liking on the scale of 5 to 9 (with 9 like extremely) but flattens out below 5. The facial expression of “disgusted” showed an inverse relationship to liking compared to the aforementioned, for both the explicit as well as for the implicit measurement. This U-shaped relation between facial expressions and liking suggested that liked samples elicit “happy”, neutral rated samples provoke only little facial expressions at all, whereas disliked ones elicit mainly negative facial expressions of “disgusted”.

In a previous study of DANNER et al. (2013) similar investigations for comparing liking ratings with facial expressions was carried out in the sensory lab at the University of Natural Resources and Life Sciences in Vienna. In the explicit case 75 participants had to taste six different orange juices without knowing about the aim of the investigation. After tasting they were asked to give a signal with their right hand and to visualize the taste experience of the sample with an intentional facial expression best representing the liking of the sample. Then a questionnaire for liking ratings on a 9-point hedonic scale followed. The whole procedure was video recorded and facial expressions were analyzed by using FaceReader 4 software afterwards. In the implicit case the 78 participants were not aware that they were being filmed during the procedure. After tasting subjects had to experience the sample and rated their liking on the 9-point hedonic scale. According to the results, the explicit measurement showed a clear discrimination between liked, neutral-rated and disliked samples on the basis of the intensity of the aforementioned significant facial expressions. The implicit measurement showed that only the least liked sample could be discriminated from the other samples.

6.4. Correlation between ANS responses and implicit facial expressions

There were only weak significant correlations between relative SCL and the facial expression of “happy” and “neutral”. But the results showed that disliked samples elicited a stronger increase in SCL and more intense facial expressions of “disgust” but also of “happy” (due to already mentioned software sensitivity) in the implicit situation. When LEVENSON and EKMAN and FRIESEN (1983, 1990) examined voluntary facial reactions and their connection to the autonomic nervous system activity, they found out that fear and disgust produced a larger increase in skin conductance than happiness. Additionally the results of a meta-analysis by CACIOPPO et al. (2000) showed that disgust was associated with larger increases in SCL than happiness.

7. Conclusion and outlook

The research questions raised at the beginning of this work can be answered as follows: this study showed that (a) tasting different juice samples provoked significantly different ANS responses (SCL and PVA) and also different intensities of facial expressions; (b) these measures correlated to moderate degree with the introspective liking (SCL significantly differentiated disliked samples from liked samples and disliked juices elicited higher changes in SCL compared to liked ones) and (c) the explicit measurement of intentional facial expressions allowed a clear discrimination between liked, neutral-rated and disliked samples and spontaneous facial reactions in the implicit situation were nevertheless a good indicator for disliked samples.

Future research projects should deal with the question what these parameters mean in terms of food related behavior and food experience. It has to be investigated whether SCL, facial reaction patterns or other implicit responses are able to predict consumers' food related decision making. Additionally future research projects should include stimuli repetition, because ANS responses like skin conductance shows decreasing intensity of response to repeated stimuli according to the mere exposure effect [DAWSON et al., 2000]. In a next step the contrast between the samples could be smaller in flavor or other types of food could be used to investigate facial expressions and ANS responses with their correlation to liking ratings.

Due to the results it would be of potential interest to use FacaReader software for analyzing facial expressions and ANS measurements like skin conductance in product acceptance tests with the target group of children. Children can't understand or handle scales properly to rate the liking of the products. But it should be remembered that FaceReader software is just able to work with children older than three years at the moment.

Sensory science and marketing research should concentrate intensively on investigating and understanding emotion-related and unconscious reactions involved in consumers' behavior and decision making processes to predict product satisfaction, product success on the market and eating habits. Therefore measurements of facial expressions and ANS responses can serve as a further tool to support product development.

This work was submitted to the Journal Appetite, an international research journal specializing in behavioral nutrition and the cultural, sensory, and physiological influences on choices and intakes of foods and drinks. After finishing the present review phase the work will be published in the above mentioned journal.

Abstract

Physiological testing methods go beyond consumer self-report data. Physiological reactions, which are controlled by the autonomic nervous system, reflect involuntary, emotional and/or unconscious processes in the body. Therefore spontaneous facial expressions in an implicit tasting situation and intentional facial expressions in an explicit tasting situation were analyzed by using FaceReader 5 technology. Additionally autonomic nervous system reactions (ANS reactions) including electrodermal activity (EDA) or skin conductance (SC), finger temperature (FT) and pulse with its derived parameters blood volume pulse (BVP) and pulse volume amplitude (PVA) were measured synchronously by using Biofeedback 2000 $^{x\text{-}pert}$ radio module MULTI and software. FaceReader 5 distinguishes between six basic emotions (“angry”, “happy”, “disgusted”, “sad”, “scared”, “surprised”) and a neutral facial state. Used stimuli to provoke changes in facial expressions and ANS parameters were five different juices (banana, grapefruit, orange, sauerkraut and vegetable juice). For statistical analysis 81 participants were available with an average age of 22.9 years (SD= 4.1 years) and with 43.2% females. It was investigated if (a) tasting different flavors of juices elicits different facial expressions and ANS responses; (b) there is a correlation between liking or conventional rating and ANS responses and/or facial expressions and (c) there are differences in facial expressions between implicit and explicit measurement.

Participants had to taste 2 cl of every sample in a randomized order and were video recorded during tasting session. In the implicit situation participants had to experience the sample. In the explicit situation they had to give a hand signal and to visualize the taste experience of the sample with an intentional facial expression best presenting the liking of the sample. Afterwards, they had to rate the liking or disliking of the sample on a 9-point hedonic scale and the familiarity on a 5-point scale.

Results showed that (a) tasting different juice samples provoked significantly different ANS responses (SCL and PVA) and also different intensities of facial expressions; (b) these measures correlated to moderate degree with the introspective liking (SCL significantly differentiated disliked samples from liked samples and disliked juices elicited higher changes in SCL compared to liked ones) and (c) the explicit measurement of intentional facial expressions allowed a clear discrimination between liked, neutral-rated and disliked samples and spontaneous facial reactions in the implicit situation were nevertheless a good indicator for disliked samples.

Kurzfassung

Physiologische Messmethoden können Zusatzinformationen zu erhobenen Daten aus hedonischen Akzeptanztests über Konsumenten liefern. Physiologische Reaktionen, die vom autonomen Nervensystem kontrolliert werden, reflektieren nicht steuerbare, emotionale und/oder unbewusste Prozesse im Körper.

Mit diesem Hintergrund wurden im Rahmen unserer Studie spontane Mimik-Veränderungen in einer impliziten Testsituation und bewusste Mimik-Veränderungen in einer expliziten Testsituation mit Hilfe von FaceReader 5, einer speziellen Softwaretechnologie, analysiert. Zusätzlich wurden folgende Reaktionen des autonomen Nervensystems (ANS-Reaktionen) gemessen: die elektrodermale Aktivität (EDA) bzw. die Hautleitfähigkeit (SC), die Fingertemperatur (FT), der Puls sowie die davon abgeleiteten Parameter Blutvolumenpuls (BVP) und Pulsvolumenamplitude (PVA). Die Messung wurde mit Biofeedback 2000 $^{x\text{-}pert}$ Software und zugehörigem Funkmodul MULTI durchgeführt.

FaceReader 5 kann zwischen sechs Basisemotionen („angewidert“, „fröhlich“, „traurig“, „überrascht“, „ängstlich“, „zornig“) und einem neutralen Gesichtsausdruck unterscheiden. Es wurden fünf verschiedene Säfte (Bananen-, Gemüse-, Grapefruit-, Orangen- und Sauerkrautsaft) als Stimuli verwendet, um Veränderungen in der Mimik und in den ANS-Parameter hervorzurufen. Für die statistische Auswertung waren Daten von 81 Teilnehmern verfügbar. Die Probanden waren durchschnittlich 22,9 Jahre alt (SD= 4,1 Jahre) und der Frauenanteil lag bei 43,2%. Das Ziel dieser Arbeit war die Beantwortung folgender Fragen: (1) Rufen verschiedene Saftproben unterschiedliche Mimik und ANS-Reaktionen hervor? (2) Korrelieren introspektive Beliebtheitsbewertungen der Proben mit den hervorgerufenen ANS-Reaktionen und/oder mit den hervorgerufenen Gesichtsausdrücken? (3) Werden in der impliziten und expliziten Messsituation unterschiedliche Gesichtsausdrücke hervorgerufen?

Jeder Teilnehmer bekam 2 cl von jeder Probe in einer randomisierten Reihenfolge zu trinken. Der gesamte Verlauf der Verkostung wurde mit dem Wissen und der Zustimmung der Teilnehmer auf Video aufgezeichnet. In der impliziten Testsituation ließen die Probanden die Proben auf sich wirken. In der expliziten Testsituation gaben sie ein deutliches Handsignal und zeigten einen absichtlichen Gesichtsausdruck in die Kamera, der den Eindruck des Geschmacks der Probe am besten wiederspiegelte. Danach bewerteten die Teilnehmer die Beliebtheit der Proben auf einer 9-Punkte Skala und die Vertrautheit der Proben auf einer 5-Punkte Skala.

Die Ergebnisse zeigten, dass (1) verschiedene Saftproben signifikant unterschiedliche ANS-Reaktionen (SCL, das Hautleitfähigkeitslevel, und PVA) und auch unterschiedliche Intensitäten der verschiedenen Gesichtsausdrücke hervorriefen; (2) eine moderate Korrelation zwischen introspektiver Beliebtheitsbewertung und den vorher genannten Messungen beobachtet wurde (SCL unterschied sich signifikant zwischen unbeliebten und beliebten Proben und unbeliebte Proben riefen größere Veränderungen von SCL hervor als beliebte Proben) und (3) die explizite Messung mit absichtlich gezeigten Gesichtsausdrücken zeigten eine klare Unterscheidung zwischen beliebten, neutral-bewerteten und unbeliebten Proben und die implizite Messung mit spontanen Mimik-Veränderungen waren ein guter Indikator für unbeliebte Proben.

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Annex I “Questionnaire“

Willkommen bei der Getränke-Verkostung

General instructions at the beginning

Ablauf der Verkostung:

1. aufgeforderte Probe (Probennummer gibt Computer vor) **kosten:**

- trinken Sie **die ganze Probe auf einmal** (bitte **nicht mehrmals** kosten) und direkt danach Probe wegstellen
- lassen Sie die Probe **ausreichend** auf sich wirken (ca. 20 Sekunden)
- **heben Sie die rechte Hand** und zeigen Sie mit einem passenden **Gesichtsausdruck** wie Ihnen die **Probe zusagt**

2. beantworten Sie die Fragen

3. trinken Sie einen Schluck **Wasser** zur Neutralisation

4. 1 Minute Wartezeit zwischen den Proben

5. nächste Probe - gleicher Ablauf!

Folgendes während der **GESAMTEN** Verkostung beachten:

- bitte **ruhig** sitzen (keine starken Bewegungen, kein Fußwippen etc.)
- bitte die Hand mit der Elektrode **ruhig** halten
- das Kosten der Probe und das Ausfüllen der Fragen am Computer erfolgt mit der **rechten** Hand

Bitte warten Sie, bis Sie aufgefordert werden, 'Continue' zu drücken

Instruction for tasting the sample

<u>Bitte kosten Sie Probe XY jetzt!</u>

- trinken Sie die **ganze Probe auf einmal** - nicht mehrmals kosten

- Probe direkt nach dem Verkosten **abstellen**

- **lassen Sie die Probe** *ca. 20 Sekunden auf sich wirken*

TIMER: 20 SECONDS

Instructions for explicit facial expression

- **heben Sie die rechte Hand**

- und zeigen Sie dann mit einem passenden **Gesichtsausdruck,** wie Ihnen die **Probe zusagt**

- Drücken Sie **anschließend 'Continue'**

Liking evaluation with 9-point hedonic scale

Wie sehr sagt Ihnen Probe XY zu?

1 ❑ Mag ich überhaupt nicht
2 ❑ Mag ich sehr wenig
3 ❑ Mag ich wenig
4 ❑ Mag ich nicht besonders
5 ❑ Mag ich weder noch
6 ❑ Mag ich etwas
7 ❑ Mag ich gern
8 ❑ Mag ich sehr gern
9 ❑ Mag ich besonders gern

Familiarity evaluation with 5-point scale

Wie vertraut sind Sie mit dem Geschmack der Probe XY?

1 ❑ überhaupt nicht vertraut
2 ❑ wenig vertraut
3 ❑ mittelmäßig vertraut
4 ❑ ziemlich vertraut
5 ❑ sehr vertraut

Tasting sample completed

<u>Sie haben die Verkostung dieser Probe abgeschlossen!</u>

- bitte nehmen Sie einen **Schluck Wasser** zur Neutralisation

- bleiben Sie ruhig sitzen bis der Timer abgelaufen ist

- drücken Sie anschließend *'Next sample'*

TIMER: 70 SECONDS

Demographic questions

Bitte geben Sie Ihr Geschlecht an:

❑ weiblich
❑ männlich

Bitte geben Sie Ihr Alter an:

Bitte geben Sie Ihr Gewicht an (in kg):

Bitte geben Sie Ihre Körpergröße (in cm) an:

Bitte geben Sie Ihren Beruf an:

- ❑ StudentIn
- ❑ ProfessorIn
- ❑ UniversitätsmitarbeiterIn
- ❑ Sonstiges

Questions about juice consumption

Wie oft trinken Sie Fruchtsäfte?

- ❑ täglich
- ❑ mehrmals pro Woche
- ❑ mehrmals pro Monat
- ❑ einmal pro Monat
- ❑ seltener

Wie oft trinken Sie Gemüsesäfte?

- ❑ täglich
- ❑ mehrmals pro Woche
- ❑ mehrmals pro Monat
- ❑ einmal pro Monat
- ❑ seltener

Danke für die Teilnahme!

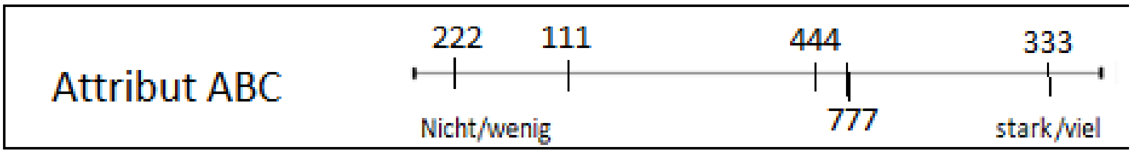
Drücken Sie bitte den Signalschalter an der Wand zu Ihrer Rechten

Annex II “Free Choice Profile”

Name: ____________________ Datum:____________

Bei diesem Test sollen Sie die Proben anhand von Kriterien bewerten, die sie selbst auswählen sollen. Kennzeichnen Sie die Ausprägung dieses Merkmals mittels einer Markierung auf der Skala. Prüfen Sie alle fünf Proben und tragen Sie für jede Probe einen Strich, den Sie mit dem Probencode versehen, auf der Skala auf. Bitte versuchen Sie möglichst viele sensorische Merkmale zu definieren, die ihrer Meinung nach das Produkt charakterisieren. Ihrer Kreativität sei freier Lauf gelassen.

Beispiel



Aussehen

	Nicht/wenig stark/viel
	Nicht/wenig stark/viel
	Nicht/wenig stark/viel
	Nicht/wenig stark/viel

Grundgeschmack und Geschmack

	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel

Geruch

	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel

Textur

	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel
	Nicht/wenig — stark/viel

Herzlichen Dank für Ihre Teilnahme an diesem Test!

Bitte geben Sie noch einige persönliche Daten an, indem Sie die entsprechenden Kästchen ankreuzen. Selbstverständlich bleiben alle Daten anonym und dienen nur statistischen Auswertungszwecken.

Geschlecht

❑ weiblich ❑ männlich

Alter

❑ 10-19 Jahre ❑ 20-29 Jahre
❑ 30-39 Jahre ❑ 40-49 Jahre
❑ 50-59 Jahre ❑ 60+ Jahre

Statement of originality

"I hereby confirm that I produced this master's thesis "Measuring facial expressions and autonomic nervous system reactions elicited by the flavor of juices, using an implicit and an explicit measurement approach" on my own and under the condition of the usual rules of citation.

Haindl Sandra, Bakk.

Vienna, 15.09.2013

Curriculum vitae

Sandra Haindl, Bakk.

Education

2011-2013	"Public Health Nutrition, Master" at University of Vienna
2010-2011	two semesters "International Business Studies" at University of Economics and Business, Vienna
2006-2011	"Nutrition Science, Bakk." at University of Vienna
2001-2006	Higher secondary school "HBLA Lentia for product management and presentation", Linz

Internships and work experience

since 2012/04	Bayer Austria GmbH, Vienna,, marketing assistant (part time), Consumer Care
2011/07-08	DLA Piper Weiss-Tessbach attorney Vienna, secretary (internship)
2010/01 - 2012/03	VMMT (association for management- and marketing coaches), Vienna, secretary and administration (part time)
2007/07 - 2010/12	Enjoy Living (online health portal), free journalist (part time)
2010/08	Nycomed Austria GmbH, Linz, pharmaceutical production (internship)
2009/10 - 2010/07	Novartis Pharma GmbH, Vienna, clinical research associate assistant, Oncology (part time)
2009/08	AKE (association for clinical nutrition), Vienna, assistant (internship)

2007/11 - 2009/07	Novartis Pharma GmbH, Vienna, assistant, General Management (part time and one month internship)

Language skills

German	mother tongue
English	independent user
French	pre-Intermediate level
Spanish	beginners level

Computer skills

MS Office, SPSS, Adobe Creative Suite, Macromedia

Personal interests

running, hiking, city trips, psychology, nutrition, health topics

Vienna, 19th July 2013