ANGST RUIKEN

Inleiding

Recent werden een aantal vragen geformuleerd vanuit de zorgpraktijk voor personen met een ernstige of diepe verstandelijke of meervoudige beperking, een doelgroep die sterk vertegenwoordigd is binnen vzw Stijn. 'Waarom reageren sommige zorggebruikers soms zo verschillend tegenover verschillende begeleiders?'

Sommige zorggebruikers zullen bijvoorbeeld gemakkelijker slaan naar de ene begeleider dan naar een andere. Begeleiders bij wie de persoon 'agressief' reageert, vragen zich af wat ze anders doen dan andere begeleiders. 'Ik doe toch hetzelfde? Ik zeg toch hetzelfde?' Het is een fenomeen dat in de zorgpraktijk al decennia meegaat, zeggen de zorgprofessionals. Er wordt over de oorzaken van dit fenomeen wel gespeculeerd maar deze speculaties brengen weinig duidelijkheid en zekerheid.

De denkpiste die bij zorgprofessionals vaak terugkomt is dat het verschil in gedrag van de zorggebruiker vooral bepaald wordt door de emotie of gemoedstoestand van de begeleider. De indruk bestaat dat ongewenst 'agressief' gedrag vaker voorkomt bij minder ervaren begeleiders of begeleiders die vrezen dat de zorggebruiker 'agressief' zal reageren. Deze begeleiders trachten hun onzekerheid niet te laten merken of het gedrag van andere begeleiders te imiteren. Maar dat helpt niet. De begeleiders slagen er niet in een losse, ontspannen of 'echte' positieve sfeer te creëren. Op één of andere manier lijkt het gevoel van angst bij de begeleider toch gesignaleerd te worden aan de zorggebruiker. De zorggebruiker haalt opnieuw uit.

Onzekere begeleiders worden nog onzekerder. De relatie met de zorggebruiker geraakt negatief gekleurd en in sommige situaties moet de begeleiding van de zorggebruiker aan anderen worden overgelaten om escalatie te voorkomen. Wat is er in zulke situaties gaande?

Er wordt wel eens gezegd: 'het lijkt wel of de gasten het ruiken'. Maar kan dat? Kunnen zorggebruikers angst of onzekerheid van begeleiders ruiken? Een fascinerende vraag. De literatuur kan misschien verhelderen.

Vanuit een gezonde kritische geest zou je kunnen verwachten dat er over dit onderwerp enkel 'zweverige' niet-wetenschappelijke literatuur te traceren valt. Echter, een zoektocht in de wetenschappelijke literatuur brengt een jong, veelbelovend en relevant onderzoeksdomein aan het licht: 'chemosignalering' en de (tot op heden onderschatte) sociale rol ervan bij mensen.

Chemosignalering is het overdragen van informatie via moleculen in lichaamsexcreties zoals bv. zweet. Als de moleculen de neus van een andere persoon bereiken, geven ze informatie over bijvoorbeeld geslacht, leeftijd, verwantschap of ziekte (Semin & de Groot 2013).

Een zoektocht in de database 'Web of Science' levert een 35-tal relevante papers op in gerenommeerde wetenschappelijke tijdschriften. Voor wie verder wil lezen: de referenties en abstracts van de papers zijn in bijlage te vinden. Hieronder een samenvatting van de meest relevante bevindingen.

Samenvatting

Relatief recent (Mujica-Parodi, Strey et al. 2009) verscheen één van de eerste papers die menselijke chemosignalering van emotionele stress demonstreren via neurobiologische effecten (fmri) en gedragseffecten (beoordelen van ambigue gezichtsstimuli). Deze auteurs verwijzen nog naar zes eerdere studies (tussen 2000 en 2009) die op verschillende manieren onderzoeken of stress via zweet kan gesignaleerd worden. Pas de laatste jaren komt het wetenschappelijk onderzoek over dit onderwerp goed op gang. Een naam die regelmatig terugkeert in dit onderzoek is die van Dr. Jasper de Groot, een Nederlandse onderzoeker aan de Universiteit van Utrecht.

Samen met zijn collega's toont de Groot aan dat angst overgebracht via chemosignalering een angstige expressie bij anderen kan uitlokken (gemeten met spieractiviteit in het gezicht) en leidt tot een hogere detectiegevoeligheid of 'sensory acquisition' (de Groot, Smeets et al. 2012). Chemosignalering van walging (disgust) lokte een walgende gezichtsexpressie uit en een lagere detectiegevoeligheid of 'sensory rejection'. Merkwaardig: dit proces verloopt geheel onbewust. Mensen 'ruiken' ahw de angst niet letterlijk want ze kunnen angstzweet niet van niet-angstzweet onderscheiden maar het opnemen van de chemische signalen via de neus heeft wel een onbewust effect op hun gedrag. Deze bevindingen staan in groot contrast met de algemeen aanvaarde veronderstelling dat communicatie tussen mensen enkel via visuele (lichaamstaal) en auditieve (spraak) kanalen loopt.

Er lijkt een verschil te zijn in hoe mannen en vrouwen reageren op sociaal relevante chemosignalering (de Groot, Semin et al. 2014). Terzijde, verschillen op basis van geslacht in hoe sociaal relevante signalen worden verwerkt, worden ook gevonden voor andere zintuigen. Bijvoorbeeld, hoe vrouwen of mannen eerder iemand naar zich toe of van hen weg zien lopen (Schouten, Troje et al. 2010, Schouten, Davila et al. 2013).

Hoe sterk weegt chemosignalering door in vergelijking met auditieve en visuele signalen? de Groot en zijn collega's tonen aan dat onbewuste olfactorische signalen even sterk werken als audiovisuele signalen in het signaleren van angst (de Groot, Semin et al. 2014). Bovendien blijven olfactorische signalen die angst signaleren een effect hebben (angstige gezichtsuitdrukking) zelfs als ze worden tegengesproken door 'geruststellende' audiovisuele signalen. Gezien de evolutionaire en sociale relevantie van angst, krijgt het zintuig dat angst-gerelateerde informatie overbrengt, de overhand.

Het is trouwens niet alleen angst dat gesignaleerd kan worden. Ook blijheid kan worden overgebracht via chemosignalering (de Groot, Smeets et al. 2015).

Conclusie

Op basis van bestaand wetenschappelijk onderzoek kunnen we zeggen dat het zeker niet onmogelijk is dat zorggebruikers beïnvloed worden door chemosignalering via een begeleider. Hiermee is zeker niet gezegd dat chemosignalering de bewezen oorzaak is van ongewenst 'agressief' gedrag bij zorggebruikers. Naast chemosignalering zijn er in een zorgsituatie vaak heel wat andere vormen van signalering die op een al dan niet bewust niveau een rol kunnen spelen. Bijna altijd zijn er ook auditieve (bv. intonatie in de stem) of visuele signalen (lichaamsdynamiek) afkomstig van de begeleider die sfeer van de situatie bepalen.

De kans lijkt klein dat je bewust alle mogelijke (ook onbewuste) auditieve en visuele signalen die angst of onzekerheid kunnen signaleren, kan camoufleren. En als dat al zou kunnen, dan lijkt het mogelijk dat de neus van de zorggebruiker toch de angst 'ruikt'.

Speculatie

Speculatief (en dus nog niet ondersteund door experimentele evidentie) zouden we zelfs kunnen stellen dat zorggebruikers met ernstige verstandelijke of meervoudige beperkingen een sterker effect op hun gedrag ondervinden van gesignaleerde angst dan personen zonder verstandelijke beperkingen. Het is bijvoorbeeld te beargumenteren dat personen met ernstige verstandelijke of meervoudige beperkingen minder onderhevig zijn aan inhibitie (remming) om te voldoen aan sociale wenselijkheid. Anders gezegd, de onbewuste overdracht van angst van een begeleider zal bij personen met ernstige verstandelijke beperkingen misschien sneller tot een ongeremde of automatische verdedigingsreactie leiden dan bij personen zonder verstandelijke beperkingen.

Personen zonder verstandelijke beperkingen worden ook onbewust beïnvloed door chemosignalering maar beschikken over meer cognitieve mogelijkheden om een hele reeks andere elementen uit de situatie en voorgeschiedenis in rekening te brengen en hun gedrag bewuster te controleren (ik weet dat de andere persoon goede bedoelingen heeft, er zal mij niets ergs overkomen).

BIJLAGE: REFERENTIES EN ABSTRACTS

Mujica-Parodi, L. R., et al. (2009). "Chemosensory Cues to Conspecific Emotional Stress Activate Amygdala in Humans." Plos One **4**(7).

Alarm substances are airborne chemical signals, released by an individual into the environment, which communicate emotional stress between conspecifics. **Here we tested whether humans, like other mammals, are able to detect emotional stress in others by chemosensory cues.** Sweat samples collected from individuals undergoing an acute emotional stressor, with exercise as a control, were pooled and presented to a separate group of participants (blind to condition) during four experiments. In an **fMRI experiment** and its replication, we showed that scanned participants showed amygdala activation in response to samples obtained from donors undergoing an emotional, but not physical, stressor. An odor-discrimination experiment suggested the effect was primarily due to emotional, and not odor, differences between the two stimuli. A fourth experiment investigated behavioral effects, demonstrating that stress samples sharpened emotion-perception of ambiguous facial stimuli. Together, **our findings suggest human chemosensory signaling of emotional stress, with neurobiological and behavioral effects.**

Lundstrom, J. N. and M. J. Olsson (2010). FUNCTIONAL NEURONAL PROCESSING OF HUMAN BODY ODORS. Vitamins and Hormones: Pheromones. G. Litwack. San Diego, Elsevier Academic Press Inc. **83:** 1-23.

Body odors carry informational cues of great importance for individuals across a wide range of species, and signals hidden within the body odor cocktail are known to regulate several key behaviors in animals. For a long time, the notion that humans may be among these species has been dismissed. We now know, however, that each human has a unique odor signature that carries information related to his or her genetic makeup, as well as information about personal environmental variables, such as diet and hygiene. Although a substantial number of studies have investigated the behavioral effects of body odors, only a handful have studied central processing. Recent studies have, however, **demonstrated that the human brain responds to fear signals hidden within the body odor cocktail, is able to extract kin specific signals, and processes body odors differently than other perceptually similar odors.** In this chapter, we provide an overview of the current knowledge of how the human brain processes body odors and the potential importance these signals have for us in everyday life.

Pause, B. M., et al. (2010). "Intensified Neuronal Investment in the Processing of Chemosensory Anxiety Signals in Non-Socially Anxious and Socially Anxious Individuals." Plos One **5**(4): 7.

Background: The ability to communicate anxiety through chemosensory signals has been documented in humans by behavioral, perceptual and brain imaging studies. Here, we investigate in a time-sensitive manner how chemosensory anxiety signals, donated by humans awaiting an academic examination, are processed by the human brain, by analyzing chemosensory event-related potentials (CSERPs, 64-channel recording with current source density analysis). Methodology/Principal Findings: In the first study cerebral stimulus processing was recorded from 28 non-socially anxious participants and in the second study from 16 socially anxious individuals. Each individual participated in two sessions, smelling sweat samples donated from either female or male donors (88 sessions; balanced session order). Most of the participants of both studies were unable to detect the stimuli olfactorily. In non-socially anxious females, CSERPs demonstrate an increased magnitude of the P3 component in response to chemosensory anxiety signals. The source of this P3 activity was allocated to medial frontal brain areas. In socially anxious females chemosensory anxiety signals require more neuronal resources during early pre-attentive stimulus processing (N1). The neocortical sources of this activity were located within medial and lateral frontal brain areas. In general, the event-related neuronal brain activity in males was much weaker than in females. However, socially anxious males processed chemosensory anxiety signals earlier (N1 latency) than the control stimuli collected during an ergometer training. Conclusions/Significance: **It is concluded that the processing of chemosensory anxiety signals requires enhanced neuronal energy. Socially anxious individuals show an early processing bias towards social fear signals, resulting in a repression of late attentional stimulus processing.**

Clepce, M., et al. (2012). "Olfactory abnormalities in anxiety disorders." Neuroscience Letters **511**(1): 43-46.

The olfactory system plays an important role in both animal and human **anxiety reactions**. However, results on olfactory performance during the course of clinical anxiety disorders remain scarce. Therefore, we conducted an exploratory pilot study in 17 patients currently diagnosed with an anxiety disorder. Patients participated in olfactory and psychological testing and were compared to 17 healthy controls. Statistical analyses revealed significant deficits concerning olfactory discrimination in patients, while no changes in threshold and identification ability occurred. Most interestingly, patients showed higher intensity estimates and an increased rating range concerning olfactory hedonic judgements. Results are discussed in light of prior findings and related to neural correlates of olfactory perception and anxiety reactions.

de Groot, J. H. B., et al. (2012). "Chemosignals Communicate Human Emotions." Psychological Science **23**(11): 1417-1424.

Can humans communicate emotional states via chemical signals? In the experiment reported here, we addressed this question by examining the function of chemosignals in a framework furnished by embodied social communication theory. Following this theory, we hypothesized that the processes a sender experiences during distinctive emotional states are transmitted to receivers by means of the chemicals that the sender produces, thus establishing a multilevel correspondence between sender and receiver. In a **double-blind experiment**, we examined facial reactions, sensory-regulation processes, and visual search in response to chemosignals. We **demonstrated that fear chemosignals generated a fearful facial expression and sensory acquisition** (increased sniff magnitude and eye scanning); in contrast, disgust chemosignals evoked a disgusted facial expression and sensory rejection (decreased sniff magnitude, target-detection sensitivity, and eye scanning). **These findings underline the neglected social relevance of chemosignals in regulating communicative correspondence outside of conscious access**.

Kelly, M. (2012). "Scent of a patient: an underestimated role in clinical practice?" British Journal of General Practice **62**(600): 378-378.

Pause, B. M. (2012). "Processing of Body Odor Signals by the Human Brain." Chemosensory Perception **5**(1): 55-63.

Brain development in mammals has been proposed to be promoted by successful adaptations to the social complexity as well as to the social and non-social chemical environment. Therefore, the **communication via chemosensory signals might have been and might still be a phylogenetically ancient communication channel transmitting evolutionary significant information**. In humans, the neuronal underpinnings of the processing of social chemosignals have been investigated in relation to kin recognition, mate choice, the reproductive state and emotional contagion. These studies reveal that **human chemosignals are probably not processed within olfactory brain areas but through neuronal relays responsible for the processing of social information**. It is **concluded that the processing of human social chemosignals resembles the processing of social signals originating from other modalities, except that human social chemosignals are usually communicated without the allocation of attentional resources, that is below the threshold of consciousness.** Deviances in the processing of human social chemosignals might be related to the development and maintenance of mental disorders.

Rubin, D., et al. (2012). "Second-hand stress: inhalation of stress sweat enhances neural response to neutral faces." Social Cognitive and Affective Neuroscience **7**(2): 208-212.

This study investigated whether human chemosensory-stress cues affect neural activity related to the evaluation of emotional stimuli. Chemosensory stimuli were obtained from the sweat of 64 male donors during both stress (first-time skydive) and control (exercise) conditions, indistinguishable by odor. We then **recorded event-related potentials (ERPs)** from an unrelated group of 14 participants while they viewed faces morphed with neutral-to-angry expressions and inhaled nebulized stress and exercise sweat in counter-balanced blocks, blind to condition. Results for the control condition ERPs were consistent with previous findings: the late positive potential (LPP; 400-600 ms post stimulus) in response to faces was larger for threatening than both neutral and ambiguous faces. In contrast, the stress condition was associated with a heightened LPP across all facial expressions; relative to control, the LPP was increased for both ambiguous and neutral faces in the stress condition. These **results suggest that stress sweat may impact electrocortical activity associated with attention to salient environmental cues, potentially increasing attentiveness to otherwise inconspicuous stimuli.**

Auffarth, B. (2013). "Understanding smell-The olfactory stimulus problem." Neuroscience and Biobehavioral Reviews **37**(8): 1667-1679.

The main problem with sensory processing is the difficulty in relating sensory input to physiological responses and perception. This is especially problematic at higher levels of processing, where complex cues elicit highly specific responses. In olfaction, this relationship is particularly obfuscated by the difficulty of characterizing stimulus statistics and perception. The core questions in olfaction are hence the so-called stimulus problem, which refers to the understanding of the stimulus, and the structure-activity and structure-odor relationships, which refer to the molecular basis of smell. It is widely accepted that the recognition of odorants by receptors is governed by the detection of physico-chemical properties and that the physical space is highly complex. Not surprisingly, ideas differ about how odor stimuli should be classified and about the very nature of information that the brain extracts from odors. Even though there are many measures for smell, there is none that accurately describes all aspects of it. Here, we summarize recent developments in the understanding of olfaction. We argue that an approach to olfactory function where information processing is emphasized could contribute to a high degree to our understanding of smell as a perceptual phenomenon emerging from neural computations. Further, we argue that combined analysis of the stimulus, biology, physiology, and behavior and perception can provide new insights into olfactory function. We hope that the reader can use this **review** as a competent guide and overview of research activities in olfactory physiology, psychophysics, computation, and psychology. We propose avenues for research, particularly in the systematic characterization of receptive fields and of perception.

Semin, G. R. and J. H. B. de Groot (2013). "The chemical bases of human sociality." Trends in Cognitive Sciences **17**(9): 427-429.

Communication is the foundation of sociality and is made possible by a diverse set of media. Research on human communication has primarily focused on auditory and visual modalities. Here, we discuss the role of the olfactory modality as an important medium of human communication and highlight the significance of interpersonal chemosignaling in the context of emerging research that investigates the adaptive effects of human chemosignals on cognitive-affective processes.

Mildner, S. and G. Buchbauer (2013). "Human Body Scents: Do they Influence our Behavior?" Natural Product Communications **8**(11): 1651-1662.

Pheromonal communication in the animal world has been of great research interest for a long time. While extraordinary discoveries in this field have been made, the importance of the human sense of smell was of far lower interest. **Humans are seen as poor smellers and therefore research about human olfaction remains quite sparse compared with other animals. Nevertheless amazing achievements have been made during the past 15 years.** This is a collection of available data on this topic and a controversial discussion on the role of putative human pheromones in our modem way of living. While the focus was definitely put on behavioral changes evoked by putative human pheromones this article also includes other important aspects such as the possible existence of a human vomeronasal organ. If pheromones do have an influence on human behavior there has to be a receptor organ. How are human body scents secreted and turned into odorous substances? And how can con-specifics detect those very odors and transmit them to the brain? Apart from that the **most likely candidates for human pheromones are taken on account and their impact on human behavior is shown in various detail.**

Radulescu, A. R. and L. R. Mujica-Parodi (2013). "Human Gender Differences in the Perception of Conspecific Alarm Chemosensory Cues." Plos One **8**(7): 8.

It has previously been established that, in threatening situations, animals use alarm pheromones to communicate danger. There is **emerging evidence of analogous chemosensory "stress'' cues in humans**. For this study, we collected alarm and exercise sweat from "donors,'' extracted it, pooled it and presented it to 16 unrelated "detector'' subjects undergoing fMRI. The fMRI protocol consisted of four stimulus runs, with each combination of stimulus condition and donor gender represented four times. Because olfactory stimuli do not follow the canonical hemodynamic response, we used a model-free approach. We performed minimal preprocessing and worked directly with block-average time series and step-function estimates. We found that, while male stress sweat produced a comparably strong emotional response in both detector genders, **female stress sweat produced a markedly stronger arousal in female than in male detectors**. Our statistical tests pinpointed this gender-specificity to the right amygdala (strongest in the superficial nuclei). When comparing the olfactory bulb responses to the corresponding stimuli, we found **no significant differences between male and female detectors**. These imaging results complement existing behavioral evidence, by identifying whether gender differences in response to alarm chemosignals are initiated at the perceptual versus emotional level. Since we found no significant differences in the olfactory bulb (primary processing site for chemosensory signals in mammals), we infer that the **specificity in responding to female fear is likely based on processing meaning, rather than strength, of chemosensory cues from each gender.**

de Groot, J. H. B., et al. (2014). "Chemical Communication of Fear: A Case of Male-Female Asymmetry." Journal of Experimental Psychology-General **143**(4): 1515-1525.

Previous research has documented **sex differences** in nonverbal communication. What has remained unknown is whether similar sex differences would exist with regard to olfactory communication via chemosignals, a relatively neglected nonverbal communication medium. Because **women generally have a better sense of smell** and greater sensitivity to emotional signals, we hypothesized that compared with male participants and relative to a neutral control condition, female participants would emulate the fearful state of the sender producing the chemosignals. Facial electromyography was used in a double-blind experiment to measure in the receiver a partial reproduction of the state of the sender, controlling for the moderating influence of the sex of the sender and receiver. The results indicated that **only female participants emulated the fearful state of the sender**. The present study revealed a boundary condition for effective chemosignaling by reporting behavioral evidence of **sexual asymmetry in olfactory communication via chemosignals**.

de Groot, J. H. B., et al. (2014). "I Can See, Hear, and Smell Your Fear: Comparing Olfactory and Audiovisual Media in Fear Communication." Journal of Experimental Psychology-General **143**(2): 825-834.

Recent evidence suggests that humans can become fearful after exposure to olfactory fear signals, yet these studies have reported the effects of fear chemosignals without examining emotion-relevant input from traditional communication modalities (i.e., vision, audition). The question that we pursued here was therefore: **How significant is an olfactory fear signal in the broader context of audiovisual input that either confirms or contradicts olfactory information?** To test this, we manipulated olfactory (fear, no fear) and audiovisual (fear, no fear) information and **demonstrated that olfactory fear signals were as potent as audiovisual fear signals in eliciting a fearful facial expression**. Irrespective of confirmatory or contradictory audiovisual information, olfactory fear signals produced by senders induced fear in receivers **outside of conscious access**. **These findings run counter to traditional views that emotions are communicated exclusively via visual and linguistic channels**.

Lubke, K. T., et al. (2014). "Does Human Body Odor Represent a Significant and Rewarding Social Signal to Individuals High in Social Openness?" Plos One **9**(4): 7.

Across a wide variety of domains, experts differ from novices in their response to stimuli linked to their respective field of expertise. It is currently unknown whether similar patterns can be observed with regard to social expertise. The current study therefore focuses on social openness, a central social skill necessary to initiate social contact. Human body odors were used as social cues, as they inherently signal the presence of another human being. Using functional MRI, hemodynamic brain responses to body odors of women reporting a high (n = 14) or a low (n = 12) level of social openness were compared. Greater activation within the inferior frontal gyrus and the caudate nucleus was observed in high socially open individuals compared to individuals low in social openness. **With the inferior frontal gyrus being a crucial part of the human mirror neuron system, and the caudate nucleus being implicated in social reward, it is discussed whether human body odor might constitute more of a significant and rewarding social signal to individuals high in social openness compared to individuals low in social openness process**.

Oliveira-Pinto, A. V., et al. (2014). "Sexual Dimorphism in the Human Olfactory Bulb: Females Have More Neurons and Glial Cells than Males." Plos One **9**(11): 9.

Sex differences in the human olfactory function reportedly exist for olfactory sensitivity, odorant identification and memory, and tasks in which odors are rated based on psychological features such as familiarity, intensity, pleasantness, and others. Which might be the neural bases for these behavioral differences? The number of cells in olfactory regions, and especially the number of neurons, may represent a more accurate indicator of the neural machinery than volume or weight, but besides gross volume measures of the human olfactory bulb, no systematic study of sex differences in the absolute number of cells has yet been undertaken. In this work, we investigate a possible sexual dimorphism in the olfactory bulb, by quantifying postmortem material from 7 men and 11 women (ages 55-94 years) with the isotropic fractionator, an unbiased and accurate method to estimate absolute cell numbers in brain regions. Female bulbs weighed 0.132 g in average, while male bulbs weighed 0.137 g, a non-significant difference; however, the **total number of cells was 16.2 million in females, and 9.2 million in males, a significant difference of 43.2%. The number of neurons in females reached 6.9 million, being no more than 3.5 million in males, a difference of**

49.3%. The number of non-neuronal cells also proved higher in women than in men: 9.3 million and 5.7 million, respectively, a significant difference of 38.7%. The same differences remained when corrected for mass. Results demonstrate a sex-related difference in the absolute number of total, neuronal and non-neuronal cells, favoring women by 40-50%. **It is conceivable that these differences in quantitative cellularity may have functional impact**, albeit difficult to infer how exactly this would be, without knowing the specific circuits cells make. However, the reported advantage of women as compared to men may stimulate future work on sex dimorphism of synaptic microcircuitry in the olfactory bulb.

de Groot, J. H. B., et al. (2015). "A Sniff of Happiness." Psychological Science **26**(6): 684-700.

It is well known that feelings of happiness transfer between individuals through mimicry induced by vision and hearing. The evidence is inconclusive, however, as to whether happiness can be communicated through the sense of smell via chemosignals. As chemosignals are a known medium for transferring negative emotions from a sender to a receiver, we examined whether chemosignals are also involved in the transmission of positive emotions. Positive emotions are important for overall well-being and yet relatively neglected in research on chemosignaling, arguably because of the stronger survival benefits linked with negative emotions. We observed that exposure to body odor collected from senders of chemosignals in a happy state induced a facial expression and perceptual-processing style indicative of happiness in the receivers of those signals. **Our findings suggest that not only negative affect but also a positive state (happiness) can be transferred by means of odors.**

de Groot, J. H. B., et al. (2015). "Rapid Stress System Drives Chemical Transfer of Fear from Sender to Receiver." Plos One **10**(2): 22.

Humans can register another person's fear not only with their eyes and ears, but also with their nose. Previous research has demonstrated that exposure to body odors from fearful individuals elicited implicit fear in others. The odor of fearful individuals appears to have a distinctive signature that can be produced relatively rapidly, driven by a physiological mechanism that has remained unexplored in earlier research. **The apocrine sweat glands in the armpit that are responsible for chemosignal production contain receptors for adrenalin**. We therefore expected that the release of adrenalin through activation of the **rapid stress response system** (i.e., the sympathetic-adrenal medullary system) is what drives the release of fear sweat, as opposed to activation of the slower stress response system (i.e., hypothalamus-pituitary-adrenal axis). To test this assumption, sweat was sampled while eight participants prepared for a speech. Participants had higher heart rates and produced more armpit sweat in the fast stress condition, compared to baseline and the slow stress condition. Importantly, **exposure to sweat from participants in the fast stress condition induced in receivers (N = 31) a simulacrum of the state of the sender, evidenced by the emergence of a fearful facial expression (facial electromyography) and vigilant behavior (i.e., faster classification of emotional facial expressions).**

de Groot, J. H. B., et al. (2015). "Rapid Stress System Drives Chemical Transfer of Fear from Sender to Receiver (vol 10, e0118211, 2015)." Plos One **10**(5): 3.

Correctie van figuren

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0128717

Iversen, K. D., et al. (2015). "Enhanced Chemosensory Detection of Negative Emotions in Congenital Blindness." Neural Plasticity: 7.

It is generally acknowledged that congenitally blind individuals develop superior sensory abilities in order to compensate for their lack of vision. Substantial research has been done on somatosensory and auditory sensory information processing of the blind. However, relatively little information is available about compensatory plasticity in the olfactory domain. **Although previous studies indicate that blind individuals have superior olfactory abilities, no studies so far have investigated their sense of smell in relation to social and affective communication**. The current study compares congenitally blind and normal sighted individuals in their ability to discriminate and identify emotions from body odours. A group of 14 congenitally blind and 14 age- and sex-matched sighted control subjects participated in the study. We compared participants' abilities to detect and identify by smelling sweat from donors who had been watching excerpts from emotional movies showing amusement, fear, disgust, or sexual arousal. **Our results show that congenitally blind subjects outperformed sighted controls in identifying fear from male donors**. In addition, there was a **strong tendency that blind individuals were also better in detecting disgust**. Our findings reveal that **congenitally blind individuals are better at identifying ecologically important emotions and provide new insights into the mechanisms of social and affective communication in blindness**.

Frumin, I., et al. (2015). "A social chemosignaling function for human handshaking." Elife **4**: 16.

Social chemosignaling is a part of human behavior, but how chemosignals transfer from one individual to another is unknown. In turn, humans greet each other with handshakes, but the functional antecedents of this behavior remain unclear. To ask whether handshakes are used to sample conspecific social chemosignals, we covertly filmed 271 subjects within a structured greeting event either with or without a handshake. We found that **humans often sniff their own hands, and selectively increase this behavior after handshake. After handshakes within gender, subjects increased sniffing of their own right shaking hand by more than 100%. In contrast, after handshakes across gender, subjects increased sniffing of their own left non-shaking hand by more than 100%.** Tainting participants with unnoticed odors significantly altered the effects, thus verifying their olfactory nature. **Thus, handshaking may functionally serve active yet subliminal social chemosignaling, which likely plays a large role in ongoing human behavior**.

Leleu, A., et al. (2015). "Contextual odors modulate the visual processing of emotional facial expressions: An ERP study." Neuropsychologia **77**: 366-379.

We studied the time course of the cerebral integration of olfaction in the visual processing of emotional faces during an orthogonal task asking for detection of red-colored faces among expressive faces. Happy, angry, disgust, fearful, sad, and neutral faces were displayed in pleasant, aversive or no odor control olfactory contexts while EEG was recorded to extract event-related potentials (ERPs). Results indicated that the expressive faces modulated the cerebral responses at occipito-parietal, central and central-parietal electrodes from around 100 ms and until 480 ms after face onset. The response was divided in different successive stages corresponding to different ERP components (P100, N170, P200 and N250 (EPN), and LPP). The olfactory contexts influenced the ERPs in response to facial expressions in two phases. First, regardless of their emotional content, the response to faces was enhanced by both odors compared with no odor approximately 160 ms after face-onset at several central, centro-parietal and left lateral electrodes. The topography of this effect clearly depended on the valence of odors. Then, a second phase occurred, but only in the aversive olfactory context, which modulated differentially the P200 at occipital sites (starting approximately 200 ms post-stimulus) by amplifying the differential response to expressions, especially between emotional neutrality and both happiness and disgust. **Overall, the present study suggests that the olfactory context first elicits an undifferentiated effect around 160 ms after face onset, followed by a specific modulation at 200 ms induced by the aversive odor on neutral and affectively congruent/incongruent expressions.**

Lubke, K. T. and B. M. Pause (2015). "Always follow your nose: The functional significance of social chemosignals in human reproduction and survival." Hormones and Behavior **68**: 134-144.

This article is part of a Special Issue "Chemosignals and Reproduction" Across phyla, chemosensory communication is crucial for mediating a variety of social behaviors, which form the basis for ontogenetic and phylogenetic survival. In the present paper, evidence on chemosensory communication in humans, with special reference to reproduction and survival, will be presented. First, the impact of chemosignals on human reproduction will be reviewed. Work will be presented, showing how chemosensory signals are involved in mate choice and partnership formation by communicating attractiveness and facilitating a partner selection, which is of evolutionary advantage, and furthermore providing information about the level of sexual hormones. In addition to direct effects on phylogenetic survival, chemosignals indirectly aid reproductive success by fostering harm protection. Results will be presented, showing that chemosensory communication aids the emotional bond between mother and child, which in turn motivates parental caretaking and protection, leading to infant survival. Moreover, the likelihood of group survival can be increased through the use of stress-related chemosignals. **Stress-related chemosignals induce a stress-related physiology in the perceiver, thereby priming a fight flight-response, which is necessary for an optimum adaption to environmental harm.** Finally, effects of sexual orientation on chemosensory communication will be discussed in terms of their putative role in stabilizing social groups, which might indirectly provide harm protection and foster survival. An integrative model of the presented data will be introduced. In conclusion, an outlook, focusing on the involvement of chemosensory communication in human social behavior and illustrating a novel approach to the significance of chemosensory signals in human survival, will be given.

Semin, G. R. and A. R. Farias (2015). "The scent of a handshake." Elife **4**: 2.

Patin, A. and B. M. Pause (2015). "Human amygdala activations during nasal chemoreception." Neuropsychologia **78**: 171-194.

This review serves as a comprehensive discussion of chemosensory stimulation of the amygdala in healthy humans. Following an introduction of the neuroanatomy of chemosensory processing in primary and secondary olfactory structures, functional resonance magnetic imaging and positron imaging tomography studies are systematically categorized based on valence of stimuli, stimulus concentration, and paradigm-dependent amygdala activation. **The amygdala shows patterns of lateralization due to stimulus valence.** Main findings include **pleasant odors being**

associated with bilateral or left amygdala activation, and unpleasant odors being associated with activation of the right amygdala, suggesting a crucial role of the right amygdala in evolutionary preservation. Potentially threatening social stimuli, however, might be processed apart from the olfactory system and tend to activate the left amygdala. Amygdala response to chemosensory stimuli correlated with simultaneous activation in the orbitofrontal cortex (OFC), piriform cortex (PC), and insula, suggesting a close-knit network of these areas during stimulus processing.

Pazzaglia, M. (2015). "Body and Odors: Not Just Molecules, After All." Current Directions in Psychological Science **24**(4): 329-333.

Interpersonal interactions are primarily mediated through vision. However, crucial information concerning other individuals is also captured through different senses. **New evidence suggests that body odors can implicitly initiate, filter, and guide the integrated perceptions that characterize real human impressions.** Human body-odor processing helps rapidly differentiate kin from friends and friends from foes, as well as identify potential threats or increase alertness to the proximity of strangers, thereby guiding social preference. Body odors, which are potent sources of discriminative, affective, and motor knowledge, elicit neural activity partly or exclusively outside the primary olfactory cortices in the brain areas responsible for the processing of social information, which are activated by equivalent visual signals. **Body odors, which can act as an authenticator of truth and are reliably invoked to shape social relations, require us to revise our view of the traditional body-communication models.**

Ferdenzi, C., et al. (2016). "The Social Nose: Importance of Olfactory Perception in Group Dynamics and Relationships." Psychological Inquiry **27**(4): 299-305.

http://www.tandfonline.com/doi/full/10.1080/1047840X.2016.1215207?scroll=top&needAccess=true

Gross, M. (2016). "The human Sense of Smell is rehabilitated. We can smell better than we think." Chemie in Unserer Zeit **50**(2): 140-143.

In ’t Duits: “Wir können besser riechen als wir denken” :)

Haviland-Jones, J. M., et al. (2016). "Testing for Individual Differences in the Identification of Chemosignals for Fear and Happy: Phenotypic Super-Detectors, Detectors and Non-Detectors." Plos One **11**(5): 17.

Mood odor identification, explicit awareness of mood odor, may be an important emotion skill and part of a complex dual processing system. It has already been shown that mood odors have significant implicit effects, effects that occur without awareness. This study applies methods for examining human individual differences in the identification of chemosignals for fear and happy, important in itself, and a key to understanding the dual processing of emotion in the olfactory system. Axillary mood odors had been collected from 14 male donors during a mood induction task. Pads were collected after 12 and 24 minutes, creating two doses. Sixty -one participants (41 females) identified the mood odor chemosignals. On a single trial, participants identified 2 doses of fear, 2 doses of happy, and a sterile control. There were 15 trials. The first analysis (r(tt)) showed that the population was phenotypically heterogeneous, not homogeneous, in identification accuracy. It also showed that a minimum of 10 trials was needed for test reliability. The second analysis, Growth Mixture Modeling, found three distinct groups of detectors: (1) 49.49% were consistently accurate super detectors, (2) 32.52% were accurate above chance level detectors, and (3) 17.98% were non-detectors. Bayesian Posterior Analyses showed reliability of groups at or above 98%. No differences related to mood odor valence (fear or happy), dose (collection at 12 or 24 minutes) or gender were found. Implications for further study of genetic differences, learning and function of identification are noted. **It appears that many people can be reliable in explicitly identifying fear and happy mood odors but this skill is not homogeneous.**

Kastner, A. K., et al. (2016). "A Scent of Anxiety: Olfactory Context Conditioning and its Influence on Social Cues." Chemical Senses **41**(2): 143-153.

Perception and evaluation of objects are highly dependent on surrounding contexts. Threatening contexts enhance processing of faces. Because odors are assumed to deliver strong contextual information, the present study aimed at demonstrating 1) that odors can constitute threat and safety contexts, and 2) consequently modulate the processing of faces presented in these contexts. Therefore, previously neutral odors were used as contextual stimuli in a context conditioning paradigm, resulting in an olfactory anxiety and a safety context. Then, faces showing angry, neutral, or fearful expressions were presented within both contexts during a test phase to investigate the effects of threat versus safety contexts on face perception. The late positive potential (LPP) from the EEG, skin conductance level, and subjective ratings were recorded. Results reveal successful olfactory context conditioning as reflected in enhanced processing of the anxiety context, indicated by enhanced LPP after conditioning, increased skin conductance level, and marginally respectively increased ratings. Moreover, faces presented within the threat context were rated as more unpleasant and marginally more arousing than faces presented in the safety context. **Thus, olfactory stimuli can serve as context in fear conditioning, and a threatening olfactory context seems to enhance processing of stimuli perceived within this context.**

Mutic, S., et al. (2016). "Chemosensory Communication of Gender Information: Masculinity Bias in Body Odor Perception and Femininity Bias Introduced by Chemosignals During Social Perception." Frontiers in Psychology **6**: 11.

Human body odor is a source of important social information. **In this study, we explore whether the sex of an individual can be established based on smelling axillary odor and whether exposure to male and female odors biases chemosensory and social perception**. In a double-blind, pseudo-randomized application, 31 healthy normosmic heterosexual male and female raters were exposed to male and female chemosignals (odor samples of 27 heterosexual donors collected during a cardio workout) and a no odor sample. Recipients rated chemosensory samples on a masculinity-femininity scale and provided intensity, familiarity and pleasantness ratings. Additionally, the modulation of social perception (gender neutral faces and personality attributes) and affective introspection (mood) by male and female chemosignals was assessed. Male and female axillary odors were rated as rather masculine, regardless of the sex of the donor. As opposed to the **masculinity bias in the odor perception**, a **femininity bias modulating social perception appeared**. A **facilitated femininity detection in gender neutral faces and personality attributes in male and female chemosignals appeared**. No chemosensory effect on mood of the rater was observed. The results are discussed with regards to the use of male and female chemosignals in affective and social communication.

Mutic, S., et al. (2016). "You Smell Dangerous: Communicating Fight Responses Through Human Chemosignals of Aggression." Chemical Senses **41**(1): 35-43.

The ability to detect conspecifics that represent a potential harm for an individual represents a high survival benefit. Humans communicate socially relevant information using all sensory modalities, including the chemosensory systems. **In study 1**, we **investigated whether the body odor of a stranger with the intention to harm serves as a chemosignal of aggression**. Sixteen healthy male participants donated their body odor while engaging in a boxing session characterized by aggression-induction methods (chemosignal of aggression) and while performing an ergometer session (exercise chemosignal). **Self-reports on aggression-related physical activity, motivation to harm and angry emotions selectively increased after aggression induction. In study 2**, we examined whether receivers smelling such chemosignals experience emotional contagion (e.g., anger) or emotional reciprocity (e.g., anxiety). The aggression and exercise chemosignals were therefore presented to 22 healthy normosmic participants in a double-blind, randomized exposure during which affective/cognitive processing was examined (i.e., emotion recognition task, emotional stroop task). **Behavioral results indicate that chemosignals of aggression induce an affective/cognitive modulation compatible with an anxiety reaction in the recipients.** These findings are discussed in light of mechanisms of emotional reciprocity as a way to convey not only affective but also motivational information via chemosensory signals in humans.

Siniscalchi, M., et al. (2016). "The dog nose "KNOWS" fear: Asymmetric nostril use during sniffing at canine and human emotional stimuli." Behavioural Brain Research **304**: 34-41.

Previous studies have reported striking asymmetries in the nostril use of dogs during sniffing at different emotive stimuli. Here we report, for the first time, that this asymmetry is also manifested during sniffing of both human and canine odours collected during different emotional events. Results showed that during sniffing of conspecific odour collected during a stressful situation (e.g. an "isolation" situation in which a dog was isolated from its owner in an unfamiliar environment) dogs consistently used their right nostril (right hemisphere). On the other hand, dogs consistently used the left nostril to sniff human odours collected during fearful situations (emotion-eliciting movies) and physical stress, suggesting the prevalent activation of the left hemisphere. The opposite bias shown in nostril use during sniffing at canine versus human odours suggests that chemosignals communicate conspecific and heterospecific emotional cues using different sensory pathways.

Tromelin, A. (2016). "Odour perception: A **review** of an intricate signalling pathway." Flavour and Fragrance Journal **31**(2): 107-119.

The perception of odours is the result of the complex processing of a signal, which initiates at peripheral receptors and ends in the brain. Along this pathway, olfactory signal processing proceeds through several steps; each step possesses its own complexity, and all steps are also intricately connected. This **review** aims to describe the main intricate steps of olfactory processing in mammals, some of which remain unclear, and the close associations and overlapping nature of these steps. The causes of both the complexity and the variability of olfactory signals are examined: the nature of olfactory receptors, involving the diversity of the genome; the spatial organization of the olfactory epithelium (OE) and the olfactory bulb (OB); connections in the OB and from the OB to the brain; integration and processing in the brain, which leads to the final perception of odours; and odour recognition and odour identification, which is associated with the difficulty to verbalize a reliable description of the perception in humans. Finally, the last part of this review encompasses recent progress made to decipher and understand olfactory coding and focuses on computational approaches.

Wudarczyk, O. A., et al. (2016). "Chemosensory anxiety cues enhance the perception of fearful faces - An fMRI study." Neuroimage **143**: 214-222.

Recent evidence suggests that humans can communicate emotion via chemosensory signals. Olfactory cues signaling anxiety can bias the perception of ambiguous stimuli, but the underlying neurobiological mechanisms of this effect are currently unknown. Here, we investigated the brain responses to subtle changes in facial expressions in response to anxiety chemosensory cues. Ten healthy individuals donated their sweat in two situations: while anticipating an important oral examination (anxiety condition) and during physical exercise (control condition). Subsequently, 24 participants completed a parametrically morphed (neutral to fearful) emotion recognition task under exposure to the olfactory cues of anxiety and sports, in the fMRI scanner. **Behaviorally, the participants rated more discernible fearful faces as more fearful and neutral faces as more neutral under exposure to the anxiety cues.** For brain response, under exposure to the anxiety cues, increased fearfulness of the face corresponded to increased activity in the left insula and the left middle occipital gyrus extending into fusiform gyrus. Moreover, with higher subjective ratings of facial fearfulness, participants additionally showed increased activity in the left hippocampus. **These results suggest that chemosensory anxiety cues facilitate processing of socially relevant fearful stimuli and boost memory retrieval due to enhanced emotional context.**

Hummer, T. A., et al. (2017). "A human chemosignal modulates frontolimbic activity and connectivity in response to emotional stimuli." Psychoneuroendocrinology **75**: 15-25.

Evidence suggests the putative human **pheromone Delta 4,16-androstadien-3-one (androstadienone)**, a **natural component of human sweat**, increases attention to emotional information when passively inhaled, even in minute amounts. However, the neural mechanisms underlying androstadienone's impact on the perception of emotional stimuli have not been clarified. To characterize how the compound modifies neural circuitry while attending to emotional information, 22 subjects (11 women) underwent two fMRI scanning sessions, one with an androstadienone solution and one with a carrier control solution alone on their upper lip. During each session, participants viewed blocks of emotionally positive, negative, or neutral images. The BOLD response to emotional images (relative to neutral images) was greater during exposure to androstadienone in right orbitofrontal and lateral prefrontal cortex, particularly during positive image blocks. Androstadienone did not impact the response to social images, compared to nonsocial images, and results were not related to participant sex or olfactory sensitivity. To examine how androstadienone influences effective connectivity of this network, a dynamic causal model was employed with primary visual cortex (V1), amygdala, prefrontal cortex, and orbitofrontal cortex on each side. These models indicated that emotional images increased the drive from Vi to the amygdala during the control session. With androstadienone present, this drive to amygdala was decreased specifically for positive images, which drove downstream increases in orbitofrontal and prefrontal activity. **This evidence suggests that androstadienone may act as a chemical signal to increase attention to positively valenced information via modifications to amygdala connectivity.**

Nederlandstalige popularisering

http://www.nu.nl/wetenschap/2041720/angst-kun-je-echt-ruiken.html

https://xyofeinstein.wordpress.com/2013/08/06/je-kan-angst-blijkbaar-echt-ruiken-onderzoek/

Referenties naar vroeger eigen onderzoek voor sociaal relevante visuele en audiovisuele stimuli

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Schouten, B., et al. (2010). "The facing bias in biological motion perception: Effects of stimulus gender and observer sex." Attention, Perception, & Psychophysics 72(5): 1256-1260.

Schouten, B., et al. (2011). "The effect of looming and receding sounds on the perceived in-depth orientation of depth-ambiguous biological motion figures." Plos One 6(2).