HUBER THE NOSE.

The Perception of Odors

PASSION FOR SCENTS

The Perception of Odors

Introduction

The human perception of odors depends on the processing of diverse sensory impressions in the brain. Besides the nose, chemesthesis[1] plays a certain role. Even the senses of sight and taste contribute to odor perception and processing, but this is often unconscious. Imagine an intensely cheesy odor while your eyes catch sight of a Limburger or Vieux Boulogne cheese: This might very well trigger your appetite. However, these same odors perceived in an environment of dirty laundry or smelly socks will probably evoke quite a different and unfavorable impression.

The Sense of Smell

In the animal world, the capacity to smell has become enormously specialized throughout evolution. Salmon, for example, swim thousands of miles to return to their spawning grounds. Insects communicate using specific scents, known as pheromones, that play a crucial role in mating rituals and social behavior. Wildcats track their mating partners over long distances by their smell. And when we compare ourselves to our family dog that has an olfactory mucosa that is 5 times larger (almost 2x4 sq. in.), and has 2-3 times more types of receptors (man: approx. 350, dog: approx. 1000), we can only be amazed at this veritable olfactory giant![2]

The external world comes into contact with the human sense of smell in the two nasal cavities. As a sense, it is often considered inferior to the senses of taste, hearing, touch and vision.[3] Nevertheless, the sense of smell is the oldest sense among mammals, and it rivals the others in complexity and capabilities. It enriches our lives substantially. We eat and drink with the nose, we judge our environment and our partners with it, and, as the saying goes, "Follow the nose, it always knows". In fact, the sense of smell still plays a key role in the search and checking of food and is an important factor in human relationships, choice of partners and social behavior.[4]

Biological and Biochemical Fundamentals

Scents, in the form of fragrances, such as perfumes[5] (alcoholic[6] solutions of essential oils, plant extracts, natural and synthetic compounds) assume a visible, almost tangible form. Nevertheless, the perception of a perfume is the result of an extremely complex interplay between the individual components and the olfactory system.

Olfactory transmission

Cilia → Olfactory Nerve Cell (Dendrite – Cell Nucleus – Axon) → Olfactory Bulbs (Glomeruli) → Mitral Cells → Olfactory Cortex (Cerebrum)

While breathing, eating and drinking, volatile molecules reach the conchae where they attach to receptors of the olfactory cells in the nasal mucosa. Depending on how well the scent molecules "fit" into these receptors, they evoke stronger or weaker nerve signals, which are first transmitted via the glomeruli to developmentally very old brain regions and then into the cerebrum where a scent impression is evoked. For identification, visual, spatial pictures (grandfather's old living room) and a verbal prompt (pipe tobacco) are coupled to the scent in the limbic brain.

Inside the left and right nasal cavities, there are three layers of scroll-shaped "shelves", the conchae, which are completely lined with mucuous membranes. The actual olfactory epithelium is found in the superior concha. It measures about 3/4 x 2 sq. in. and is distributed over both halves of the nose. Below the mucosa, about 30 million olfactory nerve cells[7] are embedded in supporting cells. These come into contact with the outside world via olfactory cilia that protrude into the upper nasal mucosa. Olfactory cells have an average life span of about one month; newly-formed cells then arise from basal cells. This is unusal as, normally, adult neurons are not capable of rejuvenation or division.[8]

Lilium candidum

At the other (basal) end of the olfactory nerve cells, thousands of axons are bundled together and continue through the foramina (holes) of the cribiform plate and reach the brain as the left and right olfactory bulbs. Axons from the same type of receptors end in a common gathering point, the so-called glomeruli. In man, there are approximately 5500 glomeruli on each side, which corresponds to about 16 times the number of the 350 functional olfactory receptor types.[9,10] The glomeruli are connected to each other via the so-called periglomerular cells. Axons of the approx. 30,000 mitral cells further transmit the signal into the olfactory cerebrum. From there, the signal goes to other regions of the brain, including the limbic system, which is responsible for our emotions and feelings.

A scent is thus the illusion that the brain creates based on the stimulation of the olfactory bulbs, that itself arises from the interactions of the individual fragrances with the olfactory receptors. This means that scent cannot be physically perceived or measured; a scent is a result of the interplay of various complex neural circuits in the brain. Precisely how the brain evokes this illusion – the impression of scent – from the olfactory bulb signals is still not fully understood. But one thing is agreed: Stimuli are not simply processed in an additive fashion, but rather in a complex manner, e.g., by an interplay among inhibitory, cancellation and synergy mechanisms initiated by the periglomerular cells.

Raw Materials

Today, a perfumer has a choice of more than 4000 odorant raw materials from natural sources, biochemical pathways and chemical synthesis. However, many of these are somewhat exotic in character. They may be scarce or a constant supply may not be guaranteed, or insufficient toxicological or dermatological data are available. In many cases, the olfactory character of certain products is quite similar to other products, so the perfumer, with warehousing considerations and resource optimization in mind, limits his selection to one or two representatives of the group. Therefore, most perfumers use only about 1000 different odiferous raw materials on a regular basis. These fragrant raw materials of the perfume industry may be pressed or distilled natural essential oils or extracts of flowers, fruits, leafs, stems, barks or whole plants, or synthetic products from the fine chemicals industry[11].

Animal products, such as ambergris (a pathological intestinal excretion from the sperm whale), musk (component of the scent gland of the male musk deer found in east Asia), civet (the secretion from the perianal gland of the Ethiopean civet cat) and castoreum (castor sac exudate from the beaver) are no longer used as aphrodisiacs in perfumes. Several factors have contributed to this: man's respect for, and protection of, the animals; the frequent counterfeiting or "cutting" (adding low-cost, similar-appearing substances of no real olfactory value for fraudulent financial reasons); the expensive price and irregular supply. Today, these long-used and well-studied natural animal products can be replaced by at least equivalent, if not better, synthetic raw materials.

The Perfumer

A perfumer's main occupation revolves around the creation of fragrance oils[12]. By blending and mixing various raw materials in the right proportions, he is able to create scents that evoke specific reactions or emotions in those who smell it. The master perfumer is capable of subtly altering the tone of a scent. The only limit to the scope of creations is his own fantasy, the requirements of his customers and legal restrictions.

Creativity

Three attributes are particularly important for a perfumer:

. A good nose as a basic tool for his work with fragrances[13]

. A good olfactory memory of odor as a requirement for the translation of a fragrance idea[14] and for the creation of scents that evoke the desired emotions

. A high level of creativity as a source of new fragrance ideas

Functional Products

Perfumes[15], Eaux de Perfume, Eaux de Toilette or Eaux de Cologne are pure fragrance products. Their only function and purpose is to enhance the scent of those who wear it.

In addition to perfumes, there is an overwhelming variety of so-called "functional" products manufactured by the cosmetic and toiletry, detergent and soap, pharmaceutical and technical industries. These products have been developed and are manufactured for special applications (e.g., to wash hair and make it soft and shiny, to moisturize dry skin, etc.). They normally contain only small amounts of fragrance oil.

The purpose of using a fragrance in *functional products* is to:

. Provide a pleasant olfactory experience when the product is used (e.g. cream, shampoo)

. Mask an otherwise unpleasant odor of the product matrix (e.g. permanent wave)

. Underscore the promised effect (e.g. youthful skin, etc.)

Technical Knowledge and Expertise

The chemical reaction of fragrances in various media that may contain alcohol, fats, surfactants, soaps, acids, bases, just to name a few, are quite complex. Physico-chemical parameters (partial vapor pressures, partition coefficients, etc.) play an important role. Aging processes, such as maceration, oxidation and chemical reactions among the fragrance raw materials or with the raw materials of the matrix may take place. These influence the stability and the character of the fragrance and its intensity. An experienced perfumer is aware of these phenomena and uses his expertise to find successful solutions to these problems.

A harmonious interaction between the product matrix and the perfume oil is the prerequisite for successfully marketing and selling of a product. The olfactory impression and function of the product must perfectly coalesce and deliver the same message, just like the color, the packaging, the product name, and effect.

Endnotes:

1. Chemesthesis has been called the common chemical sense and is mediated primarily by impulses from the trigeminal nerve; also known as the drilling nerve, it innervates many areas of the head. It is responsible for transmitting impressions of pungency, biting, stabbing, cooling and the like. Hot spices, such as capsaicin from the chili pepper, can evoke strong impulses via the trigeminal nerve that are perceived as stabbing-sharp, burning and painful. This sense is separate from the actual olfactory and taste sense, as its receptors are found in the oral cavity, in the pharynx and in the nose.

2. Dogs are mammals with a highly-specialized capacity to smell. Their nasal mucous membranes contain more than one billion olfactory nerve cells. Therefore, even if a dog's sight or hearing is inadequate, he can still find his way around quite dependably just using his nose. The keen ability of a dog's nose is not so much the result of a larger number of different receptor types, but rather a factor of the absolute number of nerve cells per specific receptor type. Research on the animal sense of smell has advanced significantly in recent years, but critical information is still lacking. Indeed, certain results appear to be distinct from those found in man. It is clear, nevertheless, that the human sense of smell, with respect to sensitivity and specificity, and in diversity and complexity in identifying scents, is far superior to those of animals. However, this does not apply when it comes to highly-specialized capabilities in the animal world, for example, with salmon, where quantitatively, high levels of achievement are reached.

3. Generally, one speaks of the five senses: vision, hearing, touch, taste and smell. But today, science tends to consider four more: the thermal sense (hot and cold), the sense of pain, the sense of balance and the sense of positional and motional perception (proprioception). This adds up to a total of nine senses.

4. It is known that, in addition to the olfactory organ, in many animals, there exists a second olfactory system, the so-called vomero-nasal organ. It is stimulated by specific pheromones and known to control certain sexual and social behavior (mating receptiveness, etc.). Opinions diverge as to whether it still functions in man.

5. From the Latin, *per fumum*, i.e., by means of smoke.

6. Rarely in other solvents, such as diethyl phthalate, for example, in countries with alcohol prohibition.

7. The receptor for fragrances in the cilia on the epithelial side is a crucial component of the (primary) olfactory nerve cell that leads from the basal end directly - without synapse - to the olfactory bulb in the brain. The tactile sense has a similar structure, while receptors for the senses of vision, hearing and taste are highly specialized epithelial cells that are transmitted via a second step (synapse) to a nerve cell.

8. Nevertheless, the most recent research indicates that other neurons are also capable of regeneration; indeed, this is an exciting area of investigation. The fact that olfactory neurons are replaced in rather short time periods may be related to the fact that they are constantly used – and thus wear out – during breathing, and so must exhibit this ability to be replaced.

9. One particular gene is responsible for the synthesis of each receptor protein. About 30,000 genes are present in man, of which 1000 are responsible for olfactory receptors. However, on average, only about 350 of these are used for the expression of olfactory receptors. Science now presumes that, in man, the biologically-relevant olfactory receptors have remained highly conserved during the evolutionary process, though we still do not know what the functions of the other 650 genes were or are. Nevertheless, 3% of the human genome is reserved for the sense of smell, which shows just how important it is for man, even today.

10. Earlier research was a proponent of the one glomerulus per receptor type theory, corresponding to 350 glomeruli present for each of the two olfactory bulbs (there is one on each side of the longitudinal fissure in the brain). However, Maresh A, Rodriguez Gil D, Whitman MC, Greer CA, PloS ONE 2008;3/7):e2640 cite some 5500 glomeruli. The reason for this 16-fold higher ratio of receptor types than glomeruli is not known. Nevertheless, we do know that many receptor types interact with various scents, and that with strong scent exposure and an ensuing overburdening, additional glomeruli may be excited (that thus transmit information about the intensity of the scent).

11. Compared to the synthetic raw materials used in perfumery, the number and amount of natural products is constantly decreasing. This is due to rising costs of the naturals: expensive land prices in attractive locations, costly labor, weather dependence of the crop, supply considerations, legislative (dermatological and toxicological) restrictions.

12. Fragrance oils are sometimes referred to as “blends” or “fragrance compositions”.

13. Of course, sophisticated and expensive analytical hard- and software systems support the work of the perfumer substantially. Nevertheless, the human nose is still superior to optimized physico-chemical apparatuses.

14. An idea can only be converted into a fragrance if the link between the fragrance raw materials and its odiferous profile and characteristics can be mastered reliably. During the development process of a fragrance composition, the perfumer must be capable of judging reliably whether a component is missing or overdosed, or even does not “fit” into the complex.

15. Perfumes are, with few exceptions, high percentage (18 - 30%) solutions of concentrated fragrance oils in ethyl alcohol, while Eau de Perfume (EdP) and Eau de Toilette (EdT) are less concentrated (EdP 12 - 18%, EdT 5 - 12%). Sometimes the Eau de Perfume or the Eau de Toilette differ from the basic perfume in their composition; they are usually fresher, greener, and less heavy than the high percentage perfume.

References

We would like to point out that this brochure considers and cites many different sources of literature in order to provide a better understanding of our specialty area. Dr. W. Huber AG did not contribute to, nor financially support in any way, the independant research or results.

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