

# **OLFACTORY CONSIDERATIONS IN DESIGN, A NEW DIMENSION TO PRODUCT EXPERIENCE**

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## **ABSTRACT**

Olfactory sense is not often incorporated in ergonomics and product design, even though it is a part of sensory ergonomics just as sight and hearing are. Technical developments allow nowadays to incorporate smell in many different products. As smell can influence experience and sense of smell has several functions, it is worthwhile for designers to know about olfactory sense and how to design for it.

In this article, an overview is given of the olfactory system and its characteristics. Information is supplied on how to design for various goals, e.g. to prevent, mask, disperse or control odours, to attain congruous smell and taste, to prevent allergies, to transfer information and to influence emotions.

A product should smell congruent to its material, function and context, unless the designer deliberately wants an incongruent smell. Odour can be a powerful instrument to influence emotion and reflexive reactions, but it is difficult to put this use into practice because the reactions to olfactory signals are often determined individually. On the other hand, odour can be used very effectively to give warning in some situations. Attention must be given to fragrance allergy, which affects up to 9,7 % of the population. This percentage is rising, allegedly because of increasing application of fragrances. Application of fragrances in public areas is advised against. The conclusion is that designers should spend conscious thought on olfactory factors in a product. Education presents a good opportunity to advance in this relatively new aspect of design.

*Keywords: Olfactory sense, design for olfaction, smell, odour, allergy, design for babies*

## **1 INTRODUCTION**

Olfactory sense is not often incorporated in ergonomics and design, even though theoretically it is part of sensory ergonomics just as sight and hearing. Modern man is interested in body odours and the scent of food, but not in the smell of products around him. Everything has a smell though and products smell, too. Some materials are renowned for a particular smell, like leather or wood. But even olfactory uninteresting materials like iron, paper or plastic can have their own smell. Smell is a source of information which can be quite intrusive.

Sense of smell has several functions which are essential for survival. By smell, the quality of food, drink and air can be assessed. Social signals are unconsciously exchanged by smell. Other animals can be detected, which is important to both predator and prey. Smell may set off reflexive reactions, like mouth watering on the smell of nice food. These qualities make smell an interesting sense to designers.

In this article, first the olfactory system is described and the working is explained. Next, several ways to design for olfaction are described. This article is based on information from the Dutch product ergonomics handbook [1].

## **2 THE OLFACTORY SYSTEM**

A short overview will be given of the anatomy of the nose, the working of the olfactory system and the connection between smell and taste. The characteristics of smell will be indicated, as well as the amount of variation between individuals and the variation due to various causes like aging and illness.

### **2.1 Function of olfactory sense**

Olfactory sense has four important functions. The most essential function is assessment of inhaled air and 'tasting' food and drink. Taste is to a large extent supported by the olfactory system, because the

taste categories that can be discerned by the tastebuds in the tongue are limited to sweetness, sourness, saltiness, bitterness and umami. Combination of primary taste with smell enables humans to discern thousands of flavours.

A second function of olfactory sense in the animal world is bonding with others from the same species. Mothers and children of many species can recognize each other by scent.

A third important function is olfactory recognition of prey by predators and recognition of predators by prey animals. Though humans do not have to hunt for breakfast any more, this function is still useful to them: the smell of food makes the salivary glands start working and the saliva assists digestion of food.

The fourth function of olfactory sense is to influence our subconscious, obviously without our notice. This is mediated through pheromones. A pheromone is a secreted or excreted chemical factor that triggers a social response in members of the same species. It can impact the behaviour and/or physiology of the receiving individual. There are various pheromones and each conveys its own message, for example about alarm, food trails, sex and many more subjects.

For a long time it was assumed that humans are cognitive higher beings who decide consciously and are not under the influence of a primitive 'animal' sense like olfaction. Research, however, has since confirmed that pheromones do influence human behaviour, e.g. humans base their partner choice unconsciously partly on body odour, such that their immune systems complement each other.

## 2.2 Anatomy and working of the olfactory system

From an evolutionary point of view, the olfactory system is the oldest of the sensory systems. At birth, olfactory sense is the best developed sense in humans. The olfactory system consists of the nose, the nasal cavity, the olfactory sensors and the olfactory nerve, see Figures 1 and 2.

### 2.2.1 The nose and nasal cavity

The main functions of the nose and the nasal cavity are cleaning, heating and humidifying of inhaled air and the perception of odours. Odours consist of chemical compounds that can be detected by the olfactory sensors. In humans, these sensors are located in the nasal cavity.

The nasal cavity, see Figures 1 and 2, extends from the surface of the face to the back of the throat. In the nasal cavity are both on the left and the right three thin, symmetric, slightly curled bone plates or *conchae*, which are covered with mucousal lining, see Figure 1. The conchae guide the air aerodynamically, enlarge the internal surface of the nasal cavity and are well supplied with blood to facilitate warming of the passing air. The conchae also guide the air to the olfactory mucosa, which is located in the upper part of the nasal cavity, above the smallest conchae (under the skull base, between the eye sockets).

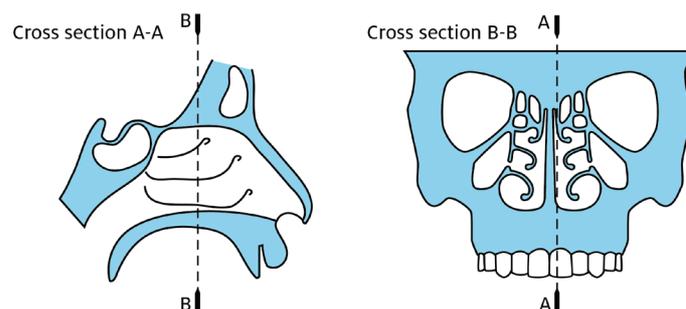


Figure 1. Left: Cross section of a nasal cavity in the sagittal plane, with three bone plates (conchae) above each other. Right: Cross-section of a nasal cavity in the transverse plane. The six curled structures are the bone plates (three per nasal cavity)

### 2.2.2 Olfactory sense

The olfactory mucosa or olfactory epithelium is composed of supporting cells and sensory cells, called olfactory receptor neurons. The distal side of an olfactory cell ends in an olfactory cone, which is covered with hairs or *cilia*. The cilia protrude from the mucosa and are covered with olfactory receptors. Some spurs of different olfactory cells form bundles which are called olfactory nerves or *nervii olfactorii*, which run from the nasal cavity to the olfactory bulb. From here, nerve impulses are

directed to other parts of the olfactory system in the brain and to the rest of the central nervous system, via the olfactory tract.

Air passing the olfactory mucosa can contain odour molecules. These molecules dissolve in the mucosa, which enables them to bind to the olfactory receptors. Which receptor an odour molecule binds to, depends on the chemical, electrical and spatial qualities of the molecule. The receptors convert the interaction with the molecules into a nerve impulse, which is passed on to the bulbus olfactorius via the olfactory cell and a nervus olfactorius.

Humans harbour about 12 million olfactory receptors, divided into 10.000 different classes. Every receptor can be activated only by odourants with a similar molecular structure. Most odour molecules activate more than one type of receptor. Difference in affinity results in various activation patterns, leading to unique flavour profiles. Virtually all fragrances activate not only the olfactory sense, but also the somatosensory receptors, which detect e.g. temperature, pain, deformation, especially at high concentrations.

Olfactory signals are processed differently from signals of other senses. Usually, when sensory signals enter the brain, they are first filtered by the thalamus. This is a part of the brain that selects which signals proceed to the cortex, where they will be noticed consciously. However, olfactory signals are the only sensory signals that are not filtered, they pass by the thalamus and go straight to the olfactory cortex and are thus always noticed. This allows the brain to react immediately in dangerous situations. The bulbus olfactorius sends the olfactory nerve stimuli not only to the olfactory cortex, but also to the hippocampus, the hypothalamus and the amygdala. The hippocampus is of importance to memory. The hypothalamus regulates the autonomic nervous system via hormones, in case of e.g. hunger, satiety, aggressive and defensive behaviour and sexual arousal. The amygdala connects information from different senses and correlates it with emotions.

Odours elicit reflexive secretion of saliva and gastric juice at the smell of food and affect the sacral spinal sexual reflexes. Smell therefore plays a role in attraction between people.

Humans have a memory for odours. Certain smells can evoke a strong association with early childhood. Perhaps this has to do with the evolutionary old age of the olfactory sense and the fact that information from the olfactory nerve is not filtered by the thalamus. 'Smell, memory and emotion' is said to be an interesting evolutionary triad [2].

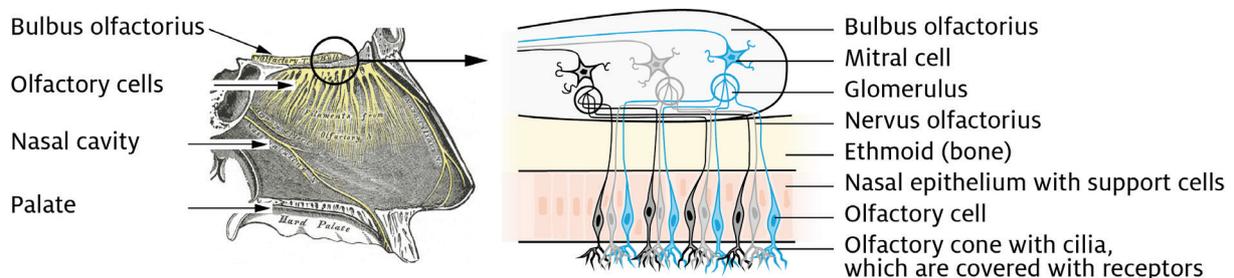


Figure 2. Left: a crosssection of the nasal cavity [3]. Right: a part of the crosssection is enlarged, the bulbus olfactorius and the olfactory cells are shown

### 2.2.3 Sense of taste

Sense of taste is the ability to perceive certain chemical compounds directly as 'taste'. There are only five types of taste receptors, perceiving the 'primary tastes' sweet, sour, bitter, salty and umami (savoury). These receptors are less sensitive than the olfactory receptors in the nose. The five primary tastes together make up only one part of taste experience. The sense of smell is an important complement, thus many more different substances can be detected. What we call 'taste' in everyday life, is actually a combination of smell and perception. When olfactory sense can not contribute to taste, e.g. in case of a stuffy nose, the taste is largely gone. This clearly 'shows' the importance of smell in taste perception.

## 2.3 Characteristics of smell

Each human has about 10.000 different types of olfactory receptors. The same amount of odours can be detected and a sheer unlimited number of combinations of these odours. With this system, scents can be identified which have never been smelled before. The olfactory sensors are very sensitive and can react to very low concentrations of gaseous substances [2]. The human ability to smell is quite good compared to animals in general. Which substances can be perceived by olfaction, varies greatly between species and also between individuals. The sense of smell is fixed in the genes, every type of olfactory receptor is encoded by a separate gene. Thus sense of smell is hereditary and we have about 10.000 different genes to code for it. Some substances can be smelled by one man, but not by another. This is equally applicable to the sense of taste: not everyone has the same taste perception. Stevia (sweetener) is experienced as bitter by some [4], [5].

Odours can be detected at a distance. Because the concentration can also be perceived, the direction of the source can be determined. The sense of smell can not be manipulated or disabled by external factors [6]. The brain, however, can influence the experience of odours. A foul odour serves to warn for spoiled food and to stay away from stools of others. This reduces the risk of infection. However, it is not useful when a smelly diaper evokes disgust in a parent. Mothers find the dirty diapers of their own babies less smelly than those of others [7].

### 2.3.1 Effect of aging and disease on olfactory ability

Sense of smell and taste both decline with aging [8]. Olfactory sense can also decline because of brain damage, infections, mental illness, smoking and hormonal changes. Taste can also decline because of consumption of drugs such as caffeine [9]. People who can not smell (sufficiently) are disabled. It is dangerous not to be able to smell gas, fire or foul food and it is impractical not to be able to judge if you clothes should be changed. As there is currently no word for smell disability, it is proposed to name it '*reuf*', which is a contraction for the Dutch words 'reuk' (smell) and 'doof' (deaf) [10].

## 3 DESIGN FOR OLFACTION

Technical development allows nowadays for many ways to incorporate smell in products. Odour may be added to plastics and printing ink, enabling amongst others *scratch 'n sniff*. Design for olfaction can have various goals, for example to prevent, mask, disperse or control odours, to attain a congruent smell, to transfer information or warn, to influence the environment, to influence the emotions of users or other people, to prevent allergies or to design for babies. These topics are discussed below.

### 3.1 Prevention and masking of odours

In modern life, a lot of attention is given to avoiding and masking scents that are considered unpleasant. Soaps, cosmetics, detergents, washing powder and other cleaning products are almost only available with added perfumes. Medication, food and clothing may contain fragrances, too. Pine scent refreshes toilets not only at home but also in most public places. Ubiquity of fragrances is very unpleasant for people who are allergic to them and it can increase the number of allergic people, too. This is reason for caution. Body odour and other natural odours have a function, so one may wonder whether it is wise to replace them with allergenic synthetic fragrances.

### 3.2 Dispersion and control of odours

Some products are specially designed to reduce odours (other than that of the product itself), or to distribute them properly. Odours can be restricted by sealing (like a refrigerator box), by adjusting the air flow (ventilation, extraction), by absorption (smell-busters in shoes) or by applying odour repellents (like sportswear with silver compounds that kill odour-producing bacteria).

Fragrance is better dispersed when the contact area with the air increases, when heated or evaporated and by ventilation. A larger contact area can be obtained by e.g. spraying. Products to spread fragrance include lavender sachets, fragrance balls, perfume atomizers, incense oil burners and air fresheners for the bathroom.

### 3.3 Congruence

Each material has its own scent. If the scent of a product does not match the expectation of the user, they are incongruent and feel like a mismatch. This also applies to taste. If you think you take a sip of wine but it is actually grape juice, you are unpleasantly surprised. In an industrial product, the smell may differ from expectation by material treatments and additives such as glue, paint or preservatives.

Disturbing incongruity may best be avoided. However, most associations with odours are acquired. By the current 'odorizing' of western society, incongruent odours are becoming more implemented and accepted. Sometimes this leads to strange conditioning or misunderstandings.

"Yuck, this pudding smells and tastes like toilet cleaner" (teenager, on lime-pineapple-coconut pudding).

"I thought I bought a nice cake with apple and cinnamon. Smells like it, anyway. But it's something else. I don't know what, but it's no apple pie. Can you see what it is?" (Woman, 77 years, on a scented candle).

Although incongruent smells are generally not advised, they may be used to obtain a certain effect.

### **3.4 Information and warning**

Scent is not often used provide information. Scent is an excellent warning sign, though, because by nature people are already alarmed by the smell of fire and they will not consume foul smelling food. To odourless gas, for example, a fragrance is added in order that a gas leak can be rapidly detected. In Germany, a bicycle helmet is developed incorporating micro-capsules which give off a smell if the helmet is damaged, even when the damage is undetectable by eye. Such a warning method is suitable for all products where material failure is difficult to observe, such as helmets, pressure pipes in washing machines and other constructions which are difficult to access. Scent sensory material can also be applied to detect cracks in water and gas pipes, because the fragrance can be smelled from a large distance.

### **3.5 Influence on the environment**

Odour can have a specific function with reference to the environment. For example an insect repellent or moth balls. The smell is functional for the users: they know that the agent is present and working.

### **3.6 Influence on emotions of users**

Because the olfactory sense, as mentioned, affects the subconscious and emotions more than the other senses, fragrance seems an attractive medium to influence the emotions of consumers or users. In marketing, fragrance is used to get people in a positive shopping mood. In doing so, the smell must fit the environment well (be congruent). Coffee scent will likely boost sales more in a food store than in a jewellery store. There are two problems here: firstly, the relation between odour and emotion is to a large extent determined individually. A pleasant perfume to one customer may not appeal others. So a specific fragrance does not evoke one and the same emotion in a group of people. It is not possible to predict or have control over the evoked emotions. Secondly, the widespread use of fragrances, especially in public places and in hygiene products, is unhealthy for people who are allergic to them.

### **3.7 Allergy prevention**

The ubiquity of fragrances is a serious health problem for people who are allergic or hypersensitive to certain fragrances which can be up to 9,7 % of the general public for a mix of fragrances [11]. They may experience, amongst others, itching, eczema, concentration problems, asthma, a runny nose and burning eyes. Fragrances are even a major source of contact allergy. About 16 % of European eczema sufferers are allergic to fragrances [12], [13]. Frequent exposure to allergens can trigger allergies. Buckley et al. [14] investigated allergy to fragrances and found that older people are more often allergic. They assume that fragrance allergy is caused by a continuation of repeated exposure to fragrances and age-related factors. An allergy to fragrances is usually permanent. It is therefore wise to be careful and apply fragrances with restraint. In public spaces and in other situations and products which users can not avoid, fragrances are advised against.

### **3.8 Design for babies**

Adults can differentiate other people by their odour, when we are open to it and stand sufficiently close with our nose. For newborn babies, the olfactory sense is paramount, because their sight and hearing is not fully developed and therefore not yet operational. Thus, babies recognize their parents by their body odour. How to design baby products according to this knowledge? Close your eyes and go around sniffing the baby room with their perception in mind. Newborn babies do not care about flowers, washing powder fragrance or fresh paint. They love the smell of breast milk and their parents sweat and body odours. Is recognition of the parents not obstructed by the use of fragranced washing powder? Perfume less washing powder may be preferred, which has another advantage: you can smell if the laundry is sufficiently clean.

## 4 DISCUSSION

In industrial design engineering, olfactory design is not a main field of interest and smell is generally given little thought. Nevertheless, for many products, more attention to olfactory factors can benefit the quality of the entire design and the health of a significant part of the population. Until now, there is no standard method available on design of industrial products for olfaction.

Education presents a good opportunity to advance in this relatively new field. Students can be requested to give attention to this subject by including olfaction in the design brief. Students have more opportunity than professional designers to explore the field freely, they are not limited by client requirements. They have to substantiate their design choices and have to defend these to their supervisors. If students give olfactory design sufficient consideration, they may advance the field by contributing to the development of a body of knowledge and a method to design for olfaction. After graduation, they can use this to advantage in their professional work, simultaneously disseminating their knowledge.

## 5 CONCLUSION

Designers should spend conscious thought on olfactory factors in a product. A product should smell congruent to its material, function and context, unless the designer deliberately intends the smell to be incongruent. Odour can be a powerful instrument to influence emotion and reflexive reactions, but it is difficult to put this use into practice. Odour can be used very effectively to give warning in some situations. Attention must be given to fragrance allergy, which affects up to 9,7 % of the population. This percentage is rising, allegedly because of increasing application of fragrances. Application of fragrances in public areas and in situations and products which users can not avoid, is advised against. Education presents a good opportunity to advance in this relatively new aspect of design.

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