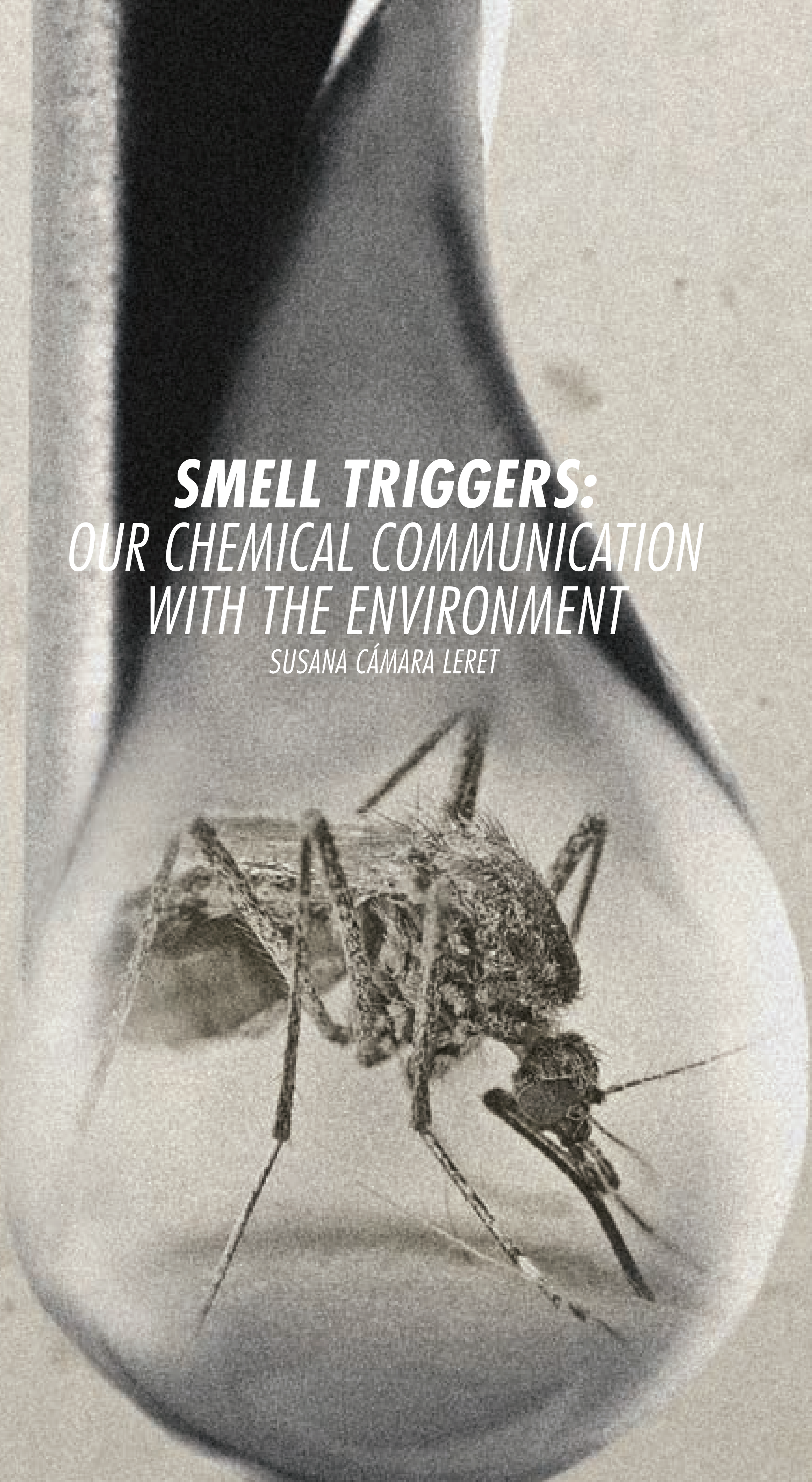
SMELL TRIGGERS:
OUR CHEMICAL COMMUNICATION WITH THE ENVIRONMENT

SUSANA CÁMARA LERET



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In memory of Gabriel Leret Ruíz & Carmen Verdú Salinas

***Fig. 1** Chemical signalling surrounds us*

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***Fig. 2** Natural translators*

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***Fig. 3** Sweat is a source of information*

INTRODUCTION

During the first half of this project I approached the topic of smell from an initial observation: we are losing smell. The repercussions of our lack of esteem towards our chemical sense quickly became apparent in our interventions with nature. In the age of biotechnology, not only are we losing out, but we are depriving some natural species of an essential tool which enables them to communicate with their surroundings. Paradoxically, smell is commonly regarded as a mere agent for the achievement of a heightened, sensorial experience. Nevertheless, it belongs to some of the most complex processes I could have ever imagined to encounter.

The second half of this study, aims to communicate this complexity of smell. Because smell is information, I aimed to envision just what kind of new interactions we could engage in.

The possibilities are many...

Fig. 4 Towards a chemical communication

HYPOTHESIS

We live in a highly visual society ruled by data and probability, yet research shows that our chemical sense of smell can provide a renewed understanding of our body and nature. Through a multidisciplinary practice, design can confront scientific data and research from the fields of biology, neuroscience, psychology and the visual arts, in order to speculate future possibilities. By considering smell as a marker for medical information we encounter a different type of communicative exchange between us and our environment.

In the context of healthcare, what are the design implications of our chemical relationship with our environment?

Fig. 5 Exchanging relevant information

Fig. 6 Changing our perception of nature

Fig. 5 Communicating chemically

Our body odour constantly communicates with our surroundings.

Fig. 6 Changing our perception of nature

Signals we emit through our sweat are perceived by insects such as mosquitoes.

1. WE SMELL

ODOURTYPES – IDENTITY – GENETICS – BIOMARKER – SURVEILLANCE – HEALTH – CHEMICAL INFORMATION

I. ODOUR – IDENTITY

"There is a general and universal system of chemical communication in which all living things are involved. The result is a coordinated ecological mechanism for the regulation of who goes where, and how many can afford to do so."[1]
- William Shakespeare

Humans have a unique odourprint, similar to fingerprints: we all have our own smell. This personal odourtype information is transmitted through body fluids such as sweat and urine, which contain chemical molecules called volatile organic compounds (VOCs).[2] The use of smell as a biomarker could lead to new ways of approaching identity and health, along with promoting a new understanding of our bodies and our constant interaction with our environment.

Our odour is composed of various VOCs such as alcohols, ketones, aldehydes, esters and hydrocarbons, amongst other substances. Studies show that our personal smell is genetically determined. This primary odour remains stable and constant over time[3] regardless of diet and other external factors. As scientists claim, each of the 6.7 billion people on Earth has a unique body odour[4] : our own chemical signature.

It has been suggested that individual identification might be one of the most important messages used in vertebrate chemical communication.[5] Body odour contains relevant information about an individual and people can distinguish the scent of others, especially if they are unrelated and have different diets. Odourtypes apparently vary by gender, as shown in a recent study, which found that men smell of cheese while women smell of grapefruit or onions.[6] But they can also reflect age, as Dr. Preti from the Monell Chemical Senses Center in Philadelphia discovered. Aldehyde nonanal, with an unpleasant greasy and grassy odour, was proven to increase with aging, being characteristic of the middle-aged and elderly's odours.[7]

"An individual's odourtype is determined in part by genes in a genomic region called the major histocompatibility complex (MHC), which plays a role in the immune system and are found in most vertebrates, our odour is a source of identity."[8]

Different body parts produce different smells due to the different types of bacteria we contain, different amounts of oxygen available and our different types of skin glands and secretions. According to Dr. Preti:

"All of these go into creating different groups of volatiles that influence the odourprint that are emanating from you (...) [Odourprints are] a group of molecules present in certain ratios that might be quantitatively different for each individual on the planet (...)[9]

In this respect, odourprints are seen by researchers as similar to facial features in the sense that no single or individual measurement on a face can be used by itself to recognise an individual. We all have our own personal chemical pattern composition.

II. ODOUR – SURVEILLANCE

The idea of an individual and personal body odour is nothing new. The Stasi secret police in Communist East Germany started researching scent analysis in 1970. This was depicted in the Oscar winning film The Lives of Others, centered on a Stasi surveillance officer.[10] They collected hundreds of scent samples from critics of the regime, which were then stored in air-tight containers:

"The Stasi stole items of clothing from the regime's opponents at their place of work or where they played sport, or they would take the odor sample from chairs they had sat on in the pub or during an interrogation."[11]

Currently, research into scent analysis is growing. In 2007 Der Spiegel magazine revealed that German authorities had collected scent samples from activists in advance of the G8 summit, to prevent these from possibly interfering with it. Dr. Kenneth G. Furton, from Florida International University, is working with the Netherlands National Police Agency on the search for detectable odourprint patterns emitted by people. The U.S. also seems to be looking into new olfactory detection mechanisms[12] and the Pentagon appears to be financing research at Darpa – Defense Advanced Research Projects Agency – to develop detectors which could potentially detect the scents of enemies in collaboration with smell-research institutes such as The Monell Chemical Senses Center. According to Gary Beauchamp, a behavioural biologist and director of this institution who is working on the Darpa project, it should be possible to:

"*(...) recognize how old someone is, what their gender is, and what illnesses they have (...) We need a big leap in technology to create sensors that can do the same thing. But there is a lot of work being done on this now. The time has come for this technology(...)*"[13]

A technology that could consist in the employment and training of insects, which are being studied as possible detecting agents:

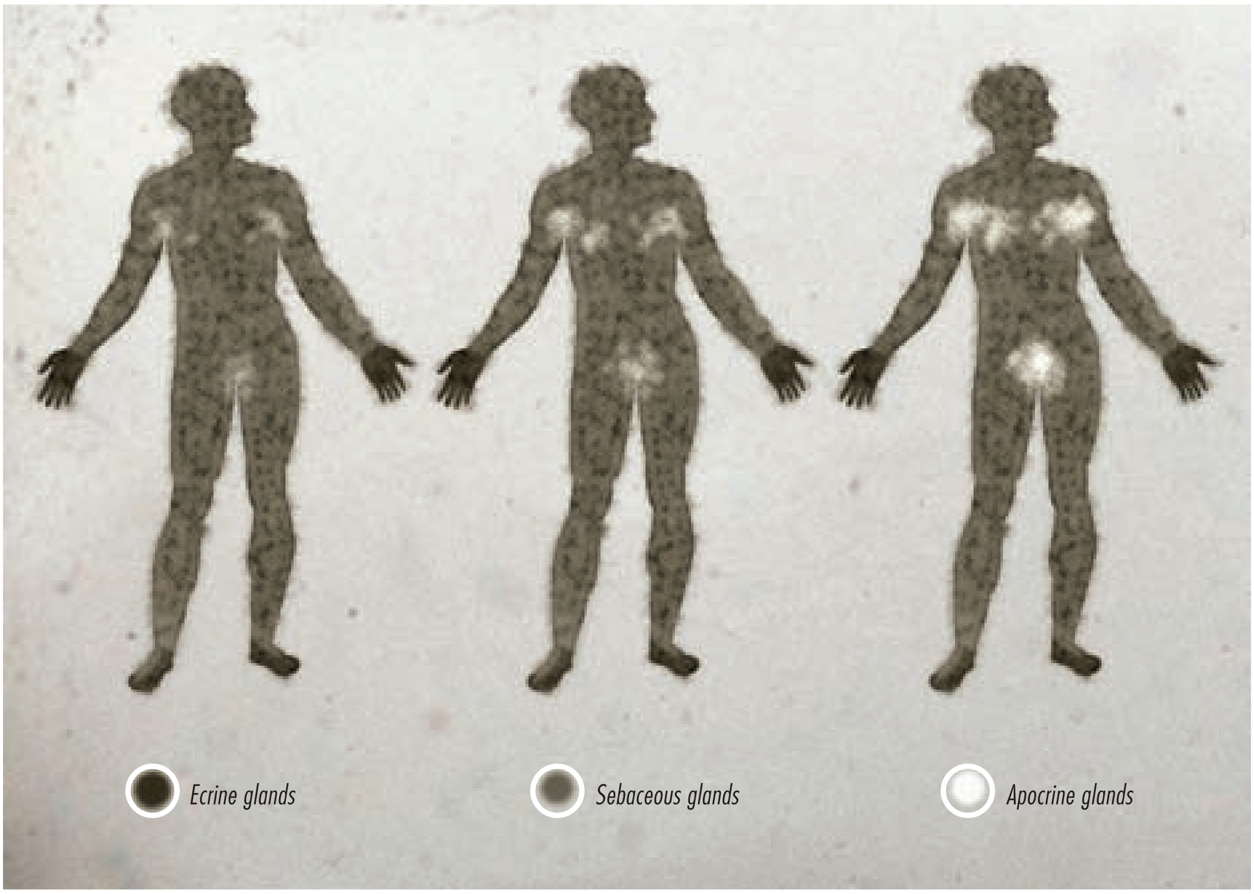


Fig. 7 Body odour is genetically determined

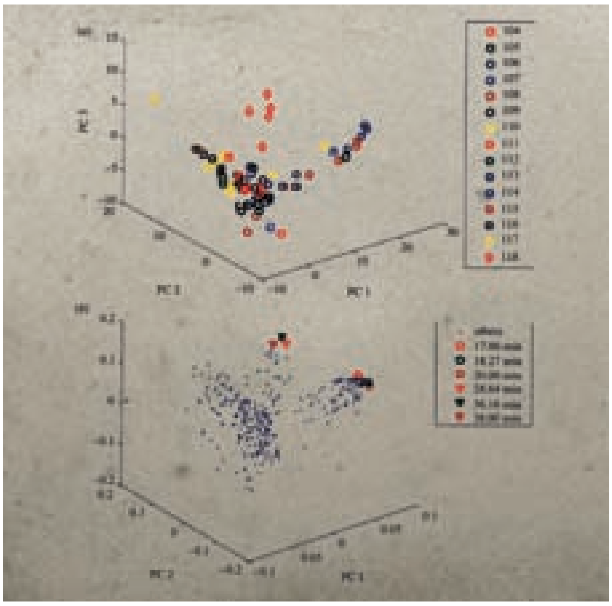


Fig. 8 We each have an individual odourprint

Fig. 7 Body odour is genetically determined
Generally, asians have less apocrine glands than caucasians and africans. Africans tend to have more and larger apocrine glands than asians or caucasians.

Fig. 8 We each have an individual odourprint
An example from a recent study which shows individual markers in the analysis of personal scent samples.

Fig. 9 Control through odour

Fig. 10 Surveillance Agents

Fig. 11 Biological Sensors

Fig. 9 Control through odour
Stasi glass jars used to store sweat samples from regime oposers.

Fig. 10 Surveillance Agents
Studies are looking into the use of animals as scent control agents.

Fig. 11 Biological Sensors
Insects such as mosquitoes possess exemplary olfactory capabilities.

"*The Home Office is known to have funded at least one study into the feasibility of releasing swarms of trained bees to search out target odours. The US has similar plans for moths, bees, wasps and cockroaches, and Russia has cross-bred jackals with dogs for an enhanced sense of smell. Even yeast has been genetically manipulated to react to molecules of interest to the security services. Companies across the globe are designing and touting "electronic noses", machines that seek to mimic the mammalian sensory apparatus, in an attempt to satisfy new security demands.*"[14]

The use of insects as biological sensors points towards a new interaction with our environment, no longer mediated by the visual sphere. These odour detection 'tools' would enable states to obtain information from individuals beyond the range of the human senses. The advantage of using smell versus other biomarkers is that smell can be recognised from a distance and it can also linger in an area. In the age of biotechnology, how could we employ these natural sensors to obtain further relevant information about ourselves?

III. ODOUR – HEALTH

Our body odour is more than just a stench which we must mask with synthetic smells to achieve social acceptance. It is a source of information and can serve as an alert mechanism, due to smell's intrinsic link with our immune system. Our body smell contains relevant medical information about ourselves.

In 1974 Lewis Thomas speculated that the genes and cell-surface proteins of the immune's system's major histocompatibility complex (MHC) could maybe be the source of individual odour profiles. One theory is that different MHCs lead to different microflora, which influence the mix of different body odour chemicals.[15] This link to immunity could be the reason why smell is a potential biomarker for disease.[16]

The literature already shows that the detection of breast cancer through breath is possible.[17] In this respect, not only can odourprints be used to detect individuals, but body odour differences could also determine disease.[18] Scientists are now busy seeking the smell signatures of diseases such as cancer and diabetes and some psychosomatic illnesses such as depression[19]:

"*(...) some medical researchers insist they can identify certain disease patterns by differences in the smell of stool, vomit and bodily gases (...) Already, specially trained service dogs can alert their owner to an approaching seizure.*"[20]
Nevertheless the link between smell and disease is nothing new. Physicians once tasted a patient's urine to diagnose disease. Diabetes mellitus means 'passing through sweet', which might be due to the fact that it was once diagnosed by the sweetness of a patient's urine and thus for centuries the disease was referred to as 'pissing evil'.[21] Records show that the use of odour in disease diagnosis was already present in Hindu and Arab medicine:

"*Nearly two centuries ago, one of the originators of Hindu medicine, Susruta Smhita, claimed that 'by the sense of smell we can recognize the peculiar perspiration of many diseases, which has an important bearing on their identification'.*[22] *One thousand years ago,* *the Arabian physician Avicenna observed that an individual's urine odour changed during sickness.*"[23]

Today, developments in sensor technology are under way, focused on the production of devices known as electronic noses, with the intention of the detection of microbial infections. It is well known that microorganisms produce a range of volatile compounds, which is partly why odour varies as a result of infections. Dr. Dustin Penn mentions that it is surprising that these chemical signals have not received more attention as potential disease indicators[24], yet current investigations show that there is increasing interest in determining if body odour can be used to diagnose disease, or altered to reduce the risk of contracting disease.[25]

The area surrounding an object or person in which their odour can be analysed is termed headspace. Analysis of these human secretions are being studied to discern which compounds constitute an attraction to disease vectors, such as for example mosquitoes. It is known that these insects are more attracted to some individuals than others, due to their chemical odour composition. What if we could use our chemical exchange with these biological sensors for a beneficial outcome?

TUBERCULOSIS - *Stale beer*

TYPHOID - *Freshly baked brown bread*

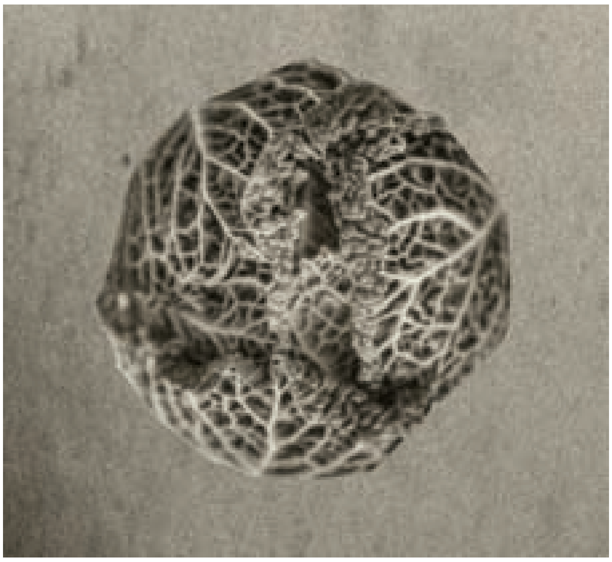
YELLOW FEVER - *Butcher shop*

DIPHTHERIA - *Sweetish*

Fig. 12 Infectious Diseases and their characteristic odour

DIABETIC KETOSIS - *Decomposing apples*

INABILITY TO METABOLISE HEXANOIC ACIDS - *Sweaty feet*



INABILITY TO METABOLISE METHIONINE - *Boiled cabbage*

DEFECTIVE METABOLISM OF AMINO ACIDS - *Maple syrup*

Fig. 13 Noninfectious Diseases and their characteristic odour

2. CHEMICAL COMMUNICATION

CHEMICAL SIGNALS – SPECIES – COMMUNICATION – MICROBES – QUORUM SENSING – MOSQUITOES – FLYING SYRINGES

I. NATURE'S CHEMICAL SENSING

The notion of chemosensory identity sustains the fact that species communicate chemically, with the aim of fulfilling different objectives. Chemical signals between the sexes for example, are employed to attract and select potential mates[26] by bacteria, fungi, protists, plants and animals:

"*There is an enormous diversity of mechanisms mediating chemical communication (...) Single-celled organisms and the gametes of multicelled organisms use chemical signals to locate and recognize their mates (...) Male mammals display their scent for females using complex mixtures of odorants secreted by a diversity of androgen-dependent scent glands (...)*"[27]

Chemical signals can communicate the presence of food for many species. Some insects such as cockroaches, crickets and locusts can even differentiate food types using scent cues.[28]
The Kenyan jumping spider E. Culicivora feeds indirectly on blood. It is a mosquito eating predator and it's food source consists mainly of the mosquito species Anopheles gambiae, the main vector of malaria. A study recently showed that both sexes of this species became more attractive once having fed on female blood-carrying mosquitoes.[29]

These chemical signals can also advertise health or genetic attributes, in aims of measuring genetic compatibility. Female house mice, for example, are attracted to the urine of male mice, which serve as scent markers. A study found that females were capable of distinguishing between the urines of parasitised and unparasitised males[30] and were more attracted to those uninfected males. The odour of those infected individuals simply lost its attractiveness. In this respect, there are many ways in which an individual's odour might signal infection:

"*First, infection might change the composition of commensal microbes that play an important role in shaping an individual's odor (...) Second, infection might also trigger* *immunological responses that alter an individual's odor (...) Third, activation of the immune system probably alters the excretion of other metabolic by-products from the, endocrine system. For example, infected individuals have high concentrations of plasma corticosterone14 and low concentrations of androgens, hormones suspected to control the production of 'alarm odors' and 'sex pheromones', respectively*"[31]

In the race for survival and reproduction, chemical signals support relevant information on who the best suited mate is, but they can also function as an alert mechanism to avoid disease contraction.

II. OUR CHEMICAL BODY

We are constantly engaging in a chemical communication with our environment. Our bodies smell and by doing so we release relevant information about ourselves. Some of this information is released in the form of volatiles and some is even detectable by the human nose. Other signals are only perceivable by biological antennae.

Bacteria communicate using chemical signals, by releasing and receiving signalling molecules in what is known as quorum sensing. They don't just communicate amongst themselves but also interact with signals sent by their human host:

"*Many species of bacteria have been shown to be in constant communication with each other (...) bacteria not only receive signals from each other, but also intercept them from the cells of their plant or animal hosts, including us (...)*"[32]

The microbiologist Steve Atkinson, from the University of Nottingham in the UK, notes that it's about "*signal production, interception – and maybe even coercion of the host to do something that it wouldn't normally do*".[33] According to Atkinson, our cells might even exploit the same signalling system to supervise our body's microbes. These are constantly engaged in a chemical communication and are present all over our body: in our mouths, in our noses and on our skin, whilst engaged in conversation with us.

Through a chemical signalling procedure, some body secretions inevitably communicate a source for food to some insects such as mosquitoes. The smelly chemicals some people secrete, such as lactic acid and nonanal[34], are specially attractive to these insects whilst others simply fail to attract. It is the female mosquitoes which require blood for reproduction, since they need proteins contained in blood to produce eggs, while male mosquitoes tend to feed on nectar. These insects are commonly regarded as a threat to humans since they are carriers of important diseases such as malaria, dengue, and west nile virus.

Research is under way to determine which human odorants can fail to attract these insects, in order to produce more effective insect repellents. James Logan, from the University of Aberdeen in the UK, isolated the most potent repellent chemicals, by strapping electrodes to the antennae of female mosquitoes and analysing their responses to several compounds:

Fig. 14 Flying Syringes

Scientists are currently genetically modifying mosquitoes in aims of using their feeding mechanism to deliver vaccines.

Fig. 15 Mosquitoes 'fish' into our skin whilst searching for a blood meal

“*Logan will not divulge the names of the chemicals until they are patented. But he does reveal that although the scent of the chemicals is normally undetectable by humans, they have a fruity smell when highly concentrated.*”[35]

Yet science is also searching in the opposing direction, with the intention of utilising these insects as cure propagators. A Japanese group of researchers is looking into the genetic manipulation of these insects to turn them into ‘flying syringes’. When mosquitoes bite us, they inject a saliva through a parallel yet separate channel, to that which they extract blood with. This saliva presents properties which prevent the blood from clotting. The Japanese researchers are looking into adding an antigen in the mosquito’s saliva to trigger an immune response in the insect’s host. Thus they found that:

“*(...) they attached SP15, a candidate vaccine against leishmaniasis, a parasitic disease spread by sand flies that can cause skin sores and organ damage. Sure enough, the mosquitoes produced SP15 in their saliva, the team reports in the current issue of Insect Molecular Biology. And when the insects were allowed to feast on mice, the mice developed antibodies against SP15.*”[36]

CONCLUSION

The chemical communication occurring between the different natural kingdoms, in a cross-signalling manner, alludes to a greater interdependency than we had imagined amongst different species. This link to our environment implies that we can no longer conceive of ourselves as human beings isolated from all other organisms, but of another active agent in a chemically-interdependent ecosystem. By addressing smell as information we are confronted with a new perception of the human body, engaged in a constant exchange with its surroundings. Our body odour is commonly regarded negatively as something offensive which we must mask. In this new context, its importance as a source of information is affirmed, questioning popular beliefs on bodily smells. The notion of cross-kingdom signalling bears many implications in relation to smell and our health. From this perspective, our body's chemical imbalance - disease - can be considered as a communicational problem and tackled through communicative strategies.

New ways of measuring health are possible which emerge from this new dialogue with nature. In this respect, it is necessary to rethink existing systems and processes concerning healthcare, by taking into account these future possibilities.

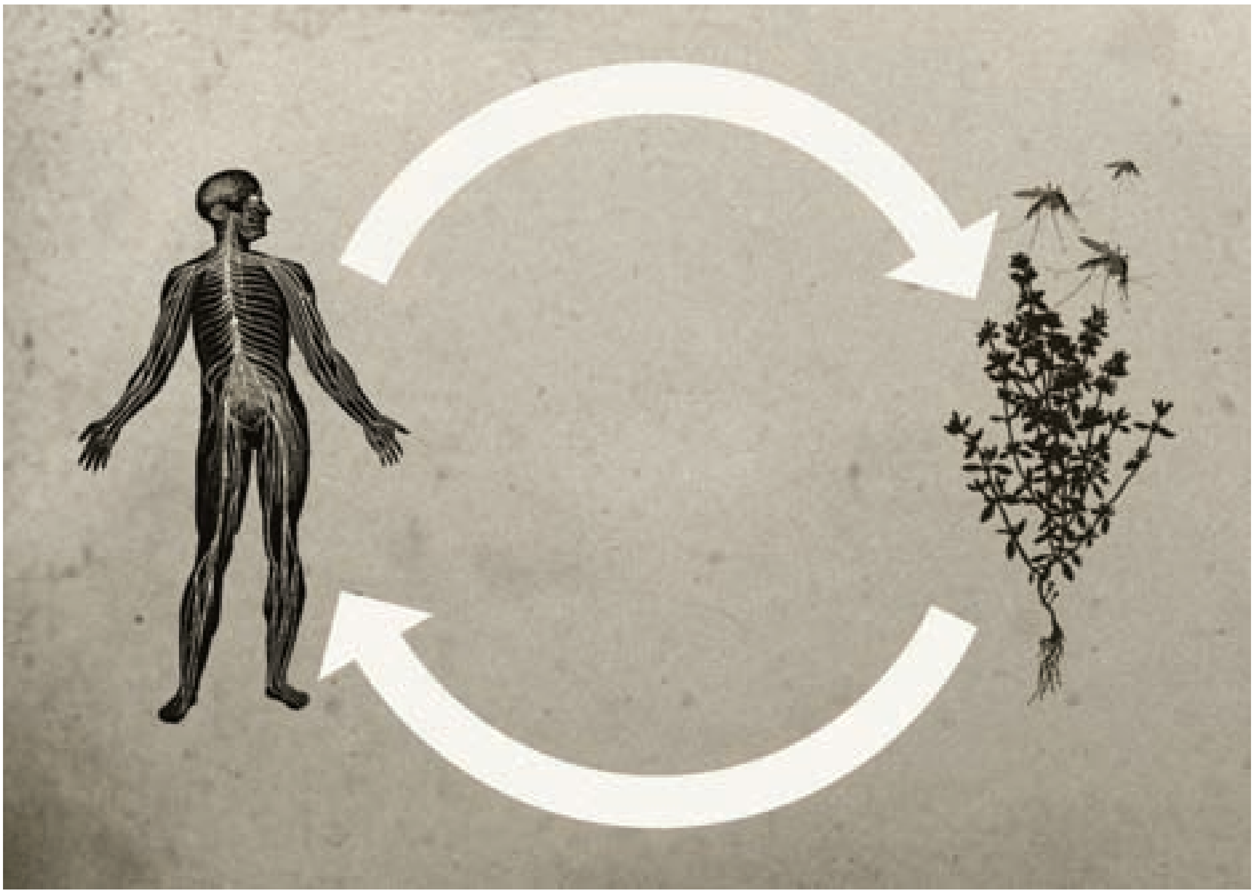


Fig. 16 *Our chemical interdependency with our natural environment*

Fig. 17 *A new approach to healthcare by considering the potentials of smell*

PROPOSAL

Scientific findings show that our body odour can transmit relevant information regarding our personal health. When we suffer from cardiac illnesses, the acidic levels in our blood rise. These chemical signals are clearly understood by insects such as mosquitoes, who are especially attracted to lactic acid. In this context of chemical exchange, disease becomes a communication problem and its prevention a communicative strategy. This means the concept of health can be readdressed as a dialogue between our body's emission of information, due to a chemical balance / imbalance, and the translation of this information by biological sensors.

I. THE DESIGN IMPLICATIONS

A SPECULATIVE SCENARIO

The genetic modification of mosquitoes already can allow the possibility of turning these insects into 'health vectors'. Our body odour varies with illnesses and individuals with specific ailments secrete particular compounds through their sweat. These variations could be a signal for GM mosquitoes to come to our aid. Our chemical attractants, would incite mosquitoes to a meal whilst allowing them to diagnose us. By communicating chemically, nature in turn, would diagnose us.

The use of a communicative strategy to deal with healthcare implies that health as such is thought through a preventive action. Currently we wait to get ill before we seek treatment. The use of smell as information and advances in biotechnology propose a new scenario, where mosquitoes would function as health surveillors.

DESIGN AS AN INTERMEDIARY

Design surrounds us in our everyday lives, subtly shaping the way we interact with our surroundings and others. It also reflects existing popular beliefs. Mosquitoes, for example, are often seen as a threat to humans, and existing designs in relation to these insects consist of barriers – both physical and chemical – to impede our contact with them. Working amongst the context of this new communicational exchange with mosquitoes, design must allow new forms of interaction, by working as an intermediary in this system and thus allowing these insects to cohabit with us.

II. CONTEXT OF HEALTHCARE: DIAGNOSING THROUGH SMELL

In order to understand the information exudated through smell, design must visualise our body's chemical signals. This implies a translation between the senses of smell and vision:

We communicate to mosquitoes via smell – Mosquitoes communicate to us via the visual.

By perceiving mosquitoes as biological sensors, and allowing their normal insect behaviour, new diagnostic processes are created. Design facilitates a chemical dialogue with these insects, by mediating two interactions:

1. A PLATFORM FOR A CHEMICAL DIALOGUE
HUMAN BODY ODOUR – MOSQUITOES

HOW DO WE FACILITATE A COMMUNICATION BETWEEN HUMANS AND MOSQUITOES?

This implies a landscaping problem since in order for a dialogue to exist, mosquitoes must coexist with humans. The creation of new habitats and ecosystems where these insects can exist is necessary. Mosquitoes need certain elements in order to grow and live, such as stagnant water, grasses, shrubs, etc. In this scenario water filtering systems in the urban landscape are designed to create incubating posts for these insects. Street sewers designed to reutilise waste water, allow a new habitat for mosquitoes to coexist with us. These become 'health posts' along the city, strategically implemented by the public healthcare system, covering the necessary distances for the mosquitoes to effectively diagnose us.

2. NEW DIAGNOSTIC DEVICES
CHEMICAL SIGNS – VISUAL TRANSLATION

HOW MIGHT WE CREATE A VISUAL SIGN FROM ODOUR?

The mosquito bite becomes the translation between the chemical information our body releases and the visual signs necessary for its understanding. A new system of diagnosis and healthcare based on prevention, instead of treatment, is necessary for the optimal functioning of these biological sensors:

The GM mosquitoes react upon nuances in our body smell which point to illness. These are equipped with a solution in their saliva which reacts to an excess of acidity in our blood, causing a slight colouring in the bite. Our skin becomes a diagnostic kit, where the contact between our chemical balance – imbalance and the injected solution, allows for a visualisation of a health condition.

For the implementation of this diagnostic process, the public healthcare system carries Diagnostic Campaigns throughout the year, pre-warning citizens through mail. On set dates, GM mosquito eggs are inserted into the GM-incubators. These are incapable of reproducing, living for a maximum of two weeks, during which individuals will be diagnosed. In health pamphlets and brochures, relevant information will be distributed to the public, regarding necessary actions, should they be diagnosed.

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