by Hartmut Ginnow-Merkert

A small but central portion of an industrial designer's responsibilities is the translation of a concept, or idea, into its material representation. This representation, or product, is characterized by its functional, aesthetic, economic, technical, and ecological qualities and certainly others more. It is therefore necessary for any designer to understand all the factors involved in the synthesis of such a design, and—beyond understanding—to skillfully orchestrate each of these factors for maximum effect and harmony.

It is my desire to show that we, the designers, are far from understanding and therefore even farther from mastering one of the most important aspects of design: human-to-product-to-human communication.

I will then present my thoughts about the direction designers need to explore unless they are prepared to surrender their profession to others.

When humans engage in a natural activity such as eating, all our senses participate. We use vision to select the most desirable piece, we touch it and receive tactile information; maybe liquids or solids inside, or the removal of a shell produce a sound. Our olfactory analysis will yield additional information, and at last, our gustatory sense produces yet another type of input.

Every single sense performs a number of tests on our food, at various stages of our interaction with it. A single failed test will lead to its rejection, voluntary or involuntary; before, during, or even some time after we ingested it.

During the past several million years human survival depended upon a proper and continuous supply of nutrients (picked or hunted), our appropriate social interaction with friend or foe, and our proper response to environmental conditions. Furthermore, our capability to predict future events of nutritional, social or environmental impact would become the base of what we now call intelligence.

In order to respond to or to predict these survival factors we extrapolate past experience into the future. Past experience is based on the information we receive through those five tiny windows into reality that we call our ‘senses’.

Much important information from the outside world does not reach us. No natural sensors exist in humans for ultrasound and infrasound, ultraviolet light, X-rays, radioactivity, magnetic fields, or most chemical and toxic substances.

Our senses provide us with a severely limited image of the world. Our failure to use *all* the available sensory information could be detrimental to our survival.

The advent of human-made artifacts did not reduce our need to carefully examine our environment. Life has not become *less* dangerous since we started to mass-produce objects.
Our senses produce data no matter whether our current environment or the things in it are natural or human-made. In our interaction with other human beings—which is mostly still that of our prehistoric ancestors—we certainly employ all our senses.

Yet when it comes to designing products, designers seem to be convinced that the visual sense is the only one that matters.

Even considering the visual impact of our products alone, most of a designer’s activity is inaccessible to rational argument. What little rational grasp we have on aesthetics we owe to long-dead Greeks or, more recently, to our study of product semantics, an area of design theory that is still in its infancy.

Other than that, Industrial Designers still operate in the dark ages, similar to the barber-surgeons of the medical profession of centuries past. Designers diagnose mysterious corporate diseases, such as chronic lack of innovation, they yield magic marker wands, they develop marvelous potions in form of sleek, new, glistening products to cure all corporate ailments.

Designers speak in strange terms which no "decent engineer" ever understands, they wear uniforms of dark textiles and round metal-rimmed glasses. Finally they charge an enormous fee, then rush to find their next victim! Do they ever stay around long enough to monitor the success or failure of their keen ideas? Have they developed scientific means to measure and predict the outcome of certain strategies? Can they prove what they are talking about?

Products today don't breathe, moan, move, wiggle, smell, sniff, withdraw, or offer themselves. Designers today—not them out there, but us, all of us!—produce nothing but Cinderellas in their caskets, or, in other terms, attractive-looking dead bodies! The designer-undertaker!

Of course, our products have acoustic, tactile, olfactory and gustatory qualities! Every product does, but these qualities normally occur just as a random consequence of other visual-aesthetic or technical decisions.

It is my understanding that the better we address a persons communication needs, the better this person will be able to use the product, and the more satisfying this person's experience with that product will be. Needless to say this means sales!

So, what is communication?

Communication is bi-directional exchange of information. As much as we use our senses to receive incoming information, we transmit information just as well, which is available to somebody or something else.

If we waste this information by not equipping our products with sensory devices and intelligence, a designer's occasional success is a random occurrence; the rule is the consumer‘s frustration and anger.

Speaking about human interface and communication, it is a shortsighted view to speak in terms of a human being's five senses alone.

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Information flowing in two directions multiplied by our five senses makes for a total of ten communication channels!

To this we need to add yet another concept.

It is not immediately obvious, but if you think about it, humans are only partially equipped with *active* transmitters. Consider the visual information carrier. Lightning bugs and LED's transmit light for communication purposes. Humans usually don't glow in the dark or shine light beams at each other from a pit in their foreheads. Human transmission of visual information is of *passive* nature. Human beings modulate existing ambient light by means of the clothing they wear, their body movements, and by artifacts they carry or use.

Our acoustic transmitter, on the other hand, is of *active* nature: our voice, our stomach growling, clapping our hands, all transmit sound actively produced inside or by means of our bodies.

So for each communication channel there is an *active* and a *passive* transmitter.

Along the same lines, a product's passive receiver would pick up the signals produced by its human counterpart, whereas a product's active receiver would transmit acoustic signals the echo of it being listened to and interpreted by the product, similar to the way a bat's sonar works.

Now that we have taken a closer look at communication, it is about time to put it all back together again. This graph lists our communication channels along with some examples for each type of information exchange.

	Channel	Type	Examples
Visual	Transmitter	active	Light bulb, LED, display, moving elements
		passive	Form, proportion, color, texture, radii
	Receiver	active	Bar code scanner, camera autofocus device, OCR
		passive	Photo cell, infrared motion detector, night-vision device
Acoustic	Transmitter	active	Loudspeaker, siren, horn
		passive	room acoustics, echo
	Receiver	active	Depth sounder, ultrasonic distance measuring device
		passive	Microphone
Tactile	Transmitter	active	Vibration, temperature change, vibration alert
		passive	Texture, form, temperature conductivity, Braille
	Receiver	active	Ophthalmic eye pressure monitor (air pulse type)
		passive	Blood pressure monitor, push button, switch
Olfactory	Transmitter	active	Material-specific smells (wood, leather, plastics)
		passive	'Scratch 'n Sniff' pad
	Receiver	active	Gas spectrometer
		passive	Smoke detector, breathalizer
Gustatory	Transmitter	active	Taste substance given off continually
		passive	Taste substance released upon contact with saliva
	Receiver	active	Imaginary robot mosquito, yet to be developed
		passive	Litmus paper; enzyme-based blood glucose analyzer

At this point I will briefly discuss some of the specifics regarding each of our ten communication channels.

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01 The Visual Transmitter of a product

Products are equipped with active as well as passive visual transmitters. Every visible detail of a product transmits visual information. Form, size, proportions, color, texture, reflectivity, every single radius all contain information sent off for the potential benefit of the human user. He or she will interpret this information as a product's statement about its purpose and functions, its value, its longevity and the gains in power, status and pleasure that it promises to provide.

While the *passive* visual qualities of our products today are defined by industrial designers in most of the cases, the *active* visual features are determined by others without our influence. The physical qualities and behavior of lights, LED's, displays or LCD-screens are specified by engineers, and at best we get an opportunity to put them in a nice-looking enclosure.

If we educated ourselves about the nature of these visual information transmitters, we could do a much better job designing our products for maximum user satisfaction.

LED's can be turned on or off. They could also vary their intensity, their color, their blinking rate, their location, their size. A single LED blinking more rapidly upon somebody approaching subconsciously enters the nervous system of the burglar, scaring him off. Using this principle, much more information could be transmitted than by, say, a simple light with a printed message next to it. [Apple Computer's line of iBooks and PowerBooks demonstrate the emotional message content of a "breathing" LED thus contributing to the cult value of this brand]

A product's visual transmitter provides most of the information during its first encounter with a potential human user.

But don't forget, there are many situations when visual transmitters can't do their job.

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A product's visual transmitter is of limited or no use

• in the absence of ambient light,
• over large distances,
• in the presence of visual obstacles,
• when the user is blind, sleeps, or when he is unconscious,
• when he or she happens to look the other way or is distracted,
• when a detail is too small for the user's optical resolution.

02 The Visual Receiver of a product

Most designers are ignorant with respect to the technological possibilities of artificial vision. If our products could see us and process the data intelligently, much of our frustration with products could be avoided.

A few examples exist where machine "vision" has been implemented, e.g. the automatic sliding doors in public places such as shopping malls and airports. We could envision more advanced applications where a product might recognize its user and alter its own user interface based on its prior "experience" with the specific individual. We could save energy by developing lighting systems that could sense the presence and body orientation of human beings to control the location and amount of light presented. We could envision vending machines that change the location of their user interface according to the body height of the user. All sorts of machines, cars, furniture, public transportation systems, or medical equipment could use artificial vision to adapt themselves to their users' special characteristics.

03 The Acoustic Transmitter of a product

Objects, animals and human beings generate and transmit acoustic signals which a human counterpart is able to pick up and interpret. Our brain has evolved into an instrument of extreme precision, for certain (survival) purpuses. It is able to distinguish minor changes in pitch, dynamics, intensity, composition, and direction of sound. When bypassing the conscious portion of the brain, its older regions trigger involuntary physiological and biochemical responses to sound, such as pleasure, relaxation, shock, fright, or alarm.

Beyond the spoken word there is a region of untapped communication potential.

Today, however, even the most sophisticated of our products generate sound of the most primitive quality imaginable. Products which cost thousands of dollars generate identical beeps for all kinds of different operations, mindless beeps with no information content whatsoever!

Electronic products that signal each keystroke with a different sound at least provide a melody for feedback. This melody adds redundancy to the tactile and visual feedback used in the operation and thus enhances the reliability of our interaction with the product. This saves cost, and adds satisfaction.

Automobiles produce many different sounds informing their drivers about acceleration, mechanical stress, maintenance requirements, and it is no wonder that people are so emotionally attached to these ecological disasters.

Clever designers, however, eagerly replace the intuitive whistle sound of a tea kettle with a "high-tech" LCD temperature display and yet another brainless beep!

I could hardly imagine a lovelier assignment than to design the new sound for a product such as an electric car, to satisfy human safety and emotional requirements.

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In a shrinking acoustic world it will be the designer's task to craft sound for communication purposes. Non-verbal sounds are especially well suited to improve the product-to-human communication and to reduce the amount of paper otherwise needed to convey instructions in the many languages spoken around the globe.

04 The Acoustic Receiver of a product

Humans are capable of producing a large variety of sounds that, in principle, are available to the product they use. The problem is, our products won't listen.

Words and language are the highest form of acoustic communication available to humankind, but language communication is slow. It requires computation, it is context and culture sensitive, and it doesn't work when you don't know the language.

But people hum, whistle, clap their hands, cough, sneeze, yawn, snore, and more. Even the growl of an empty stomach contains information that a product could use to trigger an appropriate reaction.

Examples of acoustic receivers in products exist. Remember: a microphone itself is only part of the system. It always requires a certain level of intelligence, before the product could really understand the meaning of sound. Computer voice recognition is an example of an intelligent system responding to human voice.

Less spectacular but hinting at future possibilities is a device called the "Uterine Activity Monitor", which listens to the body sounds of a pregnant woman. It ignores all but those sound patterns indicating a premature contraction unnoticeable to the woman herself. Used in cases of high-risk pregnancies, such a device is able to discover irregularities that could lead to loss of life if undetected.

More sophisticated non-verbal sound recognition could literally make our products read our minds.

05 The Tactile Transmitter of a product

Tactile information is transmitted through physical contact. For humans, this may happen by stretching out a hand, a finger, one's arm.
It may happen by running into somebody, by patting someone's arm, by hugging, and by kissing. As humans we are well equipped to perceive such tactile information, yet our products do not normally transmit active tactile information for communication purposes.

But we touch a product, we talk about "tactile feedback", about how metal feels cold and plastic feels warm to the touch? In these examples products do not really, actively, transmit information to the user. They are merely being scanned, and whatever we receive is of passive nature. A product's reaction to our touching is that of a dead body.

Instead, we could design a switch to not only receive human input, but to transmit tactile information about the product's status, or about the effect the application of force has on the product.

The principle of force-feedback in an automotive power steering system is an excellent illustration of what is possible in this respect. Other types of intelligent feedback could include the generation of vibration, and selective heat, as a means to transmit information on the conscious or subconscious level.

The designer's concept of tactile information needs to be extended beyond that of mere perception of surface pressure applied to our finger tips. Tactile information is stomach pain, the sensation of gravity, our perception of acceleration and deceleration. If we were to be exact—even human hearing is a form of tactile sensation.

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06 The Tactile Receiver of a product

This channel is well used and believed to be understood. Many a product has buttons, keys, switches, slide controls, lids that flip, doors, or locking mechanisms. In all these cases the product responds with a pre-determined response programmed into its hardware and/or software. A response may consist of the appearance of type on a computer screen, a musical sound, the lamp lighting up, the vending machine producing a can.

The typical response is crude, however. As humans we know of many different ways of being touched. A touch can provoke friendly feelings or fear, it tells us about our counterpart's intentions or mood. A collision between humans on a sidewalk can be accidental or an act of aggression preceding a fight or robbery attempt.

Human-designed products do not normally differentiate between "friendly" or "unfriendly" key pressures. Some products, e.g. musical instruments, may respond differently to forces with which a key is pressed or a string is struck, but they all fail to interpret information about the user's mood, intentions, or state of mind which are readily available but hidden in subtle changes of body temperature, skin moisture, or finger pressure.

The tactile receiver channel is normally passive. Most products wait to be touched or otherwise brought in contact with the user or his body parts, e.g. a light switch.

Active, or scanning, tactile reception occurs when a product moves itself (or a part of itself) toward the human user.
Real-world examples of tactile scanning are elevator or garage doors that reverse their direction upon accidental contact with a (human) obstacle, or the ophthalmic instrument which blows a whiff of air at the human eye reading from its "echo" the internal eye pressure.

A novel application might be the development of an “intelligent” hospital bed monitoring compression forces in several locations and occasionally adjusting or shifting pressure in order to avoid bed sores.

Tactile sensors in electronic products are too often and unnecessarily limited to buttons and switches. Rubbing his oil lamp, Aladdin had at his finger tips a much more sophisticated tactile input device.

07 The Olfactory Transmitter of a product

In nature, odors serve many purposes. Odors transmit information about the presence of a fruit or its edibility, about a sexual partner’s proximity or state of readiness. Odors in the world of human-made products attract, entice, repel, or deceive.

We rarely use odors to inform, educate, alarm or guide.

To an even lesser degree we are aware of the possibility of using scents in order to trigger pleasant memories that in turn would put a user into a desirable state of mind. Yes, it is being done, e.g. in a supermarket where the scent of freshly fried chicken is purposely blown all across the parking and entrance areas.

Smell in some products is unintentional. A car smells when oily residues contact hot areas on the engine or exhaust system. These oils burn, and their fumes inform about the presence of heat or oil leaks.

Some time ago, my four-year old daughter had paid a visit to my office. I didn’t contemplate her unusual quietness during her visit until two days later when I noticed a strange smell in my office. A smell of hot plastic.

The reason for her quietness during her visit was that she had been playing with an oscilloscope on a desk behind me. I had not noticed that she had left the oscilloscope in the “on” position, because she had also dimmed the display, and there were no status lights on the control panel. Now there was this hot plastic

smell. It took me a while before I was able to identify the oscilloscope as the source of the smell which by this time was getting *real* warm.

The smell in this case performed an alert function of the product that was not an intentional part of the design but an accidental consequence of some of the decisions the engineers had made in the development of the product.

Olfactory transmission is active. Products and humans give off scent molecules that travel in, or attach to, the surrounding medium (e.g. air, water, clothing). *Passive* olfactory transmission analogous to sound or light reflection or tactile scanning is—at this time—hard to imagine.

As technologies evolve, gaskets won't leak anymore and products will shut down automatically before they overheat. Our olfactory world is losing its richness as fewer and fewer things smell.

Designers should learn to bring back much of this richness by making themselves aware of the message value of odors.

Those among you who have read *Perfume* by Patrick Süskind know what I mean.

08 The Olfactory Receiver of a product

Scent molecules travel via the air or other media. Their range is, theoretically, unlimited and depends only on the sensitivity of the olfactory receptor.

Few products today have olfactory receptors. Smoke detectors do, gas detectors do, and "Breathalyzers" detect alcohol vapors in human breath. Much more is technologically possible. Doctors and nurses can smell a disease on the patient's breath, e.g. the smell of acetone hinting at the presence of diabetes.

Not only would diagnostic medical equipment benefit from a more extensive use of our olfactory channels, but even consumer products might.

One has to distinguish, however, between products whose only purpose it is to detect and analyze smell and those with other purposes that transmit odors to enhance communication.

We know that dogs can smell a person's unique olfactory identity. This means there is a singular combination of odors present in the vicinity of each human being. Olfactory fingerprinting could be developed to help a product identify its user. Passwords and user codes would no longer be needed. Products would smell their operators and adjust their user interfaces accordingly.

09 The Gustatory Transmitter of a product

Smell and taste are closely related. Both are of chemical nature and, under today's circumstances, more difficult to analyze, process, store, reproduce or transmit than their visual, acoustic and tactile equivalents. The olfactory and gustatory qualities of a product are essential to a human being's understanding of the material world, as every baby can attest. Babies need to see, listen to, feel, smell and taste everything in their environment in order to establish a mental model of the objects surrounding them.

Products that don't smell or taste deprive people of a learning experience. Their mental model of the product is incomplete. No future smell or taste will ever trigger memories of the product or of the circumstances present during its earlier utilization.

We learn to compensate for olfactory (and gustatory) deprivation by relying more and more on our visual, tactile, or acoustic senses. This, however, represents an artificial and undesirable reduction of information humans have learned to expect from their natural environment.

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Of course, gustatory information is of greater importance in products that are intended for human ingestion. It is the final safeguard in a series of tests we perform on food before we swallow it.

However, we do lick stamps whose taste is enhanced with mint flavors. We do chew on pencils and pens, and if this were to be considered unhealthy, an unpleasant taste could be employed to tell us not to. Some products could be protected from a small child's gustatory exploration or interaction of any kind, if they were made to taste real bad.

10 The Gustatory Receiver of a product

Do products have taste buds? I can't think of any, but what if they did? Certainly, all products that are handled or touched by humans would have the *opportunity* to taste their users. Would our communication with products improve? Become easier? More convenient? What about our learning experience?

The human user does rarely become a food item to our products, so is there any use for this channel?

If we think of taste in a more abstract way, we find that there is information available on the skin of a human user that could be sensed and processed by the product.

Sweat produced in the sweat glands embedded in our skin does change its chemical composition which itself changes in response to factors such as stress, exercise, health. Diagnostic medical products could taste these digestive byproducts and use the data to derive information about our health status. Clothing or equipment worn on our bodies could be developed to monitor our health.

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As the time for my presentation is over, I will skip the discussion of other important aspects of product communication, such as the changing levels of user expertise, and the topic of dynamic interface. I need to forgo a more detailed explanation of the active versus passive transmitter and receiver channels, and I will omit the subject of voluntary versus involuntary communication.

The topic of design *beyond cosmetics* is so huge that one person can merely scratch the surface. My own work currently revolves around the tactile user interface. And my long-term goal is to find a home for a Design Research Institute where the many issues resulting from this work could be studied and developed into real-world applications.

I will end my presentation with a brief look at the communication matrix I developed as a diagnostic and synthetic design tool that I use to detect how well a product communicates. The communication matrix as a human interface design tool is being developed and tested with a variety of products. Its main benefit today is that of providing a structured approach to human interface design.

VCR Remote Control			Contact	Analysis	Use	Post-use
Visual	Transmitter	active			Confirm functions (via TV)	
		passive	Locate device	Identify device	Locate controls	
	Receiver	active				
		passive				
Acoustic	Transmitter	active			Acoustic feedback from TV (e.g. volume increases)	
		passive				
	Receiver	active				
		passive				
Tactile	Transmitter	active				
		passive		Form of device	Position of key	
	Receiver	active				
		passive			Device receives instruction (key input)	
Olfactory	Transmitter	active				
		passive				
	Receiver	active				
		passive				
Gustatory	Transmitter	active				
		passive				
	Receiver	active				
		passive				

Example 1 **Remote control, e.g. of a VCR**

10%

This example hints at a lack of redundancy of information channels. This product uses only 8 out of 80 communication opportunities available. That is 9%.

Empty fields represent a missed opportunity to make this product work better and more intuitively for people.

Automobile			Contact	Analysis	Use	Post-use
Visual	Transmitter	active	Lights; turn signal	Kind of signal	Control lights, instruments	Parking lights Alarm signal
		passive	Locate by visual contact	Identify vehicle	Identify controls	Position of key lock levers
	Receiver	active				
		passive				
Acoustic	Transmitter	active	Noise produced by motor, wind and tires; horn signal	Sound quality and dynamics	Acoustic feedback (e.g. motor sound, controls)	Fan running, crackling sounds of engine cooling off
		passive				
	Receiver	active				
		passive				
Tactile	Transmitter	active			Vibration, heat, acceleration	Heat radiation after motor shut off
		passive			Position, form, material of switches, controls, and pedals	
	Receiver	active				
		passive			Switch operation, pedal pressure	Removal of ignition key
Olfactory	Transmitter	active	Exhaust fumes	Exhaust fumes	Material-specific smells; exhaust f	Smell of gasoline or burnt residues
		passive				
	Receiver	active				
		passive				
Gustatory	Transmitter	active				
		passive				
	Receiver	active				
		passive				

Example 2 **Automobile**

26%

This example hints at a much higher use of communication opportunities: 21 out of 80. That is 26%! Yet many of the information receivers remain unused.

Empty fields represent a missed opportunity to make this product work better and more intuitively for people.

Is there a connection between the communication opportunities used in a product and the emotional attachment between a product and its user?

More research is needed for us to better understand the roles that sound, touch, smell and taste play in product design. Much more work is needed before we will begin to understand the nature of aesthetics as a holistic experience of vision, sound, touch, smell, and taste, cooperating in a harmonious way to convey a complex message.

Our most immediate need is to comprehend the communication character of every single decision we make as designers about the visual, tactile, acoustic, olfactory, and gustatory communication qualities of our products.

Next, we need to develop acoustic, tactile, olfactory, and gustatory languages analogous to product semantics, and their harmonious interaction.

Successful design is intelligent design. The Japanese Miryokuteki hinshitsu (Real Good Quality) is pointing the way. Tokimeki, or heartbeat design, is another step in the same. Intelligent and emotional design is our chance to stay in business. Let's not miss it.

[More automotive research conducted since 1991 led to the exploitation of many additional communication opportunities in cars. Rear and front radar sensors, active force-feedback, seat occupation sensors, baby crib sensors, airbags, driver alertness systems etc. all illustrate the possibilities of product/human communication that are unfortunately still being ignored in so many other products. *Added 2006 by the author*]

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