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FACULDADE DE ENGENHARIA

The Exaltation of a Sense

Haptic Art

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Thesis advised by Prof. Dr. Miguel Velhote Correia. Faculdade de Engenharia, Universidade do Porto.

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Resumo

O "futuro é háptico" é o que temos vindo a ouvir de tecnólogos e teóricos visionários. Porém, o háptico não é um atributo tecnológico, mas sim uma função biológica. Háptico é um termo quase desconhecido fora dos discursos de investigação e dos laboratórios de engenharia. Quando se pergunta, a maioria das pessoas ignora a relação entre háptico e tato. O que geralmente se desconhece é que o háptico refere-se ao nosso complexo sentido do tato, formado pelos sistemas sensoriais cutâneo, proprioceptivo, cinestésico e vestibular.

Por isso, o âmbito de ação do háptico é muito mais abrangente, do que aquilo que somos habitualmente levados a perceber.

Esta investigação propõe redescobrir o háptico através do cruzamento entre a arte e o design mediados por tecnologias emergentes, e explorar as possibilidades ao nosso alcance para criar e experienciar o háptico, substanciado por uma compreensão mais profunda da sua essência.

Nesta investigação introduz-se o termo *Istantica* para caracterizar uma experiência sentida pelo tato, etimologicamente derivado do Grego *aisthanthike*, que significa "sentida." E elabora-se a *Teoria da Experiência Istantica* que propõe formalizar a análise da qualidade das experiências sentidas, utilizando métodos descritivos fenomenológicos avaliativos da psicologia adaptados para experiências istanticas.

Palavras-chave: sentido do tato, percepção sensorial, sistemas tangíveis, superfícies reativas, materiais que alteram a forma, dispositivos orgânicos para utilizador, eventos palpáveis, arte háptica, experiências istanticas.

Abstract

The "future is haptic" is what we have been hearing from technologists and visionary theorists. Yet, haptic is not a technological feature, but a biological function. Haptic is almost an unknown term outside the research discourses and engineering labs. When asked, the majority of people ignore the relation between haptic and touch. What is unknown is that haptic refers to our multifarious sense of touch, formed by the cutaneous, proprioceptive, kinesthetic, and vestibular sensory systems. Therefore, the scope of haptic is far more comprehensive than what we are generally taken to perceive. Proposing to rediscover the haptic sense through crossroads of art and design mediated by emergent technologies, this research explores the possibilities within our reach to create and experience the haptic, substantiated by a deeper understanding of its essence.

Introducing the term *Aisthantic* to characterize a felt experience through touch, etymologically derived from the Greek *aisthanthike*, meaning 'felt.' Formulating the inductive *Theory of Aisthantic Experience* proposing to formalize the analysis of quality of felt experiences. Using assessable phenomenological descriptive methods of psychology adapted to aisthantic experiences.

Keywords: sense of touch, sensorial perception, tangible systems, reactive surfaces, shape-shifting materials, organic user interfaces, palpable events, haptic art, aisthantic experiences.

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The Institute for Ethics and Emerging Technologies (IEET) for the Rights of Non-Human Persons *
http://ieet.org/index.php/IEET/RNHP

Non-human Rights Project: Justice for non-human animals, founded in 1995.
"The mission of the Non-human Rights Project is, through education and litigation, to change the legal status of appropriate non-human animals from mere 'things,' which lack the capacity to possess any legal right, to 'persons,' who possess such fundamental rights as bodily integrity, bodily liberty, and those other civil rights to which evolving standards of morality, scientific discovery, and human experience should entitle them."
http://www.nonhumanrights.org

to Rudolfo

* my dearest four-legged non-human person

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Publications

with Referee:

"Haptic in Art: Behavioral Materials Prompt Tangibility in Contemporary Art" in proceedings of Contemp Art'14 Contemporary Arts and Art Theory Conference on New Approaches, New Techniques, New Materials in Contemporary Arts. Hosted by MSFAU (Mimar Sinan Fine Arts University), Istanbul, Turkey, 24–26 April 2014. Organized by DAKAM (Eastern Mediterranean Academic Research Center) ISBN 9786055120726. [Paragraphs of this paper appear in the summary of chapter 6 on Materials]

"Tactile-Kinesthetic Interactions: Interdisciplinary Technological Materials Challenge Design Innovation" in proceedings of IASDR 2013 International Congress of International Association of Societies of Design Research on Consilience and Innovation in Design. Hosted by Japanese Society for the Science of Design, Japan Society of Kansei Engineering, and Science Council of Japan, at Shibaura Institute of Technology, Tokyo, Japan, 26–30 August 2013. http://design-cu.jp/iasdr2013/papers/1261-1b.pdf [Paragraphs of this paper appear in chapter 6 on Materials]

"Somatic Mediation: Contemporary Art is Becoming Haptic" in proceedings of Contemp Art'13 Contemporary Arts and Art Theory Conference on Urban Life and Contemporary Arts. Hosted by MSFAU (Mimar Sinan Fine Arts University), Istanbul, Turkey, 10–12 April 2013. Organized by DAKAM (Eastern Mediterranean Academic Research Center) and MSFAU. ISBN 9786054514052.

"Rediscovering the Haptic Sense through Crossroads of Art and Design Research", in Haptics: Perception, Devices, Mobility, and Communication. Poika Isokoski, Jukka Springare (Eds.): International Conference, EuroHaptics 2012, Tampere, Finland, June 13–15. Lecture Notes in Computer Science, 7283, pp.13–18, Heidelberg; New York: Springer, 2012. ISBN 9783642314032. http://dx.doi.org/10.1007/978-3-642-31404-9_3

"Art Evolves Through Technology: Haptic After the Hegemony of Visual Art", in Arts and Technology. Anthony L. Brooks (Ed.): Second International Conference, ArtsIT 2011, Esbjerg, Denmark, December 7–8. Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering. LNICST 101, pp.171–176, Heidelberg; New York: Springer, 2012. ISBN 9783642333286. http://dx.doi.org/10.1007/978-3-642-33329-3_21
[A paragraph of this paper appears in the summary of chapter 7 on Technologies]

Participations

Meeting:

Co-organizing within the Research Group in Art and Intermedia (NAi), from the Research Institute in Art, Design and Society (i2ADS), at Faculdade de Belas Artes, Universidade do Porto (FBAUP) the 1EIAI 1st Meeting of Researchers in Art and Intermedia, June 7, 2013, at FBAUP. Creating the graphic identity and the communication materials for the meeting.

Course:

Human-Computer Interaction (HCI) in the areas of interaction design, social interaction, emotional interaction, interfacing, and empirical methods, comprising reading assignments, class presentations, and a final exam. Led by Luis Francisco-Revilla at Digital Media Summer Institute of UT Austin–Portugal Digital Media Program. Carried out at FEUP, July 2–20, 2012.

Workshops:

Psychological Impact of Colors in Design, led by Zoran Markovic, at Shibaura Institute of Technology, Tokyo, Japan, 26–30 August 2013. A theoretical and practical exercise to explore the psychological effects of color.

Haptic InterFace, led by Patricia Flanagan, held in Wearables Lab, at the Academy of Visual Arts, Hong Kong Baptist University, November 10–20, 2012. Creating a tactile reactive wearable prototype. http://hapticinterface.hkbu.edu.hk/?speakers=sandra-coelho

TECHTILE toolkit: Haptic design environment for sharing haptic experience, led by Masashi Nakatani, Kouta Minamizawa, and Yasuaki Kakehi of Keio University Graduate School of Media Design, and Soichiro Mihara of Yamaguchi Center for Arts and Media (YCAM InterLab), June 12, 2012, at Eurohaptics 2012, June 12–15, 2012, held in Tampere, Finland. Exploring the TECHTILE toolkit potential possibilities. http://www.techtile.org/activities/techtile-toolkit-haptic-workshop

Electronics as material: littleBits, led by Ayah Bdeir and Ted Ullrich, held at the fifth international conference on Tangible, Embedded and Embodied Interaction (TEI) January 23, 2011, in Funchal,

Madeira, Portugal. Creating a prototype of an interactive gadget using littleBits, which is an opensource kit of pre-assembled electronics that snap together with tiny magnets, crafted with traditional materials.

Presentations:

"What if the course of the history of digital media was more focused on fingers and less in figures?" At the 1st Meeting of Researchers in Art and Intermedia (1EIAI), June 7, 2013, Fine Arts Faculty, University of Porto (FBAUP), Porto, Portugal.

"Haptic Art: Addressing Touch Creatively." Haptic InterFace Public Lecture given by invited 20 Artists and Designers, led by Prof. Dr. Patricia Flanagan. November 14, 2012, Koo Ming Kwon Exhibition Gallery, Communication And Visual Arts Building, Hong Kong Baptist University, Kowloon Tong, Hong Kong.

"Haptic Art: Conducting a Research on the Multifunctional Sense of Touch." Presentation in a Research Seminar at FEUP, November 10, 2011, Engineering Faculty, University of Porto, Portugal.

"Haptic Art: The Exaltation of a Sense." Presentation in Digital Media Doctoral Symposium of FuturePlaces Festival at FBAUP, October 21, 2011, Fine Arts Faculty, University of Porto, Portugal.

Exhibitions:

"Ephemeral Appearance: Touch to read me" is an artist book that combines poetry, craft, and technology in a pocket format, hand-painted with thermochromic ink that reveals the text after being heated by the reader's fingers. Changing from an overall black to colorless to let read the black printed text beneath at human's temperature. Reached the transition temperature of 27°C the black disappears reversibly upon tactile input or ambient temperature. The concept is about something that is hidden and it only appears after being touched or influenced by an external cause. The text describes the ambiguity of a thoughtful soul that sometimes is, but at times is not, available to others. An invitation by artist, curator, and professor, Dr. Patricia Flanagan to exhibit the book, May 27–June 6, 2013, in Haptic InterFace pop-up exhibition, at Vivid Sydney 2013, Australia.

The hapticwear "Butterflies by you" is a proposal for a sculptural kinetic garment that reacts to tactile inputs. It is a project on transformational wearables through tactile responsive movements, merging organic fibers, smart materials, and electronics, for a technologically enhanced relational body. Exploring creative possibilities through materials and electronics for a semi-living second skin interface that tangibly communicates through touch. A concept developed by Sandra Coelho (PT), Meiyi Cheung (HK), and Karyn Henson (NZ). Presented at Haptic InterFace Exhibition, November 21–December 16, 2012, Koo Ming Kown Exhibition Gallery, Hong Kong.

Blog:

Regularly updating a blog reporting and documenting the research, http://moniablog.wordpress.com

Survey:

To verify the degree of familiarity with the terminology of haptic and the user experience of interaction with haptic interfaces, it was conducted a structured questionnaire and collected the answers that resulted in a sample for quantitative data analysis. It also served to assess the relevance of the topic, resulting in the necessity to pursue it due to its highly topical interest.
During a whole day meeting at FBAUP, 28 Portuguese graduated artists and designers (15 women and 13 men) with the average age between 25 and 34 agreed to answer the questions hand delivered in printed format. [The questionnaire is attached at the end of the thesis, in Appendices on page 201]

1. Are you familiar with the term haptic?
   — 18 respondents answered NO. This sample comprised of people with similar backgrounds and regular use of technology were not aware of the term haptic, which confirmed the initial suspicions that have supported this survey.
   This outcome could eventually be extrapolated to a larger population, and informally, family, friends, and acquaintances with different backgrounds and variable experience with technology were asked about the word haptic. The answers were in much greater number NO.

2. Do you know what haptic means?
   — Aligned with the previous question, 18 respondents answered NO. Consequently, people who had answered unfamiliarity with the word haptic, that had never heard about this term, could not know its meaning.

3. Do you know that haptic refers to your sense of touch?
   — Again, a majority of 18 respondents answered NO. The respondents in the sample could not relate haptic with touch. Similarly, other people interpellated with this question got surprised with the association of haptic with touch.

From the previous answers, one can objectively infer that most of the people surveyed (64.3%) did not know what haptic was, had never heard the word, nor could correlate haptic with touch. Additionally, people questioned outside the survey had most of them similar reactions.

The following questions are related to tactile sensitivity when using technologies that require dexterity to manipulate them.

4. Did you know the term haptic before the advent of consumer haptic devices?
   — Here, a big majority of 26 answered NO. From the 18 respondents of the previous questions that currently still do not know about haptic, plus 8 of the total of 28 respondents answered not being aware of the terminology of haptic before the introduction of haptic devices in the consumer market. This may mean that the recent haptic devices available to the consumer have made known the term haptic.

5. Are you familiar with tactile screens?
   — 26 respondents in the survey answered YES. The tactile screens are becoming wide known for

the majority of people, most probably because all recent technological devices have tactile screens. Other people who were asked about tactile screens even if they did not use technologies with much regularity knew about tactile screens.

6. Are you familiar with tactile feedback screens?
   — To this question, a large number of 18 respondents answered YES. Although, most of the consumer tactile devices do not have perceptible tactile feedback in their screens. Not sure if they were certain of what tactile feedback screens really mean.
   Other people to whom it was asked about their familiarity with tactile feedback screens, only the ones with regular experience with technological devices possibly knew about their existence.

7. Do you usually use tactile feedback screens?
   — A majority of 20 respondents answered NO. Probably because most of the brands available in the market that provide technologies with tactile screens do not supply the feedback feature. But not sure if the reason was the lack of accessibility.
   Also, most of the other people asked outside this survey about their use of tactile feedback screens answered NO. In here, not sure if the explanation would be receptiveness.

8. Do you find the vibrating tactile screens a satisfying response to your sense of touch?
   — When questioned about being satisfied, 16 respondents answered NO, and 2 answered Indifferent. While 10 respondents answered YES. These results may possibly express that the current state of technology development available in the consumer market may not fully satisfy its potential users. People have yet the option to turn off the vibrating feature, and wait for advancements in the electronic components that would provide a more gratifying user interaction with digital tactile feedback screens.

9. How much is important for you to have a tactile feedback screen?
   — On a scale of 1–not important to 5–very important, 10 respondents undoubtedly answered not important to have a screen that responds with feedback to their tactile inputs, while none answered to be very important. 8 respondents answered to be mildly important, and 6 answered moderately important, and the remaining 4 respondents answered fairly important.
   This outcome may signify that users are not very eager to adopt the tactile feedback screens, and they do not keenly expect other developments in haptic feedback technologies.

10. Would you prefer a different tactile feedback than the vibrating?
    — On a scale of 1–strongly disagree to 5–strongly agree, 20 respondents answered to be neutral. This group of people either did not express any opinion or feel indifferent to the vibrating response. While 8 answered that agree to prefer screens with a different tactile feedback than the vibrating, and no one answered that disagrees. This outcome says that the current haptic feedback consumer devices with tiny vibrating motors under the screens do not satisfy near a third of these respondents and left the others indifferent. The reason may be because it feels strange to sense a vibrating mechanical feedback that pretends to simulate the behavior of a physical button. After a regular use, this persistent event numbs the sensory receptors in our fingertips.

11. Would you prefer the device to have another type of responses?

— It was suggested 6 possibilities for different types of responses other than the vibrating, each with a scale of 1–strongly disagree to 5–strongly agree:

Movement — 14 respondents answered to be neutral, which means that this group of people did not engage in this option, while 6 answered that strongly agree, and no one strongly disagreed. Other 4 respondents agreed, and the remaining 4 disagree to have movement simulating the behavior of physical buttons and other flat digital elements on the screen as an alternative to the vibrating tactile feedback.

Texture — 16 respondents answered to be neutral, meaning that these people did not find particular interest in this option. Only 2 strongly agreed, while 6 answered that agree, other 4 respondents disagreed, and no one strongly disagreed to have texture stimulating their tactile sense as a variation to the vibrating feedback.

Temperature — Again, 14 respondents answered to be neutral, which means that these people do not find that variations in temperature would excite their tactile sensations. And actually, 6 respondents disagree, and other 2 strongly disagree that temperature would enhance their tactility while 4 respondents agreed, and only 2 strongly agreed to have temperature as an option.

Light — For this option, 12 respondents answered to agree that light would be their possible option while 8 respondents answered to strongly agree that variations in the light of the digital elements on the screen would be their preferable alternative. And 8 respondents answered to be neutral, meaning that changing the light ambiance would not affect much their phenomenological tactile experience. Whereas, no one disagreed or strongly disagreed with this option.

Color — This option received the neutral answer from 14 respondents, meaning that color would not be of their preference. While for 8 respondents that agreed, this option could be the one for them. But for 6 respondents that strongly agreed, variations in color would definitely be the option that could thrill their tactile intentness. And no one disagreed or strongly disagreed about having the color option.

Sound — The last option offer variations in sound, for which 12 respondents answered that agree to have it. While for 8 respondents that answered to strongly agree, this option would without a doubt highly improve their overall experience with the tactile feedback screen. And for another 8 respondents that answered to be neutral, this option would not enrich much their experience of usability with tactile feedback screens. At last, no one disagreed or strongly disagreed with the sound option.

The options that have received more agreement among the respondents were variations in light (71.5%) and sound (71.5%). But, it could be that the respondents got emotionally attached to what they already know or they are routinely used to interact with. However, as tactile signals intensify audio and visual signals become less significant. (New Oxford American Dictionary)

In their preferences, none of the options light and sound is about sensing through touch a perceptible physical reaction on the surface of the tactile feedback screen, as a response from the activation of the digital elements on the device.

Moreover, the majority of respondents (64.2%) do not believe that a tactile feedback in a vibrating screen as a response to their sensory inputs will greatly enhance their sensory experience, and according to the results (85.7%) nor they desire to have a device with a vibrating feedback feature.

The questions that follow are specifically about the physical characteristics of the material of the tactile feedback screen, challenging the respondents imagination for a prospective material that could alter its physical nature when touched.

12. Would you rather prefer to have a surface screen that changes its shape?
    — On a scale of 1–strongly disagree to 5–strongly agree, 16 respondents in the survey answered to be neutral or indifferent to the desire of having a surface screen that would change its shape as a tactile reaction to the user touch inputs. While 6 answered that would agree to have a surface screen that changes its physical state when touched rather than having vibrators underneath the screen. When defied to envision a shape-shifting material for the screen, 2 respondents answered that definitely would want it. Whereas 4 answered that disagree to interact with a reactive material, and no one strongly disagreed.

13. Would you prefer a different material for the screen than the glass or plastic?
    — On a scale of 1–strongly disagree to 5–strongly agree, 14 respondents answered to be neutral or not particularly concerned about the material of the screen. But 8 respondents answered to agree with a different material than the glass or plastic. And 4 respondents answered strongly agreeing with an alternative material that would greatly enrich their overall tactile experiences while 2 respondents disagreed, and no one strongly disagreed. This question may be challenging to some people that do not know other possible material for the screen, and is not able of envisioning other material than glass or plastic.

14. Would you prefer a soft and warm material for the screen?
    — On a scale of 1–strongly disagree to 5–strongly agree, 8 respondents answered to be neutral or not sensitive to the material properties. While other 8 respondents answered to agree in wanting to experience a soft and warm material in the screen. But 6 respondents answered, without doubt, to strongly agree. While 4 respondents answered to disagree, and 2 strongly disagreed. A soft and warm material may give the impression of amenity, comfort, and consolation.

15. Or do you prefer a slick and cold material for the screen?
    — On a scale of 1–strongly disagree to 5–strongly agree, 14 or half of the respondents answered to be neutral or not feeling affected by the material properties of the screen. While 6 respondents answered to disagree and unwilling to have a slick and cold material. But 4 respondents answered to strongly disagree to interact with a slick and cold material in the screen. Whereas 2 respondents answered to agree, and other 2 strongly agreed. A slick and cold material may give the impression of discomfort, distress, and stiffness.

The concluding remarks that one may make from this questionnaire (participated by 28 respondents with similar backgrounds and regular use of technology), is that the percentage of people that have answered about the importance of having a tactile responsive screen is 14.3% of favorable answers. Whereas, the respondents answered about their satisfaction with a vibrating response as a reaction to their sensory inputs with 64.2% of unfavorable answers.
42.9% of the respondents would prefer an alternative to the material in the screen different than the glass or plastic. But when requested to visualize a surface screen that could change its shape, 71.4%

were not supportive of the idea of a material that could react to their tactile inputs when activating the digital elements on the screen, or it could be that the respondents were not capable of envisioning the possibility of a viable shape-shifting material.

To avoid the resulting doubts, a few questions would have benefited from descriptive responses for a phenomenological qualitative data analysis.

Preface

We desire to enhance our experiences when dealing with the most disparate situations and events, from the everyday simplest actions to interactions that challenge our knowledge. Those improvements are related to how we use our senses when experiencing those moments.

In an era of transition from the sight hegemony of the visual culture to another one more tactile, people are evolutionarily interacting with electronic devices by touching on screens, trackpads, and other surfaces. Consumer technologies are widely becoming multi-touch devices or requiring gestural movements of parts or the entire body. The sense of touch is finally becoming as significant as the senses of sight and hearing for the design and development of human-computer interfaces to enrich the user experiences.
As it has been promised by promoters, the consumer technologies will be haptic. People will be able to feel the virtual objects and environments, and products will be more gratifying to touch. The future will be changeable at our moods, with live surfaces that sense, react, and change their physical state as a response to our haptic inputs.

To research in haptics is to study the human perception and manipulation through the multifunctional sense of touch. But still, we know very little about the haptic dominance and how much we depend on it.
Being the sense of touch essential for human existence, it should always be considered fundamental for the development of everyday gadgets, tools and appliances, and other interactions mediated by technology.
Artists and designers may create concepts and provide products and events

Multi-touch:
a functionality that allows touch gestures of pinching and twisting for zooming and rotating elements directly on a screen, or from a trackpad to register multiple points of contact made on the surface simultaneously.

Haptic:
of, or relating to the sense of touch, in particular relating to the perception and manipulation of objects, experiencing their physical properties and the forces that act on them, (*e.g.* texture, weight, gravity, momentum, friction, resistance) using the senses of touch, proprioception, and kinesthesia.

for comprehensible interpretations about conscious and unconscious somatic reactions.
While unfolding the idiosyncrasies of touch, this research intends to clarify a few established assertions, following creative demonstrations, aimed at general people awareness and individual analytical assessment.

Somatic:
of, relating to, or affecting the body as distinguished from the mind.

Stimulus:
is anything that can trigger a physical or behavioral reaction.

General Questions

The majority of us do not think of the sense of touch as a primary sense. Possibly, it is because we do not know this sense well enough.
Do we, in our common daily lives, completely ignore its multiple fundamental capabilities? Why we usually think of touch as a minor sense?

What if we only had the sense of touch, as some animals do? What if the sense of touch did not exist? What would we be without it? — How would we stand or move, react or behave, relate or interact with ourselves, with others, or with our everyday objects, surfaces, places and spaces?
Can we learn more about us, as sensuous beings, through our touch reactions?

What if the surfaces would dynamically adapt to us instead? How to design having haptic in mind? — How does it influence the things we create or design, do and use? How can touch inform or redefine our design, perception, and experience of interaction? How do we express meanings through touch? How does the sense of touch shape our experiences? How does touch shape us?

Specific Questions

Knowing that the response to an event is determined by subjective sensitivity, state of awareness, and previous experiences, the following research questions are intended to infer the importance of the level of expectancy:

How does the tactile interaction intensify the subjective experience?

How does the change of a tactile stimulus enhance the sensation?

Hypothesis

Integrating the sense of touch in digital creations, change the way we interact, our perception, and consequently our behavior.

Methodology

Research process:
is following a methodology and opting for a method epistemologically appropriate to the research intents, adapting the method if necessary.

Ontology:
the branch of metaphysics dealing with the nature of being.

Epistemology:
the theory of knowledge, especially with regard to its methods, validity, and scope. Epistemology is the investigation of what distinguishes justified belief from opinion.

Phenomenology:
is a philosophical method developed by German philosopher Edmund Husserl (1859–1938), for a description of phenomena as consciously experienced, without theories about their causal explanations or their objective reality. It refers to the study of structures of consciousness experienced subjectively. Phenomenology of an experience is how someone describes a sensation, feeling, perception, meaning. It concentrates in understanding an event based on qualitative information recording qualities that are descriptive, subjective and difficult to measure.

To research in art is to reflect upon the reflected. It is to inquire the processes, productions and outcomes, to discuss the artist disposition, social, intellectual and historical context, and intents through the creative processes. Ultimately, to research in art is to debate the ontological activity of art in human culture. Reflective art poses interrelational existentialist questions in symbolic referential representations. Differing the inherent philosophical thought from the scientific experimentation, the German philosopher Martin Heidegger (1889–1976):

> "pointed out that philosophical reflection informed by a genuinely questioning attitude is not science, nor should it be." (in Elo 2012)

Art is not science, and science is not art. Art does not explain nor gives answers. Art interpellates, challenges, teases, questions, summons, conspires, provokes. Art is the particular understanding that each one takes from it. The apperception of art is subjective and singular. If art were to seek for answers it would potentially get as many as the number of people experiencing it.
Science is instrumental to art. The art making is a systematic process drawn from the referential outer world and the perceptual inner world.

The epistemology of research in art does not rely on statistical quantities. Unless it is in its concept an infographic approach, art does not quantify. Its aim is not to produce assessable measurements in quantifiable results. Art is not interested in checking how many people perceived the same way, but rather in inquiring qualitatively the perceptions and meanings of its particular contents and messages. Art does not collect numerical data if it was not an integral part of its creative concept.
Therefore, a valuable assessment for participatory art will be of a descriptive phenomenological interpretation of qualitative data analysis.

The experiential assessment made for this research methodology is based on the qualitative method of conducting semi-structured interviews and carrying out direct observations in a natural setting. Inquiring a purposive small group of participants to describe their sensory and somatic reactions for interpretative analysis and reflective reasoning. The interviews were done immediately after each individual participative experience as a way to evaluate the sensitivity and awareness to unexpected tactile sensations. Asking the participants to answer to questions on feelings, perceptions, meanings, and by carefully observing their responsive behavior. Phenomenological responses are prompted by subjective perception, individual reasoning, and behavioral meanings. Throughout the process answering the research questions and validating the hypothesis, looking for potential particularities and the possible experiential patterns of phenomenological intersubjectivity.

Objectives

To analyze the quality of physical inputs that may give a sense of compelling immersion in the experience, when the user is able to touch, feel and manipulate objects and surfaces in addition to seeing and hearing them.

To contribute to the general understanding of feeling and perceiving in digital technologies through art, combining visual with haptic (tactile, proprioceptive, and kinesthetic) experiences.

To interpret how tactile interactions change behavior, and how behavior changes interactions.

To explore physical interactions between users and digital systems by means of smart materials and emergent sensitive technologies intended to give the user a physical sensing experience with artificial surfaces.

To conceptualize and develop examples of haptic art to demonstrate the items thoroughly investigated, intending to analyze the requisites under which the physical interactions intensify the experience.

Tactile:
of or connected with the sense of touch; perceptible by touch; designed to be perceived by touch.

Kinesthetic:
awareness of the movement and position of limbs, by means of sensory organs (proprioceptors) in the muscles, tendons and joints.

Proprioceptive:
refers to stimuli that are produced and perceived within the body, concerning the relative positions of the body parts.

Contributions

Looking at everyday things from a different perspective or with an added meaning rather than predictable can make them seem new or revealing. Happening to look at something apparently ordinary in a new way can make it out of ordinary, or even extraordinary. To think that we know something well because we use it every day, it is a common misconception. Just because we are used to use it, does not mean that we understand it profoundly. On this curiosity, the Japanese graphic designer, curator, and author Kenya Hara (1958–) keenly observed:

> "To understand something is not to be able to define it or describe it. Instead, taking something that we think we already know and making it unknown thrills us afresh with its reality and deepens our understanding of it." (Hara 2007)

This research rediscovers the senses of touch in their extensive possibilities, exposing what it is beyond the outer layer and hidden inside the body.

This thesis selectively and critically synthesizes and analyzes fundamental research drawn from a broad range of disciplines that contribute in important ways to our understanding of the human senses, in particular, the sense of touch, in social, cultural, and technological contexts.

In *Search of Lost Time* (*À la recherche du temps perdu*) [earlier translated as *Remembrance of Things Past*], French novelist Marcel Proust (1871–1922) utters, "The only true voyage of discovery, [...] would be not to visit strange lands but to possess other eyes." (Proust 2006 (1913), 657)

In *On Looking: A Walker's Guide to the Art of Observation*, American cognitive scientist, professor of psychology, and author Alexandra Horowitz reveals, "In this way, the familiar becomes unfamiliar, and the old the new." (Horowitz 2014, 3)

It is a transdisciplinary overview that proposes to be a useful theoretical framework about the senses of touch, with convergences of biology, ethnography history, philosophy, psychology, technology, art, and design.
It is a comparative outlook on the haptic, that urges to dissolve the gap between aesthetics and functions, or the meaningful intents in art and technology.

This research delivers a comprehensive understanding of the phenomenology of touch through art. On why and how the sense of touch is absolutely essential to us, using as resource merging theories from different disciplines and practices. Giving an understanding of why it should be considered vital, and how we have been relating to touch, attempting to unveil its hidden characteristics.
Conceiving haptic experiences as a mean of demonstrating behavioral reactions, deconstructing the technological perceptual device, that offers haptic experiences through a very restrictive way. Using low-tech artifacts to address issues that may often leave us uncomfortable in high-tech devices.
Experimenting tactile metaphors conceived to show how our actions influence behaviors, of ourselves and of others. And how our immediate reactive instinct predicts our consequent behaviors. Concerning the instinctive reaction to an unexpected touch, or the first reaction to the embodied experience of feeling something on our skin. The first moment we experience something new is the alluring of an instant that will determine future behaviors to similar experiences. A lasting involvement depends on the quality of the first impression. We are moved by feelings, constantly looking for unforgettable ones.

This research thesis creates a convergence of thought and interpretation to be used as a conceptual resource guide for artists and designers doing creations involving haptic explorations. It results in developing collaborative relationships between disparate practices to explore emergent technological manifestations, implicating public awareness and individual involvement.
For future proximal articulation between scholarly research and public curiosity, merging scientific findings with common knowledge narrowing the prevailing detachment.
Concerning the public interest, the main contribution is to society, aiming at constructing the knowledge of the self through the sense of touch.

I-physiological:
refers to the notion that:
— We are who we are, because we are how we are. — The result of a more or less sensitive nervous system.
We sense and perceive the world differently, in part, due to our physiology, and outwardly, to the configuration of our body schema.
It is a derivative term from the *I-function* used in psychology, that refers to how the brain creates a sense of self, distinguishing the outer reality from the inner conscious and unconscious reality.
Emily Dickinson asserts that there is more to the brain than the self:
"The Brain – is wider than the Sky – ;
For – put them side by side – ;
The one the other will contain ;
With ease – and You – beside – " (in Grobstein 2002)

Physiology:
from the Greek *physis*, meaning 'nature, origin,' and *logia*, meaning 'study of.' It refers to the organic processes or functions in an organism or in any of its parts. (Dictionary.com)

Structure

Part I: Describes through our I-physiological what touch is and how it works.
Chapter 1, Definition: The essence of the senses
— defines haptic, clarifying its terminology, and how touch is related to other senses. Touching the adverse consequences of having a disobedient body, and the unconventional effects of experiencing a cross-sensory perception.

Chapter 2, Physiology: The inner functioning
— looks into the sensory sensitiveness and the mechanisms of touch, for it is in knowing it thoroughly that we understand its predominance and pertinence to extrapolate to outer experiences with touch.

Part II: Characterizes the construction of an I-conscious within a body.
Chapter 3, Perception: In the creation of consciousness
— reveals contents of the mind, on how we become aware of, or perceive our surroundings through the senses and experience a conscious corporeity through touch. How the perception shapes us and how it deceives us.

Part III: Reveals an evolution of touch through the social history and cultural geography.
Chapter 4, History: A phenomenon with sense
— contextualizes briefly the sense of touch historical and culturally, concerning customs, ideas, and social dispositions of societies through the eras, up to the technological implications of contemporary digitization of touch, or the removal of touch from the experience.

Chapter 5, Aesthetics: Or how we feel touched
— suggests differing subjective interpretations for what may induce or affect the somatic sensations. On how we may feel moved by the sensations of touch. Followed by examples of sensory experiences, which in different ways relate to haptic interfaces or explore the tactile qualities of surfaces.

Part IV: Explains how technological materials and means can help us extending our uses and comprehensions.
Chapter 6, Materials: To stir sensations
— refers to how the materials are implicated in the sensory experience, as to ways of intensifying the haptic experience through materials, and the emergent sensitive materials that give rise to potential extensive sensory possibilities.

Chapter 7, Technologies: For perceptual mediation
— speaks about the evolving technological means used to emphasize the senses of touch, the somatic adaptations to technology, and the growing sensitive technologies that promise to enhance the digital sensory experiences.

Part V: Shows examples of conceptual haptic experiences in different formats and materials.
Chapter 8, Explorations: Conceived to be touched
— presents practical examples demonstrating previous statements, considering the two major concerns: proof of concept and demonstration,

and experiential assessments, while adapting phenomenological methods for aesthetic felt experiences, and formulating the inductive *Theory of Aisthantic Experience* to formally analyze the quality of felt experiences.

Finally draws some remarks as conclusions about our haptic dispositions, and offers a guide to future research, suggesting pathways for further explorations on sensory potentialities.

Touch, the essential sense.

Life without it, is impossible.

Chapter 1

Definition
The essence of the senses

Introduction

This chapter introduces the senses and defines haptic. Considering the specificity and the importance of the senses, with special emphasis on touch, or what we usually ignore about this sense and its relation to other senses. Acknowledging the consequences of living with touch impairments, and the unusual experiences of perceiving cross-sensory sensations.

1.1 Senses

Everything we know about the world comes through our embodied senses. Differences are genetic (sensory processing disorders), of gender (physiology), sensitivity (education, training), lesion (disease, accident), age (sense and faculty losses), cultural (moral, customs, beliefs and social behaviors), historical (changes over time), and technological (tools artificially extending the senses). Traditionally, we were thought to have five senses — sight, hearing, smell, taste, and touch. In 1906, the English neurophysiologist Charles Sherrington (1857–1952) called "secret sense, or sixth sense" to proprioception. (in Pines 1995, 8) This sense enables:

> "[The] awareness of one's own body, the spatial position of the body parts relative to one another and in relation to its surroundings. It contributes to capabilities that the majority of people take entirely for granted, such as walking or just standing still." (May 2007, 78)

Senses:
sight (vision, optic, ocular ophthalmoception), hearing (audition, audioception), smell (olfaction, olfacoception, olfacception), taste (gustation, gustaoception), touch (tactition, tactioception), body position (proprioception), body movement (kinesthesia), balance (equilibrioception), temperature: heat and cold (thermoception), pain (nociception), vibration (mechanoreception), acceleration (kinesthesioception).
"Their functioning, classification, [cont. ...].

Currently, researchers are attributing the seventh sense to the sense of balance (equilibrioception) distinguishing it from proprioception. And, they acknowledge the existence of additional sensations, such as pressure, temperature, joint position, pain, muscle sense, and movement sense, but all these are generally included in touch. (Pines 1995, 8)

"Senses are physiological methods of perception." Ordinarily, a sense is a faculty by which outside stimuli are perceived, but due to a differing interpretation of the definition of a sense, there is not an agreement among neurologists about how many exact senses there actually are. So, some say we have seven, while others, nine different senses (sight, hearing, smell, taste, touch, proprioception, equilibrioception, thermoception, nociception), and other animals have several other senses (magnetoreception, electroreception, mechanoreception, echolocation, ultraviolet, infrared, and polarized light detection). Some animals have the senses humans have but to a far higher acuity, or they sense the world in totally different ways. "Some animals have all the senses, others some of them, while others only one, the most indispensable, that is, touch" (Aristotle 1907 (350 BC), 57) (*e.g.* sea anemones and other cnidarians).

As the German physiologist Johannes Müller (1801–1858) described:

> "The essential attribute of a new sense is, not the perception of external objects or influences which ordinarily do not act upon the senses, but that external causes should excite in it a new and peculiar kind of sensation different from all the sensations of our five senses." (Müller 1842, 1087)

Earlier, Greek philosopher Aristotle had formulated a concurring opinion saying that "Sense is that which is receptive of sensible forms apart from their matter." (Aristotle 1907 (350 BC), 105) Meaning that it is what it transmits and what it is perceived from it rather than the inherent characteristics of the sensible object. As Wade pointed out, the considerations about senses are generally explained more by anatomy and physiology than by behavioral evidence. (Wade 2003, 175) Whilst, acknowledged by American psychologist James J. Gibson, senses are not "mere receptors, that is receivers and transducers of energy," but rather "systems for exploring, searching, and selecting ambient energy." (Gibson 1963, 12) Senses are what make the body active and life vibrant. It is through our senses that we have a feeling of existence, encompassing body, memory, and identity. I am what I and others see. I am what I feel and think about me. — "I am my body," wrote French philosopher Gabriel Marcel (1927 in Danto 2001, 67) Senses are part of the body, enriching and transcending it. If it were not our senses, we would not experience the world as we do. Our body would be inert, and unquestionably, we would not feel the ground under our feet. When forming first impressions, it is what we see, hear, smell, taste, and touch that influence our assessments and determine future connections. Regardless of the number, senses are crucial to our relationship with ourselves, with others, and with everything around us.

[... cont.] and theory are overlapping topics studied by a multiplicity of disciplines, especially neuroscience, cognitive psychology (or cognitive science), and philosophy of perception." (Encyclopedia)

In *The Senses Considered as Perceptual Systems*, published in 1966, the American psychologist J. J. Gibson (1904–1979) argued that we have outward-orientated (exteroceptive) senses and inward-orientated (interoceptive) senses.

The *Tolkappiyam* is an ancient text on the grammar of the southern India Tamil language, with unknown date but a few evidences set it between the 3rd century BC and the 10th century CE, known as the first to describe six senses. One of its verses states, "Beings with one sense are those that have the sense of touch. Beings with two senses are those that have the sense of taste along with the above. Beings with three senses have sense of smell in addition. Beings with four senses have sense of sight, along with the above. Beings with five senses have sense of hearing, in addition. The beings with six senses have a mind, along with the above." (in Hood 2015, 160)

In different circumstances and contexts, senses have deserved either eloquent or trivial references and have inspired marketers and creators alike.
Denis Diderot (1713–1784) expressed his lyrical emphasis on the senses, saying:

> "Of all the senses, I found the eye to be the most superficial, the ear the most arrogant, the nose the most voluptuous, the tongue the most superstitious and inconsistent, and touch the most profound and philosophical." (Diderot 1751 in Migone 2004, 1)

In Diderot, senses own attributes, as if they did not belong to one body. Some more tamed, while others, like touch, unrevealed and unknown.

1.2 Sight

We are able to see when there is light, and only when light reflects on an object we are able to detect it. Light hits an object and bounces off in light waves, that enter the eye through the cornea. (Bjorklund 2010, 17) The physiology of sight begins with the detection of light by photoreceptors located in the retina at the back of the eye. The light sensitive cells are comprised of 6 million color sensitive cones, that function in bright light to give us a plentiful color vision during the day, and 120 million rods that only detect black, gray, and white, and function in dim light to give us night vision. Light hits 126 million sensory cells, which is transduced into electrical signals. (Bjorklund 2010, 7) A photon, the smallest unit of light, can stimulate one of the sensory cells, but the human eye needs at least 100 photons hitting at the same time to be able to detect something. We see well in bright sunlight when the brightness is over 10,000 lux, but we can hardly see below 1 lux. Eyes possess lenses, but every image is processed in the brain, where sight holds the largest area dedicated to the senses. (Bjorklund 2010, 6) Lens adjust in size, and depending on the light or focus, it either shrinks to fixate on a far center of attention or enlarges to concentrate on a nearer one. The pupil also dilates whenever we look at something exciting. The size of the pupil causes variations in light entering the eye.
Our eyes are sensitive and reactive to light. Light on the eyes forces "focusing, fixating, converging, and exploring of the light." (Gibson 1963, 12) When we see something that instantly grabs our attention, instinctively we move the muscles around the eyes and make spontaneous facial expressions in response to it. Consequently, if it is distant and moving, we may react weaving our arm or even heading towards it. Eyes arrive far, to the horizon, and up to the sky. The shy look to the ground to avoid eye contact while the amazed one opens his eyes wide. Eyes reflect the state of the soul. A someone's look may touch our heart. And images that eyes have seen dominate our minds. Scenes that eyes have witnessed can leave us speechless and breathless.
The agnostic ones need to see to believe. But the inventive ones envision a future of possibilities and are called visionary. Daydreamers constantly see

Light:
is of electromagnetic radiation that travels through space as waves. Human sight is adapted for wavelengths of light within the visible spectrum of 400 to 700 nanometers (nm). The radiation of shorter wavelengths, the ultraviolet light (UV), spans from 10 nm to 400 nm, and is absorbed by the atmosphere's ozone layer. The radiation of longer wavelengths, the infrared light (IR), spans from 700 nm to 1 mm, and is filtered out of the atmosphere by carbon dioxide and water vapor. (Light 2005, 57) The sun's radiation that reaches the earth's surface spans a range from 300 to 1,100 nm (a nanometer is one billionth of a meter). (Gallagher and Nelson 2003, 47)

Cones:
are photoreceptors in the retina that detect colors in bright light. Each cone has a pigment that responds to one of three colors, red, green, or blue. Cones combine the visual sensitivity to create all the variety of colors we see.

Rods:
are photoreceptors in the retina that detect black, gray, and white in dim light.

Lux:
is the amount of light per square meter.

their inner worlds and daily put their heads on the moon in reverie. And how exquisite it is to watch something grow naturally. Lovers kiss with eyes shut, to avoid any distractions from the pleasurable sensations of taction. Tears made of salted water wash the eyes of those who have a broken heart. And tears feel sweet in the eyes of those who are ecstatic by a stirring instant. Sight is a receptive sense, but seeing is not passive, and may affect us intensely. A flash bright light hurts our eyes, and either we close them tight and look down, or we cover them with a hand to protect. A harsh lighting causes us to constrict the muscles around the eyes in an effort to see anything. On fog days, we cannot see far. We can barely see with dim light, and unlike the cat, we do not see in the dark. Species have evolved to have very complex eyes, and some with extraordinary functional capabilities. A few species have large eyes for the body size (*e.g.* tarsier, slow loris, dragonfly) while others have them tiny (*e.g.* blue whale), albeit possessing the vital requisites for survival in their environment. The genetic diversity of human eyes, boosted by the adaptability to the dissimilar environmental conditions around the planet, causes to exist various eye shapes and iris colors. And when the sight fails, we make use of alternative technical medicinal means (*e.g.* glasses, lens). Man has developed the substitute prosthetic mechanical eye, and built the camera as a sensory extensional electronic eye.

"There is disagreement as to whether sight constitutes one, two or three distinct senses. Neuroanatomists generally regard it as two senses, given that different receptors are responsible for the perception of color (the frequency of photons of light) and brightness (amplitude/intensity of the number of photons of light). Some argue that stereopsis, the perception of depth, also constitutes a sense, but it is generally regarded that this is really a cognitive function of brain to interpret sensory input to derive new information."
(Encyclopedia)

1.3 Sight and Touch

The affinity between the two senses is probably the most recognizable. A unique sight and touch experience is that of handling a book, feeling its weight, texture, character, its message through the object. Certainly much different than reading an ebook. And how wonderful it is to be surprised by a dear one when affectively covers our eyes to playfully ask — Guess who! Or to gaze in admiration while holding hands with a loved one, as times have redefined the hand-holding act. (in Rosenbloom 2006) Sight is a receptive sense while touch is exertive. Touch affects and alters its environment acting upon it. Sight collaborates with touch in the recognition of surroundings for touch to "muscle in." Acting interrelated "the senses of sight and touch function coordinated of each other." (Robles 2006, 24) But sight is subject to light. What we think we might have seen can be far from reality as our sense of sight requires favorable external conditions of light to be accurate in making objective evaluations. While touch contacts directly with the reality, sight is mediated by an external factor that is variable and, therefore, misleading — I can assure it is true; saw it with 'my' eyes! We may believe that we had seen or witnessed something that to us seemed to be true, but ultimately, it was just a mirage. What we have perceived with sight is dependable on light or environmental conditions. If these conditions are not the most favorable, the apprehension of reality may not be of much accuracy. French philosopher René Descartes (1596–1650) "equated sight with touch, a sense he considered to be 'more certain and less vulnerable to error than sight'." (in Pallasmaa 2012 (1996), 22)

We act upon our surroundings through an operative muscular touch. The enactive touch is the only sense capable of changing the world around. For only sight and touch enable us to locate objects in the space around. Ernst Weber (1795–1878) acknowledged the relationship between touch and sight and its importance to spatial awareness, arguing, "The touch organs, like the sight organs, have a localization-sense, but to a far less developed degree: we therefore owe our accurate perception of spatial relationships to both senses."
(in Prytherch 2002, 4)

Not only are the lighting conditions the reason why the perception of a color may differ, but also that the identification of a hue is dependent on the person who sees it: If someone says — "It looks like royal blue to me;" someone else might say — "No, I think it's navy blue;" and another person could reply — "No, it's clearly purple!" Everyone is correct, by the fact that for each one the color is exactly what they believe to have seen. American professor of ophthalmology and a color vision researcher at the University of Washington, Jay Neitz affirms that each of the three retinal photoreceptor cone cells for red, green, and blue, can detect about 100 different gradations of color. Yet, the brain combines the color variations exponentially, multiplying each new variety of cone by 100, so that the average human *trichromat* can distinguish about one million different hues. (Neitz *et al.* 2001) The identification of a specific color is entirely subjective, and because we are not symmetrical, the two eyes of a single person perceive colors slightly different. For this reason, the number of colors that we can discriminate depends mainly on the color sensitivity of each person's eyes. Our experience of a color is influenced not only by the wavelength of the light rays that hit the retina, but also the context in which we perceive the color, that is contingent on surroundings, background colors, illumination, and familiarity:

> "We do not recognize the "color" of certain wavelengths that stimulate the eye, as is so often said. If we did, an object's color would change continually as the illumination changed [...]. Rather, we perceive the permanent properties of colored surfaces under varying illumination: what remains constant under shifting lighting is an object's lightness compared to everything else in the spatial surround." (Cytowic 2002, 321)

Commonly, men have more difficulty in identifying hues, and easily distinguish the dominant wavelength of a color. While in general, we tend to identify colors by comparison. American author, poet, and naturalist Diane Ackerman (1948–) in *A Natural History of the Senses* asserts that "the eye works with ratios of color, not with absolutes." (Ackerman 1990, 252) Another reason for the differing perception of color may be due to color blindness or more accurately color vision deficiency that most frequently affects men, which is the inability to perceive color differences and subtle mixtures of color under normal lighting conditions. In philosophy, sight is associated with intellect. To Vasseleu sight is "credited with facilitating objective, theoretical knowledge, while touch is considered more qualitative and intuitive." (in Mileaf 2010, 7) Expressions 'insight,' 'point of view,' 'vision of things,' 'observation,' allude to someone's intellect. Metaphorically enunciated by Goethe, sight and touch aspire to cross sensations, "the hands want to see, the eyes want to caress." (in Pallasmaa 2012 (1996), 17) Sight reports "salience, orientation, arousal, attention, and identification of things" while touch transmits "motion, spatial orientation, self-definition, and safety" as mentioned by artist Rosalyn Driscoll. (in *Whole Body Seeing*, chap.5) Touch is "receptive, expressive," and communicates "empathy." (Paterson 2007, 1) — But also does

Greek philosopher Heraclitus (c. 535–c. 475 BC), stated, "Men are deceived over the recognition of visible things." (Fragment 56, 500 BC in Levin 1993, 1)

American philosopher Nelson Goodman (1906–1998) stated, "The eye comes always ancient to its work, obsessed by its own past and by old and new insinuations of the ear, nose, tongue, fingers, heart, and brain. It functions not as an instrument self-powered and alone, but as a dutiful member of a complex and capricious organism. Not only how but what it sees is regulated by need and prejudice. It selects, rejects, organizes, discriminates, associates, classifies, analyses, constructs" (Goodman 1968, 7)

Image consultant Kerry Cordero of *The First Look* recalls how our eyes convey our essence. "When someone focuses on our eyes, they're able to see who we are, connect with our authentic self, and trust us." (in Alterman 2015) For which, the daily intake of vitamin B1 (Thiamin) (with higher concentrations in sunflower seeds, navy beans, black beans, barley, dried peas, green peas, lentils, pinto beans, lima beans, oats) [cont. ...]

sight. Sight permits a wider prospect and contemplation from far, while touch needs closeness to reach its subject. Pallasmaa said, "the eye is the organ of distance and separation, whereas touch is the sense of nearness, intimacy and affection." (Pallasmaa 2012 (1996), 46) — Although a loving eye contact also enhances intimacy. Pallasmaa wrote that sight and touch differ in attitude; "the eye surveys, controls and investigates, whereas touch, approaches and caresses." (*ibid.*) In true, these two senses can be very close and interrelated. Touch may help us reinforce the sensation acquired by sight. In some circumstances, we need touch to perceive it clearly. — "I see things better with my feet," said the solitary 'blind traveler' James Holman (1786–1857) preferring to hike rather than ride on muleback. (in Roberts 2007, 2) Feeling palpably to see it deeply. Unlike sight, the sense of touch is closely related with the tangible world. Notwithstanding, sight is capable of apprehending a much detailed information with a fixed eye than is a stationary hand, (Helmholtz 1878) in such that sight gives us the notion of the whole surface qualities. With sight, we have promptly the perception of the whole, while with "touch, the construction of the whole is a mental process that takes place after the perception of the parts." (Révész 1950) Parts only conquered by tactual exploration. It is "through one's own muscular activity," (in Katz 1989 (1925), 2) that touch have a truthful perception based on active tactual exploration. Yet, our mothers used to shout at us in a porcelain shop — "Don't touch, you don't see with the hands," immediately aborting our tactual expeditions. The expression, "Seeing with the hands," by René Descartes (1637) has contributed to the spread of the relation between sight and touch. When sight is not enough to feel the qualities of a surface, touch may come to assert its material characteristics. Touch guarantees the proximal veracity of a physical experience, confirming or contradicting the possible illusory perception given by sight. Sight and touch act interrelated and clarifying one another:

> "The mechanisms by which we feel and perceive the tactual qualities of our environments are considerably more complex than the visual modality. There is considerable experimental evidence that touch and sight are perceptually linked and informing each other." (Prytherch and McLundie 2002)

Brian O'Shaughnessy (1989) suggests that touch "involves the use of no mediating field of sensation. There is in touch no analogue of the visual field of visual sensations which mediates the perception of the environment." (in Fish 2010, 159) Contradicting, Révész (1950) asserted that "when we touch some common object, the tactile impression is always permeated with visual experiences." (in Katz 1989 (1925), 2) Sight can only suspect based on memory, or in what one has retained in memory from a visual experience, how it would be to feel the surface. Yet, referred by Driscoll, "touching taps into the somatic dimension of memory, evoking different images and feelings than those evoked by seeing." (Driscoll 2006) Touch has greater resonance in memory. Therefore, learning by doing is

[... cont.] and B2 (Riboflavin) (in soybeans, spinach, broccoli, beet greens, tempeh, yogurt, wheat germ, mushrooms, asparagus, almonds) reduces the risk of blurred vision. (onegreenplanet.org)

In chapter *Aesthetic Touch*, of *Art and the Senses* published in 2011 (edited by Francesca Bacci and David Melcher), Rosalyn Driscoll argues, "Seeing seeks to identify and categorize an image and its parts, to create hierarchies of salience, form, space, and color. Haptic knowing is more horizontal, non-hierarchical, and democratic. It produces a more fluid, changing, evolving, open-ended sense of an artwork, supporting the transient nature of reality and the multivalent nature of art." (in Bacci and Melcher 2011, 113)

Modality:
is a particular physical property of a stimulus that can generate activity in sensory neurons. (Bushnell and Smith 2007) It refers to the type of stimulus (*e.g.* mechanical, thermal, chemical, visual, or auditory) that activates sensory receptors. (what-when-how)

Ancient Chinese aphorism says:
I hear... I forget;
I see... I remember;
I do... and I understand.

more easily kept in memory and recalled later on than learning by seeing. And as asserted by Driscoll "seeing is often infused with the somatic senses, just as touching draws on visual memory and imagination." (Driscoll 2013)
We close our eyes to get in touch with our perceptual mind, to focus deeply on the sensations and avoid distractions from sight. Sight distracts touch scattering attention and preventing a full touch involvement. Withal "sight dominates and educates touch." (Rock and Harris 1967 in Katz 1989 (1925), 3) Sight is important in guiding touch to interpret the tactual sensations.
Texture, which characterizes the smoothness or roughness, softness or hardness of surfaces, is one of the attributes that can be perceived primarily by touch. In the same level, sight can anticipate a textural feeling before we extend our fingers to touch it, or before we walk on it barefeet. But, when stroking a surface, touch always surpasses sight in the assessments of roughness, (Heller 1982, 1989; Lederman *et al.* 1986 in Katz 1989 (1925), 3) and other information on properties such as temperature, weight, and hardness, are generally accessible only to touch. (Klatzky and Lederman 1987 in *ibid.*) Accordingly, Driscoll asserts that touch assists and extends sight in analyzing the characteristics of surfaces:

> "Touching allows us to know directly the properties and meanings of materials, the differences between materials, and even some properties of materials we can not gain as fully through sight, such as temperature, hardness, resilience, fragility, and weight." (Driscoll 2006)

Klatzky and Lederman (1987) mention the attributes that are more applicable for touch than sight remarking that touch "is oriented towards the encoding of substance and sight towards the encoding of shape." (in Katz 1989 (1925), 3)
In Katz's view, sight is "crucial in providing the quality of spatiality to the tactual representation." (Katz 1989 (1925), 3) However, in Helmholtz's opinion:

> "When we inquire into the empirical conditions under which our intuition of space is formed, we must concentrate in particular [on] the sense of touch, for the blind can form complete intuitions of space without the aid of vision." (Helmholtz 1878)

Yet, sight is limited. We cannot focus on everything in front of us. We are only able to clearly focus on one point at a certain distance with a blurred peripheral image. Withal, when sight fails, it is the touch that compensates this absence, which confirms the close relationship between sight and touch.

1.4 Hearing

Hair cells in the cochlea are the most sensitive mechanoreceptors, transducing air pressure waves into nerve signals sent to the brain. Hearing happens when the brain processes vibrations caused by the waves that travel through the air, water, and solids to the inner ear, which produce a sound. The sound makes

Cochlea:
is a snail-shaped, fluid-filled organ of the inner ear that contains the basilar membrane. It is responsible for translating the motion of this membrane into nerve signals that lead to the perception of sound.

Mechanoreceptor:
is a sensory receptor that transduces mechanical pressure or or deformation of the skin into neural signals that are sent to the brain.

Transduction:
happens in the eyes, ears, nose, tongue, and skin, where physical energy of environmental stimuli, such as light, heat, or vibration is converted into electrical energy (neural impulses) that can be recognized by the nervous system, so the information can be interpreted in the brain. "All animals have evolved sensory receptors, which provide the central nervous system with information about events in the physical world. These receptors consume metabolic energy and are designed so that a physical or chemical stimulus triggers an electrical response in the cell membrane: a process known as sensory transduction." (Torre *et al.* 1995, 7757)

us move our head in the direction of its source. Subsequently, a combination of sounds creates rhythm, which generates music. Harmonized music has melody, which makes us move our body in synchrony, commonly called dancing. Street runners take workout music tracks to runs. Interventional songs lead crowds to protest in the streets. Some weep to the sound of Blues while others dance while cooking to the sound of Indie. We have songs for special occasions that connect us throughout life to certain places and events. Therefore, hearing can be a full body experience. Some people are very talkative and then there are the ones who love gossip. The world around us is noisy and like touch, we cannot stop hearing. We may hear less with help from earbuds or our hands covering the ears, but we cannot stop hearing voluntarily without an external help or accessory. Even though, like sight, we can concentrate our full attention on one person talking to us and ignore all the others around. We can hear about 340,000 individual audio tones. Some sounds are contemplative, as those of birds chirping at dawn, the wind chimes tinkling in the breathing air outside the Japanese houses, or those of bamboo fields moving in the cold wind at dusk. With those, we stand still, and close our eyes in meditation. In the winter, the sound of wood logs burning in the fireplace comfort us greatly, the cracking noise that our feet make while we walk on the snow amuse us. Whereas in the summer, the sound of ocean waves moving back and forth relax us, and the sound the wind makes against the car on road trips is adventurous. Hearing capacitate us to perceive our surroundings through the sounds it emanates, and to which we feel and react accordingly. While some people may believe to hear voices inside their head, others believe that conscious has an autonomous existence living inside our body that we should listen to, like — "Listen to your inner voice." Referring to intuition, as if it is a wiser entity that could take us to make the right choice. Hearing through bone conduction is the capacity we have to hear from the conduction of audio and higher frequency vibrations through the cranial bone directly to the inner ear. The transmission through bone conduction can be used with people with normal hearing or an aid for the impaired hearing. One can use a *bone conduction microphone* to record spoken sounds via bone conduction. The sounds are conducted to the microphone through the bones of the skull, and any vocal content that is received is nearly inaudible to other people. (Vandrico Solutions 2014) Hugo Gernsback (1884–1967), inventor, writer, editor, and publisher of Radio-Electronics magazine, conceived in 1923 the *Osophone*. This was "the first bone conduction device with which the deaf could hear through the teeth." (Radio-Electronics (formerly Radio-Craft) 1958, 50) And later in 1934, Gernsback developed it further to become the *Phonosone*. (*ibid.*, 55) An art project effectively took advantage of the introspective possibilities of bone conduction to create a thought-provoking public event from a dramatic historic moment. *Touched Echo* was a site-specific performative installation created in 2007 (–2009) by the German media artist Markus Kison, that used bone conduction to recall the tragic moments that people lived in Dresden when bombers B-25 invaded and attacked the city on February 13 of 1945.

Sound travels much slower than light on about 331 m/sec (0.2 miles/sec) in dry air at a temperature of 22.2° C (70° F), compared to 300,000 km/sec (186,000 miles/sec) for light. This is why a lightning flash is seen almost immediately after it occurs, but the thunder is heard much later. For each second that passes between a lightning bolt and the thunderclap informs that a storm is about one-fifth of a mile (or one mile in five seconds, or one kilometer in about three seconds) farther away. (Light 2005, 90; Encyclopædia Britannica)

Sonic weapons: "use sound to injure, incapacitate, or kill an opponent. Extremely high-power sound waves can disrupt or destroy the eardrums of a target and cause severe pain or disorientation. Less powerful sound waves can cause humans to experience nausea or discomfort. The use of these frequencies to incapacitate persons has occurred both in counter-terrorist and crowd control settings." (Wikipedia)

Near the end of the Second World War, the United States and British air forces carried out a bombing that nearly destroyed the city of Dresden, in East Germany, on the banks of Elbe river. To endure the sound of the air raid, the survivors of Dresden covered their ears and bowed their heads, just as the audience experienced at the installation on the iron railing, which vibrated when playing sounds of the bombing, bringing to mind the tragic events in the city. When people land elbows on the railing at the Brühlsche Terrasse overlooking Dresden and put the hands over their ears, they can hear the sounds of bombers B-25 and bomb blasts on the conduction of sound vibrations through the bones of the arms, skull bones until the inner ear. (markuskison.de/#touched_echo)

1.5 Hearing and Touch

There were a few hearing and touch experiences that nostalgically got lost with the advent of digital technology: The characteristic noise of the typewriter that immediately associated the physical action of writing with its inherent tactile feedback. The distinctive noise of the 8 mm film running in the camera, or the noise of the projector playing the movie. The noise of the carousel moving to pass the analog slides. Or the noise produced by the 33, 45, and 78 RPM vinyl records playing on the turntable. Now obsolete media, these provided an absolute connection between hearing and touch as they all required manual handling. To appreciate intimately a song we increase the sound volume and close our eyes. Then we feel its waves through the skin and its rhythm from the pressure disturbances inside our chest. When sensing the audible vibrations, the body feels a compulsive motive for movement. Quoting Nietzsche, "The dancer has his ear in his toes," (in Pallasmaa 2012 (1996), 17) like obeying a desire to move to the rhythm of the sound. For Katz, (1925) the capability for the impaired hearing to feel the music through skin vibrations reveal how close it is the connection between skin and hearing. There is some sense of hearing in hearing loss.

> "[A] person suffering from conduction or transmission deafness rather than nerve deafness, the intense vibrations produced by the loudspeakers in concert halls might reach an intact inner ear through bone conduction." (Georg von Békésy (1967) in Katz 1989 (1925), 6)

The skull conducts lower frequencies better than air. The reason why our voice sounds different when it is recorded and played back; we perceive our voice to be lower and fuller than it sounds to others.
We hear to communicate, but in the lack of hearing we gesticulate to be 'heard.' "Psychologists have long [defend] that much of our hearing takes place through the skin." (McLuhan 1964, 137) When we speak we emanate vibrations, commonly known as 'vibrational energy,' that are felt by, and affect, others from the inside out. Specific spoken words can stimulate the hypothalamus area in the brain, trigger strong emotions, increase the heart rate, provoke sweating, and literally

UltraHaptics:
is a system for creating haptic feedback in mid-air, initiated in 2012 by team Tom Carter, Mark T. Marshall, and Sriram Subramanian at the Bristol Interaction and Graphics group within the Department of Computer Science at the University of Bristol, UK. (big.cs.bris.ac.uk/projects/ultrahaptics)
"[A]n array of ultrasonic transducers emit very high frequency sound waves that are used to displace air, creating a pressure difference, [...] called acoustic radiation pressure. [...] [T]he sensation produced on the skin is perceived as vibration." (Berman 2013)

'Goose bumps:'
is explained as "a roughness of the skin produced by erection of the papillae especially from cold, fear, or a sudden feeling of excitement," (Merriam-Webster Dictionary)
nostalgia, pleasure, euphoria, awe, and admiration. (Wikipedia)
When experiencing a sudden intense emotion instinctively we have a "piloerection reflex, which makes the muscles attached to the base of each hair follicle contract and force the hair up." (New Oxford American Dictionary)

give 'goose bumps' or 'chills' visibly felt on the skin and raised hairs. Subsequently, the tone of voice may change to become low and shaky with emotion.

1.6 Smell

The sense of smell enables us to distinguish scents, for this only, it makes our lives much more interesting. Furthermore, it is directly connected with breathing. When we inhale we sense the scents hovering in the air. Smell is a chemical sense. Olfactory chemoreceptors respond to odor-bearing chemicals in the surrounding environment. When the nose senses scent, we may focus on the sensation by closing our eyes, while inhaling deeper through the nose and lightly elevating our head. — "I smelled the wind today," said Lynley Scott. A scent can be ephemeral, but the memory of it or its trail can remain with us for a long time. It can mark the passage of time and create an identity. It can make us remember of someone, a place, a moment or a season. It can remind us of a dear one we have lost. The ethereal floral fragrances can make us anxiously desire for the spring arrival, and it can make us longing for the fruity aroma of a summer peach orchard. As the recalling of the stimulating scent of freshly cut grass. Or a book read, for the smell of its paper and the ink of the printed text. Simultaneously, our capacity to sense odors alert us to a dangerous situation prompting in us the urgency to move away from it. The sense of smell "protects us from breathing unsafe air or fumes and stops us from eating anything spoiled or poisonous." (Bjorklund 2010, 13) Referring to the emotional states that smell elicit, Ackerman stated "we may not need smell to survive, but without it, we feel lost and disconnected" (Ackerman 1990, 40) as smell may easily prompt in us the memories of home and enjoyable moments spent at family gatherings. Carried within us, the recollection of a scent may evoke distant memories of childhood events. The memory of a scent triggers proximity for a scent long ago disappeared. Ackerman reminded, "Nothing is more memorable than a smell." (Ackerman 1990, 40) Despite the possible distance, the sense of smell gives us the intimate sensation of connection to a time and a place. For the ability to sense gives an overall secure sensation of presence and belonging. The detection of a scent initiates when volatilized chemical compounds enter the nose. The odor-bearing chemicals begin a reaction stimulating the olfactory cells, then the olfactory bulb transduces the chemical signals into electrical. The electrical impulses go to distinct areas of the brain: *hippocampus*, *amygdala* and *hypothalamus*, and *frontal cortex*, where the sensations are converted into meaningful perceptions and memories. The limbic system is the area of the brain where "strong emotional and physical reactions" (Light 2005, 52) are triggered, and smell activates it recurrently. We have nearly five million olfactory nerve cells, and nearly 50 million olfactory receptors (Bjorklund 2010, 34) sensitive to seven primary types of sensations: "camphor, musk, flower, mint, ether, acrid, or putrid." (Shergill 2012, 60) Just four

Normally, we take 23,040 breaths a day, and each inhale fills the olfactory system with scent. (Ackerman 1990, 6)

"An odorant is a substance capable of eliciting an olfactory response whereas odor is the sensation resulting from stimulation of the olfactory organs." (Rieck-Hinz *et al.* 2004)
"An odorizer may add an odorant to a dangerous odorless substance, like propane, natural gas, or hydrogen, as a warning." (Wikipedia)

The first researcher to classify odors was the Swedish botanist, physician, and zoologist Carl Linnaeus (1707–1778), who in 1756 have distinguished seven classes of odors: aromatic (as carnation), fragrant (as lily), ambrosial (as musk), alliaceous (as garlic), hircine (as valerian), repulsive (as certain bugs), nauseous (as carrion). There is less agreement among psychologists about primary odors than primary tastes. (Shergill 2012, 61)

Anosmia:
is the inability to smell.
Hyposmia:
is a reduced capacity to smell.
Cacosmia:
feeling sick from the smell of environmental chemicals. (Fox 2006, 12)

molecules of an odorous substance can activate an olfactory receptor and its coupled nerve fibers, (Light 2005, 51) "but forty nerve endings must be excited" (Ackerman 1990, 13) before we are aware of a stimulus. The sense of smell is more sensitive to a new stimulus. If a scent persists we lose the perception of it:

> "Olfactory receptors adapt very little to a persistent stimulus, and it is instead adaptation in the central nervous system that makes us quickly lose awareness of a particular smell, but remain sensitive to others." (Light 2005, 51)

In an article published in 2014 in *Science* magazine, it was stated that "humans can discriminate more than 1 trillion olfactory stimuli." Much more than the 10,000 odors previously widely disclosed but never "empirically validated." (Bushdid, *et al.* 2014) The sensitivity to smell varies on gender; the woman's sense of smell is keener than the man. (Fox 2006) We feel attracted to particular scents as well. A baby recognizes the mother by her scent. The body is not devoid of scent, apart from the baby skin scent and hormonal changes during puberty, the scent of the skin accompanies us distinctively throughout life. A perfumer does not have more olfactory sensors, but is trained and can discriminate hundreds of scents by name. Smell sensitivity is explored in the novel *Perfume: The Story of a Murderer* (*Das Parfum*) first published in 1985 by German author Patrick Süskind, revolving around the human spirit and morality, through the alluring uniqueness of smell, coupled with a male character devoid of personal scent. Due to the subjective quality of a perception and the difficulty to specify a scent, unless it is based on patterns of neighborhood relationships, one scent can be identified as different for each person. Mentioned by Ackerman, "our sense of smell can be extraordinarily precise, yet it's almost impossible to describe how something smells to someone who hasn't smelled it." (Ackerman 1990, 6) Inevitably, the number of olfactory receptors declines and become less sensitive as we age. This is why older people often have difficulty detecting odors in low concentrations, and they exaggerate in the perfume. (Light 2005, 50) When we have a cold with blocked airways, we are suffering from an allergy, hay fever, asthma or bronchitis, head trauma, or diabetes, we lose the capacity to smell, therefore, we lose taste and appetite. In the lack of smell, we lose taste because the two are physiologically connected. (Ackerman 1990, 41) Reason why there are smells that we can 'taste.' "Without the sense of smell, coffee would lose its appeal and would simply taste bitter. Similarly, without smell, cinnamon would have only a faintly sweet taste." (Light 2005, 40) Smell contributes to enhance or suppress appetite and impacts the appreciation or rejection of flavors.

Central Nervous System: is composed of the spinal cord and parts of the brain, brainstem, thalamus, basal ganglia, cerebellum, and cerebral cortex. (Amen 2005) It carries electrical impulses between sensory organs, muscles, and brain allowing for motor and sensory responses.

"For the eyes, there is painting. For the ears, there is music.
For touch, there is sculpture. But what is there for smell?
I want to make perfume known as a true work of art," uttered the first president of Shiseido and renowned Japanese photographer, Shinzo Fukuhara (1883–1948). (everbloom.shiseido.co.uk)

The vibrational scent of the frankincense essential oil is used in meditation to help us to go into a deeper connection of one's own understanding.

Sensorwake: is an alarm clock that wakes us up to the smell of aromas. It contains recyclable scent cartridges filled with treated polymer beads with no volatile particles or solvents. Yet, after a while we may get used to one scent and it will cease to be an alarm to become a sleeping helper entering a dream. (sensorwake.com)

1.7 Smell and Touch

Quietly, the smell interacts profusely with touch by delicate touches through the cilia hairs inside the nose. While sometimes, we may put our nose where

we were not called in, there are a few more particular behaviors correlating smell with touch. When a scent is pleasurable, we may tend to approximate the nose to the source, using the needed body movements to become nearer and enjoy it a bit longer. As in touching a flower in the garden with the nose to intensify the feeling of its scent, using a hand to have it closer. If we do not know where the scent comes from, we raise the nose searching for its origin, turning our heads around, and then moving our body seeking for it. Following one's nose means to trust in one's instincts. Smell lead us to a distinct place. A scent creates ambiance and grants a memorable identity to a space. A scent outlines spaces where we desire to be in, feeling sensorially surrounded by it. Like a marvelous handmade candy shop in Barcelona, or an exquisite handmade soap shop in Nuremberg, or even a delicious homemade fruity cupcakes shop in Berlin, where just passing the shops while breathing deeply is not enough for an absolute sensorial experience. Whereas, if something smells unpleasant we will not want to grab it, and we will do our best efforts to keep away from it. Like when entering an old house that is full of degraded wood furniture and ripped wallpaper covered in humidity. We cannot stop the sense of smell from sensing, but with the help of a hand, we can tighten the nose to make the odor less sensed. It is curious, how smell impels us to let out exceptional emotional and somatic reactions to the presence of scents. Or to their reminiscence, like when passing on the street where once there was a biscuit factory in Porto. And the recollection of a scent that invites us to recreate often a recipe from our grandmother that used to fill the house with a warm and unforgettable aroma.

At 30,000 feet, the "lack of humidity, lower air pressure, and the background noise" cause taste to be different in an airplane, stated professor of experimental psychology at Oxford University, Charles Spence. "Our perception of saltiness and sweetness drop when inside a pressurised cabin," said director of In-flight Dining & Retail at American Airlines, Russ Brown. (in Moskvitch 2015)

"Weightlessness makes astronauts lose taste and smell in space. In the absence of gravity, molecules cannot be volatile, so few of them get into our noses deeply enough to register as odors." (Ackerman 1990, 13)

1.8 Taste

With splurge, taste is one of the pleasures of life. Food comforts us in the winter and refreshes us in the summer. Food nourishes our body and recharges it with the energy to be active, but we would not think of food if it was not for its taste. Foodies find tastes alluring, and may travel far to experience unusual flavors. We gather around food. Taste is social, it reunites people. Some sign contracts over lunch, while others get engaged over dinner. We celebrate with a meal in good company, as we have recently found happiness mixing newly discovered ingredients. How delightful it is to have a lazy meal in the garden, accompanied by the warm scents brought by the breeze on a summer night. Or serendipitously, appreciate a casual picnic by the lake in an autumn afternoon.
A taste refers to someone's liking of something The expression "in good taste," it is connoted with clean, decent, and proper. Popularly told, we may easily share the bread with a stranger at our table, because what makes someone a companion is to "eat bread with another." (Ackerman 1990, 126) And because we can hardly think with an empty stomach, a Spanish proverb says — *El vientre gobierna la mente* (the belly rules the mind). Similarly, many of memories that populate our minds are about gatherings around food.

Taste:
the term derives from the Middle English *tasten*, meaning "to examine by touch, test, or sample," (Ackerman 1990, 126) evolving from the Old French noun *tast*, and verb *taster* 'touch, try, taste,' probably based on a blend of Latin *tangere* 'to touch', *gustare* 'to taste' (New Oxford American Dictionary) and *taxare*, 'to touch sharply.' (Ackerman 1990, 126)

The inability to taste is called ageusia.

In *In search of lost time* (*À la recherche du temps perdu*) French novelist Marcel Proust (1871–1922) wrote what the narrator felt after eating a madeleine cookie he had dipped in lime-flower tea reminding him of aunt Léonie (Proust 2006, 1152):

> "Suddenly the memory revealed itself. [...] Immediately the old grey house upon the street, where her room was, rose up like a stage set [...] and the entire town, with its people and houses, gardens, church, and surroundings, taking shape and solidity, sprang into being from my cup of tea." (in Pines et al. 1995, 50)

Proust phenomenon: is the sudden occurrence of a powerful memory. The memory is so powerful and vivid it can also contain a number of sensory and emotional components. (Psychology Dictionary)
"The sight of the little madeleine had recalled nothing to my mind before I tasted it. And all from my cup of tea." wrote Marcel Proust in *In Search of Lost Time* (*À la recherche du temps perdu*), a novel in seven volumes published in France between 1913 and 1927, where he makes at least half a dozen references since the first volume to the 'episode of the madeleine.' (Proust 2015)

A latent memory of a flavor may drive us to another time and a different place. It may remind us of someone dear who used to prepare food for us but that no longer lives:

> "When nothing else subsists from the past, [...] after the people are dead, after the things are broken and scattered... the smell and taste of things remain poised a long time, like souls... bearing resiliently, on impalpable droplets, the immense edifice of memory." (Proust in Pines *et al.* 1995, 50)

The first impressions are more intense. When something comes in contact with the tongue, the first taste signals are more vivid than the following ones:

> "[...] the first bite of a peach is distinctly sweet, but the nerve signals adjust to the sensations. The brain becomes accustomed to the sensation and subsequent bites seem less flavorful than the first." (Bjorklund 2010, 33)

Taste sensitivity varies on gender and age. Whereas education and eating habits at home influence greatly our taste preferences, like the responsiveness to very sweet or salty foods. If the social and cultural environment in which we live in does not change, our taste preferences will not change either. Notwithstanding, good nutrition contributes to good health or higher sensitivity of our taste buds:

> "[...] studies have shown that certain trace minerals may play a role in keeping the proteins responsible for taste and olfactory cell growth healthy, such as copper, zinc, calcium, and magnesium." (Bjorklund 2010, 67)

These minerals can be found in greater quantities and combinations in almonds, buckwheat, cacao, flax seeds, quinoa, pumpkin seeds, and sunflower seeds. Three senses are correlated; smell, taste, and touch. Acting interdependently these senses contribute to our ultimate appreciation of flavors.

The electrical impulses go to distinct areas of the brain: *somatosensory and frontal cortex* (conscious perception of taste) *hypothalamus* and *amygdala* (emotional quality of taste) *hippocampus* (memories of taste). (Krebs *et al.* 2012)

Butterflies taste with their feet:
The butterfly sense of taste is 200 times stronger than humans and is coordinated by chemoreceptors on the tarsi (feet), which work only on contact.

1.9 Taste and Touch

Taste is intrinsically correlated with touch. The act of eating necessarily activates "orofacial mechanoreceptors" (Trulsson and Johansson 2002, 27) for the chewing process. This implies mechanical movements that oblige to a control of facial muscles, tongue, and jaw bones working coordinated "to position the food

between the teeth, cut it up, and then prepare it for swallowing." (Lund 1991, 33) Popularly, to chew someone out means to reprimand someone severely, as in, — The boss chewed me out for being late. And in an allegoric metaphor, Miguel de Cervantes (1547–1616) uttered — "The pen is the tongue of the mind." (in Ackerman 1990) Taste is not dissociated from touch because we cannot taste without touch. Aristotle asserted that taste is "a form of touch." (Aristotle 1907 (350 BC), 95) The gustatory perception of flavors is preceded by the contact of a substance with the taste buds on the tongue. As it inherently implies taction "taste is an intimate sense." (Ackerman 1990, 126) It is after the contact with the tongue and the information sent to the brain that we are able to recognize and appreciate the flavors of food. We are born with nearly 10,000 taste buds (Corbin 2006, 5) positioned within the fungiform papillae on the surface of the tongue, soft palate, upper esophagus, the cheek, and epiglottis. Each taste bud holds 50 to 100 sensory taste receptors (Smith and Margolskee 2001, 87) that can distinguish the tastes sweet, salty, sour, bitter, and savory (umami). However, the number drastically decreases by age 50 (reason why elderly people lose interest in food), and we may die with a few 2,000 to 4,000 taste buds. (Light 2005, 41) Commonly unknown "all taste buds respond to all taste qualities, and all primary tastes can be detected by all areas of the tongue that contain taste buds," (Light 2005, 39) and not by different parts of the tongue, as it has been misinterpreted from the research reported in the 19th century. (Smith and Margolskee 2001, 87)
The perception of a taste is not achieved in the mouth. The chemical reactions are transduced into electrical signals and interpreted as impulses in the brain:

> "Each of these tastes cause[s] a sensation within the oral cavity that is conducted through nerves to the brain where perception occurs. The chemicals which make up the food [tastants] are detected by taste receptor cells within the taste buds of the mouth after being dissolved in saliva." (Corbin 2006, 5)

When we taste something bitter, we shrink the tongue so we do not have to feel it. Also, a bitter taste may alert us to the presence of an inedible or poisonous substance. Popularly said, to have "a bitter taste in the mouth" means a feeling of anguish or repulsion after a disturbing experience. Similarly, "the sour taste of spoiled foods also contributes to their avoidance." (Smith and Margolskee 2001, 90) Whereas, a pleasurable experience with a taste raises the desire to repeat leaving us salivating in anticipation.
Certain tastes may cause a physical reaction such that excludes them from the common classification of the five taste qualities. These may include spicy (*e.g.* hot pepper), dryness (*e.g.* unripe fruit), or coolness (*e.g.* spearmint). (Bjorklund 2010, 34) A very spicy taste may provoke distress with tears and a burning sensation in the throat. Whereas, something very dry makes it difficult to swallow. But a fresher taste causes a sensation of relief and relaxation.
Although the sensorial stimuli are chemical, taste exerces contact on the

Umami:
from Japanese *umai* 'delicious' and *mi* 'taste,' meaning 'pleasant savory taste,' commonly used as 'savory.' It was identified in 1908 by the Japanese researcher Kikunae Ikeda as a taste that responds to amino acids like glutamate, generally found in its salt form as the food additive monosodium glutamate, distinct from saltiness. He found that glutamate was responsible for the palatability of the broth from kombu seaweed. It can be described as a pleasant "brothy" or "meaty" taste with a long lasting, mouthwatering and coating sensation over the tongue.

In recent years, the science of nutrition is claiming that "food is not only calories or fuel, but is information. Food has instructions that communicate messages to our genes, hormones, immune system, gut flora, to every system in our body. Health results from the quality of the information we put into our bodies. Food carries more than nutrients, it carries intelligence." (John Robbins interviewing Sayer Ji, Food Revolution Summit 2015) This changes the perception we have of our body. Organic plant-based food gives body vitality, creates clarity of mind, and brings peace to the spirit.

receptors for the sensations to occur. None of these sensations would be possible if were not the contact of these substances with our taste receptors:

> "Most taste receptors are chemoreceptors, which means they respond to chemicals that enter the mouth. [...] As the receptors are stimulated by the chemicals, they convert the chemicals into nerve signals, or action potentials. Inside each taste bud is a network of taste nerves." (Bjorklund 2010, 32)

The author Jorge Luis Borges stated "the taste of the apple [...] lies in the contact of the fruit with the palate, not in the fruit [...]." (in Pallasmaa 2012 (1996), 17) The experience of the physical act attributes a tasteful and memorable meaning to the fruit, that otherwise would remain inert and unknown.
When we put something in our mouth, touch receptors (mechanoreceptors) respond to substance textures as creamy, crunchy, watery, chewy (Bjorklund 2010, 34) influencing our present and future experiences with similar textural qualities. Kids tend to dislike certain flavors, not only for their tastes but also for their shapes and textures. Then we grow up and our perception of taste changes.

1.10 Touch

In *A Natural History of the Senses*, published in 1990, Diane Ackerman (1948–) affirms lyrically that "Touch seems to be as essential as sunlight." (Ackerman 1990, 80)

Touch:
encompasses all sensations from the body skin, muscles and joints, to viscera, including pain, thermal sensitivity, and position sense. Commonly, it is the sense by which we determine the size, shape, and texture of objects using receptors in the skin.
In medicine the term 'touch' is replaced with 'somatic senses' to consider the array of mechanisms involved. (Wikipedia)

Inherently touch is, although most of the times unknowingly, a vital sense of any living being, and is the most complex of all sensory systems. It is systemically intricate connecting through inner and outer inalienable complexity. Millar observed, "touch is not a single modality, nor even a single perceptual system." (Millar 1999) In its sensory complexity, touch intervenes not only in our capacity of movement and interaction, but it is also entailed in thought. The way we position ourselves in our environment structures the way we build our thoughts. Derrida (1981) noted, "Touch is the sense most affected by its object." (in Vasseleu 1998, 100) Touch shapes us. Touch enables us a cognitive apprehension of our surroundings. "Touch is the sensory mode which integrates our experiences of the world and of ourselves." (Pallasmaa 2012, 12) Driscoll reveals her experience:

> "Touch by its very nature creates a continuum of experience that transcends the mental divisions separating me from my depths and from the world around me. I found my place in the world by touching it." (in *Whole Body Seeing*, chap.11)

"Touch can be defined as the sensation evoked when the skin is subjected to mechanical, thermal, chemical, or electrical stimuli." (Cholewiak and Collins 1991 in Kortum 2008, 28) Commonly, touch is the tactile sensation the body receives, enabling us to detect objects, surfaces, substances, or events in contact with the skin. We "touch to experience, to acquire knowledge," (Lythgoe 2005, 41) and when there is the other, "we touch to communicate" (*ibid.*), and "to connect." (Driscoll, *Whole Body Seeing*, chap.11)

Touch is essential for a corporeal existence. It provides us a physical body with which we can feel what surrounds us. To Merleau-Ponty, touch is "a perceptual domain in which our sense of embodiment emerges." (in Vasseleu 1998, 98) Touch makes it possible for humans and other animals to perceive their body and its movement in space. Usually, we ignore that this sensory system is intertwined with the body mechanism that produces movement. Touch enables us to survive reacting and acting upon our habitat. Touch is the only sense capable of sensing and manipulating the environment powering a physical effect and transforming it to our needs and desires. Touch has the ability to simultaneously receive and give tangible stimuli. The sense we do not usually notice, which seems wrongly a passive sense, is constantly sending and retrieving messages susceptible of interpretation about how we experience our world. Gibson discriminated the tactual experiences of "stroking, caressing, twisting, pulling, sucking, prodding, and 'the crawling insect, the scratching thorn, the brushing leaf, and the shaking branch that need to be distinguished'." (Gibson 1966, 117) These events can be felt instantly at a light touch. Only a new sensation or a change in the quality of a sensation will stir up our touch receptors, otherwise, we become numb to a continuous one. As Ackerman puts it, "after a while we completely ignore it. [...] When any change occurs, the receptors fire and we become suddenly aware." (Ackerman 1990, 80) This enables us to be alert to a new sensation. Or we would feel a sensory overload from being continuously stimulated.
We have four distinct tactile receptors: *Meissner corpuscles*, *Merkel cell-neurite complexes*, *Pacinian corpuscles*, and *Ruffini endings*. Each touch receptors differ in the size of the receptive field, the type of stimulation it responds to, and the rate of adaptation. Ackerman describes the differences in sensations:

> "Pain produces irregular bleats from the nerves at jagged intervals. Itching produces a fast, regular pattern. Heat produces a crescendo as the area heats up. A little pressure produces a flurry of excitement, then fades, and a stronger pressure just extends the burst of activity." (Ackerman 1990, 81)

There is much more about the sense of touch than we usually notice or our intuition can tell, and more than technology is able to show. We do not often realize how touch is irreplaceable, its predominance, and importance. Taylor (1921) observed, "the greatest sense [of] our body is our touch sense." (in Montagu 1978, 1) Touch is the deepest and most complex sensory system, which integrates distinct body functionalities inside and out. Montagu calls it:

> "The mother of the senses, [because] in the evolution of the senses the sense of touch was undoubtedly the first to come into being [and] it is the sense which became differentiated into the others." (Montagu 1978, 1)

In order of appearance and dominance throughout our lives, the sense of touch is the prevalent sense. It is the first sense we experience before birth and the

To French-Algerian philosopher Jacques Derrida (1930–2004), "Touch signifies 'being in the world'." (in Kates 2008, 160)

In *Doing Before Hearing: On the Primacy of Touch*, from *Textes pour Emmanuel Levinas*, published in 1980, the American Jewish philosopher Edith Wyschogrod (1930–2009) interprets the French philosopher of Lithuanian Jewish ancestry Emmanuel Levinas (1906–1995) saying, "Touch is not a sense at all; it is in fact metaphor for the impingement of the world as a whole upon subjectivity... to touch is to comport oneself not in opposition to the given but in proximity with it." (in Paterson 2007 (Blanchot 1980, 199), 147)

last we sense before death. As Frederick Sachs (1988) so sensitively expressed in *The Intimate Sense of Touch*, in *The Sciences*, "the first sense to ignite, touch is often the last to burn out; long after our eyes betray us, our hands remain faithful to the world." (in Ackerman 1990, 71)

As we age we lose sensory acuity and dexterity. Sight and hearing diminish or we totally lose them, but the sense of touch remains almost unchanged unless we suffer from an extremely rare neurological condition. Senses grow with us. Practice makes them better, and maturity perfects them. Inexorably, as we age the skin becomes thinner, wrinkled, paler, more fragile, which in turn makes it less sensitive. (Hurd 2014) The complexity of touch allows a simultaneous interplay between touching and being touched, sensing and feeling. Acting on the discovery and risk for numerous corporeal possibilities. Touch makes an experience truly personal. The sense of touch is indispensable for our existence, but its capabilities have not been exhaustively studied as those of human sight and hearing. As Robles-De-La-Torre (2006) pointed out, this may be due to the complexity of what we term the sense of touch since in reality it is not a single sense, but many closely related sensory mechanisms. Referring to its complexity, Marshall McLuhan claimed that "it is the tactile sense that demands the greatest interplay of all the senses." (McLuhan 1969) Touch is implicated in all human activities even when we are not moving we sense the place we are in. To perceive its importance, Robles-De-La-Torre (2006) posed this thought-provoking question: — What would be worse, losing the sense of sight or losing the sense of touch? Most people would immediately assert that sight has more value than touch before they know how it is to lose their sense of touch. Possibly because we are unaware of the unbearable absence of touch, or how touch contributes to our daily abilities. (Prytherch and Jerrard 2003 in Robles 2006, 28) This is partly because of the subtle, effortless functioning of the sense of touch that we so readily neglect. (Robles 2006) Yet, we are continually in touch with something. Regardless the initial reaction, people have been acknowledging that the sense of touch is essential for their integral existence. As McLuhan specified, struggling for not feeling bodiless, "the weightless occupant of the space capsule has to fight to retain the integrating sense of touch." (McLuhan 1964, 122) Pallasmaa revealed:

> "Gravity is measured by the bottom of the foot; we trace the density and texture of the ground through our soles. Standing barefoot on a smooth glacial rock by the sea at sunset, and sensing the warmth of the sun-heated stone through one's soles, is an extraordinarily healing experience, making one part of the eternal cycle of nature. One senses the slow breathing of the earth." (Pallasmaa 2012 (1996), 62)

On Earth, humans have weight and due to gravity we are "attracted toward the center of the earth by a force proportional to its mass, as Newton discovered." (in Gibson 1966, 10) Unless jumping, we are incessantly in contact with something. We cannot "long avoid contact with the earth." (Gibson 1966, 10) When standing,

and despite most of the times wearing shoes having their sensitivity diminished, our feet touch a surface and through touch we feel our sensory body.

1.11 Haptic

The terms touch and haptic can be used interchangeably as they inhabit the same sense. The term *Haptik* was coined by the German psychologist Max Dessoir (1867–1947), who suggested in *About the Sense of the Skin* (*Über den Hautsinn*) published in 1892, to name the scholarly research about the sense of touch similar to the terms of acoustic and optic. Therefore, the term haptic is to touch, as optic is to sight, and acoustic is to hearing. (Grünwald 2008, 22)
In developmental and experimental psychology, the term haptic is used to distinguish between tactile or cutaneous sensation attributed to passive touch from the tactual or haptic perception attributed to active and exploratory touch. Haptic is tactual and muscular. It stands for an exerted muscular force implying a physical taction that is either done lightly or effortfully. Asserted by Gibson, "the sense of touch, or haptic, encompasses both cutaneous and kinesthetic or muscle-joint-tendon sensitivity." (Gibson 1963) Gibson defined haptic as "the sensibility of the individual to the world adjacent to his body by use of his body." (Gibson 1966) Haptic allows the pathic, or more prosaically, haptic is an integrative sense, due to bringing up our daily disposition to be receptive and responsive to sensations as sentient beings.
Though haptic is a fancy word for the most people. We have been dealing with haptic all our lives, but we never use the term haptic when referring to touch. Now, engineered technologies are becoming haptic, which means the ability to feel the physics of the objects, their weight, resistance, and texture features in virtual objects and environments with tactile feedback as a physical response to user inputs, but still many of us continue unaware to the terminology.
Articulated by Paterson, haptic is a combination of somatic senses, including the modalities of proprioception, meaning the body's position felt as muscular tension, the kinesthesia, which is the sense of the body movement, and the vestibular sense, the sense of balance derived from information in the inner ear. (Paterson 2007, 4) Haptic is the largest system of perception. The haptic system consists of "the entire sensory, motor and cognitive components of the body-brain system." (Oakley *et al.* 2000, in Paterson 2007, 132) The haptic sensory system is comprised of all the somesthetic senses. Haptic is the sense of touch, which includes the entire body through all its senses. In particular, it is connected to the perception and manipulation of objects using the cutaneous senses along with proprioception. It is the mechanism we use to situate our body in space feeling it and relating with it. Haptic refers to the capacity to experience the environment through active exploration, usually with the hands, as when palpating an object to determine its shape and material properties. (Robles 2006, 27) Commonly called active or haptic touch, (Gibson 1962, 477) it is where the

Haptic:
from the Greek *haptikos*, meaning 'pertaining to the sense of touch,' 'able to touch,' and the verb *haptesthai*, meaning 'to touch,' 'to grasp,' and *haptós*, 'palpable.'
As an adjective it means 'relating to,' or 'based on,' or 'proceeding from the sense of touch.' Used as a noun in the plural form 'haptics' refers to the physiology of manual sensing and manipulation of surrounding objects and environments through the sense of touch.
Touch is classified as passive and active, whereas haptic is often used associated with active touch, for using purposeful movements, generally with the hands, to explore the tangible world.

Pathic:
from the Greek *pathos* referring to sensitivity, affection, susceptibility, suffering, and more generally, exposure. In a larger life context, it refers to the general mood, sensibility, and felt sense of being in the world.

cutaneous and kinesthetic faculties are engaged in. Haptic is, therefore, the whole body inside and out. The whole body is made of a sensitive matter. The soul inhabits the body. Aristotle inferred "the soul cannot be without a body." (Aristotle 1907 (350 BC), 36) We cannot live dissociated from a corporeal existence. The soul is the cause and essence of the breathing body. The whole body is "perceptible by touch." (*ibid.*, 95) Haptic gives it physicality and allows it to be a sensing and moving body. "For every body that has [a] soul in it must [...] be capable of touch." (*ibid.*, 96) A body in its whole has a soul that guides it, a structure that forms it, muscles and tendons that give it the ability of movement, and a shell that protects it and provides sensation. We sense through the skin where the multisensory complexity of touch is much deeper than its outer layer.

1.12 Skin

In *Skin: Surface, Substance, and Design*, published in 2007, the American graphic designer, educator, writer, and curator Ellen Lupton (1963–) states, "Skin is a multilayered, multipurpose organ that shifts from thick to thin, tight to loose, wet to dry, across the landscape of the body." (Lupton 2007, 29)

Epidermis:
from the Greek *epi*, meaning 'over' or 'upon,' which with the dermis forms the cutis.
It is the thin protective, nonvascular, and nonsensitive outermost layer of the skin composed of stratified epithelial dead tissue, pigment, and proteins.

Dermis:
the middle of the three layers of skin, between the epidermis and the hypodermis (subcutis).
It is the thick layer of living tissue containing blood capillaries and lymph vessels, nerve endings, sweat and sebaceous glands, hair follicles, and a complex sensory nerve network.

Hypodermis:
the subcutaneous layer, the inner layer under the dermis, contains sweat glands, some hair follicles, blood vessels, and fat.

Skin is the primal organ of touch. Skin is the largest organ of the body and also the one where touch acts in its ultimate relation with the external world. Skin is universally the most associated with touch. Skin is tactile, sensitive, protective, identitary, and highly complex. British anthropologist Ashley Montagu (1905–1999) asserted, "the skin [is] the oldest and the most sensitive of our organs, our first medium of communication, and our most efficient of protectors." (Montagu 1978, 1) Besides being a container holder skin defines personal identity. (Benthien 2004) It communicates through evident characteristics that intervene in individual social behavior. Skin is what defines someone by race (color), health (clear skin), age (wrinkles), culture (ink, scarification, piercings, jewelry), individuality (freckles, signs, scars), and singularity (fingerprints, pore patterns). Skin is uniquely distinctive. As Ackerman remarked, "not only do we have unique fingerprints, we have unique pore patterns." (Ackerman 1990, 68) Skin is a living tissue:

> "Breathing and excreting, shielding us from harmful rays and microbial attack, metabolizing vitamin D, insulating us from heat and cold, repairing itself when necessary, regulating blood flow, acting as a frame for our sense of touch [...] and it is constantly renewing itself." (Ackerman 1990, 68)

Skin is in constant renewal throughout a person's life. Curiously, by the end of our lives, we may have lost about 50 kg (110 lbs) of dead skin. "Skin is made up of many layers, and new skin cells are being made all the time and push dead cells to the top layer where they are worn away." (Bjorklund 2010, 67) The layers of skin, or *strata*, are divided into three main sections, the *epidermis*, the outer layer, that mainly consists of a protective cover; the *dermis*, the middle layer, which contains cutaneous receptors, sweat glands, hair follicles, oil glands, and blood vessels; and the *hypodermis*, the inner layer, that is the subcutaneous tissue where fat is stored acting as insulator to help regulate body temperature. On the body surface, there are three kinds of skin, the *hairy skin* that has hair, the *glabrous skin* without hair, and the *mucocutaneous skin* at the entrance to

body cavities at the junction with mucous membrane. (Goldstein 2005, 537) Skin is also very fragile and can be easily damaged. It needs appropriate care to maintain its high sensitivity. "Keeping the body well nourished and supplied with plenty of water helps the skin stay healthy." (*ibid.*, 67) Skin is "waterproof, washable, and elastic." (Ackerman 1990, 68) Adapting to all stages of life, skin may bruise from falls, breakout often, have marks and scars due to acne, grooves as we grow up or gain weight, extend dramatically due to pregnancy and gain folds after weight loss, burn and blister from fire or sun exposure, cut and tear in accidents, pores open in dehydration, dry, thin, wrinkle, and have dark spots as we grow old. And, it can be softened, moisturized, toned or else badly cared, but along the time bearing all life transitions and situations. Skin reveals "health, youth, beauty, power, enjoyment, fear, fatigue, embarrassment, or suffering." (Connor 2004, 51) Differing in sensitivity from young to old age, but throughout life always sensing and being sensed. Whereas an encounter with the skin may be "passive," (Mileaf 2010, 11) it is not devoid of sensory information. Being touched is to touch with, therefore, the skin intensifies our inner and outer embodied experiences. Pallasmaa alluded "the skin reads the texture, weight, density, and temperature of matter." And "traces temperature spaces with unerring precision [...]." (Pallasmaa 2012 (1996), 62) Through skin, we can feel the temperature as a pleasurable event depending on the conditions. The heat of the sun radiation touching and coloring our skin make us anxiously desire for the summer arrival, where the cold of the ocean water invites us for a refreshing plunge. Whereas, the warm breeze caressing the skin make us yearn for the summer nights, but certainly, a cold shower feels good in the hot summer days. The skin color is given by the amount and distribution of melanin pigment in the epidermis. A variation in the outer layer skin makes it the only racial difference. The varying color of our skin reflects our psychological state, as when we feel blushing scarlet from embarrassment, shame, or timidity. Or from being enraged. "Green with envy." Or even completely white with fright, or pale from nausea. It also reflects our health condition. If our skin and eyes are yellow, it may due to being suffering from jaundice. But if our skin or lips turn blue, it may be a sign of cyanosis. And when we feel inner peace the skin glows from within. Thus, our skin is throughout a diary recording daily our outer and innermost conditional states of events and experiences. However, the first notion that commonly comes to our mind about touch are the tactile sensations felt on the skin. Although not restricted to it Marshall McLuhan asserted that touch "is not skin but the interplay of the senses." (McLuhan 1964, 72) Contradicting, the German physicist and philosopher Hermann von Helmholtz (1821–1894) who stated: "[E]verything's an event on the skin." (in Hara 2007, 101) Touch is (also) skin. The other senses are skin, as they consist of thin layers of skin called membranes. While the other senses are located in specific areas of the body, the cutaneous touch exists all over the skin in variable sensitivity. It varies in different parts of the body depending on the number of nerve endings exist in the area.

In *Touching: The Human Significance of the Skin*, first published in 1971, Ashley Montagu states, "Most of us take our skin entirely for granted, except when it burns and peels, or breaks out in pimples, or perspires unpleasantly." (Montagu 1978 (1971), 7)

"Actually, there are four different types of skin:
– Mucocutaneous: at the junction of the mucous membrane, hairy skin, lips, and tongue;
– Mucous membrane: lining the inside of body orifices;
– Glabrous: skin without hair;
– Hairy: skin with hair."
(Chudler 1996–2015)

"Glabrous skin has an epidermis layer of about 1.5 mm thick, and a dermis of about 3 mm. Hairy skin has an epidermis layer of 0.07 mm thick and a dermis of about 1–2 mm." (*ibid.*)

"In just a single square inch of skin exists 3 primary layers, 11 miles of blood vessels, 650 sweat glands, 60,000 melanin-maker cells, and over 1,000 nerve endings. On average the skin is 2–3 mm thick. On the upper back, skin can be 5 mm thick, while the thinnest eyelid flesh is around 0.05 mm."
(curiosityaroused.com)

Also "hairs on the skin magnify the sensitivity [...]." (Shergill 2012, 56) The neck, face, lips, tongue, hands, fingertips, and feet are of the most sensitive areas, whereas the back and parts of the limbs are the least. (*cf.* Weber 1996, 112–118)

1.13 Hand

As the other senses have dedicated organs (eye, ear, nose, mouth), Katz regarded not the skin, but the hand the organ of touch. Katz described the hand as a "unitary sense organ" (Katz 1989 (1925), 5) ending the arm and branching the body. Kant termed the hand the "man's outer brain." (in Katz 1989 (1925), 5) To him, the hand is "the visible part of the brain." (in Ackerman 1990, 116) The brain thinks and hands execute in a continuum exteriorization of thought. To Honoré de Balzac, "a hand is not simply part of the body, but the expression and continuation of a thought which must be captured and conveyed [...]." (Balzac 2012 (1899), 13) Dutch industrial designer Hella Jongerius says, she thinks with her hands and could not possibly work in a different way. (Jongerius 2011) — "Hands are the sculptor's eyes [...]," Pallasmaa replied. (Pallasmaa 2012 (1996), 60) Artists express creatively through their hands. Artists create with hands, but unavoidably the computer disrupts this dynamic bond. Hands are the connection between concepts and conceptions. Hands are utterly expressive so that artists have dedicated a long time studying and drawing them.
Socially, the hand represents a symbol that substitutes the whole body. It is tradition to ask for a woman's hand in marriage, or in — "I'll give you a hand," when offering help to someone. Hands care, hold, embrace. Hands slap, push, and pinch. Hands tell stories and not only by their wrinkles. When we speak or act our hands go ahead of us. They reach further, and when words escape us, they express our intents instead. Hands communicate quietly. To Henri Focillon, hands are "eyeless and voiceless faces that nonetheless see and speak." (Focillon 2013 (1934)) People who communicate through hands do it skillfully, as they have to express tone, a subtlety of feeling, and emphasis of meaning while forming words. For the deafblind, hands are "tools, sense organs, and voice." (Miles 2003) Marc Le Bot (1921–2001) stated that "because the hand is deaf, blind, and dumb, it is devoted to action. Hearing, sight, words keep their distance with respect to objects. The hand, touches, grasps, shapes them." (in Migone 2004, 3) To Le Bot, hands are inexpressive and soulless ends that obey to the mind. Nevertheless, hands want to act autonomously. Austrian poet Rainer Maria Rilke (1875–1926) uttered on the hands in his monograph on French sculptor Auguste Rodin:

> "[H]ands are a complicated organism, a delta in which life from the most distant sources flows together surging into the great current of action. Hands have histories; they even have their own culture and their own particular beauty. We grant them the right to have their own development, their own wishes, feelings, moods, and occupations." (Rilke 1919, 50)

Popular phrases on skin:
— *to be skin and bone.* 'to be very thin.'
— *to get under someone's skin.* 'to annoy or irritate someone intensely.' 'to fill someone's mind in a compelling and persistent way.' 'to reach or display a deep understanding of someone.'
— *it's no skin of my nose.* 'one is not offended or adversely affected.'
— *only skin deep.* 'not deep or lasting; superficial or slight; not profound or substantial.'
— *to have a thick* (or *thin*) *skin.* 'to be insensitive (or oversensitive) to criticism or insults.'
— *by the skin of one's teeth.* 'by a very narrow margin.'
— *to give someone* (*some*) *skin.* slang for 'shake or slap hands together as a gesture or friendship or solidarity.'

In *Letter on the Blind* (*Lettre sure les Aveugles*) published in 1749, the French philosopher, art critic, and essayist Denis Diderot (1713–1784) writes of a congenital blind man asked if he would be overjoyed to be able to see, to which the man replied, "I would just as soon have long arms: it seems to me that my hands would tell me more about what happens on the moon than you [cont. ...]

When the hand grasps an object, Lederman and Klatzky (1987) "described the exploratory procedures of 'the intelligent hand,' associated with the extraction of specific object properties." (in Katz 1989 (1925), 5) The hand, when kept motionless relative to the object is beset with a partial anesthesia. Movement is almost as indispensable to touch as light is to sight. (Katz in Krueger 1989 (1925), 5)
We 'see' with hands. Hands explore the world through the tactility of its fingertips. Hands operate the "mind's eye" through the fine dexterity of writing and drawing. *Ten Little Fingers* is the Orange's TV commercial, for the time of renaming the communication group from "France Telecom" to "Orange" in 2013, that says "the digital revolution is underway," the world is at the distance of a finger, yet reassuring us that no matter how technology evolves the human's essence will prevail — "This little finger will...," says the long gray beard grandpa to his six-month-old grandson. Hands narrate in angular movements the mystic stories of *Bharathanatyam*, the Indian classical dance from Tamil Nadu, South India. Hands are embellished distinctively depending on culture. For particularly auspicious occasions, as weddings, hands get ornamented with *Mehndi*, the traditional art of henna painting in India, brought by the Arabic Muslims, which symbolizes the quality of their love by the design, dye, and stain durability. The crafter is skilled working with hands. The jeweler elaborates preciously intricate pieces by hand. The *Hamsa* hand is an ancient Mesopotamian (Iraq) symbol of an open hand with the five fingers outstretched, believed to help banish evil or any negative energy, and bless its owners with luck and good fortune, that still today people choose to have it tattooed.
Hands are resourceful working forces, talkative, outgoing, affectionate, generous, and healers of ails, yet vulnerable to the passage of time, long time underwater, excessive cold, poor blood circulation, and people who bite their nails.

1.14 Pressure and Vibration

The ability to sense and exert pressure and vibration allows us to discern basic qualities of disparate stimuli. Pressure allows us to infer the inherent properties of fragility and weight that we need to assess for grabbing and holding an object in our hands without crushing or breaking it or letting it slip through our fingers. Bjorklund asserted "the ability to sense textures and pressure allows the body to accurately hold, grab, and lift, as well as to pull away or push against objects." (Bjorklund 2010, 38) Pressure provides the information on the soles of our feet against the ground, that our body needs to make the muscular adjustments that allow us to maintain the upright position. Cutaneous senses detect the sensations of tactile, pressure, vibration, temperature, and pain through four main types of somatosensory receptors: mechanoreceptors, proprioceptors, thermoreceptors, and nociceptors. The skin holds receptors responsible for conveying sensations from light to deep pressure, and from brief to sustained pressure. Depending upon how many receptors exist in the area, the skin is

[... cont.] can find out with your eyes and your telescopes; and besides, eyes cease to see sooner than hands to touch. I would be as well off if I perfected the organ I possess, as if I obtained the organ which I am deprived of." (in Paterson 2007, 37)

Tattoo:
from the Polynesian word *tatau*, meaning 'correct, workmanlike.' It is a form of body modification made by inserting indelible ink into the dermis layer of the skin to change the pigment. (Wikipedia)

Pressure Sense:
ability to discriminate various degrees of pressure on the surface of the body.
Also called baresthesia, piesesthesia. (Dictionary)

Vibration Sense:
ability to feel vibrations against various parts of the body. Vibration sense is tested (with a tuning fork) as part of the sensory portion of the neurologic exam. Referred as pallesthesia. (*ibid.*)

Pallesthesia:
from the Greek *pallein*, meaning 'to quiver.' It refers to hypersensitivity to vibration, particularly that caused by a tuning fork placed on a bony prominence. (The Free Dictionary)

particularly responsive to pressure. The fingertips are acutely sensitive and can sense a pressure that pushes less than 0,001 mm. (Schiffman 1976 in Shergill 2012, 56) The fingertips are sensitive to fine discriminative touch, meaning the determination of the precise location, texture, and form of objects pressed against the skin. (Linden 2015) Kenya Hara called the touch "the sense of pressure," as it enables differing pressure sensations that ought to be distinguished. Hara specified, the feeling of brushing softly with the fingertips is much different from grasping something with the whole hand. (Hara 2007, 101)

The sense of pressure enables us to distinguish degrees of pressure on our skin, wherein pressure can be characterized by a continuous type of sensation of a heavier touch, which means a continuous physical force that is exerted on or against our body by something in contact with it.

The sense of vibration enables us to feel vibrations against our skin, wherein a vibration presupposes a quivering type of sensation that varies in frequency and deepening. A vibration means a mechanical event of rapid linear motion. Researchers in Experimental Psychology have argued dissenting views on the qualities of pressure and vibration senses. German physiologist Max von Frey (1904) included the "pressure sense with our impressions of vibration, as well as those of contact, and tickle." (in Katz 1989 (1925), 7) German psychologist David Katz (1884–1953) stated (1925) that "vibration is a separate modality." (*ibid.*) Despite not having the necessity of its own sense organs, Katz replied. Katz agreed with Frey that vibration sensations are tied to the organs of the pressure sense, but disagreed with Frey saying "these organs can transmit vibratory and pressure sensations simultaneously and independently." (*ibid.*) Vibration is not a variant of the pressure sensation, but something qualitatively different, Katz continued. Due to disagreements in conducting procedures and interpreting experimental findings, "Katz became engaged in a long, spirited debate with von Frey as to whether vibration ought to be considered a separate sense from pressure." (*ibid.*, 6) From Geldard's data and other results, as to if the areas of the skin most sensitive to pressure are the same to vibration, Geldard (1940) "concluded that there is not a separate vibratory sense." (*ibid.*, 7) Though, other demonstrations, (Quilliam 1978; Vallbo and Johansson 1978) assist Katz's proposition that "vibration is indeed a separate sense." (Schiff and Foulke 1982, 15)

Katz affirmed that evolutionally the vibratory sense represents the connection between pressure and hearing. Saying that "in deaf people it functions vicariously for the absent auditory sense, and may even render music accessible to them." (in Krueger 1989, 3) Confirming Frey's finding that vibration sensations are clearer with tight and stretched skin, and with bone close beneath it, due to the greater resonance capacity of stretched skin and the bone conduction. (in Katz 1989 (1925), 197) Furthermore, Katz (1930) found that for the motionless organ of touch, the hand, adaptation happens rapidly, but not when there is movement. And Katz concluded that the vibratory sense, as the auditory sense, is almost tireless. (in Krueger 1989, 6) However, other evidences indicate that considerable adaptation

German-Swedish psychologist David Katz (1884–1953) published in 1925, the monograph *The World of Touch* (*Der Aufbau der Tastwelt*), which became a classic for researchers on the senses of touch. Katz's emphasis on active manual exploration of objects have influenced the increasing curiosity in exploring haptics today. Katz dealt particularly with the significance of movement for tactually experiencing objects and their attributes; the psychophysics of tactual texture perception; the function of vibration; and the contribution of temperature sensations to object perception. To Katz, the movement of the organ of touch relative to the object touched was crucial, as it provided input for the sense of vibration, which he regarded as a fundamental and sensitive modality and one that is independent of the sense of pressure. (Krueger 1982 in Prytherch 2002, 5) Yet, the scientific and systematic examination of the human sense of touch began with the investigations of German anatomist and physiologist Ernst Heinrich Weber (1795–1878), known as one of the earliest experimental psychologists. [cont. ...]

occurs even with the vibration sense. (Geldard 1940; Hahn 1974; Lederman *et al.* 1982 in Katz 1989 (1925), 6) The vibration sense may provide the movement the touch requires to keep it actively stimulated, but the continued sensation of the same vibratory stimulus numbs the sensory receptors and desensitizes the skin at the stimulated area.

To Katz, "the pressure sense determines the presence of a surface, whereas the vibration sense determines its properties." (*ibid.*) Just for resting the hand on a material may evoke the impression of a surface, but movement is necessary to discern its surface qualities and recognize its specific material. The movement of the hand when in contact with objects is fundamental, as it provides input for the sense of vibration, a cutaneous quality Katz regarded, all along, as a sensitive and separate modality, and independent of the sense of pressure, adding to the four basic cutaneous qualities or specific nerve energies previously proposed by Frey (pressure, pain, warm, cold).

Katz pointed out that "whereas the pressure sense is a proximal sense, the vibration sense is also a remote sense; it helps us to detect the approach of a far-off train or a herd of buffalo." (in Krueger 1989, 5) — But these vibrations are felt under our feet as proximal as the ones detected by the pressure sense.

[... cont.] In *The Touch* (*De Tactu*) published in 1834, and in *The Touch Sense and Common Sensibility* (*Der Tastsinn und das Gemeingefuhl*) published in 1851, he describes experiments on sensory psychology. A series of experiments curiously identified the left-right asymmetry in sensitivity, where the left side of the body is measurably more sensitive to stimuli than the right. Weber research contributed significantly to the understanding of the mechanisms of touch. (Grünwald and John 2008, 15)

1.15 Speech and Gesture

Before humans could verbalize intelligible words they exchanged gestures. Speech and gesture stem from the same stream of thought, that branch into divergent manifestations; to muscular and vocal, and to muscular and gestural. Our capacity to voice through speech is physiologically connected to the tongue. The fleshy muscular organ in the mouth is used by humans to articulate speech, which frequently is used in conjunction with hands or the whole body.

We gesticulate semantically to help emphasize discursive words and empower speeches. In some cases, gestures substitute speech, as in communicating at a long distance instead of shouting, when speaking is impossible or not allowed in places that ask for silence. Informally, we greet with a kiss on the face. While formally we handshake, originally signaling that we have come in peace. Whereas in some Asian societies, a nod of the head or a slight bow is culturally adequate. And formerly, it was usual among Eskimos, Maoris, and some other Pacific Islanders to rub noses in greeting as a sign of friendship.

Commonly, we point when we want to select someone or choose something. We wave through windows. We do the victory sign in revolutions fighting for new systems, civil rights marches, and political demonstrations. Religions have different signs to demonstrate devotion. The military have distinctive formal salutes to show hierarchical respect. Gangs have characteristic signs to express loyalty. Our hands speak for us when words do not come or they are not enough. We communicate with hands when a silent gesture says everything. We speak to a lover moving our mouths in mute mode when a sound is not needed.

Semantic:
from the Greek *semantikos*, meaning 'significant.'
It is the study of meaning. It focuses on the relation between signifiers (words, phrases, signs, and symbols), and what they stand for; their denotation.
Linguistic semantics is the study of meaning that is used for understanding human expression through language. (Wikipedia)

Sign:
is comprised of a signified, meaning the concept it represents, and signifier, which is the form the sign takes, and it can be referred to an image, word, sound, gesture, object.

We say how much we care for someone by caressing his or her face with a gentle touch. He shows protection when he kisses her forehead, she shows appreciation for him when she smiles. We make kids laugh with tickling, and we show approval, praise, or encouragement by clapping and cheering with joy.
Blind people have striking dexterity, reading books with fingertips up to 300 words per minute in braille alphabet, (Shergill 2012, 56) which are patterns of small raised dots on an embossed paper that varies from language to language. Deaf people communicate through sign language, which has different signs depending on the spoken language of a country. Socially, and many times unknowingly, we communicate through body language, manifesting facial expressions, body posture, hands position, and overall attitude. While touch bears emotions, the nonverbal and also the nonvisual signs of haptic communication in interpersonal relationships demonstrate how touch is extremely important for communication and is vital in conveying physical intimacy.

1.16 Senses of Touch

Touch is basilar. Touch is the "primary sense in all animals," Aristotle asserted. (Aristotle 1907 (350 BC), 55) "Without touch, it is impossible to have any other sense." (*ibid.*, 96) Usually, we do not notice how much the touch is present in all other senses. In different dimensions, all senses need contact for sensations to happen. Eye requires rays of light hitting the retina; a circular membrane 21 mm (0,82 in) in diameter and 0.5 mm (0,01 in) thick. Ear requires sound waves crossing the middle ear and striking the eardrum; the tympanic membrane 7 mm (0,28 in) in diameter to produce sound pressure vibrations in the ossicles, that reach the fluid-filled cochlea in the inner ear. Nose requires chemicals to reach the two nostrils mucus-coated membranes of 25 mm^2 (0,4 sq in) each up in the olfactory epithelium, where cilia hair cells "have olfactory receptors on one end and nerve fibers or axons on the other." (Bjorklund 2010, 35) Tongue requires chemicals reaching the taste buds, which are bumps under the mucous membrane of the tongue. None of these sensory sensations would happen if we could not sense them through contact. Aristotle asserted that "All the senses are thus but modifications of touch." (in Aristotle 1907 (350 BC) xxvi) The reason why in 2004, in Tokyo, Kenya Hara called *Haptic – Awakening the Senses* to his curated design exhibition relating all the senses to touch. To McLuhan, this relation to other senses defines the essence of the sense of touch when he says "it may very well be that in our conscious inner lives the interplay among our senses is what constitutes the sense of touch." (McLuhan 1964, 122) Canadian media theorist and curator Laura Marks relates haptic to whom who perceives with all the senses. (Marks 2002, 18) While the Finnish architect Juhani Pallasmaa (1936–) refers that all the senses have skin and that fact connects them to the sense of touch:

"All the senses, including vision, are extensions of the tactile sense; the

Ossicles:
are the three tiniest bones of the body: malleus, incus, and stapes, terms translated in Latin as *hammer*, *anvil*, and *stirrup* respectively. "Although the cavity they sit in is only about a third of an inch wide and a sixth of an inch deep, the air trapped there by blocked Eustachian tubes is what gives scuba divers and airplane passengers such grief when the air pressure changes. The three bones press fluid in the inner ear against membranes, which brush tiny hairs that trigger nearby nerve cells, which telegraph messages to the brain." (Ackerman 1990, 177)

Mucus:
is a noun referring to the viscous, slippery substance secreted as a protective lubricant coating cells and glands of the mucous membranes. (grammarist.com)

Mucous:
is an adjective meaning containing, producing, or secreting mucus; or relating to, consisting of, or resembling mucus. (grammarist.com)

> senses are specializations of skin tissue, and all sensory experiences are modes of touching, and thus related to tactility." (Pallasmaa 2012 (1996), 10)

Montagu noted that "even the transparent cornea of the eye is overlain by a layer of modified skin." (Montagu 1978, 1) All are, "Events on the skin." (Hara 2007) In all sensory systems, there is an element in common that bind them to the tactility of touch. And because each sense is not restricted to its organ, and a sensuous phenomenon can be systemic, "instead of the five detached senses, Gibson categorized the senses in five sensory systems: visual system, auditory system, the taste-smell system, the basic orienting system and the haptic system." (in Pallasmaa 2012 (1996), 45) Formerly, it was thought by the scientific community, that each sense acted isolated from the other senses. But actually, the senses are interconnected, one assisting the other, and if one misses, another sense may be trained to compensate the loss, albeit just in part. Or two senses in Helen Keller's case, and she compensated with touch.
Aristotle stated that "all the other organs of sense, no doubt, perceive by contact, only the contact is mediate[d]." (Aristotle 1907 (350 BC), 97) All life experiences are comprised of somatic sensations. A haptic phenomenon happens even without an explicit tactile contact. When an unpleasantly harsh optical event of a bright white light striking the eyes with an immense intensity, force us to an immediate reaction of closing them to protect the eyes from a temporary blindness. Or, the strong pressure waves felt in the chest when we are near the big loudspeakers of a live concert in an enclosed venue are perceived as internal involuntary vibrations. All our somatic sensations exist because we have a fully functional somesthetic system. But what would happen if we did not have it? What more is touch implicated in?

1.17 Somesthesia

Almost unnoticed, touch is the sense we regard closely when we lose it. Although being possible to receive tactile guiding cues with the eyes closed, when there is damage to the nerves that carry sensory information to the central nervous system, it is impossible to close eyes and not have the sense of touch, resulting in losing the visual contact with the ground, with a frightening feeling of being levitating, due to the lack of bodily sensation for bearing a numb and unfeeling body. (Robles 2006, 25) The impressive case of Ian Waterman (1952–) reported in *Pride and a Daily Marathon*, published in 1995 by neurophysiologist Jonathan Cole, demonstrates how it is to lose the perception of the body.
When he was 19, and after a viral infection, Waterman suffered a sudden and total deafferentation of his body, meaning the near total loss of all the touch. Waterman lost cutaneous touch, movement and position sense below the neck. He could not walk or stand upright, but retained temperature and pain sensation. He retained motor capabilities because there was no damage to the nerves that

American graphic designer, educator, writer, and curator Ellen Lupton articulates on the comprehensiveness of the skin, "Lacking definitive boundaries, it flows continuously from the exposed surfaces of the body to its internal cavities." (Lupton 2007, 29)

Cue:
in Psychology refers to a stimulus, perceived either consciously or unconsciously, that elicits or signals a type of behavior. (The Free Dictionary)

In *Phenomenology of Perception* published in 1945, French philosopher Maurice Merleau-Ponty (1908–1961) states, "In so far as I have hands, feet; a body, I sustain around me intentions which are not dependent on my decisions and which affect my surroundings in a way that I do not choose." (Merleau-Ponty 2002 (1945), 511)
In case of Ian Waterman, those intentions were performed by a body hardly controlled, yet conducted by a conscious will, but sometimes just happening unconsciously. (thearticulatehand.com/ian.html)

communicate the central nervous system to the muscles. His muscular control was unaffected by the infection, therefore, he could move his limbs, but could not control them in a desirable way, because he had no feedback from his peripheral nerves. (Cole and Waterman 1995 in *ibid.*, 25) His sense of proprioception was affected (or the "sense of self," expression used by psychologists to describe the perception of where our body parts are). When not looking at his limbs, Waterman could not tell their position or if they were moving. His arms would move uncontrollably. Sometimes they would unwittingly hit him. When lying in bed, he could not feel the body nor the bed. Proprioception, as kinesthesia, is driven by somatosensory receptors in muscles and joints. The nerves connecting Waterman's proprioceptive receptors to his brain had been cut off. (Cole 1995 in Wolfe *et al.* 2009) In the early years, and although he was not paralyzed, Waterman had to live with a wheelchair. Later and through a tremendous conscious effort, he learned to use sight to tell him what his proprioceptive receptors could not. Thus, he was able to walk seeing his legs moving, and putting one foot down when it moves in front of the other, (Cole and Waterman 1995 in Wolfe *et al.* 2009, 27) but not feeling the ground, though.

After two months of relearning, he was able to sit up. Relearning to stand up took about one and a half year longer, and several months later, he learned to walk again, (Cole and Paillard 1995 in Robles 2006, 25) despite he has never recovered the ability to perceive the position or movement of his limbs. Through the guidance of sight, Waterman must exert an extensive conscious effort to apply appropriate muscle force during a certain duration to accomplish any task.

In the beginning of his state, and if the lights went off, happening to be standing up, Waterman would fall to the floor, because of his inability to supervise his body in the dark, without sight. (Robles 2006, 26)

Years later, Waterman could avoid falling, exerting an incredible effort to tense his muscles. This conscious and extremely exhaustive effort required several days of rest for mental and physical recovery. (*ibid.*, 26)

The loss of position sense in his limbs had other frightening consequences. It could happen that when waking up in the morning, Waterman would feel momentarily terrified with a hand on his face, not realizing for an instant that the hand was his. (*ibid.*, 26)

With sight, Waterman learned to control the spontaneous arm movements, but still he is unable to use his hands normally. He relearned the ability to write, where he has to put full attention, not being able to listen to people and simultaneously controlling his handwriting. With the lack of accuracy, he tends to use excessive force when holding objects, preferring to deal with rigid objects instead of deformable ones, such as plastic cups. (*ibid.*, 26)

Waterman lost all his proprioceptive capabilities and most cutaneous sensations, except pain and temperature sensations, retaining "the sensation of muscle effort, cramping, tiredness, and tension." (Cole 1995 in *ibid.*, 27) Without the response from his peripheral nerves, Waterman is incapable of obtaining cues from the

Somesthesia:
is the faculty of bodily perception, and the sensory systems associated with the body, which includes the skin senses, proprioception and internal organs.
(The Free Dictionary)

Somatosensory System:
is the network of nerve endings and sensory receptors in the skin and epithelial tissues, skeletal muscles, bones and joints, internal organs, and the cardiovascular system. It indicates a sensation, such as pressure, pain, or warmth, that can occur anywhere in the body, in contrast to one localized at a sense organ, such as sight, balance, or taste.
(Wikipedia; New Oxford American Dictionary)

Deafferentation:
is the absence of peripheral sensory afferences happening when there is elimination or interruption of sensory nerve impulses by destroying or injuring the sensory nerve fibers.

Afference:
from the Latin, *ad* meaning 'to' and *ferre* meaning 'to carry.'
It refers to conducting or conducted inward or toward something.
It is the brain's reception of signals from the body.

active touch; being unable to determine the properties of objects by haptically exploring them, and use the "force-feedback information about the environment to control his body or perceive the world." (*ibid.*)
The sensory loss of Waterman can be remotely experienced after local anesthesia to a hand, resulting in having extreme difficulty "to grasp and manipulate small objects, or perform precision actions such as buttoning a shirt or lighting a match." (*ibid.*, 26) Losing the sense of touch is not common, for this reason, the consequences are not known for the most people. The lesions in the nerves that carry sensory information to the central nervous system result in disorders of touch that are the most severe:

> "Proprioception can be damaged by viral or bacterial infections of the inner ear, the vestibular nerve, or the lining of the brain (meningitis). Head or brain injuries can also damage proprioception. Nerve disease, such as multiple sclerosis, can also impair the vestibular system and interfere with proprioception." (Bjorklund 2010, 52)

Mexican computer engineer and the founder of the International Society for Haptics, Gabriel Robles-De-La-Torre summarized the relevant consequences of having a major loss of somesthetic capabilities (*ibid.*):

- Loss of capability to sense limbs movement and position.
- Major impairment in skilled performance, even with full sight and hearing. Aggravated as visual information degrades.
- Abnormal movements and the inability to walk having to exert extreme effort to relearn how to walk.
- Major loss of precision and speed of movement, particularly in the hands.
- Major difficulty performing tasks that combine significant cognitive loads and fine motor skills such as handwriting.
- Major difficulty learning new motor tasks, relearning lost ones or using previous experience to guide these processes.
- Loss of the unconscious ability to communicate through body language. (Cole and Paillard 1995 in *ibid.*, 28) Only possible of relearning a limited number of gestures.

The loss of sight is generally compensated by strengthening the other senses, but it is hard to imagine experiencing the drastic consequences of even partial impairment of somesthesia. Specified by Robles-De-La-Torre, the loss of the sense of touch would result "in catastrophic impairments of hand dexterity, haptic capabilities, walking, [the] perception of limb position..." (*ibid.*, 24) Waterman had difficulty in explaining his rare neurological illness and consequential devastating losses to other people.
Much is still unknown as to the somesthetic functions. Because touch involves the whole body, is systemic rather than localized, "the overall effects of major somesthetic loss could probably surpass those of blindness or deafness," as

Haptic sensitivity can be impaired by a multitude of diseases and disorders.
Predominantly are skin injuries (insicions, burns) and nerve lesions (injury or impaired circulation). Additionally, loss of sensitivity (neuropathy) can be caused by metabolic, toxic and/or immunologic factors. Exemplary medical conditions are diabetes mellitus, chronic kidney disease, thyroid dysfunction (hyper- and hypothyroidism) as well as hepatitis, liver cirrhosis, and alcohol dependency. (Wikipedia)

There was a described case of neurological discoordination of a musician that could only function when there was music or he was singing. Otherwise we would even mistake his wife for a hat. A clinical case reported among others in *The Man Who Mistook His Wife for a Hat*, published in 1986, by the English neurologist Oliver Sacks (1933–2015).

The myelin sheath that covers nerve fibers can deteriorate due to heredity or nutrition problems and cause disorders of the neurological system. (wisegeekhealth.com)

Robles-De-La-Torre adverted. (*ibid.*, 28) Somesthetic information is essential for accurate interaction with our environment. Usually, we perform somesthetic functions effortlessly, without conscious awareness, but without adequate somesthetic responses, it is extremely difficult or even impossible to accomplish ordinary tasks on everyday activities that require complex dexterity. To grab, grasp and handle small objects seems deceptively simple, but actually requires exquisite dexterity that relies on adequate somesthetic information. (*ibid.*, 28) It must be strenuous to deal with daily life suffering from the adverse effects of losing the somesthetic control. With great amounts of effort to regain the ownership of his body, Waterman endured an unfeeling and untamed body. Waterman lost the body perception and control over his body to perform daily activities, but there are cases of sensory processing disorders of young children struggling with their disobedient bodies:

> "He was born with no sense of touch in his arms, hands, legs, and feet. With a few spots as exceptions, he feels in his limbs neither heat nor cold nor contact nor pressure nor vibration nor pain, although he experiences normal sensation in his head and trunk. His legs were repeatedly damaged in childhood when he walked, ran, and played baseball." (Brynie 2009, 3)

Proprioception disorders happen when the brain knows what to do, but the body does not obey. It happens when the brain does not update perceptual sensory information for the body awareness, control, safety, and well-being. The *hypothalamus* is the area of the brain responsible for controlling autonomic functions of our body that we daily do unconsciously and effortlessly.
To these uncoordinated children, the daily tasks can be a struggle and often grueling. "As a small child, he could grasp with his palm but he never learned to make the finely controlled, pinching movements needed to pick up small objects." (Brynie 2009, 5) If children have proprioceptive dysfunctions manifested in poor body awareness or motor control, they will have difficulty climbing, running, riding a bike, hitting a ball, roller skating. They will have difficulty tying shoes and "buttoning shirts." (*ibid.*, 3) They will frequently bump into things and people unwittingly. They will trip and fall often. They will have difficulty learning to go up and down stairs avoiding them. (sensory-processing-disorder.com) These kids difficulties will be reflected in insecurity and anxiety, and lack of interest in learning and overcoming challenges.
Frequently, we disregard how the somesthetic senses impact our emotional and intellectual being.

1.18 Proprioception and Equilibrioception

The sense of proprioception enables us to detect stimuli arising from within the body (interoception) about its position, location, orientation, and movement

Proprioception:
British neurophysiologist Charles S. Sherrington (1857–1952) named the sense proprioception, in the article *On the proprioceptive system, especially its reflex aspect*, in Brain 29(4): 467-482, 1906. From the Latin *proprius*, meaning 'one's own,' 'individual,' and *capio*, *capere*, 'to take' or 'grasp.' It is the sense of the relative position of neighbouring parts of the body and strength of effort being employed in movement. After the work of the Scottish surgeon, illustrator, anatomist, physiologist Charles Bell (1774–1842) on 'muscle sense' in the article *On the Nervous Circle Which Connects the Voluntary Muscles with the Brain*, at Philosophical Transactions of the Royal Society of London, 116(1/3): 163-173, 1826.

Proprioceptive sensation:
informs us, consciously and subconsciously of the degree to which the muscles are contracted, amount of tension present, position of joints, and orientation of the head.

Proprioceptor:
allows us to estimate weight of objects and determine amount of effort necessary to perform a task.

of the body and its parts. If it was not for the proprioceptive sense, we would not perceive the body as a whole in its different moving parts. We would not be able to control our limbs. If we close the eyes, we can touch with the forefinger the tip of the nose, and we know exactly if an arm is above the head, hanging by the side of the body, or stretched parallel to the ground. The state of the body is essential for our embodied existence.
Proprioception is comprised of information from sensory neurons located in the inner ear (orientation and movement) and in stretch receptors located in the muscles, tendons, and joint-supporting ligaments (stance).
While there are specific organs for exteroceptive senses, as sight and hearing, there is not an equivalent correlation between receptors (proprioceptors) and organs for proprioception. Proprioception is one of the somatic senses within the sensory system of touch:

> "Proprioception is the ability to sense position, location, orientation, balance, and movement of the body and all its parts. Proprioceptors are special nerve endings found in muscles, tendons, joints, organs, and the inner ear. These sensory receptors respond to stimuli inside the body that react to the body's position, movement, or speed." (Bjorklund 2010, 30)

Both somatic senses, proprioception, and equilibrioception are based on sensors in the inner ear (vestibular system). The vestibular system consists of two parts: the *otolith organs* that sense the head's linear acceleration (motion in a straight line), the head's position relative to gravity, and "bodily postural equilibrium" (Gibson 1966); and the *semicircular canals* that detect the head's rotation (turning motion). The sense of equilibrium (equilibrioception) is what prevent us (humans and animals) from falling when walking or standing still (balance) and helps us walk in a straight line (coordination). "Like the sense of hearing, equilibrium depends on mechanoreceptors (hair cells) located in the inner ear." (Light 2005, 106) "The sense of equilibrium (balance and coordination) lets us detect the position of our head by monitoring gravity, linear acceleration, and rotation." (Light 2005, 106, Bjorklund 2010, 30) The sense of equilibrium is the result of different body systems functioning jointly: the eyes (visual system), inner ears (vestibular system) and the body's sense of where it is in space (proprioception). Disturbances affecting the balance system, or within the brain's integration of inputs can cause the feeling of dizziness or unsteadiness, resulting in losing our balance and falling, due to the sensation of spinning around in the head.
Equilibrioception disorders when claiming that symptoms may include "dizziness, motion sickness, imbalance, disorientation." (Bjorklund 2010, 52) Douglas Light asserts that motion sickness is a common equilibrium disorder of when the brain receives conflicting information. It is caused by a disparity of sensory input to the brain. *e.g.* When reading in a moving car, the visual inputs tell the brain that the body is fixed with reference to the motionless book. As the car turns and changes the speed the vestibular system detects movement and

Exteroception: responsiveness to external stimuli. The faculty of sensation.

Interoception: sensitivity to stimuli originating inside the body, in blood vessels, visceral organs, and muscles. Provides information about the internal environment (pain and pressure).

Equilibrioception: is maintained by a complex interaction of visual inputs, proprioceptive sensors, which are affected by gravity and stretch sensors found in skin, muscles, tendons, and joints, the inner ear (vestibular system), and the central nervous system.

Vestibular: of or relating to a vestibule, in particular of the inner ear, or generally to the sense of balance, (New Oxford American Dictionary) pertaining to the perception of head position, acceleration, and deceleration.

Kinesthesis: the British neurophysiologist Henry Charlton Bastian (1837–1915) introduced the term Kinesthesis, in the article *The 'Muscular Sense'; its Nature and Cortical Localization*, in Brain 10: 1–36, 1888.

sends impulses that contradict the visual information. Symptoms include excessive salivation, turning pale, rapid deep breathing, profuse sweating, nausea, and vomiting. Similarly happens in a boat, the visual inputs suggest that the body is not moving, but the inner ear can sense the boat moving in the water. This leads to seasickness, which is a form of motion sickness. Anti-motion medication can relieve this condition by inhibiting vestibular inputs to the brain. (Light 2005, 110) Moreover, the fit condition of our senses (proprioception and equilibrioception) depends on good sight, healthy eating habits, resting sleep, good coordination, muscles and tendons strengthened by regular exercise.

1.19 Kinesthesia and Walking

The kinesthetic sense is what enables us for the sensation inside the body of the movement of muscles, tendons, and joints. Formerly, it was called "visceral sensitivity," "muscle sense," or the "inner sense." (Çelik in Jones 2006, 161) So, that we hardly associated the sense of touch to a sensory system dedicated to the body movement.

> "[...] walking is the forward motion of the body created by the pendulum-like swinging limbs and the body's balance with gravity, but we do not undertake each instance of this activity in any planned manner." (Hara 2007, 103)

Since our first effortful attempts to start walking when we were of very young age, we now walk almost unaware of the complexity of movements our body has to process. "We usually don't examine every external stimulus involved in walking before we take the next step." (Hara 2007, 103) Our brain has about 100 million neurons coordinating to just make our bodies walk. (everybodywalk.org) "Walking is man's best medicine," said Greek physician Hippocrates (c.460–c.370 BC). Our somatosensory system would greatly benefit from swapping a sedentary life for an active lifestyle, walking and running outside. Leaving the car at home and not being sitting so much time. Walking upright is what make us humans, but we spend most of our lives in a seated position. A way to combat economic crisis and oil dependency, as to raise environmental responsibility is to start using our legs more often to walk; to do long walks in nature. British walking artist Hamish Fulton (1946–) promptly asserted:

> "Our rejection of nature is the cause of global warming — walking [...] allows us the opportunity to be influenced by nature and gain an attitude of respect for all life-forms, not just human life." (Fulton 2010)

So, could we reduce the damages we cause to the environment if we walk more, directly feeling and appreciating in respect the grounds under our feet? Could we change the perception we have of our surroundings enhancing the proximity between humans and nature?

Kinesthesia: from the Greek *kinein,* 'to set in motion,' 'to move,' and *aisthesis* 'perception.' It is the awareness of movement of muscles, tendons, and joints allowing to coordinate them when we walk, talk, and use the hands. However, it has been used inconsistently to refer to proprioception or the brain's integration of proprioceptive and vestibular inputs, but while some joints have movement-sensing capabilities they do not have static-position-sensing ones. (Clark *et al.* in Robles-De-La-Torre 2006, 27)

Neuroscience made a description of what happens in the brain for us to walk: "Voluntary movement starts in the motor cortex, at the rear of the brain's frontal lobe. The motor cortex communicates with other parts of the brain, including the visual cortex and cerebellum, and the vestibular system, the balancing apparatus in our inner ear — a feedback loop of electrochemical information about the body's position in space, the goal to be attained, an appropriate strategy for attaining it and memories of past strategies. The cerebellum, tucked beneath the back of the brain, is like an [cont. ...]

A few hikers interviewed for the National Geographic video documentary *Into the Wilderness*, at Glacier National Park, USA, have answered feeling stronger, better people, having more respect for nature, and more aware of themselves. The relation with the surroundings attributes to walking a relevant kinesthetic experience. When walking, we experience strongly the entire body, and we have a better perception of what surrounds us. Much different from what we have when we are sitting inside a car. Not only we are able to feel directly the ground under our feet with its inherent challenging tactile qualities, but that we improve our overall physical condition, relaxing and tensing muscles at our will and with the freedom of movements. When walking, we have a broader perspective of space with a wider visual field, which augments our perceptiveness. Whereas inside a car our visual attention is confined to framed windows as screens and is conditioned by road velocity regulations, road obligation directions, and by traffic conditions. Surrounded by many highways and not enough walkable sidewalks, the city dwellers live enclosed in four walls and inside cars, both distancing them from the natural world. In the non-pedestrian apologist cities, floors are covered with hard materials that drive us away from the natural tactile sensations. Cities grant us concrete and mechanical locomotion. Edmund Burke said, "the sense of feeling is highly gratified with smoothness." (Burke 1998, 211) Smoothness is pleasurable to all our embodied senses. Opposite sensations cause "violent tension or contraction of the muscular fibers." (Burke 1998, 211) These somatic reactions may happen involuntarily as a result of an adverse event and are contrary to the sensations of relaxation in pleasurable moments. Whereas, "a walk through a forest is invigorating and healing due to the constant interaction of all sense modalities." (Pallasmaa 2012 (1996), 44) The somatic awareness of the natural elements makes us be more attentive and feel more perceptive. The American philosopher and psychologist John Dewey (1859–1952) believed that "humans only feel properly alive when absorbing the aesthetic features of nature." (in Leddy 2008) We not only inhabit a place, but we interact with the environment. When walking, we feel the smooth breeze on our face and the gentle wind in our hair, the caressing warmth of the sun and the light rain on our skin, the scent of grass after rain or the soft touch of freshly trimmed grass. These are all very much pleasurable and a full awakening of the senses.
If daily we had more opportunities to promptly feel the ground idiosyncrasies we would respect it more in return. We could alter our haptic perception and intensify our awareness, honoring our need of memorable moments of gratifying somatic sensations. From making the brisk walk a regular routine, of an average of 30 minutes a day five times a week, favors a healthy somatosensory system for a desirable thriving life. Taken from a social transformation program that intends to change sedentary habits motivating people to walk, these are the health benefits listed:

> Boosts endorphins easing stress, tension, anger, fatigue, and confusion; Reduces glaucoma risk; Limits sickness by halving odds of catching a

[... cont.] air-traffic controller, regulating the details of each motion. Neurons in the motor cortex have long extensions, or axons, that descend into the spinal cord. As we evolved from quadrupeds into an upright species, our bodies realigned into a column, with the long, forward-tilting primate pelvis taking on the squat, vertical form it has today. The skull also changed; the foramen magnum, the hole through which the motor cortex axons connect to the spinal cord, shifted from the back of the skull to the bottom. These axons transit information to motor neurons in the spinal cord via connecting synapses, and the motor neurons send impulses to our muscles, causing them to contract. In total, about 100 million neurons fire, and your foot — an intricate structure with 26 bones, 33 articulations, 111 ligaments and more than 20 muscles — begins to lift." (Montreal's McGill University in Rubinstein 2015, 23)

"Babies learn to walk from a progression that requires sufficient strength, balance, practice, and brain development." (Rubinstein 2015, 28) And then in adults forget to walk.

> cold; Halves Alzheimer's disease risk over 5 years; Works arm and shoulder muscles; Improves heart health by increasing heart rate and circulation; Engages AB muscles; Improves blood pressure; Builds bone mass reducing risk of osteoporosis; Limits colon cancer; Strengthens legs, including quadriceps, hip flexors, and hamstrings; Improves balance preventing falls; Burns more fat than jogging. (everybodywalk.org)

The Greek physician Hippocrates (c.460–c.370 BC) affirmed, "If you are in a bad mood go for a walk. If you are still in a bad mood go for another walk." Like an optimized gear, the brain works better when we put our body to move. Walking strengthens jointly body and mind. German philosopher Friedrich Nietzsche (1844–1900) said, "All truly great thoughts are conceived by walking." The brain gets increased oxygenated hemoglobin with walking, and that is why we are more creative during and after a walk. But only when walking outside, among the invigorating nature and natural elements. It depends on the nourishment our body receives to maintain a good balance between bone structure, muscle tone, and body fat, that is essential to keep the body lean, fit, and vibrantly healthy, to make the movements free, graceful, and highly sensitive. Without body shame or guilt, we may have more disposition to seek for quality options, and to focus on living a life full of new and gratifying somatosensory experiences. Our body is permanently being transformed by our perception and by the social and cultural environment in which we live. As Pallasmaa asserted, "our bodies and movements are in constant interaction with the environment; the world and the self inform and redefine each other constantly." (Pallasmaa 2012 (1996), 44) Our body is vital for our existence, and touch is the primal sense of the connection with the environment in which we operate, sending and retrieving information to and from the body while transforming it at our will.
Our body is an enclosed container working autonomously with a highly complex metabolic system, and to have it functioning right, we need to be aware of what we put inside. Richard Rorty stated, "if the body had been easier to understand, nobody would have thought that we had a mind." (in Pallasmaa 2012 (1996), 14) A mind capable of learning by mimicking and association, of abstract thinking, of educating the body and transforming it entirely for our best well-being. For this, the intake of vitamin B3 (Niacin), existent in carrots, broccoli, tomatoes, potatoes, wheat germ, whole wheat, and peanuts, helps to obtain energy from the food and is essential for healthy skin, blood circulation, and nervous system. Excellent to intensify tactile sensations making our skin much more responsive.

1.20 Thermoception and Nociception

Senses that respond to temperature and pain act to keep us securely protected. Thermoreceptors in the skin and inside the body respond to sensations of heat and cold. These are responsible for keeping us safe from burns and to regulate

Thermoreceptor:
is a sensory receptor or sensory neuron (nerve cell) that responds to changes in temperature (heat and cold) and transduce heat energy into nerve impulses sending signals to the spinal cord and brain.

Nociceptor:
from the Latin *noci* meaning 'injurious' or 'hurt.' It is a sensory receptor or sensory neuron (nerve cell) that responds to injurious or painful stimuli, and transduce various forms of energy (mechanical, thermal, chemical, or electrical) into nerve impulses.

Paresthesia:
from the Greek *para*, meaning 'beside,' *i.e.* abnormal, and *aisthesia* meaning 'sensation.' It is the sensation of tingling, prickling, numbness of the skin, and impaired dexterity that may be temporary, or permanent resulted from nerve damage. Paresthesia of hands, arms, feet, and legs, popularly known as "pins and needles," or of a limb "falling asleep" are common transient symptoms caused by restriction of nerve impulses to an area of nerves, or lowered blood supply, usually by leaning or resting on parts of the body.

the vital body temperature at 37°C (98.6°F). (Bjorklund 2010, 38) The mouth contains mechanoreceptors, thermoreceptors, and nociceptors that coordinated help in the chewing and swallowing processes in safety conditions. (Light 2005, 40)
Most of the receptors in the skin are pain responsive. *Myelin sheath* is a layer of fat and protein that wraps the nerve fibers. This allows the nociceptors to transmit signals at a rapid pace responding to sharp and fast pain. And the unencapsulated nerve fibers do not have the membrane. They transmit a much slower pain responding to dull and aching pain. (Bjorklund 2010, 37)
The somatic pain is caused by stimulating the nociceptors in the skin, muscles, tendons, bones, joints, and ligaments. Visceral pain is produced by nociceptors found in internal organs and body cavities normally with fewer nociceptors. (*ibid.*) Street runners have chest pain while running in cold weather because they inspire much faster than the lungs can heat the air. Pain is a necessary physiological component to alert us that something is doing us harm.
The problem is when one feels it exacerbated because the brain is not receiving and responding properly to information that comes in through the senses. Clothes hurt when children have hypersensitivity, which is a sensory processing disorder in the nervous system to interpret a tactile stimulus. This is manifested in being easily overwhelmed by tactual sensations and fearful of ordinary daily experiences and activities involving touching. Avoiding it, becoming nervous about it, or bothered by textures, rough, messy, or bumpy fabrics, tags on shirts, seams on socks, shoes, wind blowing on bare skin, bare feet touching grass or sand, because these sensations are overly intense for them. These children respond aggressively to whom that unknowingly try to impose them on tactile interactions like a kiss or a hug. (sensory-processing-disorder.com)
There are also cases of young children who suffer from hyposensitivity to tactile stimulation. These children do not feel pain, and they easily get burned or have the body bruised from falls, trips, and crashes. "Because he felt no pain, everyday activities were hazardous." (Brynie 2009, 5) These children are very susceptible to dangerous situations because the unresponsive pain sensors in the skin do not warn them of the danger. They seem to be in a permanent state of anesthesia due to their inability to feel any somatic pain.

1.21 Synesthesia

Is a sensory condition of someone experiencing unwittingly cross-perceptual stimulation of two corresponding senses. It happens when a stimulation evokes the sensation of another, *e.g.* hearing a sound induce to visualizing a color, or a shape is sensed as a smell. Or when a sensation felt in one part of the body results in a stimulus applied to another, *e.g.* alluding to pain. And when the description of one sense impression is made of words that normally describe another. Synesthesia is a hereditary neurological phenomenon of one sensation that is interpreted by areas of the brain dedicated to another sense, resulting

Myelin sheath:
is a layer of fat and protein that covers the axon of a neuron, or nerve cell. The axon, which is a long, thin projection, is designed to carry electrical signals from a neuron to other cells. The purpose of the sheath is to insulate the axon so electrical energy is not lost as it travels along the pathway. (wisegeekhealth.com)

Synesthesia:
from the Greek *syn*, meaning 'together,' *aisthanesthai* meaning 'to perceive,' and *aisthsis*, meaning 'sensation.' It means co-perceiving, 'union of senses,' 'joined sensation,' or experiencing a sense impression relating to one sense by the stimulation of another sense. (New Oxford American Dictionary; Ackerman 1990)

In *Synesthesia: A Union of the Senses* published in 2002, Richard E. Cytowic suggests that "the limbic system may act as a bridge to bind the various corticol areas involved in the experience of synesthesia." (Cytowic 2002, xiv)

Chromesthesia:
a form of synesthesia in which nonvisual stimulation results in the experience of color sensations. (The Free Dictionary)

in a sensory response to one sense of another sense perception, or more commonly, in experiencing sensations together, with descriptions like "seeing yellow on touching a matte surface, smelling the passage of time." (Ackerman 1990, 295) of a "man who tasted shapes" (Cytowic 2003 (1993)) or "Wednesday is indigo blue." (Cytowic and Eagleman 2009)

A research done by the synesthete Sean A. Day (1993) listed nearly 40 distinct types of synesthesia. It also reported a greater occurrence in women. (in Heyrman 2005) One of the most reported dual sensory correlation is between sound and "patterns of colors (photisms)," (Dworak 2010) but combinations can be between time units and colors, smell and color, taste and color, numbers or alphabet (graphemes) and color...The latter one can be particularly impeditive for the graphic designer who fixedly see colors associated with matching letters. Although, there are cases of artists who have integrated synesthesia productively. One of those synesthetes was the Finnish composer Jean Sibelius (1865–1957):

> "For him, there existed a strange, mysterious connection between sound and color, between the most secret perceptions of the eye and ear. Everything he saw produced a corresponding impression on his ear — every impression of sound was transferred and fixed as color on the retina of his eye and thence to his memory." (Ekman 1938, 41)

Another artist that used prolifically the cross-sensory perception as a creative advantage was the French composer Olivier Messiaen (1908–1992), who whenever he heard sounds and musical chords or even read music he perceived colors, (in Cytowic 2002, 308) or more specifically, combinations between chordal structures and systematized colors.

Messiaen's synesthesia was bidirectional, meaning that music is color and color is music. (*ibid.*, 310) In his compositions, he used to translate colored landscapes into music, (*ibid.*, 309) and he referred the importance of using color relations in his compositional process. Not exclusively plain colors, but textures associated with colors and gemstone-like reflexes. "Messiaen specifies not only colors and color combinations but also their texture and gem-like character (*e.g. topaze jaune*, *chrysoprase vert clair*, *et cristal*)." (Dworak 2010) Messiaen described his color hearing synesthetic experience:

> "I am... affected by a kind of synopsia, found more in my mind than in my body, which allows me, when I hear music, and equally when I read it, to see inwardly, in the mind's eye, colors which move with the music, and I sense these colors in an extremely vivid manner... For me, certain complexes of sound and certain sonorities are linked to complexes of color, and I use them in full knowledge of this. (Samuel 1976)"
> (in Bernard 1986, 41)

With the American composer, pianist, and bandleader of jazz orchestras, Duke Ellington (1899–1974) it was a case of timbre and color synesthetic association:

Ideasthesia:
from the Greek *idéa* and *aísthesis*, meaning 'sensing concepts,' or 'sensing ideas.'
It is a phenomenon in which activations of concepts (inducers) evoke perception-like experiences (concurrents). It was introduced by the Croatian neuroscientist Danko Nikolic. (Wikipedia)

Grapheme:
from the Greek *gráphein* meaning 'to write,' and *graphema*, meaning 'letter of an alphabet.'
It refers to a unit of a writing system consisting of all the written symbols or sequences of written symbols that are used to represent a single phoneme, *e.g.* f, ph, and gh for the phoneme f. (The Free Dictionary)

Synopsia:
referred by Messiaen, it relates to his acquaintance with the painter Blanc-Gatti who had this disorder that "causes confusion as to the actual stimulus provoking sensory response. [Unlike Messiaen that could] tell the difference between color sensations provoked by visible wavelengths of light and color sensations arising from aural stimuli." (Bernard 1986, 42)

> "I hear a note by one of the fellows in the band and it's one color. I hear the same note played by someone else and it's a different color. When I hear sustained musical tones, I see just about the same colors that you do, but I see them in textures. If Harry Carney is playing, D is dark blue burlap. If Johnny Hodges is playing, G becomes light blue satin." (George 1981, 226)

And Vladimir Nabokov (1899–1977) author of *Lolita*, when interviewed for the BBC in 1962 answered that could 'hear' different colors in different languages:

> "The long "a" of the English alphabet has for me the tint of weathered wood, but a French "a" evokes polished ebony. This black group also includes hard "g" (vulcanized rubber) and "r" (a sooty rag being ripped). Oatmeal "n", noodle-limp "l", and the ivory-backed hand mirror of an "o" take care of the whites. I am puzzled by my French "on" which I see as the brimming tension-surface of alcohol in a small glass." (Vladimir Nabokov Talks Synesthesia)

Phenomenologically, the experience is described as different for each synesthete. But common to all is to be unintentional, recurring, unavoidable, excelling the "emotion over reason," (Cytowic 2003 (1993)) and of unchangeable matching combinations throughout a synesthete's life:

> "Some synesthetes perceive photisms as spatially extended. They often describe their perception as a set of patterns localized somewhere in space in front of them, with patterns that may move from left to right as the sound changes. [...] It also is involuntary, memorable, different for each synesthete, and persistent. Throughout a synesthete's life, his or her color association with a particular sound will not change. (Roberston and Sagiv 2009)" (in Dworak 2010)

Not witnessed by those who are not synesthetes, a few descriptions may seem to be of hallucinatory provenance. Reason why some synesthetes may not disclose their synesthetic capacities:

> "Synesthetes report a variety of photisms: thin lines, thick lines, parallel lines, curves, circles, spirals, etc. More than one photism may occupy the visual scene. Scenes with multiple colors may occur in various parts of the visual scene and move or dance among the photisms, or different colors may dissolve into a white connection." (Campien, 2008; Dworak 2010)

Photism:
the color that a synesthete may report seeing in association with a particular sound, letter or number.
In Psychology is a hallucinatory sensation or vision of light.
(wiktionary)

It is important, however, to distinguish synesthesia from inspiration, and from metaphor. Inspiration is triggered by an internal force that is driven by a mental stimulus to do or feel something caused by the perception of the physical world. As is the case of Georgia O'Keeffe (1887–1986) who created a series of paintings inspired by music rather than from synesthesia:

> "For many vanguard artists in the early twentieth century, music offered a model for expressing nonverbal emotional states and sensations. Georgia O'Keeffe was fascinated with what she called "the idea that music could be translated into something for the eye," but her references to music in the titles of her paintings derived equally from her belief that visual art, like music, could convey powerful emotions independent of representational subject matter. In Music — Pink and Blue II [1918], the swelling, undulating forms imply a connection between the visual and the aural, while also suggesting the rhythms and harmonies that O'Keeffe perceived in nature." (Whitney Museum of American Art, New York)

Whereas a metaphor is a "figurative expression" (Heyrman 2005) of a concept in a literary or poetic form that is applied comparably to describe another concept of a different context, or to which it is not literally applicable. A metaphor is a product of imagination as bespoke by French poet Charles Baudelaire (1821–1867):

> "It is imagination that first taught man the moral meaning of color, of contour, of sound, and of scent. In the beginning of the world, it created analogy and metaphor." (Baudelaire in Heyrman 2005)

And a synesthetic metaphor explores semantically a figurative similarity from cultural and linguistic imagery "belonging to one or more different perceptual modes." (Day 1996) The Italian poet of the late Middle Ages, Dante Alighieri (c.1265–1321) used it, in the epic poem *Divine Comedy* (c.1308 completed 1320) to evoke through hearing a desperate place with an absent sun: — "The region where the sun is silent."
Similarly, other authors *e.g.* the English Romantic poet John Keats (1795–1821), American poets Emily Dickinson (1830–1886), Robert Frost (1874–1963), or the haiku poet Matsuo Basho (1644–1694) of the Edo period in Japan, used synesthetic metaphors to emphasize a literary concept with a deeper meaning:
— "As the bell tone fades; Blossom scents take up the ringing; Evening shade."
Whereas to the American Jewish philosopher Edith Wyschogrod (1930–2009) touch is "metaphor" in its multi-agency dimensions, for it is "interpretive, enactive, expressive, an experiential framework and conceptual resource." (Wyschogrod 1980 in Paterson 2007, 147)
Synesthesia, inspiration, and metaphor imply transposition of something into something else not directly related, but only the synesthetic sensory perception is a neurological phenomenon of cross-sensory correspondence.
Yet, what could be a sensory overload to some, to a few others synesthesia can be an ingenious way for creative wanderings.

Summary

Often culturally infamous, touch is our most marginalized sense. To imagine how it would be not to have it, it is necessary to understand what it is, what it

does, and how it relates to the other senses. Only after recognizing the extension of its significance we are able to extrapolate to inner and outer experiences of the sense of touch. Touch is not just surface. Touch is much deeper than the outer layer of this sense. Touch is greater than its organ, the skin. All the other senses use the organ of touch to sense. They depend on contact through a thin membrane of skin. In spite of this, senses should be treated as equal, not hierarchized by means of value. They act interconnected, and they are not individually dispensable. Changing our life irreversibly if we lose one sense.

Although we are not always consciously aware of the sense of touch, this sense is always active. There is an inevitability in touch, for we cannot stop touching. With touch, we are not a levitating matter but we have a physical existence. Touch allows us a body. We are a body that is in constant contact with something. Touch keeps us simultaneously upright and in safety contact with the ground. If it was not for the somatosensory system the bodily reality would be indubitably unsustainable. And if it were not the external stimuli coming through all our senses, there would be nothing left for the mind to build on. Memory would vanish, and thoughts would become empty.
Our growing development depends on touch, our physical bodies and our inner selves, as well as the healthy relationship of our bodies with the world around and with others. We feel what surrounds us, and we recognize our physical limitations. The sense of touch is ontological and phenomenologically of utmost importance for our normal functioning and well-being.

Still there is a lack of haptic knowledge, or what we are able to obtain through tactile, proprioceptive, and kinesthetic sensations because much is performed unnoticed below the conscious threshold. The difficulty is in the interpretation of haptic sensations experienced by the body.
The whole life is a haptic experience but sadly we do not know much about it, and even less of its value. To better make use of it, and to fully live our sensory existence, it is imperative to raise consciousness, and educate ourselves about understanding the complexity, prevalence, and broadness of the sense of touch, altering the perception and shifting the behavior towards it. This circumstance alone could solve some of the prevalent issues of humanity, of one feeling out of touch, disconnected, lacking contact with reality.
Touch is undoubtedly in need of more attention and research of its importance and possibilities.

Chapter 2

Physiology
The inner functioning

Introduction

This chapter characterizes the high sensory sensitivity and shows the intrinsic particularities and mechanisms of the sense of touch. Potentially, the more is our understanding of the somatic senses and their functionality the better we can extrapolate to develop experiences involving touch.

2.1 Sensitivity

Sensitivity:
is the quality of being physiological 'sensitive' (in Greek *evaisthitos*); of having a capacity of sensation, and of responding to external stimuli: sensitiveness to light; the sensitivity of a nerve. (Dictionary.com)

The body where all the senses are connected and interrelated, and where the touch is phenomenally of utmost importance, is comprised of extremely delicate bundles of sensory receptors, whose ability becomes more sensitive or blunt, depending on personality, experiences, attention, and training. The reason why we say that musicians have "good hearing" from a trained sense and string players have "trained fingers" from practice. Attention as Gibson said, "is part of sensitivity, not as an act of the mind upon the deliverances of the senses." (Gibson 1963, 12) Of the ones with intensified sensory sensitivity, it is said that they are highly sensitive, who easily feel everything on the "edge of the skin." With a sensitive insight of the environment, creatives are known for being highly sensitive, or for being highly sensitive, they are creatives. American author and novelist Pearl S. Buck (1892–1973), winner of Pulitzer Prize in 1932 and Nobel Prize in Literature in 1938, effusively asserted that "the truly creative

mind in any field is no more than this: A human creature born abnormally, inhumanly sensitive." (in Ward 2013) Analogously, the American author, creativity coach, and therapist Lisa A. Riley affirmed that the creators intense perceptiveness enables them to touch the others sensibility:

> "Creatives often feel and perceive more intensely, dramatically, and with a wildly vivid color palate to draw from, which can only be described as looking at the world through a much larger lens. [...] For without this quality, their art, script, music or performance might lack a necessary element capable of touching an audience deeply." (Riley 2008)

As well as the introspective introverts, who endowed with "rich and complex inner lives" (Helgoe 2008; Cain 2012; Buelow 2012; Dembling 2013) for deriving energy from within, rather than from external sources, are generally more sensitive than their counterparts, the gregarious extroverts.
The innate trait of high sensory processing sensitivity, denotes having a very responsive nervous system, and simultaneously to be more susceptible to the degree of sensory stimuli. Feeling very receptive to sensory subtleties, but also strongly reactive to whatever sensory stimuli coming from an inner state, *e.g.* pain, muscle tension, or the outer environment, like a continuous buzzing, can be an impediment to productivity or a strong smell can provoke a headache:

> "Highly sensitive people often have a heightened sense of smell or touch and, say, zero tolerance for itchy fabrics or sudden sounds — reflecting their low threshold for sensory input." (Bartz 2011, 75)

The highly sensitive person (Aron 1996) often absorbs and processes the sensory information more intensely, for having "a nervous system set to register stimuli at very low frequency and amplify them internally." (Bartz 2011, 74) Yet, a highly responsive nervous system is not indicative of keener senses, but of having keen awareness, as for being very attentive to surroundings the "brain processes information and reflects on it more deeply," (Aron 2015) as argued the American author and psychologist Elaine N. Aron:

> "The difference seems to lie somewhere on the way to the brain or in the brain, in a more careful processing of information. We reflect more on everything. And we sort things into finer distinctions. Like those machines that grade fruit by size — we sort into ten sizes while others sort into two or three." (Aron 1996, 20)

High sensory sensitivity means being more perceptible to details, for having a nervous system that reacts to "subtle experiences." (Aron 1996, 24) As did the poet Rilke when alluded to the sculptor's attentive way of seeing:

> "[Rodin] advanced from surface to surface following Nature's laws. Nature herself pointed out to him, as it were, the places in which he saw more than was visible." (Rilke 1919, 58)

Highly Sensitive Person: ascribed by American author and psychologist Elaine N. Aron in 1996, is a person that has the innate trait of high sensory processing sensitivity, or "innate sensitiveness" as Carl Jung originally designated. It means more awareness and increased emotionality: "This excessive sensitiveness very often brings an enrichment of the personality... Only, when difficult and unusual situations arise, the advantage frequently turns into a very great disadvantage, since calm consideration is then disturbed by untimely affects." (Jung 1913 in Aron 2006, 11) Common signs may be sensitivity to loud noises, bright or fluorescent lights, and strong smells. They may process sensory data much more deeply and thoroughly due to a biological difference in their nervous systems.

Nervous System: the network of nerve cells and fibres which transmits nerve impulses between parts of the body. It is made up of the brain, the spinal cord, the nerves, and the sense organs. It controls internal functions of the body and receives, interprets, and responds to stimuli. (The Free Dictionary)

Although men find it difficult to reveal the intensity of their sensitivity in public for fear of being shunned. The *'1000 Lives'* a TV commercial for the Dior Homme campaign in 2013 directed by Romain Gavras, with photography by Nan Goldin, and music by Led Zeppelin "Whole Lotta Love," starring Robert Pattinson and Camille Rowe, embraces the male sensitivity in a irresistibly seductive manner, characterizing "a manhood where vulnerability makes their difference, and sensitivity their strength." (http://m.dior.com/en_int/minisite/th/dior_homme.html) Predictably, greater sensory sensitivity leads to expressions of high emotionality, due to a very permeable nervous system. Both stimuli of beauty and ugliness, thrill and anguish, ecstasy and misery, success and failure, kindness and hostility may easily trigger emotional responses. Of those, it is said, who feel it all so intensely close to their heart. — "At its worst, my sensitivity turns me into an emotional weather vane at the whim of my environment," avowed Jodi Fedor. (in Bartz 2011, 74) Feeling overwhelmed by the intense sensory sensations is common in higher sensory sensitivity, which can lead to moments of mental strain or physical exhaustion. — "Which also makes us slower to recover when we must react to intense stimuli," knowingly declared Aron. (Aron 1996, 24) And besides the soothing recovery of an invigorating walk in nature, a deep breathing meditation, a mood changing music, a nutritional snack or a herbal tea, a warm touch of a lengthy hug stimulates the release of oxytocin, the "cuddle hormone" that elicits feelings of trust and bonding, and reduces levels of cortisol, the stress hormone. Although not uniformly, we have sensory sensations throughout the body due to touch receptors being distributed all over it. As Müller reminded "touch is not confined to particular parts of the body of small extent, like the other senses." (Müller 1842, 1324) Touch exists all over the body, on the surface where we have sensations and deep inside where we feel emotions:

> "Nerve receptors are embedded not only on the surface of the skin but also throughout the body. They lie in the deeper layers of skin where we feel pressure; in our muscles where we feel motion and bodily presence; in the joints where we feel movement and spatial location; and deeper still, in the visceral core where we feel emotions and gut response." (Driscoll 2013)

In the *Sefer Shaarei Rachamim*, a book of Hebrew religious literature, the Polish-Lithuanian Talmudist Vilna Gaon (1720–1797) based touch in the heart, commonly known as the center of our emotions, for the other four senses are located in the head, they are directly ruled by the mind:

> "Man possesses five senses. Four of them are mainly in the brain. From there they come and to there they return. Our fifth sense — touch — involves the entire body. Just as the brain is the center of four senses and "rules" them, the heart is the center and "ruler" of the fifth sense — the sense of touch. Our fifth sense gives rise to four different categories of action: deeds done with the hands, walking with our feet, use of other

Sensory Processing Sensitivity: an inherited personality trait and not a flaw nor a disorder, found equally in men and women. But men find it harder to admit their sensitivity socially. (Zeff 2010, 2004) Biographer David Wallechinsky remarked that in the early 30's MGM studio chief Louis B. Mayer recognized the actor Clark Gable "as a sensitive man wary of his own sensitivity." Aron (1997) made available an online questionnaire at http://hsperson.com/pdf/HSPSCALE_2007_research.pdf for anyone to find out if is a highly sensitive person. Check *5 Gifts of Being Highly Sensitive* in an interview to psychologist Douglas Eby, (in Borchard 2011 (2010)) and article *The Highly Sensitive Person* by Peter Messerschmidt. (2015)

In the treatise *De Anima* [*On the Soul*], Aristotle states that "[...] touch [resides] in the internal organ of touch (probably the heart) or in the intra-organic medium, the flesh, according as we adopt the more scientific or the popular standpoint." (Aristotle 350 BC, I) Thus, "The organ of the sense of touch is not the skin, but the heart. The corresponding medium (the flesh) is thus in the body itself, and not outside it." (Jütte in Grünwald 2008)

> limbs and parts of the body, and finally, touch or feeling, which includes the entire body. Although the fifth sense has numerous categories, the seat of all of them is one place in the heart." (in Rubin 2005, 102)

Yet, nothing is perceived locally and everything is carried into the brain to be interpreted. A large part of the brain is dedicated to processing and storing sensory information and each sense has a specific area of the cerebral cortex. The nervous system has a sensory structure dedicated to each sense. Nerve endings positioned in the skin convey the sensations to the brain. Different from a sight or hearing experience, an experience involving physical activity creates particularly strong neural pathways in the brain assuring that the event will be retained in the long-term memory. (Furth, *et al.* 1975 in Raffle, *et al.* 2003, 1) Mandayam A. Srinivasan, founder of the Laboratory for Human and Machine Haptics, the Touch Lab, at the Massachusetts Institute of Technology, asserts:

> The haptic system, with its tactile, kinesthetic, and motor capabilities, with the associated cognitive processes, presents a uniquely bi-directional information channel to the brain, yet it remains underutilized. (Srinivasan 2005, 1)

When developing technological interfaces for haptic interactions, it is required to have a comprehensive understanding of the functioning of the mechanical, sensory, motor, and cognitive subsystems of the haptic system (Srinivasan 2005, 4) as well as its limitations (Hale and Stanney 2004, 33) to be able to greatly enhance the experiences with touch. For the body is the biological interface that connects our inner self with the physical world, and touch is the medium through which we experience all the sensations. American professor of neuroscience at Johns Hopkins University, David J. Linden affirms in *Touch: The Science of Hand, Heart, and Mind*, published in 2015, that "the skin is an interface between our internal and external worlds and is, by virtue of this topology, the locus of touch." (Linden 2015, 38) Touch gives to body the sentient corporeity to exist in the world.

How does the stimulus transduction work? David J. Linden have answered the following question:
"One enduring question is how the mechanical energy of skin deformation is transformed into an electrical signal in the nerve ending.
The best present hypothesis is that this is accomplished by a type of molecule embedded in the membrane of the nerve ending called a stretch-activated ion channel. These molecules form a pore that is closed at rest, but when the cell membrane is stretched the pore opens, allowing positive ions like sodium and calcium to flow into the nerve cell and thereby trigger an electrical spike."
"This electrical information is encoded by brief changes in voltage lasting about one one-thousandth of a second, called spikes." (Linden 2015, 42)

2.2 Somatosensory System

The somatosensory system, or the ability to have sensations when the body has a physical contact, depends on the cutaneous mechanoreceptors existent in the two outer layers of the skin, muscles, tendons, joints, ligaments, and on the transduction of mechanical forces sensed by the receptors into electrical signals that will be processed and interpreted in the brain. The physiology of the somatosensory system includes touch receptors, peripheral nervous system, and brain. Touch is part of the somatosensory system, which is mostly formed by the distinctive sensory systems: cutaneous, proprioceptive, and kinesthetic:

— The cutaneous system refers to tactile sensations. It receives sensory inputs from the mechanoreceptors, which are specialized nerve endings embedded

Peripheral Nervous System:
situated outside the brain and spinal cord, it is the network of nerve cells and fibres that transmit nerve impulses between parts of the body.

"[M]en and women do not differ in their pain tolerance, pain threshold, or pain ratings." (Robinson *et al.* 2003)

in the skin that respond to mechanical stimulation of light touch, heavy pressure, vibration, and skin stretch; the thermoreceptors, the sensory receptors that respond to absolute and relative changes in temperature (warm or cold); the nociceptors, that are sensitive to pain: cutaneous (including itch and tickle), somatic (muscle), and visceral (organ); and the chemoreceptors, the sensory cells of olfactory receptor neurons and taste buds that detect chemical stimuli. Distinct receptors to detect warm and cold are located in the upper dermis. In much greater quantity, cold receptors are sensitive to temperatures between 20–30°C (68–86°F), whereas warm receptors to temperatures ranging 30–40°C (86–104°F). With signals arriving at the brain up to ten times faster, cold receptors are activated at a temperature above 45°C (> 113°F), leading to the perception of a paradoxical response to heat. (Hoffman 2014)

> Paradoxical cold only activates a part of cold receptors, to which the body temperature at the time, determines whether we feel it. Having a higher internal body temperature lowers the threshold for sensing cold, so the warmer we are, the greater the chance of experiencing a paradoxical cold response. (*ibid.*)

Cold receptors stop being receptive when the surface of the skin drops below 5°C (< 41°F). The reason why hands or feet go numb when they are submerged in icy water for a long time. Warningly, more quickly we sense pain than temperature, this is why a high temperature above 45°C (> 113°F), or a low temperature below 15°C (< 60°F) is felt as pain. Pain receptors are located closer to the skin's surface, near the base of the epidermis, that in the case of impairment, pain ceases to be felt. Endorphins are analgesic chemicals produced by the brain and nervous system under situations of stress, for us to be able to withstand even under conditions that would normally cause ache or pain. Pain can be alleviated resorting to pressure, using rubbing, temperature, or a chemical stimulus like capsaicin, which is an active component of chili peppers. Thermoreceptors also respond to specific chemicals, as menthol, which activates cold receptors. Identifying the source of a pain is not always easy, as it is difficult to make the connection between pain pathways and parts of the body. The *referred pain* is indicative of the complexity of pain pathways. Pain that had origin in an internal organ (*e.g.* heart) is perceived as originating in a part of the body surface (neck, shoulders, back) far from the real origin of the pain, hindering a clinical diagnosis.

— The proprioceptive system refers to sense the state of the body. It allows us to infer where our limbs are in relation to other parts of the body and in space. The proprioceptive system, together with the peripheral nervous system, the *cerebral cortex* (conscious) or *cerebellum* (nonconscious) keep track and control the relative positions of the body parts. Proprioception enables us to function daily in a controlled, coordinated and oriented manner. Muscles and tendons have bundles of afferent neurons that respond to stretch or tension. Activation of these proprioceptors signals the position and movement of limbs, as also

Endorphins: any of a group of hormones secreted within the brain and nervous system and having a number of physiological functions. They are peptides that activate the body's opiate receptors, causing an analgesic effect. (New Oxford American Dictionary)

Referred pain: is pain felt in a part of the body other than its actual source. (New Oxford American Dictionary)

Cerebral cortex: is the outer layer of the cerebrum composed of folded gray matter. It is important in memory, attention, perception, awareness, thought, language, and consciousness. The human cerebral cortex is 2–4 millimetres (0.079–0.157 in) thick. (Wikipedia)

Cerebellum: in Latin for 'diminutive of cerebrum,' is an area of the brain responsible to coordinate and regulate voluntary muscular activity.

Muscle spindles: are located in skeletal (flexor and extensor) muscles for sensing muscle length, and the velocity with which the muscle length is changing.

the degree of contraction and weighting of muscles. *Muscle spindles*, the most sensitive and complex of the proprioceptors (Rothwell 1987, 74), inform higher order neurons of the length of the muscle and the velocity of the stretch. The density of muscle spindles within a muscle increases for the muscles involved in fine movements. The brain requires input from many of these spindles to register changes in angle and position of the muscle. Muscles of arms and legs have more spindles for they must maintain posture against the force of gravity. The proprioceptors *Golgi tendon organs* are located within the tendons that attach muscles to bone. They sense changes in muscle tension, sending detailed information about the tension occurring in specific parts of the muscle. Whereas, *Joint receptors* are proprioceptors that send information to the nervous system from joint capsules and ligaments. Depending where in the body, on the amount, and from what proprioceptors the different input is coming from, determine if the information will be made conscious (from joint receptors) or processed unconsciously (from muscle spindles and Golgi tendon organs). All the input coming into the nervous system is processed, and then depending on the state of the muscle commands are sent back to the muscle. A reflex mediated through the spinal cord enables us to use this information to control muscle contractions and thereby maintain body position. But, the sense of proprioception declines with age, and a sedentary lifestyle accelerates it. The decrease in number and size of muscle fibers, inflamed and arthritic joints, and the stiffness of ligaments are partially responsible for an increased risk of falls in the elderly. Walking, running, gardening, stretching, bicycling, and swimming are all recommended activities for maintaining fitness as we age. (American Academy of Orthopaedic Surgeons) The phantom limb phenomenon is the sensation experienced by whom has had a limb amputated that the limb still exists. Experimental evidence has shown that this happens because of the blocking of peripheral nerves. "Motor areas in the brain are able to generate conscious sensations of limb displacement and movement in the absence of any sensory input." (Proske and Gandevia 2012, 1651) The brain continuously sends impulses to different parts of the body to check on the condition and location of parts, assessing the state of the body.

— The kinesthetic system refers to sense the movement or strain in muscles, tendons, and joints. It receives sensory inputs from the mechanoreceptors located within the muscles, tendons, and joints. It refers to their forces, torques, movements, positions, and angles, signaled by peripheral receptors, muscle spindles, skin stretch receptors, and joint receptors. (Collins *et al.*, 2005, 1706) Conscious awareness of kinesthesia depends mainly on joint receptors. (what-when-how) The kinesthetic system characterizes the notion of active touch:

> "Haptics is now commonly viewed as a perceptual system, mediated by two afferent subsystems, cutaneous and kinesthetic, that most typically involves active manual exploration." (Lederman and Klatzky, 2009, 1439)

All inputs received from the sensory receptors are transduced into electrical

Golgi tendon organs: are located in the muscle tendon, and detect the tension or force that the muscle is exerting.

Joint receptors: are nerve fibers located in the joints, and are most sensitive to positions at extreme joint angles.

Fasciculus cuneatus: is a tract of nerves in the posterior column-medial *lemniscus* pathway of the spinal cord that primarily transmits information from the arms. It transmits fine touch, fine pressure, vibration, and proprioception information from the spinal nerves. (Wikipedia)

Fasciculus gracilis: is a bundle of axon fibers in the posterior column-medial *lemniscus* pathway of the spinal cord that carries information from the middle thoracic and lower limbs of the body. It is one of many ascending tracts, which carry received sensory information to the brain via the spinal cord. It provides conscious proprioception of the lower limbs and trunk, and carries deep touch, vibration, and visceral pain information to the brainstem. (Wikipedia)

signals and carried into the brain. Receptors respond to touch by setting off signals that are routed to the brain for interpretation, wherein the spinal cord functions as a conduit for the sensory fibers. Specialized nerve fibers from receptors in the skin go to the spinal cord in bundles, the peripheral nerves. The mechanical, thermal, or chemical stimuli activate the receptors, causing them to transmit electrical impulses via the afferent neural network to the central nervous system, which in turn sends commands through the efferent neurons to the muscles for responsive motor action. Different areas of the body have different sensory pathways for touch. A touch is sensed in the upper body by the *fasciculus cuneatus* and in the lower body by the *fasciculus gracilis*. (what-when-how) Both these nerve fibers go to the brain via the spinal cord. Touch takes two pathways to the brain. The pathways that relay information to the brain about the material qualities of an object, its hardness or softness, heaviness or lightness, roughness or smoothness, which are crossed more rapidly than the slower route taken by information as to temperature and pain. Nerve fibers conveying different types of sensory information have different diameters. Large-diameter, myelinated nerves such as those from the cutaneous pressure or vibration receptors conduct information rapidly. Small unmyelinated nerves from the free nerve endings conduct information slowly. Information from the cutaneous receptors is transmitted from the spinal cord to the *ventral posterior nucleus* of the *thalamus*, via large-diameter fibers that run in the *dorsal columns* of the spinal cord and *medial lemniscus* in the brain.

Stimuli of pain and temperature are routed to the thalamus via small diameter fibers that run in the *spinothalamic tracts* of the spinal cord and *anterolateral* pathway in the brain. From the thalamus, signals are sent on to the *primary somatosensory cortex* in the parietal lobe's *postcentral gyrus*, posterior to the *central sulcus*. The primary somatosensory cortex is the main sensory receptive area of the brain for interpretation of stimuli from touch. If a touch is sustained, the sensitivity to the stimulus will decrease. This enables the body to be aware of other touch sensations. The end of a continuous touch will be noted and the receptors that have a fast adaptation rate will be receptive to another sensation. Then, a response transmitted by the brain to the body generates a reaction to touch and a conscious awareness of kinesthesia. These reactions may go from quickly pulling a finger away after the prick of a rose bush thorn, to shaking the hand in pain for grabbing a hot pan from the stove, to take the thumb to the mouth for it has been poked by the tip of a sewing needle. Touch receptors are not distributed uniformly throughout the surface of the body. On average, there are about 50 receptors for a square centimeter of the skin and about five million total all over the body that are wired to the brain. Yet, some areas are more sensitive, like the tongue and fingertips (fine or discriminative touch) have 100 receptors per square centimeter, while the back of the hand has less than ten receptors. The density of cutaneous tactile receptors on an area of the body is generally indicative of the degree of sensitivity to tactile stimuli.

Spinothalamic tract (anterolateral system or ventrolateral system): is a sensory pathway from the skin to the *thalamus* important in the localization of stimuli of pain and temperature.

Primary somatosensory cortex:
different areas process touch information from different parts of the body. These areas form a map of the body surface on the cortical surface. The more cortex is dedicated to a body area, the greater is the sensitivity of that area. (Blake and Sekuler, 2006) The sensory and motor representations on the map are orderly arranged in an inverted way from toes at the top of the cerebral hemisphere to tongue at the bottom. Although, some body parts may be controlled by partially overlapping regions of cortex. Each cerebral hemisphere of the primary somatosensory cortex only contains a sensory representation of the opposite side of the body. The amount of primary somatosensory cortex devoted to a body part is not proportional to the absolute size of the body surface, but to the relative density of cutaneous tactile receptors on the body part. (Penfield and Rasmussen 1950, 214)

2.2.1 Somatosensory Receptors

Sensory receptors are classified into five categories based on the form of energy of stimuli they transduce: mechanoreceptors, proprioceptors, thermoreceptors, nociceptors, and chemoreceptors. There are four major types of tactile mechanoreceptors in the somatosensory system that individually signal and process touch. These are receptors that respond to mechanical stimulation of touch, pressure, vibration, and stretch. Each touch receptors differ the type of stimulation it responds to, the size of the receptive field, and rate of adaptation. The size of the receptive field determines how sensitive is an area of the skin. Lips, fingertips, and toes have a great quantity of receptors with small receptive fields, that occupy larger cortical areas and provide higher acuity. Less sensitive areas like stomach and back have few receptors with large fields. A method to discriminate touch acuity is the *two-point threshold test*, where two fine points close together are gently pressured on the skin, so it can only be felt one point, then they are gradually separated until they can be perceived as two points.
The mechanoreceptors positioned in the dermis, are encapsulated with a layer of fat and protein, named *myelin sheath* that wraps the nerve fibers, transmitting signals at a fast adaptation rate, to respond to sharp and fast tactile sensations.
In a greater quantity, the free nerve endings positioned in the epidermis are unencapsulated nerve fibers. These are sensitive to sustained pain, temperature, touch, pressure, and stretch. Are slow to adapt to a stimulus, and so are less sensitive to abrupt changes in stimulus.
Hairy skin also contains hair follicle mechanoreceptors, in which a nerve ending is wrapped around the base of a hair so that movement of the hair, even if not been touched directly, stimulates the nerve ending.
The receptors were named after their discoverers rather than for their functions:

— *Meissner's corpuscles* were discovered (1852) by the German anatomist and physiologist Georg Meissner (1829–1905):
Are bulboid shaped nerve endings of the sensory nervous system, positioned in the upper dermis, near the base of the epidermis, in areas of glabrous skin, of eyelids, lips, tongue, palms of hands, fingertips, nipples, genitals, and soles of the feet; have small receptive fields 30–140 µm long and 40–60 µm wide; fast adaptation rate; are encapsulated neurons sensitive to low-frequency vibration, to flutter and fine or light touch, to shape and textural changes in exploratory and discriminatory touch; have highest sensitivity (lowest threshold) when sensing vibration at 3–40 Hz; the nerve fibers send brief electrical signals to the brain, at the beginning and end of a sustained touch.
If we gently run our fingers over the back of our hand. Then, turn our hand over, and gently run our fingers over the palm of our hand. We feel a higher sensitivity because the palm of our hand has Meissner's corpuscles. They are what make our fingertips and palms so sensitive. Though, the number of tactile

Adaptation:
occurs when there is a loss of sensation even though the stimulus is still being applied.

Rapidly adapting mechanoreceptors:
include *Meissner* and *Pacinian* corpuscles as well as hair follicle receptors and some free nerve endings, that respond only when the stimulus starts and sometimes when a stimulus ends.
Slowly adapting mechanoreceptors:
are *Merkel* and *Ruffini* corpuscles and some free nerve endings, that continue to discharge during a stimulus..

Encapsulated nerve endings:
are dendrites of sensory neurons enclosed in connective tissue capsules on receptors for touch, pressure, and vibration.
Unencapsulated or free nerve endings:
are bare dendrites of sensory neurons on receptors for pain, temperature, tickle, itch.

Dendrites:
a short branched extension of a nerve cell, along which impulses received from other cells at synapses are transmitted to the cell body.

corpuscles per square millimeter on the fingertips drops fourfold between the ages of 12 and 50.

Axon:
from the Greek *áxon*, 'axis,' (nerve fibre), is a long, slender projection of a nerve cell, or neuron, that conducts electrical impulses away from the neuron's cell body. It transmits information to different neurons, muscles and glands. (Wikipedia)

— *Merkel's disks* or *Merkel cell-neurite complexes* were discovered (1875) by the German anatomist and histopathologist Friedrich Sigmund Merkel (1845–1919):
Are oval disk-shaped nerve endings of the sensory nervous system positioned at the base of the epidermis, in areas of hairy or glabrous skin, more densely distributed in lips, palms of hands, and fingertips; have small receptive fields 2–3 μm long and 0.1–0.25 μm wide; slow adaptation rate; are unencapsulated nerve endings sensitive to steady pressure, gentle or light touch to discriminate edges of objects, shapes and textures, and fine spatial details; are the most sensitive of the four main types of mechanoreceptors to vibration at low-frequency around 0.3–3 Hz; the high tactile discrimination enables the fingertips to feel fine detailed surface patterns (*e.g.* reading Braille) "that are only about 0.7 millimeter[s] apart" (Linden 2015, 42); the nerve fiber sends continuous electrical signals to the brain throughout the touch stimulus.

Different types of mechanoreceptors respond to different physical conditions:
Meissner's corpuscles – medium fast-frequency (3–40 Hz): flutter;
Merkel's disks – slow-frequency (0.3–3 Hz, continuous): pressure;
Pacinian corpuscles – very fast-frequency (10–500 Hz, transient): vibration;
Ruffini endings – fast-frequency (15–400 Hz, continuous): stretching.
(Bolanowski and Zwislocki 1984 in Herbert at University of Calgary)

— *Pacinian corpuscles* were discovered (1831) by the Italian anatomist Filippo Pacini (1812–1883):
Are oval shaped nerve endings of the sensory nervous system consisting of concentric onion-like layers of nonneural (connective) tissue, positioned deep down in the dermis of hairy or glabrous skin; have large receptive fields 0.5–1 mm long and 0.3–0.7 mm thick; fast adaptation rate; encapsulated nerve fibers sensitive to deep and transient pressure, to high-frequency vibration between 10–500 Hz, with optimal sensitivity at 250 Hz, which is the frequency generated upon fingertips by textures smaller than 200 μm; the nerve fibers send brief electrical signals to the brain, at the beginning and end of a sustained touch.

— *Ruffini endings* or *bulbous corpuscles* were discovered (1898) by the Italian anatomist, histologist, and embryologist Angelo Ruffini (1864–1929):
Are elongated shaped nerve endings of the sensory nervous system, positioned deeper, near the base of the dermis in areas of hairy or glabrous skin and along joints, tendons, and muscles; have large receptive fields 0.2–1 mm long; slow adaptation rate; are encapsulated receptors sensitive to high-frequency vibration around 15–400 Hz, sustained downward pressure, skin stretch, and joint torque; provide feedback for gripping objects, for controlling hand and finger position and movement, they also contribute to proprioception and kinesthesia; the nerve fibers send continuous electrical signals to the brain throughout the touch stimulus.

If for a sensory disorder a touch receptor does not adapt to a tactile stimulus and keeps repeating the stimulation, wearing a piece of clothing can be constant and painful felt. This condition is clinically known as mechanical allodynia (touch pain). (Jänig 2011)

Summary

The physiology of the human body is of immeasurable complexity, so are the senses of touch, whose research branch into sensory psychology, sensory deprivation, and sensory overload, to explain the human behavior towards

emotional touch, social touch, media touch, and aesthetic touch. Touch is intuitively emotional and has the immediacy of triggering emotional connections, whatever is the essence of the connection. Touch can convey a message more strongly for it creates an instinctive reaction of an instant bond or an immediate revulsion.

Touch is a language we need to acquire skills on. It is our first language and we depend entirely on touch for our survival and well-being, but it takes a life, if ever, to gain fluency on it. Touch has its signs, signals, and codes that personal, contextual, and culturally are susceptible to diverse interpretations of multiple meanings. Touch acts bidirectionally, not only between the peripheral sensory receptors and the brain but also between the heart and skin, the gut and flesh — hence the expression of the intuitive "gut feeling." Touch is simultaneously physical and mental, emotion and cognition, ethereal and earthly.

Touch affects greatly the way we are in the world. On how we interact with our surrounding environment, connect to ourselves, communicate and bond with the others around us. We exist in body and mind through physical experiences, as it is in the capacity to touch that we are able to function.
But without a comprehensive understanding of how touch works, its implication in the body, or the severe impact that is not developing it since birth, having it functioning uncoordinated, or even of losing it, we do not give to touch the due value. And, it is in the knowledge of its inner functioning and manifold functionality that we can elaborate on touch, designing and developing experiences regarding haptic interactions.

Chapter 3

Perception
In the creation of consciousness

Introduction

This chapter focuses on how we perceive and retain our surroundings through our senses that provide us a conscious existence. Throughout distinguishing the immeasurable perceptiveness of physicality in touch. Along reflecting on how perception originates and influences the notion of corporeality.

Sensation:
the subjective awareness of changes in the internal and external environment.

Awareness:
the ability to perceive, to feel, or to be conscious of events, objects, thoughts, emotions, or sensory patterns.
(Wikipedia)

Consciousness:
the state or quality of awareness, or of being aware of an external object or something within oneself.

3.1 Awareness

Sensation is the first awareness of a stimulus. It is attained through the ability to see, hear, smell, taste, and touch. It results from becoming aware of something that happens to or comes into contact with the body through the senses. British neurophysiologist Mark Lythgoe asserted that "Sensations provide our conscious and subconscious awareness with the internal and external conditions of our body." (Lythgoe 2005, 41) Perception is a subjective interpretation of the inner and outer environment through the mental processing of the stimulus that comes from a sensation. Perception is then, a personal way of regarding, understanding, or interpreting something. It is acquired through neurophysiological processes, including attention and memory, by which one becomes aware of and interprets external and internal stimuli:

> "Both sensation and perception are functions of the brain — specifically, a part of the brain called the cerebral cortex, or cerebrum. Nerve impulses

> that go to the brain are called sensations. A sensation is defined as the awareness and localization of a stimulus, a change in the internal or external environment that leads to a response. Once our brain is aware of sensations, it interprets them, letting us perceive a stimulus. A perception, therefore, involves giving meaning to a sensation based on what we have experienced and learned." (Light 2005, 10)

Asserted by Aristotle, what is known to us is gain through the senses. Nothing is in the intellect that was not in the senses. Aristotle differentiated outer from inner senses. Outer are the ones situated on the periphery of our body, as those of sight, hearing, smell, taste, and touch, which when properly stimulated acquire sensations from the external environment. The inner senses are the brain and central nervous system, which have four components: the common sense, imagination, memory, and instinct. These are not related to sensation but with percept. A unified sense image, or a composite representation of the sensation produced by the outer senses. (in Wallace 1996, 103) "Perception enables us not only to sense but to perceive the environment and react properly to it." (Wallace 1996, 104) What impacts perception are experiences (social, cultural, emotional), memories, attention and learning, motivations and expectations. David J. Linden stresses that "Our perception of a sensory stimulus is crucially dependent upon our expectations." (Linden 2015, 80) Thus, sensory experiences cannot be objectively assessed as they are subjectively perceived.
German-American artist and visual theorist Josef Albers (1888–1976) observed that there are as many perceptual interpretations of a color as there are people perceiving it:

> "If one says "red" [...] and there are 50 people listening, it can be expected that there will be 50 reds in their minds. And one can be sure that all these reds will be very different." (Albers 2006 (1963), 3)

Because perception is individual, so is consequently the ascribed significance, wherein the message, therefore, is affected by the circumstances in which it is perceived. "Perception precedes meaning, and medium precedes message." (Heyrman 2005) Furthermore, similar stimuli are perceived differently depending on the sensory receptors. Hermann Helmholtz noted in *The Facts of Perception*:

> "The same vibrations of the ether which the eye experiences as light, the skin feels as heat. The same vibrations of the air which the skin feels as a flutter, the ear hears as sound." (Helmholtz 1878)

Marshall McLuhan noted that since Aristotle, ancient Greeks had the notion of a "common sense," which they believed, it translated each sense in the other senses, and conferred consciousness on man. (McLuhan 1964, 122)

> "The 'common sense' was for many centuries held to be the peculiar human power of translating one kind of experience of one sense into

Perception:
the ability to become aware of something through the senses; the way in which something is regarded, understood, or interpreted. (New Oxford American Dictionary)

Percept:
a mental concept that is developed as a consequence of the process of perception. (*ibid.*)

Apperception:
the mental process by which a person makes sense of an idea by assimilating it to the body of ideas he or she already possesses. (*ibid.*)

Roman poet and philosopher Lucretius (c. 99 BC–c. 55 BC) stated, "Blame not on eyes the error of the mind." (in Levin 1993, 70) Since, "it is the mind which senses, not the body; for we see that when the mind is distracted [...], the entire body remains without sensation [...]." (*ibid.*) And French philosopher René Descartes (1596–1650) asserted that "it is not [...] because the mind is in the parts serving as organs to the exterior senses that it experiences sensation, but because it is in the brain, where it exercises that faculty which is called common sense." (2001 (1637), 87)

> all the senses, and presenting the result continuously as a unified image to the mind." (*ibid.*)

While it is generalized that the Aristotle's "common sense" could correspond roughly to the current notion of 'logical reasoning,' suggesting a prudent sense and reasonable judgment in practical situations. Which entails recognizing the cues obtained by the senses, and comparing them to previous experiences, conducted by the inner sense that configures perception. In *The Inner Touch: Archaeology of a Sensation*, published in 2007, the professor of comparative literature at Princeton University, Daniel Heller-Roazen retrieves the concept saying that it is all about "sensation." (Heller-Roazen 2007) Referring to experience the inward sensation of existence attained uniquely from sensing, correlating consciousness to the awareness of sensation. Heller-Roazen discusses the single sense, the "sense of sensing," a "sense of being sentient." Wherein the common sense denotes a sensation of an inner unifying sense that is integral to our sense of being. For senses act interrelated giving us the awareness of a sensing corporeal existence that fully enables us to be in the world. Touch is the unifying common sense that connects our inner sensing and thinking self with our outer acting and reacting being. Heller-Roazen inquires if actually our whole being is enabled by sensing through "an inner touch:" (*cf.* Geurts 2002, 10)

> "What if the activities of awareness and self-awareness were forms not of cognition but rather, as Aristotle maintained, of sensation? What if consciousness, in short, were a variety of tact and contact in the literal sense, 'an inner touch,' as the Stoics are reported to have said of the 'common sense,' 'by which we perceive ourselves'?" (Heller-Roazen 2007)

Sentience is perceived from the ability of touch, giving us a sense of being, through sensing and thinking. Sentience "is related to the sensitivity of thought." (on Aristotle in Elo 2012) Heller-Roazen proceeds inquiring, "What would it mean for touch to be the root of thinking and for thinking, in turn, to be in its most elevated form a kind of touch?" (Heller-Roazen 2007, 285) Since, touch is the sense of the senses and, therefore, a generator of thought, only through the integrative touch, there is the possibility of thinking. For touch is implicated in the sensory, cognitive, affective, and conative parts of the brain. Ken Johnstone realizes that a mindful acting touch informs the apperception of our being:

> "The haptic sense meant much more 'mind' since it meant grasping, getting something whole. Grasping means that in some sense I become what I know in its concrete reality and so get it whole. It is this complete act of knowing, that then allows me to analyze my percept intellectually as well as affirm its reality in judgement. And it is this complete act of knowing that realizes my own centre." (Johnstone 1996)

The awareness of the self-sensing entails a consciousness of one's existence. Conscience comes into being when at a young age we start to make sense of

Sentience:
"is the ability to feel, perceive, or experience subjectively. The 18th century philosophers used the concept to distinguish the ability to think (reason) from the ability to feel (sentience). In modern Western philosophy, sentience is the ability to experience sensations." (Wikipedia) Which cuts across all species, human inclusive.

Conative:
from the Latin *conatus*, meaning any 'natural tendency,' 'impulse,' 'striving,' or 'directed effort.' It is one of three parts of the brain besides cognitive and affective. Wherein the cognitive measures intelligence, the affective deals with emotions, and the conative drives how one acts on those thoughts and feelings. (*ibid.*)

Kant (1724–1804) affirmed, "[T]he proposition, 'I think,' in so far as it declares, 'I exist thinking,' is not the mere representation of a logical function. It determines the subject (which is in this case an object also) in relation to existence; and it cannot be given without the aid of the internal sense, whose intuition presents to us an object, not as a thing in itself, but always as a phenomenon." (Kant 2015 (1781), 179)

our surroundings and our body in it, also through interactions with others. The emerging sense of self in the world is informed primarily by our sense of touch:

> "Informed fundamentally from haptic and orienting experiences early in life. Our visual images are developed later on, and depend for their meaning on primal experiences that were acquired haptically." (Bloomer and Moore 1977 in Pallasmaa 2012 (1996), 44)

Initially, our mind is empty of imagery and devoid of memories. Diverse sensory experiences are structural for our integrative development. For we recognize our body inner and outer conditions through the sensations we experience. In *Critique of Pure Reason* (*Kritik der Reinen Vernunft*), first published in 1781, German philosopher Immanuel Kant (1724–1804) attempts to explain the relation between reason and experience, establishing that our knowledge of the outside world depends on our modes of perception:

> "All our knowledge begins with sense, proceeds thence to understanding, and ends with reason, beyond which nothing higher can be discovered in the human mind for elaborating the matter of intuition and subjecting it to the highest unity of thought." (Kant 2015 (1781), 179)

Yet, not all sensations get to consciousness, many go without being noticed, and this lack of awareness impacts how present and connected we may feel:

> "The environment is perceived through the sensory receptors but not all of our sense signals reach our consciousness. We sense more than we are aware of and this influence our emotional, psychological and physical conditions." (Berzina 2004, 58)

Senses are operatively interrelated, but our narrow capacity to focus limits the awareness of incoming sensations. As most of the touch that we undertake daily is done unconsciously.

3.2 Sensory Limitation

Our senses are unable of detecting physical stimuli above and below a certain range. We may not perceive the real physical stimulus. Our sense organs may detect a stimulus, but we may not perceive it. Our sensory ability has evolved to meet the most pressing needs. Maya Pines *et al.* noted:

> "Our nervous system reacts only to a selected range of wavelengths, vibrations, or other properties. It is limited by our genes, as well as our previous experience and our current state of attention." (Pines 1995, 9)

The apprehension of reality is conditioned by what we can absorb through our senses. However, we are capable of detecting and using only a tiny fraction of events that occur around us. (Wolfe 2009) For the range of our sensory capacity

In *The Eyes of the Skin: Architecture and the Senses*, first published in 1996, Finnish architect Juhani Pallasmaa (1936–) observed, "Vision reveals what the touch already knows. We could think of the sense of touch as the unconscious of vision." (Pallasmaa 2012, 46)

In *Pride and a Daily Marathon*, reporting the clinical case of Ian Waterman (the "deafferented" man) published in 1995, by British physician and neurologist, Jonathan Cole, who collaborated writing and narrating a BBC television documentary on *The Man Who Lost His Body*, broadcasted in 1997, affirms, "Vision is also the sense that tends to dominate our thoughts and our intellectual faculty. Hearing may be placed a little way behind, while the other senses impinge much less on our intellects and less often on our conscious attention." (Cole and Waterman 1995, 139)

In *On Looking: A Walker's Guide to the Art of Observation*, published in 2014, American cognitive scientist and professor of psychology, Alexandra Horowitz states, "We are limited by our sensory abilities, by our species membership, by our narrow attention." (Horowitz 2014, 263)

is significantly short comparing to other animals. And the stimulus threshold our senses require for we to become aware of a sensation is substantially high. We can only see a part of the color spectrum (excluding the infrared with a wavelength greater than the red end of the visible light spectrum, and the ultraviolet with a wavelength shorter than the violet end of the visible light spectrum). While normally, we have "three types of retinal photopigments [red, green, and blue] transducing light into a trivariate neural color code," (Jameson *et al.* 2001, 244) there are possibly 2–3% of women who perceive color differently, because they differ genetically from the common. They are *tetrachromat* rather than the norm *trichromat*, meaning their retinae have four different types of cone cells, with another type of cones in between the red and green, reports Jay Neitz. (in Roth 2006) This happens when the two X chromosomes (that women have (NLM 2015)) possess a mutant gene of "shifted green, or shifted red" (McKenna 2004) retinal photopigments. Potentially, the 100 shades of each variety of cone cells carried by four channels multiplied in the brain by 100 could allow them "higher dimensional perceptual experience" (Jameson *et al.* 2001, 258) into seeing 100 million different hues (Neitz in Roth 2006) and even enhancing vision in dim lighting. (Jameson in Robson 2014) Commonly, we are able to discern seven colors of the rainbow (red, orange, yellow, green, blue, indigo, and violet), but these women can see about 10 different colors. (McKenna 2004) Confirmed in 2012, the Australian artist based in San Diego, California, Concetta Antico is a tetrachromat. Tetrachromacy most likely happens in women with fathers or sons who have color vision deficiency (known as color blindness). Reason why the most common form of color vision deficiency, red-green, is hereditary and affects about eight percent of men and less than 0.5% of women. They inherit two red or two green type of cones sensitive to the middle-to-long wavelength spectrum, and a blue type sensitive to the short wavelength spectrum. (Jordan *et al.* 2010, 1) Resulting two normal type of cone cells, and a mutant type that is less sensitive to either red or green, making it difficult for them to distinguish the two colors. (De Vries in Greenwood 2012) While with normal vision, "it gets harder to tell blues from greens than it is to tell reds from yellows" as we age. (Martin 2014)

We are not capable of hearing all the audio frequencies. Infrasound is the span of low-frequency sound waves that are below the lower limit of human hearing. And ultrasound has a frequency above the upper limit. Although variable, the frequency capable of being perceived by a healthy human hearing is normally between 20 and 20,000 Hz (cycles per second). Under laboratory conditions, it is possible to hear sounds as low as 12 Hz. Commonly, we are more sensitive to sounds in the 2,000 to 4,000 Hz range. Very high frequencies are painful to bear. In a conversation the most significant frequencies for speech are between the 300 and 3,000 Hz range, wherein vowel sounds are lower frequencies, below 1,000 Hz and consonants are in the 2,000 to 3,000 Hz range. The upper limit decreases drastically with age also affecting balance as we "sit, stand, and walk." (Martin 2014) Generally, women experience a lesser degree of hearing loss.

In *Phenomenology of Perception* published in 1945, French phenomenological philosopher Maurice Merleau-Ponty (1908–1961) states, "Attention first of all presupposes a transformation of the mental field, a new way for consciousness to be present to its objects." (Merleau-Ponty 1945, 33)

German physicist and philosopher Hermann Helmholtz (1821–1894), splits perception into two levels:
— *Analytic*, where the sense organs analyze the physical world into fundamental sensations.
— *Synthetic*, where we integrate and synthesize these sensory elements into perceptions of objects and their properties.
Helmholtz's theory proposes that we learn how to interpret sensations on the basis of our experience with the world. Our interpretations are informed guesses about perceptions. (in Levitin 2002, 146)

When we are in loud environments for some time, we sense a loss of hearing after we come out and for minutes long. Prolonged exposure to loud noises within the audible range cause permanent hearing loss over time.
Our ability to perceive a scent varies widely, and differences are partially due to "age, smoking habits, gender, nasal allergies, or head colds." (Rieck-Hinz et al. 2004) Generally, "nonsmokers over the age of 15 show greater acuity." (*ibid.*) Normally, the smell sensitivity declines with age. Yet, for a substance to be detected by the smell receptor cells, it must comply with some requirements:

> Be volatile to permeate the air, and enter the nose to stimulate not less than forty nerve endings (Ackerman 1990, 13); Be at least slightly water-soluble to pass through the mucous layer and to the olfactory cells; Be lipid-soluble because olfactory cilia are composed primarily of lipid material; A smallest concentration of scented particles must be in contact with the receptors for a minimum length of time. (Rieck-Hinz et al. 2004)

Unpleasant smells can impact our perceptions and judgments. Whereas pleasant scents can influence our decisions and evaluations; improve our mood, (Fox 2006, 5) and alter our sense of attractiveness. Our preferences go for scents that we are "able to identify correctly;" that we classify as pleasant, like *vanilla*. (*ibid.*, 6)
Our sensitivity to taste depends on the variable density of fungiform papillae, the bumps on the tongue that hold the taste buds, as reported by American psychologist Linda Bartoshuk (1938–) during her long time research on subjective experiences of taste. For there are those who have 425 taste buds per square centimeter and others that only have 96 taste buds per cm^2. But on average we have about 184 taste buds per cm^2, and more men are in the average values. (in Bohannon 2010) Perception is normally multisensory, reminded Cytowic and Eagleman (2009). To which Auvray and Spence "argue that the unification of sensory impressions enabled by the act of eating does not occur at the level of sensation, but [...] of perception." (Auvray and Spence 2007, 1017) Evidence based on *The Senses Considered as Perceptual Systems* published in 1966 by Gibson, who introduced a designation of the senses referring to them as "perceptual systems capable of obtaining information about objects in the world without the intervention of an intellectual process." (Gibson 1966, 1) For the senses are actually the cause of and the reason for intellectual processes. Gibson called these systems, the visual, auditory, taste-smell, basic-orienting, and the haptic system. (Gibson 1966) In turn, Auvray and Spence suggest the "flavor perception [...] to describe the combinations of taste, smell, the trigeminal system, and touch, [plus] visual and auditory cues," because they are all involved in the perception of tasting food. (*ibid.*)
Misperception may happen concerning the cutaneous touch, if we do not slide the fingers across a surface, we will not have a full grasp of its characteristics. We discern easily an object by active touch than by having it touching our skin. Even though these sensations will differ largely when we touch or not a familiar

Trigeminal nerve: from 'tri-,' or 'three' and '-geminus,' or 'twin;' 'thrice-twinned,' is a nerve responsible for sensations in the face and motor functions, as biting and chewing. Each trigeminal nerve (one on each side) has three major branches: the ophthalmic nerve, the maxillary nerve, and the mandibular nerve. The ophthalmic and maxillary nerves are purely sensory, and the mandibular nerve has sensory and motor functions. (Wikipedia)

Tactile Perception: from the Latin *tactilis*, from *tactus*, past participle of *tangere*, 'to touch.' Results from the mechanical deformation of indentation, vibration, or stretching of the skin.

Haptic Perception: refers to the combination of cues provided by tactile, proprioceptive, and kinesthetic receptors during active manipulation of objects in the environment.

surface. While touch permits reciprocity of sensations between touch and being touched, in the active touch the attention is given towards the identification of the surface and less to the sensations felt internally.
Whereas in passive touch, while it permits the detection of outer and inner states, the attention given to the sensations change focus. Here, are stronger the sensations produced in the skin. Mark Paterson mentioned that "The feeling of cutaneous touch when an object brushes our skin is simultaneously an awareness of the materiality of the object and an awareness of the spatial limits and sensations of our body." (Paterson 2007, 2) We interpret reality in function to our limitedness. Paterson asserts that when reporting sensations isolatedly, it is not possible to distinguish what is felt inwardly or outwardly, as somatic sensations are felt throughout the body distributed through the nervous system. (Paterson 2009, 780) Concordantly stated by Janine Mileaf:

> "The faculty of touch occupies multiple loci within the perceiving body. Difficult to pin down because it cannot be associated with any single organ [...], touch remains [...] decentralized." (Mileaf 2010, 9)

There is not a part of the body that is desensitized of touch, it is rather distributed asymmetrically with varying degrees of sensitivity. "The skin and the hands or fingers are the most obvious agents of tactile perception." (*ibid.*)
Tactual explorations and the sensations felt add meaning to the perceiver and turn interactions more particular, proximal, intimate, and possible.
The way we behave depends directly on the way we perceive our environment. On the apperception of the self in relation to reality. According to Ackerman, the sense of self "has to do with touch, with how we feel." (Ackerman 1990, 95) The sense of self is the expression of how we experience the world. To Pallasmaa, "Touch is the sensory mode that integrates our experience of the world with that of ourselves." (Pallasmaa 2012 (1996), 12) We are sensitive beings with a complex nervous system, which make us feel, consciously aware and actively responding to our surroundings. Or to what we are able to feel and grasp. As Mileaf simply described, "I feel things that I brush up against or take in my hand [...]." (Mileaf 2010, 9) Yet, the construction of an apperception and subsequent behavior is easily dictated by what we may have believed, even if not all these are evident:

> "Our lives and behaviors are much more profoundly affected by the beliefs we hold unconsciously than by those we hold consciously, and processes of interpretation are also influenced by those beliefs." (Cytowic 2002, 308)

The unfocused and unconscious experiences we hold of the world sustain us beyond a clear perception of reality. Pallasmaa unfolds his perceiving experience:

> "The role of peripheral and unfocused vision in our lived experience of the world, as well as in our experience of interiority in the spaces we inhabit, has also evoked my interest. A remarkable factor in the

In chapter *Aesthetic Touch*, of *Art and the Senses* published in 2011 (edited by Francesca Bacci and David Melcher), Rosalyn Driscoll asserts that "Deep, unconscious currents run through even the most cursory of touches." (in Bacci and Melcher 2011, 113)

> experience of enveloping spatiality, interiority and hapticity is the deliberate suppression of sharp focused vision. [...] The very essence of the lived experience is moulded by unconscious haptic imagery and unfocused peripheral vision. Focused vision confronts us with the world whereas peripheral vision envelops us in the flesh of the world." (Pallasmaa 2012 (1996), 14)

A distracted sense is subliminally absorbed, and while not serving as a natural body extension for we are unaware of surrounding phenomena, it incorporates the sensations of the world unconsciously through habit and intuition. And since, "all consciousness is consciousness of something," which is the basis of Husserl's phenomenology, the "acts of thought" (*noesis*) occur correlated with "intentional objects of thought" (*noema*). (Husserl 2012 (1913), 182) In *Phenomenology of Perception* published in 1945, French philosopher Maurice Merleau-Ponty (1908–1961) assigns the "perception of the world" to the experience of "phenomenal body," that is "inhabited by a consciousness." (Merleau-Ponty 2002 (1945), 408) To Merleau-Ponty, "all consciousness is perceptual consciousness," (*ibid.*, 459) where the body is a permanent condition of experience, receptive to perceive the objectivities of the world. Going from the intentionality of the body to a corporeity of consciousness for an embodied worldly experience. Senses act in objective or subjective domains according to our dispositions. German philosopher Immanuel Kant (1724–1804) classifies the senses:

> "Kant divides the senses relatively into objective ["mechanical"] senses (touch, vision, and hearing) which contribute to the knowledge of objects in their externality, and subjective ["chemical"] senses (taste and smell), through which objects are enjoyed according to one's own disposition." (Kant 2012 (1974), 36 in Vasseleu 1998, 99) "The value of the senses for Kant is their delineation of a folded corporeal schema which establishes the interiority of perceptions and the exteriority of objects." (in *ibid.*, 100)

Of all senses, touch is the only one that has objective and subjective magnitude. German-Swedish perceptual psychologist David Katz suggested that the senses may go on a continuum between objective and subjective dimensions. Sight belongs primarily to the objective, but touch can function anywhere along the continuum between objective and subjective perceptions, requiring an existing object and the sensation of its contact. (Katz in Driscoll 2006) A tactile contact with an object may provide us with more information about its characteristics, which may be translated into deeper sensations. At the experiential level, touch gives concrete knowledge of the physical nature of objects and their surfaces. In *Touching and Imagining: An Introduction to Tactile Art*, published in 2014, Czech Surrealist filmmaker Jan Svankmajer (1934–) expounds an interpretation on touch's both subjective and objective intrinsic qualities:

> "While vision and hearing are plainly objective senses, taste and smell

In *Ideas: General Introduction to Pure Phenomenology*, published in 1913, the German philosopher Edmund Husserl (1859–1938) introduced the terms *noesis* from the Greek *nous*, meaning 'mind,' and *noema* from *nóima*, which translates 'meaning' or 'content of a thought,' 'judgment,' or 'perception,' to specify correlated elements that comprise an intentional experience. (Husserl 2012 (1913), 182) "Like perception, every intentional experience —and this is [...] the fundamental mark of all intentionality—has its "intentional object," *i.e.*, its objective sense." (Husserl 2012 (1913), 187) American philosopher, Taylor Carman, professor of Philosophy at Barnard College, Columbia University, states, "Husserl's mature phenomenology is based on two strict categorical distinctions. The first is between the inner and the outer: the 'immanent' sphere of conscious experience and the 'transcendent' domain of external objects. The second is between concrete and abstract entities: the 'real' things existing in space and time and 'ideal essences'." (Carman 1999, 205)

In *Art as Experience* published in 1934, the American philosopher and psychologist, [cont. ...]

are subjective. Touch is somewhere in the middle, partly objective, partly subjective. While touching, we project a sensation outwardly, outside of us; at the same time, we perceive it subjectively, on our skin." (Svankmajer 2014)

Professor of neuroscience at Liverpool John Moores University, Francis McGlone recalls that touch has two sides: "one senses, one feels." (in The Zanvyl Krieger Mind/Brain Institute) Touch balances between the outer and inner worlds, while we try to understand, interpret, and ultimately make sense of both.

3.3 Perceptual Subjectivity

Sensory sensitivity, education, training, interests, curiosity, passion, all shape how we perceive the world. Because "We don't see things as they are; we see them as we are." (anonymous in quoteinvestigator.com) What we find magic, what we see as marvelous, can stand in the ambivalence of not being able to know what is beyond the reach of our sensorium, and wondering what is hidden from us. Yet, one could argue that we do not absolutely need to know specifically everything about anything, as it can break the magic of wonders of the world. American theoretical physicist Richard Feynman (1918–1988), Nobel Prize laureate in Physics in 1965 for the theory of quantum electrodynamics, took part in the development of atomic bombs during Second World War, "that slaughtered over 300,000 civilians at Hiroshima and Nagasaki" (Hudson 2015) in August of 1945; Feynman narrates the world seen by a scientist, and how the perception of each one differs depending on their character defined by their profession. Disagreeing with his friend who holding a flower says, "I as an artist can see how beautiful this is but you as a scientist take this all apart and it becomes a dull thing." (Feynman 2011 (1988), 11) Unable to appreciate the simplicity of beauty without dissecting it, Feynman contends:

> "I can appreciate the beauty of a flower. But at the same time, I see much more in the flower than he sees. I can imagine the cells inside, which also have a beauty. There's beauty not just at this dimension of one centimeter; there's also beauty at a smaller dimension. There are complicated actions of the cells and other processes. The fact that the colors in the flower have evolved in order to attract insects to pollinate it is interesting; that means insects can see the colors. That adds a question: does this aesthetic sense we have also exist in lower forms of life? There are all kinds of interesting questions that come from a knowledge of science, which only adds to the excitement and mystery and awe of a flower. It only adds. I don't understand how it subtracts." (*ibid.*)

British journalist and author Bryan Appleyard (1951–) retorts that Feynman

[... cont.] John Dewey (1859–1952) states that "[A]ll deliberation, all conscious intent, grows out of things once performed organically through the interplay of natural energies. [...] Through consciousness, [man] converts the relations of cause and effect that are found in nature into relations of means and consequence. Rather, consciousness itself is the inception of such a transformation." (Dewey 1980 (1934), 24) For man acts conscious of his consciousness.

David Howes, professor of Anthropology at Concordia University, Montreal, affirms, "Perception is not just a matter of biology, psychology or personal history, but of cultural formation." (Howes 2005, 3) British political activist, General Secretary of the Campaign for Nuclear Disarmament (CND), Kate Hudson (1958–) arguments, "[I]f Japan was ready to surrender, why were atomic bombs dropped on Hiroshima and Nagasaki? [...] One is forced to conclude that the US wanted to demonstrate its unique military power — its possession of the atomic bomb — in order to gain political and diplomatic advantage over the Soviet Union in the postwar settlement in both Asia and Europe." (Hudson 2015)

"seemed, at times, overcome by the grandeur of science and bewildered by the notion that it could in any way reduce human experience." (Appleyard 2004 (1992), 168) Appleyard incisively says that "science can subtract from excitement and mystery. It can subtract everything," (*ibid.*) tactlessly.
Sensory sensitivity through attentive observation and imagination can lead us to a particular perception of the world that only adds:

> "The senses not only mediate information for the judgement of the intellect; they are also a mean of igniting the imagination and of articulating sensory thought. Each form of art elaborates metaphysical and existential thought through its characteristic medium and sensory engagement." (Pallasmaa 2012 (1996), 49)

What is not inputted sensorally, is imagined. Hungarian professor and author of psychology, Mihaly Csikszentmihalyi (1934–) affirms:

> "Good things in life do not come only through the senses. Some of the most exhilarating experiences we undergo are generated inside the mind, triggered by information that challenges our ability to think, rather than from the use of sensory skills." (Csikszentmihalyi 1990, 117)

Yet, without further sensory stimuli, the brain would not have an archive of episodic memories to mix with and stir the imagination. Aristotle affirmed that "nothing is in the mind that does not pass through the senses." (in Light 2005, 13) Our brain works making associations of old and new concepts, thoughts, feelings, images, sounds, smells, tastes. Memory archives are packs of present and past experiences all felt sensorially. Our brain recalls saved memories and combines them with new ones, every time something triggers a memory.
Memory is about the experience, mediation, and representation. It is cumulative, but also selective, it is not factual, but defiled by similar experiences. Only the more salient events will be retained and recalled.

3.4 Perceptual Illusions

We tend to think that touch is somehow more veridical than other senses, that it cannot be deceived. Perhaps, this is because we are aware of the many optical illusions, but we rarely hear about tactile illusions. Yet, all senses are susceptible to perceptual illusions, (Hayward 2015) and daily our sense of touch is deceived by technology. In touch screens, the impression of physical buttons reacting when we press, and objects moving and changing shape under our fingertips happens projected on the glass, intangible for touch, developed precisely to deceive our cutaneous system and lead the brain to think to be interacting with real elements. The expression, "Seeing is believing, but feeling is the truth," (Fuller 1640 in Paterson 2007, 2) by English churchman and historian Thomas Fuller (1608–1661), may not always be correct, as tactile perception may be deluded.

Perceptual Illusion:
"is a percept that arises from a stimulus combining two separable components. One component is fixed and the observer attends to it. What makes it an illusion is that the perception of this component is strongly contingent on the variation of a second component, perplexing the person made aware of the unchanging component of the stimulus." (Hayward 2015)
Vincent Hayward, researcher of haptics in the Institut des Systèmes Intelligents et de Robotique, at Université Pierre et Marie Curie in Paris, France, developed a taxonomy surveying more than twenty types of tactile illusions. (Hayward 2008)

"[T]he somatosensory system has evolved to solve perceptual problems quickly and reliably, subject to constraints that are physical (*i.e.* skin mechanoreceptors cannot be at a small distance from the surface comparatively to their size), physiological (*i.e.* neural computation is powerful but limited; mechanoreceptors must have a refractory period), and metabolic (*i.e.* only a proportion of afferent fibers from the periphery to the brain can be myelinated) in origin." (Hayward 2015)

A tactile spatiotemporal perceptual illusion was described in 1972 by Frank Geldard (1904–1984) and Carl Sherrick (1925–2005) of Cutaneous Communication Laboratory (1962–2004) at Princeton University (tactileresearch.org), to which they called the *cutaneous rabbit* (and later *cutaneous saltation*) referring to the leaping notion of the percept. The illusion is most easily perceived on areas of the skin that have lower spatial acuity, as are the forearms. The experiments consisted in using a vibrotactor to cause five brief pulses (2 msec duration each, separated by 40 to 80 msec) delivered near the wrist, and then five more at a locus 10 cm centrad, followed by another five at a locus 10 cm proximal to the second and near the elbow, creating sensations of sequential taps hopping up the arm from wrist to elbow, when no real stimuli were applied between the three stimulated loci. (Geldard and Sherrick 1972) The Japanese Tomohisa Asai and Noriaki Kanayama conducted experiments to determine the cause of the rabbit illusion, and evidence suggests that in unimodal causality, "our brain interprets successive stimuli on the skin as motion in terms of time and space." In multimodal causality, and presenting spatiotemporal synchronicity to modalities, "the concurrent signals from other modalities provide cues for creating unified representations of this external motion." (Asai and Kanayama 2012) The brain expects a stimulus to happen with spatiotemporal regularity.

The *tau effect* is a spatial illusion described in 1914 by German psychologist Adhémar Gelb (1887–1936) and named in 1930 by American physiological psychologist Harry Helson (1898–1977), where the distance perceived between tactile stimuli depends on their temporal separation. A shorter time separation corresponds to a smaller perceived spatial separation. The experiments consisted of three pressure stimuli provided in succession on forearms at equal spatial but unequal temporal intervals. Under certain laboratory conditions, "using a kinohapt, consisting of 3 solenoids controlling stimulator rods weighing 11.5 gm, and dropped 2 mm on the skin, and a commutator type interval timer." (Helson 1930) Demonstrating the perceptual dependence of space upon time.

The *kappa effect* is a temporal illusion first described in 1952 as the *S-effect* by Japanese psychologist Suto Yoji, that arises when the elapsed time is perceived different between the sensory stimuli applied sequentially at different loci. Experiments consisted of three pressure stimuli provided in succession on the inner side of left forearms, with eyes kept closed. (Suto 1952) In perceiving a sequence of consecutive tactile stimuli, we tend to underestimate the elapsed time between two successive stimuli when the distance between the stimuli is decreased and to overestimate the elapsed time when the distance is enlarged. Evidence indicates that perceived stimuli may not correspond to physical stimuli.

Summary

Since it is carried out through the senses, perception is personal. Everything is caused by perceptions. All interpretations are relative for they are the result

Aristotle's illusion: when we cross the middle and index fingers around a small marble, we seem to feel two marbles instead of one. Merleau-Ponty argues, that "is primarily a disturbance of the body schema." (Merleau-Ponty 2002 (1945), 238 in Carman 1999, 219) "For it is not just that our fingers are only rarely ever in such an awkward inverted position, it is rather that they cannot get themselves there by their own effort: 'The synthesis of the object here is thus effected through the synthesis of one's own body.' The perception of objects is structured by our body and by what it senses that it can and cannot do." (Carman 1999, 219)

Kinohapt: from *kino*, 'Kinesthetic,' and the Greek *Hapto*, meaning 'to touch.' It "is an esthesiometer for applying several stimuli to the skin at different distances and frequencies." (lexic.us/definition-of/kinohapt)

Solenoid: from the French *solénoïde*, derived from the Greek *solen* 'pipe, channel,' combined form of the Greek *eidos* 'form, shape.' The term was introduced by French physicist André-Marie Ampère (1775–1836) to designate a helical coil (Wikipedia)

of individual perceptions. Each one is influenced by experiences, memories, emotions, expectations, motivations, and attention. Perception is affected by what we might have sensed from our inner and outer worlds. It is inherently subjective and subject to change. Senses do not sense separately and perception depends on the awareness. The perception of our environment changes when we take a particular attention to an individual sense, from which we may experience the thrill of feeling anew what supposedly we already knew. Through the senses, we perceive and interpret the world and ourselves in it. The reality can be different for each one of us for it depends on how our senses enable us to experience the state of things. Experiences impact perceptions and perception builds knowledge. A perception is informed or conditioned by the meaning a sensation has acquired subjectively, and the constructed cultural value that is individually apprehended. Perception is, therefore, subjectively relative and sensorially limited. As our sensorium is unable to grasp most of what happens in our environment.

Being aware allow us to develop subjective assumptions that we take for interpretations from our perceptions. When we become aware of a condition or an event, our consciousness guides behavior. However, much of what we perform daily is done unconsciously. We act before or without being fully conscious of a sensation. An impression is elicited by a perception. In which, touch denotes a perceiving body that feels from within while sight implies a conceiving mind that takes in the outside.
Yet, most of the phenomena happening around us are imperceptible by our sensorium, adding the ones that we do not give account for the lack of attention. We act aware of our unconsciousness, and daily we are more aware of the senses over which we have more control because we can stop them from sensing, and thus switch the stimulus. A continued stimulus desensitizes the senses and we cease to perceive sensations.

The recollection of a memory is an interpretation of an experience that is being transformed over time. An experience that when occurred might be accurate was susceptible to subjective perception. Our sensory perception varies over time; hence the statement: — "Now I see the world through different eyes." And memory blurs the accuracy of the experience, by adding or removing facts that may alter its interpretation. The accuracy of a memory may be misled by imagination. A memory today, may well be an assemblage of past experiences. The experience of the world is a combination of multisensory impressions. Feelings, thoughts, and ideas that form in our minds are the result of associations and interconnections of those impressions.

Chapter 4

History
A phenomenon with sense

Introduction

This chapter runs briefly through the history of human senses. Surveying the cultural, philosophical, social, and technological implications regarding how we sense the surrounding spaces and objects through touch. Showing a number of references that explore different perspectives related to conceptions of touch, where creative outcomes mediate or ideate somatic sensations.

4.1 Evolution

Culture:
is heritage and transformation. As the British anthropologist Edward Burnett Tylor (1832–1917) stated, "is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society." (E. B. Tylor 1920 (1871), 1)

The way we regard our senses, as well, the way we relate to our senses change over time, geography, and climate variability. Historically, our senses have been subject to different concerns depending on the spirit and morality of the time. While culturally, we have dealt with the senses distinctively. Eastern cultures are different in what bears upon sensory sensitivity and sensibility. In the East, the ancestral thoughtfulness is based on balance, harmony, simplicity, peace, acceptance, and connection. Whereas in the hedonistic West, the majority of people focus predominantly on desire. In the immediate fulfillment of one's needs, wishes, expectations, and the pleasure derived in rapid satisfactions. From East to West there are opposing modes of manifesting sensory awareness, of spiritual contrasting materialistic dispositions, which inevitably impact how we sense the world. The traditional selfless appreciative contemplation of the

East is diametrically opposite to the individualistic possession of the West. The ancient Indian Hinduism philosophy revealed in the *Vedas*, which means 'knowledge' in Sanskrit, are religious texts consisting of hymns from about 1500–1200 BC. The *Rigveda*, the oldest of Vedic texts, has not yet a term for 'touch' nor an expression for the corresponding sensation of 'feeling.' (Jütte in Grünwald 2008, 3) The fourth Vedic text called *Atharvaveda* comprised of hymns, many of which charms, magic spells, and incantations, feeling is termed *samsparsa*. In the *Ayurveda*, which is an appendix to the Atharvaveda, the primeval matter (sattva) realizes the five senses of knowledge or *Buddhindriyas*. (White 1996, 34) The sense capacities of hearing, feeling, seeing, tasting and smelling were symbolically connoted with five natural elements: hearing is assigned to space; feeling to wind; sight to fire; taste to water; and smell to earth. (Jütte in Grünwald 2008, 3)

> "The sense of touch is associated with the wind. The skin, as one of the sense organs, is envisaged simply as the meeting point of the qualities or object assigned to this sense: skin-finger-grasping-feeling." (*ibid.*)

Also in ancient China, the sense organs of human anatomy were interpreted by association to five natural elements: the eye is correlated with wood; tongue with fire; mouth with earth; nose with metal; and ear with water. (*ibid.*) While in the West, the Greek philosopher Empedocles (490–430 BC), known for being the creator of the cosmogenic theory, that all matter is made up of four elements: earth, air, water, and fire; used the term *pagamai*, meaning 'flat of the hand' or 'gripper,' to refer to all the senses, which means that "his descriptions of sensory perception, in general, refer to the sense of touch." (*ibid.*, 4) In Plato's (c. 428–347 BC) *Timaeus* written circa 360 BC, he does not attribute touch to a definite sense organ. (*ibid.*, 4) Instead, he generalizes the sensations affecting the flesh systemically, like pain and pleasure, warm and cold, as "disturbances that affect the whole body in a common way." (Plato 2000 (c. 360 BC), 65c) The interpretation of the senses started in Greece with Aristotle (384–322 BC), who named, counted, and classified hierarchizing the five senses: *visus*, *auditus*, *odoratus*, *gustus*, and *tactus*. Sight was the noblest while touch was relegated to the lowest position. (in Paterson 2007, 1) To Aristotle, the reason for disregarding touch was that sight "approximates the intellect most closely by virtue of the relative immateriality of its knowing." (in Pallasmaa 2012, 18) Albeit, Aristotle has mentioned that "The most acute of all man's senses is the sense of touch." (in Heller-Roazen 2007, 292) For touch is intuitive, instinctive, visceral, muscular, corporeal, Aristotle considered touch an inferior sense. Although touch has been relegated to the base of a classified list, touch is only base, because it is basilar to all other senses. In *Sensible Flesh: On Touch in Early Modern Culture*, published in 2003, editor Elizabeth D. Harvey quotes touch, "The sense of all senses." (Harvey 2003, 1) Harvey recalls that "Touch occupies a complex, shifting, and sometimes contradictory position in the representation of the five senses in Western culture." (*ibid.*)

"The Middle Ages was the middle period in a schematic division of European history into three 'ages:' Classical civilization, the Middle Ages, and Modern Civilization." (timelineindex.com/content/view/540)

Early modern period: of modern history follows the late Middle Ages (c. 1301–1500) of the post-classical era in the 16th century through the beginning of the Age of Revolutions in the 18th century (c. 1775–1848). "[...] initiated with [...] the beginning of the High Renaissance in Italy; the invention of moveable type printing in the 1450s; the Fall of Constantinople in 1453; the end of the Wars of the Roses in 1487; the Voyages of Christopher Columbus and the completion of the Reconquista in 1492 or the start of the Protestant Reformation in 1517. [Ending] with the outset of the French Revolution in 1789." (Wikipedia)

Court physician to King James I of England, Helkiah Crooke (1576–1648) in the treatise on anatomy *Mikrokosmographia: A Description of the Body of Man*, published in 1615, called touch "the onely sense of all senses." (in Harvey 2003, 83)

Italian Dominican friar and catholic priest St Thomas Aquinas (1225–1274), most influential medieval philosopher and theologist of the West, endorsed Aristotle's realization "that without the sense of touch there could be no other senses." (Jütte 2004, 42) In Aquinas's terse wording, touch is "the first sense, the root and ground, as it were, of the other senses." (*ibid.*) Underlining its primacy, Aquinas defends that touch is what makes a living being sensitive (*ibid.*, 70):

> "In the first place touch is the basis of sensitivity as a whole; for obviously the organ of touch pervades the whole body, so that the organ of each of the other senses is also an organ of touch, and the sense of touch by itself constitutes a being as sensitive." (Jütte in Grünwald 2008, 6)

Aquinas regarded the fine or discriminative touch the one capable of gathering knowledge and providing intelligence:

> "Therefore the finer one's sense of touch, the better, strictly speaking, is one's sensitive nature as a whole, and consequently the higher one's intellectual capacity. For a fine sensitivity is a disposition to a fine intelligence." (*ibid.*)

Touch is primal, instinctual, earthly. Touch is crucial for survival. In *De Anima*, Aristotle suggests that "Earth [...] at most, is a constituent peculiar to touch." (Aristotle 1907 (350 BC), 109) In the Renaissance (14th–16th centuries) reigns a return to the classical notion of the senses corresponding to natural elements:

> "During the Renaissance, the five senses were understood to form a hierarchical system from the highest sense of vision down to touch. The Renaissance system of the senses was related to the image of the cosmic body; vision was correlated to fire and light, hearing to air, smell to vapour, taste to water, and touch to earth." (Pack in Pallasmaa 2012, 18)

Despite touch have gained a reappraisal in the Middle Ages by Christian, Muslim and Jewish scholars, across the periods of Renaissance and Baroque, touch falls increasingly into disrepute (Jütte in Grünwald 2008, 6), all the while sight has largely conquered the cultural sensorium of the West since the Greeks. (Levin 1993, 283)

4.2 Sight Hegemony

In sight hegemony, vision dominates and overshadows other senses, relegating them to lower planes of consideration, value, and importance. This occurs due to a constructed sensuous cultural history, not physiologically related. Since, we sense the world through all the senses in unison, nothing in the body denotes a supremacy of sight, nor it attests an accentuated "vision-generated, vision-centered interpretation of knowledge, truth, and reality." (Levin 1993, 2) Meanings vary according to uses and customs. Wherein, "The cultural meaning of the senses [...] is not simply derived from any presumed inherent psychophysical

St Thomas Aquinas (1225–1274), stated, "Among men it is in virtue of fineness of touch, and not of any other sense, that we discriminate the mentally gifted from the rest." (in Classen 2012, xi)

Renaissance: a revival Italian cultural movement initiated in Florence, in the Late Medieval period disseminated into Europe, from the Middle Ages of the 14th century to the modern history of the 16th century. With intellectual basis on humanism, boosted by the recovery of classical Greek philosophy of, "Man is the measure of all things." proclaimed by Protagoras (c. 490–c. 420 BC), which became manifesto in art, architecture, politics, science, and literature. American art historian and expert in the Renaissance Bernard Berenson (1865–1959) stated, "Not what man knows but what man feels, concerns art. All else is science."

by not dissociating thought from sensory apperception even if metaphorically through the 'mind's eye,' the Belgian Surrealist painter René Magritte (1898–1967) stated in a letter to Michel Foucault "Thought is what sees and can be described visually." (in Hubert)

characteristics, but elaborated through their use. (Classen 1990; Leavitt and Hart 1990)" (in Howes 2003, xx) To the senses have been assigned constructed values, oftentimes disembodied.

In *Republic* (*Politeia*) a Socratic dialogue written by Plato around 380 BC, "sight is by far the most costly and complex piece of workmanship which the artificer of the senses ever contrived." (Plato 2002 (c. 380 BC) Book VI, 367) To Plato, sight is correlated with "the creation of human intelligence and soul." (Kavanagh 2004, 6) stating "the soul is like the eye" (Plato 2002 *ibid.*, 369) filled with intelligence when it sees clearly. Dividing the visible from the intelligible, "which can only be seen with the eye of the mind." (*ibid.*, 371) And sight is through light, connected to "the sun deity," (Kavanagh 2004, 6) by telling, "the sun is not sight, but the author of sight who is recognised by sight." (Plato 2002 *ibid.*, 368) Whereas the other senses belonged to the "material being." (Kavanagh 2004, 6)

French philosopher, mathematician, and scientist René Descartes (1596–1650), in *Optics* (*La dioptrique*), which is a short treatise published in 1637 included in one of the essays of the *Discourse on the Method* (*Discours de la méthode*), expounds on the illusion of sight and the primacy of the mind, contributing to the epistemological disregard for the senses in favor of a thinking mind. Descartes dismissed the unreliable sensory perception admitting the rationalist method of deduction:

> "Descartes's dualistic division into a rational world of the mind and an irrational world of the [...] senses contributed in no small measure to the rise of sight as the main sensory apparatus of the western world." (in Day 2009, 1)

Despite Descartes have emphasized the deceptiveness of sight, he endued the mind with metaphorics of vision, "transferring the properties of the visible to the reason." (Levin 1993, 10) "to attain certitude as clear and distinct ideas." (Judovitz in *ibid.*) Thereby, Descartes' enduring rational thought have largely privileged the visual modality:

> "René Descartes regarded vision as the most universal and noble of the senses, and his objectifying philosophy is consequently grounded in the privileging of vision." (in Pallasmaa 2012 (1996), 22)

Descartes was influential in postulating the supremacy of vision though turning it into a "construct" (Levin 1993, 10) of the rational mind. Yet, his notions swung between vision and the perceptive veracity of touch, less prone to error than vision. (in Pallasmaa 2012, 22) For touch is the most convincing of a real existence.

4.3 Touch in Art

The concept that one has of touch varies according to the social and cultural momentum, the political and economic state, and the intellectual and scientific

Enlightenment: "intellectual movement in 18th century in Europe, whose purpose [...] was to establish an authoritative ethics, aesthetics, and knowledge based on an enlightened rationality," celebrating the human reason, with a keen interest in science, for the promotion of religious toleration, and a desire to construct governments free of tyranny.
"The movement's leaders [among them David Hume, Immanuel Kant, John Locke, the Baron de Montesquieu, Jean-Jacques Rousseau, and Voltaire] viewed themselves as a courageous elite [...] of intellectuals who were leading the world toward progress, out of a long period of irrationality, superstition, and tyranny which began during a historical period they called the Dark Ages. [It] provided a framework for the American and French Revolutions, as well as the rise of capitalism and the birth of socialism. It is matched by the high baroque era in music, and the neo-classical period in the arts." (timelineindex.com/content/view/542)

advancement of the time. Art is not alienated to any of those, and therefore, it reflects the spirit of a society at a given time.

The rise of Renaissance perspective, with the rule of the central vanishing point first used in 1423 by the Italian painter Masolino da Panicale (c.1383–c.1447), "to rationalize the representation of space and produce a compelling illusion of depth" (in Douma 2008) drawing the eye to the center of the scene or event, marks the reemergence of the dominant sight.

In early modern period in the 16th century, art had a suggestive tactile appealing. In 17th and 18th centuries, the Ashmolean Museum in Oxford and the British Museum in London allowed the exhibited art to be experienced by touch. (Howes and Classen 2013) The appreciation of art by sight, although prevalent in the West, "only reached its full fruition in the modern period." (*ibid.*) Concurred with the period of Enlightenment, the Age of Reason in the 18th century, which entitled throughout the visual modality. Wherein "the privileging of a contemplative sight over an inquiring touch was fully elaborated as a philosophy of aesthetics." (*ibid.*) Much influenced by the contemporary scientific discoveries on light and optics, and the theory of color by the English natural philosopher, physicist, and mathematician Isaac Newton (1643–1727) in the treatise *Opticks* published in 1704. (Newton 1718 (1704))

The Romanticism of the 19th century attempted to deviate from the rationalism of the period of Enlightenment. (Kavanagh 2004, 11) Preferring the intuition and emotion, emphasizing "the imaginative, the irrational," and the superlative of the creative mind. (*ibid.*) The Romantics were highly fond of contemplating natural phenomena, opposing the industrialization and the scientific rationalization of nature. They were keen on experiencing the sublimity and beauty of nature, leaving it untouched, unaltered, and unaffected by human intervention. For nature offered the ideal scenery for the expression of feelings of an artist, as he often found himself alone and surrounded by it.

The craftwork "appreciated by how it felt" (Howes and Classen 2013) prevailed in the pre-industrial societies [1450–1789 in Western Europe]. (*ibid.*) The era that preceded the mechanization of the industrial revolution [1709–1914 in Britain] (Dewald 2004) wherein the manual labor is replaced by machinery, assembly line, and serial production and the craftsmanship decreases and devalues. Art becomes predominantly visual with the invention of photography and film in the 19th century, and in the 20th century with the advent of television, video, the personal computer, (Howes and Classen 2013) and the broadening of public surveillance gaze. While multimedia implies several mediums, it does not immediately implicate multi-sensoriality. Often it is narrowly duo-sensoriality, involving just the audio and visual.

The prevalence of privileging vision depreciates touch and other senses. In the age of image reproducibility, (Benjamin 1935) everything visual is highlighted. For a visual culture favors exclusively the sense of sight. Pallasmaa stressed:

> "The hegemony of vision has been reinforced in our time by a multitude

Romanticism: artistic, literary, and intellectual movement originating in Europe at the end of the 18th century (1770–1850), that praised the natural phenomena and accentuated intense emotion. Coinciding with the American and French revolutions, it appeared as a reaction to the Industrial Revolution, the aristocratic social and political norms of the period of Enlightenment, and the scientific rationalization of nature. Charles Baudelaire (1846) defined, "Romanticism is precisely situated neither in choice of subject nor exact truth, but in the way of feeling." (in Jones 2014, 319) It was most strongly manifested in the visual arts (Turner, Constable, Delacroix), music, and literature (Goethe, Wordsworth, Shelley, Byron, and Keats), but had a major impact on historiography, education, and the natural sciences. With a relevant and complex effect on politics, and while it was associated with liberalism and radicalism, the effect on the growth of nationalism was probably more significant. (Wikipedia)

> of technological inventions and the endless multiplication and production of images." (in Pallasmaa 2012 (1996), 24)

Although the meanings we attribute to senses have been evolving throughout the human age, not all historical eras devoted much attention to them. As McLuhan has referred:

> "The tribal man existed in a harmonious balance of the senses, perceiving the world equally through hearing, smell, touch, sight and taste. Technological innovations are extensions of human abilities and senses that alter this sensory balance — an alteration that, in turn, inexorably reshapes the society that created the technology." (McLuhan 1969)

Throughout human history, tools have been defining societies, extending culturally human activities and behaviors, delivering more or fewer stimuli for the senses. In McLuhan's opinion, it is time to reclaim our connection between mind and body, affirming:

> "Our mechanical technologies for extending and separating the functions of our physical beings have brought us near to a state of disintegration by putting us out of touch with ourselves." (McLuhan 1964, 122)

The imposing technological rationalization is making us feel disconnected and desensitized beings by objectifying our senses. As technology becomes progressively more pervasive and immersive, we become increasingly more detached from the reality, which impacts the way we sense the world around.

4.3.1 Tactual Ocularity

Tactual ocularity means kinesthetic vision, which implies the movement of the eye and the associated six extraocular muscles for an exploratory inspect of the visual perceptible qualities of something observed. In a metaphorical way, eyes touch, actively. Inexorably connected touch and sight act correlated. In late 19th century, touch was reputed "a cruder scanning at close range," and sight "a more subtle touching at a distance." (Vischer in Copoeru and Sepp 2007, 484) In *On the Optical Sense of Form: A Contribution to Aesthetics* (*Ueber das optische Formgefühl: ein Beitrag zur Aesthetik*) published in 1873, the German philosopher Robert Vischer (1847–1933) differentiates vision into two moments, as *seeing*: "a nervous moment, passive and receptive;" and *scanning*: "a muscular moment, active and constructive." (in Frank and Adler 2012, 17)

> "Seeing is a mere apprehension of visual stimuli relatively undifferentiated, the reception of a first vague impression. Scanning, on the contrary, explores that impression in all directions, investigating it in its components. Such exploration attributes objects with the same life, dynamism, and rhythm. 'Scanning is a much more active process than

Industrial Revolution: "a period of the 18th century marked by social and technological change in which manufacturing began to rely on steam power, fueled primarily by coal, rather than on animal labor, or on water or wind power; and by a shift from artisans who made complete products to factories in which each worker completed a single stage in the manufacturing process. Improvements in transportation encouraged the rapid pace of change." (timelineindex.com/content/view/544)

Arts and Crafts: a movement for the union of art and handicraft. The term was introduced by T. J. Cobden-Sanderson at a meeting of the Arts and Crafts Exhibition Society in 1887, although the principles and style on which it was based had been initiated in England in 1860 by the time the artist William Morris (1834–1896) built his Red House around London "and served his apprenticeship to the industrial arts by designing and executing the decoration and furniture of his home." (Triggs 1902, 1) The movement was inspired by the writings of the architect Augustus Pugin (1812–1852), and the writer John Ruskin (1819–1900), [cont. ...]

seeing because it does not simply rely on the natural impulse to seek a relative whole; instead, our eye wanders up and down, left and right [...]'." (*ibid.*)

In *The Problem of Form in the Fine Arts* (*Das Problem der Form in der Bildenden Kunst*) published in 1893, the German sculptor and theorist Adolf von Hildebrand (1847–1921) formulates the distinction between a *visual representation*: "a vision from a distance, in which the eye sets the object in a unitary perspective, perceiving it at a glance as a far image;" and a *kinesthetic representation*: "a closer vision, in which the eye progressively explores the object and gets a near image of it." (Copoeru and Sepp 2007, 485)

> "The closer the observer comes to the object, the more eye movements he will need, and the less coherent will be the visual impression. Finally, the field of vision becomes so confined that he will be able to focus only on one point at a time, and he will experience the spatial relationships between different points by moving his eyes. Now seeing becomes scanning, and the resulting ideas are not visual but kinesthetic." (Hildebrand in Copoeru and Sepp 2007, 485)

In a scanning vision, sight builds up something observed from a scrutinizing viewing, similar to what touch does by summing up perceived parts of a whole.

4.3.2 Tactile Vision

In tactile vision is given to sight attributes of touch to ideate groping, grasping, and highlighting forms on a plane space. Tactile viewing comprises the visual exploration of forms for the perception of depth.
In *The Group Portraiture of Holland* (*Das holländische Gruppenporträt*) published in 1902, proposing a formal analysis of style of Dutch Baroque, the Austrian art historian Alois Riegl (1858–1905) distinguishes tactile and optic to discern "proximate vision," "in which objects seen at close range stand tangibly side by side in height and width," and "distant vision," "in which objects seen from a distance are presented to the eye even though they are tangibly behind each other at different depths." (Riegl 1999 (1902), 281) With the rise of Baroque returned the domain of vision. *e.g.* In Rembrandt's (1606–1669) painting, group figures and their surroundings make an "undifferentiated whole," (*ibid.*, 282) of a single optical plane. Rembrandt's figures merge in the background eliminating the "impression of the tactile plane." (*ibid.*) Riegl contends that progressively Rembrandt realized that figures are connected within the plane, interspaced with "circulating areas of atmosphere." (*ibid.*)

> "[For] when the figures in a painting are allowed to recede conspicuously in space at varying depths, the viewer's attention becomes too narrowly fixed on the solid objects in the image." (*ibid.*)

[... cont.] and spread into Europe and North America as opposition to industrialization, until Modernism in the 1930s, emerging in Japan in the 1920s, and continued among craft makers, designers and town planners long afterwards. (Wikipedia)

In *Crafting Selves: Power, Gender, and Discourses of Identity in a Japanese Workplace*, published in 1990, the professor of Anthropology and American Studies at the University of Southern California, Dorinne K. Kondo states that in Japan the term artisan was attributed to everyone working with hands even if working on an assembly line, because the modern technology is tuned with traditional practices. As well, the Japanese artisan did not have his or her work culturally depreciated compared to of the visual artist, as it often happens in the West, a paragone since the Italian Renaissance. (in Classen 2005, 401)

Since the tactile proximate vision focuses on the narrow viewing excluding everything around, and the optical distant vision is all-embracing and unifying. Reason why by the end of the 1640s, Rembrandt got to "appreciate the advantages of optical symmetry as a principle of composition." (*ibid.*) Depicting visual phenomena as "subjective, optical sensations of color." (*ibid.*, 288)

> "Rembrandt developed an optic spatial composition that gives figures moving at different depths the tranquillity of appearing to belong to a single plane, just as they would be seen from a great distance." (*ibid.*, 289)

Swiss art historian Heinrich Wölfflin (1864–1945) formulated classifying principles of style that were influential in the development of formal analysis in art history in the early 20th century. In *Principles of Art History* (*Kunstgeschichtliche Grundbegriffe*) published in 1915, Wölfflin proposes the distinction in painting of the styles *linear* in the 16th century, that "sees in lines;" and *painterly* in the 17th century, that "sees in masses" (Wölfflin 2012 (1915), 18) of "light and shade," (*ibid.*, 29) according to conceptions of the world at those times. (*ibid.*, 18)

> "Linear vision, [...] means that the sense and beauty of things is first sought in the outline [...] that the eye is led along the boundaries and induced to feel along the edges, while seeing in masses takes place where the attention withdraws from the edges, [...] and the primary element of the impression is things seen as patches." (*ibid.*)

Tracing a line stirs the tactual imagination into perceiving a grasping move. Wölfflin affirms, "The tracing out of a figure with an evenly clear line has still an element of physical grasping." (*ibid.*, 21) The appreciation of a linear style is not devoid of an ideated feeling of tactility, for a line may have a perceived corporeal echo. Wölfflin contends that a "line is a tangible value, and every form finds its reaction in the organs of touch." (*ibid.*, 72) In contrast, a painterly representation originates in the eye and "appeals only to the eye." Turning art into a mere appearance. (*ibid.*, 21) Hence, "the whole notion of the pictorial has shifted. The tactile picture has become the visual picture." (*ibid.*) Wölfflin considers touch as important to discern the particularities of the represented world, claiming:

> "[T]here will always arise the need for a type of art which does not merely catch the moving appearance of the world, but tries to do justice to being as revealed by tactile experiences." (*ibid.*, 29)

Wölfflin characterizes the linear style as having a "solid figure; enduring form, measurable, finite; the thing in itself;" where "the hand has felt out the corporeal world essentially according to its plastic content." (*ibid.*, 27) Contrasting it with the painterly style, which was about "the changing appearance; the movement, the form in function; the thing in its relations;" (*ibid.*) wherein,

> "the eye [...] has become sensitive to the most various textures, and it is no contradiction if even here the visual sense seems nourished by the tactile sense—that other tactile sense which relishes the kind of surface, the different skin of things. Sensation now penetrates beyond the solid object into the realm of the immaterial. The painterly style alone knows a beauty of the incorporeal." (*ibid.*)

In *The Italian Painters of the Renaissance*, published in 1930, the American art historian Bernard Berenson (1865–1959), pointed out that sight alone is incapable of apprehending the three-dimensionality (width, height, and length) or volume that something occupies in space, by arguing that "Psychology has ascertained that sight alone gives us no accurate sense of the third dimension." Berenson asserts that touch gives "the test of reality." For "every time our eyes recognize reality, we are [...] giving tactile values to retinal impressions." (in Copoeru and Sepp 2007, 486) The sensation of tactuality induced through visual impressions is to Berenson the vehemence of a veracity that touch enables. Italian professor of Aesthetics at the State University of Milan, Andrea Pinotti elaborates on the sensory disposition for the ideated "tactile values" on Berenson's theory of an eliciting figurative art experience:

> "Since the painter has to render the third dimension on a two-dimensional surface, he can do this only in the way in which we usually interpret visual reality, *i.e.* by giving a tactile value to retinal impressions. First of all, the painter must be able to stimulate the tactile sense, to provoke in the observer the illusion of touching the represented figure and the muscular stimuli in his palms and fingers corresponding to the different projections of the figure, even before he assumes it to be real." (Pinotti in Copoeru and Sepp 2007, 486)

The notion of a veracity attained by tactile feelings through an art encounter experience also contributes to what Berenson alluded of "life-enhancement." This perception happens from the awareness that touch is vital for our body and mind existence and that from this consciousness we may feel strengthened.

> "[T]he stimulation of our tactile imagination awakens our consciousness of the importance of the tactile sense in our physical and mental functioning, and [...] by making us feel better provided for life than we were aware of being, gives us a heightened sense of capacity." (in *ibid.*, 488)

Berenson enunciated that for a painting to be able to enhance life depends upon the "medium and the kind of ideated sensations that constitute its material." (*ibid.*) Enumerating the characteristics of "tactile values, movement, and space-composition" a painting is required to possess to educe the "ideated sensations of contact, texture, weight, support, energy, and of union with one's surroundings." (*ibid.*)

> "The extent that a painting provides life-enhancement is in proportion to the extent that an artist succeeds in giving that painting artistic existence through tactile values." (Price *et al.* 1996, 24)

Tactile values formulated by Berenson suggest a physical appreciation of art, wherein the elements represented are given conspicuous volume and muscle movement in a contextual space for an apparent "artistic existence" generating "ideated sensations of touch, pressure, and grasp." (in *ibid.*, 24) In *Aesthetic and History*, published in 1948, on the imaginative beholding of the tactile values, Berenson affirms:

> "[O]ccur in representations of solid objects when communicated, not as mere reproductions [...], but in a way that stirs the imagination to feel their bulk, heft their weight, realize their potential resistance, span their distance from us, and encourage us, always imaginatively, to come into close touch with, to grasp, to embrace, or to walk around them." (in Copoeru and Sepp 2007, 488)

Objects have inherent tactile qualities that adjacent to their spatial volumetry invite us for a kinesthetic appreciation of shapes and surfaces. They challenge us with convexities and concavities, taking us to a relational dialogue between their tactile values and our tactile ideations.

4.3.3 Tactile Experience

Russian painter and art theorist Wassily Kandinsky (1866–1944), impressed by the Monet's painting *Haystacks*, that he had admired in 1896 in St. Petersburg, caused him to move towards abstraction, declaring:

> "The painting showed itself to me in all its fantasy and all its enchantment. Deep within me, the first doubt arose about the importance of the object as a necessary element in a picture." (in Douma 2006)

In 1911, Kandinsky is one of the first to execute purely abstract paintings. The suppression of a recognizable figurative cause to affect touch through a visceral nervous system that integrates the other senses. As the Canadian philosopher of communication theory Marshall McLuhan (1911–1980) puts it:

> "For more than a century now artists have tried to meet the challenge of the electric age by investing the tactile sense with the role of a nervous system for unifying all the others. Paradoxically, this has been achieved by "abstract art," which offers a central nervous system for a work of art." (McLuhan 1964, 122)

Since abstract art cannot be objectively explained, it confronts the viewer with the inner resonance of an idiosyncratic language of line, shape, and matter.

Abstract:
an art movement that began in the early 20th century with works as the oil on canvas *Picture with a Circle* (*Bild mit Kreis*) by Russian artist Wassily Kandinsky (1866–1944) attempting to deviate from the figurative representation of physical references to explore relationships of line, shape, color, scale, brushstroke. Kandinsky believed that colors provoke emotions theorized in *Concerning the Spiritual in Art* (*Über das Geistige in der Kunst*), published in 1911 by Kandinsky. By the end of the 19th century artists started to create art influenced by the fundamental developments in technology, science, and philosophy.

Informalism:
a pictorial movement that included all the abstract and gestural tendencies initiated in France and spreaded to Europe during the World War II, equated to the post-war American abstract expressionism. From 1954 onwards, the Spanish painter, sculptor, and art theorist Antoni Tàpies (1923–2012), developed his particular interpretation, characterised by the material density of the surfaces with their emphasis on tactile values.

In a period of strong social and political upheaval between the two world wars. Particularly, the turmoil state in a time immediately following the great social distress of a war, there are a few attempts to disrupt through disaffected cultural, intellectual, and political acts alienating normative social tendencies that led to the war. *The Manifesto of Tactilism* (*Il Manifesto di Tattilismo*) presented in 1921 at the Théâtre de l'Oeuvre in Paris, post First World War (1914–18) period, was produced with the assumption of a guiding tab in training touch for tactile sensitivities, by the Italian poet and editor Filippo Tommaso Marinetti (1876–1944), founder of the Futurist movement. Attempting to streamline pathways through the skin for conveying thoughts:

> "I have understood that human beings speak to each other with their mouths and with their eyes, but do not manage a true sincerity because of the lack of sensitivity of the skin, which is still a mediocre conductor of thought." (Marinetti 2007 (1921))

Marinetti justified it as a "first educational scale of touch, which is, at the same time, a scale of tactile values for Tactilism, or the Art of Touch." (*ibid.*)
The training process consisted firstly in conducting a series of rules on himself:

> "I started by submitting my sense of touch to an intensive treatment, pinpointing the confused phenomena of will and thought on various points on my body, and especially on the palms of my hands. This training is slow but easy, and all healthy bodies can, through this training, give surprising and exact results." (*ibid.*)

The experimental evidence was exhaustively reported in "suggestive tactile boards" of his "hand journeys." (*ibid.*) The following is an excerpt from a "physio-psychic-tactile portrait of Marinetti" with semantic associations to materials:

> "Central generating block. Roughness in part, roundness without being coarse, strength, and softness at the center revealing the sensibility of the person. (A warm brush = aspiration in lite. A block of rock and wood = the highest potential. Sponge = sensitivity to the environment.)" (*ibid.*)

The training was to be proceeded on other tactilists, for results to be presented publicly. Concluding the manifesto with the following declaration of intent:

> "It must, simply, have as a goal tactile harmony, and it must indirectly collaborate in the perfecting of spiritual communication between human beings through the epidermis." (*ibid.*)

Marinetti proclaimed training touch to enable experiencing and communicating more intensively through tactile demonstrations in the art for public expressions. Whereas the dominant intents of Dadaist artists were to provoke disturbance and discompose behaviors through scandal and shock. (Bütger in Brill 2010, 59) Romanian-French avant-garde poet, essayist, and performance artist Tristan

Manifesto:
public declaration of policy and aims, often political in nature, of a group or individual's principles, beliefs, and intended courses of action. (moma.org)

Futurism:
Italian movement in art literature, and music, founded in 1909 by Filippo Tommaso Marinetti (1876–1944), (*cf.* Antonello 2013) in which forms derived chiefly from cubism were used to represent rapid movement and dynamic motion, intended to replace traditional aesthetic values with the characteristics of the machine age.
Between the fast pace of laborious industrial machines, and the expectant looking to the future in the beginning of a new century.

Cubism:
was founded by the artists Pablo Picasso and Georges Braque in 1907, in Paris, consisting of geometric planes and compressed spaces that rejected conventions of perspective and representation, where a subject was often broken down into geometrical components being represented from several angles at once. (moma.org)

Tzara (1896–1963), one of the founders of the anti-establishment Dada movement, stated that Dada was determined to "scandalize society." (in Brill 2010, 60) And many Surrealists used objects and images of the body as their primary form of expression, mutilating, dismembering, and distorting with the intent of shocking. Others used parts of the body to humorously taking the audiences to explore with touch the eroticized forms. Assertively disrupting taboos, rules, and norms. French-American painter and mixed media artist Marcel Duchamp (1887–1968) associated with Cubism, Dadaism, and Surrealism, yet he has refused categorized affiliations to often stretch and rip conventions, (Stafford 2008) and the Italian-American Surrealist painter and sculptor Enrico Donati (1909–2008) glued a foam rubber (latex) female breast on black velvet to the front covers of the exhibition catalogues *Please touch: Surrealism in 1947* (*Prière de toucher: Le Surréalisme en 1947*), teasingly inviting the visitors to touch the art exhibited at the Galerie Maeght in Paris in 1947, the post-Second World War (1939–45) period. Offering a resonant bodily experience usual to dadaist and surrealist experiments since 1913. After the readymades insurgence of everyday objects that were brought to galleries to be tactually explored and defiantly valued as art. (Mileaf 2010, 2) Denying the assumption that art is to contemplate, and defying institutionalized norms that claim exhibited art can not be touched. Finnish media archeologist, curator, and professor of Media History and Theory at UCLA, Erkki Huhtamo asserts that "Duchamp's idea of displaying these in the gallery as legitimate "untouchable" art objects created a powerful irony." (Huhtamo 2007) Huhtamo elaborates on the visitors temptation to touch:

> "Far from nullifying the tactile nature of these objects, admiring them from a distance may have increased the temptation to touch them as a subversion of their newly acquired 'status'." (Huhtamo 2007)

American art historian Janine Mileaf wrote in *Please Touch: Dada and Surrealist Objects After the Readymade*, published in 2010, on the multifarious significances of touch:

> "[F]or this lineage of artists who depart from the readymade, touch signifies a form of interaction characterized by reciprocity, decentralization, contact, and multiplicity." (Mileaf 2010, 3)

Often provocatively, real or illusory, touch was used to stir the tactile imagination of viewers. Due to the social and political precariousness of the post-war period, artists strove to confront the despondency with rupture and change. Duchamp, in particular, sought to create art where he could fill the mind with thoughts and not merely retinal imagery. The notion of object art brings to art experience the multisensoriality of an embodied involvement. (Mileaf 2010, 7) The mundane character of exhibits removes the insurmountable aura that makes art intangible. Since touch removes the distance and introduces the body participation into an art encounter, sight and touch cohere heightening the art experience.

Dadaism:
Zurich movement in art, literature, and thought, initiated in 1916 (–1920) and rapidly spreading to Berlin grewing out of dissatisfaction with traditional social values and conventional practices in art during World War I (1914–18). The term *anti-art*, a precursor to Dada, was coined by Marcel Duchamp in 1913 when he created his first readymades. Dada artists were disillusioned by the social values that led to the war and sought to expose accepted and often repressive conventions of order and logic by shocking people into self-awareness. (moma.org)

Surrealism:
disseminated Parisian movement in art, literature, film, music, political thought and practice, philosophy, and social theory, initiated in 1924 (–1939) was active through the World War II. Influenced by Sigmund Freud's writings on psychology, Surrealists, led by André Breton, were interested in how the irrational, unconscious mind could move beyond the constraints of the rational world. It grew out of dissatisfaction with traditional social values and artistic practices after the World War I. (moma.org)

4.3.4 Virtual Touch

With the advent of digital technologies, the experience of touch in art changed to become virtual. The hand was converted into a tool mostly to handle a keyboard and a mouse, but the experience of an ideated touch was almost nonexistent. The computer screen is the main mean assessable to retinal wonder, wherein what happens behind a glass can hardly be ideated as touchable. An artist creating with a computer was about to cede power to the machine to produce by chance within a specified range of possibilities while standing by to watch it perform the programmed and stochastic outputs. At most, a brief contact would be needed to activate the system. The exhibition *Cybernetic Serendipity* showed at the Institute of Contemporary Arts, London in 1968, on the computer and the arts, curated by the British-Polish art critic, curator, and writer Jasia Reichardt (1933–) featured in one section, algorithms, and devices for generating music. Some exhibits were pamphlets describing the algorithms, whilst others were musical notations produced by computers. Some devices made musical effects and played tapes of sounds made by computers. Another section showed moving machines that created kinetic environments, pulsing TV screens and distorted images that could be activated manually with magnets. Sculptures of vibrating stainless-steel rods, stroboscopic light, and audio feedback control. And some other devices that created patterns. A third section of the exhibition explored the computer's ability to generate text with devices producing Haiku, children's stories, and essays. (cyberneticserendipity.net) The Canadian programmer-artist Leslie Mezei wrote on the journal *Computers and the Humanities* in 1967:

> "Although there is much interest in applying the computer to various areas of the visual arts, few real accomplishments have been recorded so far. Two of the causes for this lack of progress are [the] technical difficulty of processing two-dimensional images and the complexity and expense of the equipment and the software." [...] Reichardt continues "Art made with these techniques was instantaneously recognisable as having been produced either by mechanical means or with a program. It didn't actually look as if it had been done by hand." (in Reichardt 2005)

Digital technologies have affected the way we feel the world around, our bodily existence balances between two realities: the physical and the virtual, dislocating the cultural status of touch and what we are capable of creating with hands-free.

Summary

Commonly, we have a hierarchized relationship with our senses. In particular with the sense of touch, which is often relegated to the lower level of importance.

Cybernetics:
from the Greek *kybernetes*, means 'skippers,' 'rulers,' or 'governors.' The term was first used by Norbert Wiener in his book *Cybernetics* published in 1948, subtitled *Communication and Control in Animal and Machine*. Currently, the term "refers to systems of communication and control in complex electronic devices like computers, which have very definite similarities with the processes of communication and control in the human nervous system." (in cyberneticserendipity.net)

Serendipity:
the term was introduced by Horace Walpole in 1754, after a "legend about three princes of Serendipity (former name for Ceylon) while traveling throughout the world whatever was their aim or whatever they looked for, they always found something very much better. Walpole used the term to describe the faculty of making happy chance discoveries. Through the use of cybernetic devices to make graphics, film and poems, as other randomising machines which interact with the spectator, many happy discoveries were made. Hence the title of this show."
(in cyberneticserendipity.net)

Depending on the era, we have attributed different values, uses, and meanings to the senses, and most deliberately to touch.
Touch is socially unsettled, culturally mutable, and climatically dependent, since warmer ambient temperatures permit the exposition of skin, make the people more affable, and influence the disposition for social touch.

Throughout historical epochs and across contrasting cultures, senses have been hierarchized in variable rankings depending on the intellectual and spiritual dispositions of the time. While most of the religious moralities make touch amoral, a few theologists and theoreticians dignify touch and deconstruct the hierarchy in which it has been erroneously positioned. Throughout history, the repute of touch has fluctuated between high and low to high again. Nonetheless, the notion that we have of the senses, particularly of touch, has changed over the history depending on the momentum of the society, the evolution of ideas, new discoveries in science, and developments in technology. Still, sight remains predominant occupying the sensorium of the Western culture. Where man is connoted with sight and woman with touch, which may partially explain the sight domain.

Touch along with body awareness has a long existence, but a short history in our understanding of its capabilities. Although its brief history, since it became an issue for research matter, touch has been considered a significant sense. Much has changed since Aristotle and other earlier thinkers and researchers that conceptualized the senses, until the moment where the digital technologies culminating in a digitized body dominated our perceptual understanding of reality. The virtual space alters our reality into the dematerialization of physical existence, where the sensory experiences are replaced by digital simulations. One cannot interpret the existing relation between media technologies and the haptic apparatus without analyzing clearly the historical evolution of the sensory perception, cultural use, social interpretation, of the differing meanings of touch. For all that exists today is built upon what has existed yesterday.

Chapter 5

Aesthetics
Or how we feel touched

Introduction

This chapter examines different interpretations from our ability to apprehend, appreciate, and respond to occurrences of phenomenal events. On how we may feel emotionally and cognitively touched by aesthetic manifestations from art and design able of inducing or affecting the somatic sensations.

Sensibility:
is the capacity to respond to aesthetic and emotional stimuli.

Aesthetics:
from the Greek *aisthetikos* meaning 'sensitive,' 'sentient,' the verb *aisthesthai* 'to perceive,' derived from *aisthanomai*, means 'I perceive,' 'feel,' 'sense.' (etymonline.com) Used since the ancient Greeks to mean the ability to receive stimulation from one or more of the five bodily senses. The term, which previously merely meant 'sensation,' was adapted to Æsthetik to mean 'taste' or 'sense of beauty,' by the German philosopher [cont. ...]

5.1 Sensibility

Aesthetics refers to our sensibility to be receptive to the distinctive manifestation of something, for what we may feel moved by, and how we respond and attribute value to it. Conventionally, aesthetics is used to measure standards of beauty quality. Taste measurements, which are highly subjective, and depend directly on each one's sensibility to appreciate and attribute value to the one or thing appreciated. The beautiful is a judgment of value. Heidegger distinguished aesthetics from beautiful saying, "what determines human feeling, that is, aesthetics, and what feeling comports itself toward, is the beautiful." (in Thomson 2010) John Dewey (1934) in turn, opined that a genuine aesthetic experience is not only something that provides an immediate and fleeting consumption but also that gives further satisfaction. (in Leddy 2008) It is a feeling that remains in time as long as perdures the sensation of satisfaction. In the philosophy of Kant, beauty is sensorial, emotional, and intellectual. The aesthetic appreciation

is a relation of oppositions. It is the understanding of this comparative distinction that defines what is beauty. Each one knows what it is not to oneself. In Denis Diderot's words "beauty is the perception of relations." (Diderot 2011, 13) Beauty is relative and does not rely on perfection. Beauty is "perceived," (Diderot 2011, 14) and there are as many meanings for beauty as there are tastes. Beauty may be in the subtlety of a slight whisper. Georgian-British singer, songwriter, and musician Katie Melua tells — "That beauty need only be a whisper," in a verse of the song *I Cried For You*, from the album *Piece by Piece*, of 2009. Yet, as simple and ephemeral as it can be, throughout history philosophers have committed their knowledge in finding explanations for perception and judgment of beauty. Created beauty is not sublime perfection, as the one apparently achieved by nature. Imperfection is closer to us, touchable, graspable and comforting while sublime perfection is intangible, untouchable, and distant. We are all imperfect. Nature, is not ultimately perfect but disguises it well. When something seems to be growing deviated, nature opts seamlessly for the deviation. — "They are all perfect," is a line from the movie *The Last Samurai* spoken by the charismatic samurai leader Moritsugu Katsumoto, portrayed by Ken Watanabe, whom after his last battle referred to the cherry blossoms rendered to their beauty.
For those brokenhearted due to falling below the intrinsic beauty of things or life imperfect, *Of Beauty and Consolation* (*Van De Schoonheid en de Troost*) was a Dutch serial television program transmitted by VPRO, in 2000, that was based on interviewing the most prominent thinkers, writers, researchers, and artists, on the subject of cultivating the most beautiful and consoling elements of life. Touching on the impossibility to achieve perfection in beauty and how or where do we seek for consolation. And how do we evolve and adapt to a certain beauty. The drama movie *Perfect Sense*, directed by David Mackenzie in 2011, starring Ewan McGregor and Eva Green, tells what happen when a worldwide epidemic makes humans lose sensory perceptions one by one: smell, taste, hearing, and sight. Each loss is preceded by uncontrollable emotional outbursts. Momentarily, people lose connection to each other and to the world around them, to then moved by survival instinct have to adapt to the sudden changes in circumstances. The highly subjective aesthetic impressions are immeasurable, but there have been several attempts through science to measure them. Neuroesthetics, a sub-discipline of empirical aesthetics, uses neuroscience to understand and explain aesthetic experiences at the neurological level, identifying the brain functions and mental states. Various attempts are being made to measure aesthetic impressions using survey instruments and scanning technologies, namely explicit ratings; speed tests, implicit tests; electroencephalogram (EEG); functional magnetic resonance imaging (fMRI); eye movement measurement; and posturography. Models to measure aesthetic experiences have been developed by Chatterjee, 2003; Leder et al., 2004; Bullot and Reber, 2012. Fundamentally, something aesthetic has a natural propensity to make us feel in some way. Hence, the notion of aesthetics has an intrinsic strength to affect

[... cont.] Alexander Gottlieb Baumgarten (1714–1762). To "a science of how things are to be known by means of the senses" (*scientiam sensitive quid cognoscendi*) in *Philosophical Considerations of Some Matters Pertaining to the Poem* (*Mediationes Philosophicae de Nonnullis ad Poema Pertinentibus*), a doctoral dissertation published in 1735, and *Aesthetica* published in 1750. (Guyer 2005, 3)

Aisthesis:
from the Greek *aísthes*, meaning the ability of 'sense perception.' The general perception with all the senses, as well as the impression that the perceived leaves on the body. Originally, tactile and visual perception constituted a whole, but after Kantian tradition, the meaning was reduced to just an eye that observes, without a body. (Bleeker *et al.* 2002, v)

Coenesthesia:
general awareness of one's own body; of bodily existence. (The Free Dictionary)

Cognition:
the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses. (New Oxford American Dictionary)

us somehow. Senses are used metaphorically to generate meanings out of sensations. Alluded by Driscoll:

> "We say I see to mean I understand. We say we are touched to mean I am emotionally affected. We link sight to comprehension and touch to emotion. Sight to brain, touch to heart." (Driscoll, *Whole Body Seeing*, chap.5)

Yet, touch not only affects us emotionally but it participates in the construction of understanding. Extending Driscoll's statement, the opposite also happens when we say — "To have at one's fingertips," meaning readily available or within one's mental grasp, for touch can be directly associated with knowledge. As in — "We touch and we know." In martial arts movie *The Grandmaster* (*Yi Dai Zong Shi*), that tells the life's story of Ip Man, strikingly shows that he has something to say, but not with spoken words. Ip writes in Chinese characters with his finger on the palm of his wife's hand: — "A young man's heart has a pair of legs. Even if divided by a river or an ocean, he always comes back." It was directed by Wong Kar Wai and premiered in 2013, starring Tony Leung as Ip Man, and Ziyi Zhang as Gong Er. Touch is sensation and feeling in psycho-physical states. We may feel deeply moved by something that was remarkably touching, or feel shaken for an unpleasant experience. We may feel touched in many ways. Actually, we do not need a physical contact to feel touched. English essayist, poet, dramatist, politician, and co-founder of *The Spectator* magazine, Joseph Addison (1672–1719) in *The Pleasures of the Imagination*," published in 1712 (and often referred as the first treatise on a theory of aesthetics), eloquently wrote, "Sight [...] may be considered as a more delicate and diffusive kind of Touch." (Addison 1712) The American photographer Nan Goldin (1953–) forcefully believes that "Photography is the opposite of detachment. It is a way of touching the other: it is a caress." Suddenly, a frugal eye contact may trigger an unexpected inner bond with a stranger, which sometimes appears to be almost physical. Depending on our sensitivity to others, we may feel empathically touched by someone's eyes. "An animal's eyes have the power to speak a great language," as so emphatically expressed the Austrian-Israeli Jewish philosopher Martin Buber (1878–1965). We may as well feel profoundly touched by an eloquent discourse, an outstanding moment, or by someone we admire. Emotional and intangible touch happens similarly in the expressed desire to maintain the connection with a friend, in "keep in touch," even at distance. Or the "get in touch," in request for further contact at the end of a first conversation.

High-touch (synonyms of personal touch) refers to someone in a business who favors a personalized contact with customers, as opposed to transacting with an impersonal voice response system or through high-tech.

A detached touch happens to someone who has a "lack of touch," referring to the rudeness of behavior, or the use of the wrong language, or even if he or she is improperly dressed for an occasion. "Being out of touch," is when someone is out of reality. (Montagu 1978, 6) "To have touch," alludes to someone who has

In *Observations on the Feeling of the Beautiful and Sublime*, published in 1764, German philosopher Immanuel Kant (1724–1804) expounds the subjective nature of aesthetic qualities and experiences.
Kant contributes to aesthetic theory in *Critique of Judgment* (*Kritik der Urteilskraft*), published in 1790, where he discusses, "The judgment of taste is aesthetical." (Kant and Bernard 2012 (1790)) To Kant, "beauty is not an objective property of things." (in Houlgate 2014 (2009)) When one judges something as beautiful, one is asserting that it exerts an effect, prompting the understanding and imagination in "free play." (*ibid.*)

In *The Meaning of the Body: Aesthetics of Human Understanding*, Mark Johnson argues, "The rise of the sciences of human nature during the 17th and 18th centuries prompted philosophers interested in the arts to change their focus from the nature of art to an almost exclusive concern with how the mind works in aesthetic judgment. By focusing primarily on the faculties of the mind that give rise to judgment about beauty." (Johnson 2012, 209)

grace in moving and style in presentation. While being a "soft touch" or an "easy touch" it is said of someone who readily gives or does something for another if asked. Alexander of Aphrodisias (*fl.* 198–209 AD) asserted that "among human beings an innate subtlety of touch seems to be the sign of a good nature." (in Heller-Roazen 2007, 292) Whereas, when we say of someone being "touchy" is because he or she has a tendency to be irascible, or easily offended. — "Touchy, that is, over sensitive or easily irritated," reiterates Ashley Montagu. (Montagu 1978, 6) And "touchy-feely" is of someone openly expressing emotions and affections. — "I was never insane except upon occasions when my heart was touched," retorted Edgar Allan Poe. And Diane Ackerman beautifully put in this way:

> "Above all, touch teaches us that life has depth and contour; it makes our sense of the world and ourself three-dimensional. Without that intricate feel for life, there would be no artists, whose cunning is to make sensory and emotional maps." (Ackerman, 1990, 95)

French poet Arthur Rimbaud (1854–1891) voiced how the poet's creative moment is inner felt. — "The poet makes himself into a seer by a long, tremendous and reasoned derangement of all the senses." (in Heyrman 2005) And those, the sensitive appreciators of art who feel goose-pimply (Montagu 1978, 6) from a deep emotional feeling inadvertently manifested on the skin.

The calligraphy fervidly handwritten on the skin is exquisitely sensuous on the movie *The Pillow Book* (*Makura no Soshi*) directed by British Peter Greenaway and premiered in 1996. Starring Vivian Wu as Nagiko and Ewan McGregor as Jerome, it is based on an ancient Japanese diary; the book of observations and musings written by Sei Shönagon (pen name of Kiyohara Nagiko) during her time as court lady to empress consort Teishi (1013–1094) of Japanese emperor Go-Suzaku. Nearly 1000 years later, having the same first name as the author and inspired by the book, and by her father's written word on her face, Nagiko searches for a calligrapher-lover who will use her body as a paper. Eventually, she comes across Jerome, an English translator who tells her instead — "Treat me like the pages of a book." Nagiko ends up writing dexterously 13 books on the bodies of men and sends them to an elderly publisher who becomes obsessively anxious for her work while she kept secret her identity.

Nothing happens that is not touched somehow. The aging process is touched by the time leaving its wear marks in wrinkles, cracks, and scars. *Wabi Sabi* is a Japanese concept of natural beauty that gracefully preserves the marks of the passing time. In essence, wabi sabi means "finding beauty in imperfection and profundity in nature, of accepting the natural cycle of growth, decay, and death." The Japanese architect Tadao Ando defined the notion of wabi sabi in "the Japanese view of life embraced a simple aesthetic that grew stronger as inessentials were eliminated and trimmed away." (in Nobleharbor 1992) It refers to "an aesthetic that appreciates the beauty of ordinary objects no matter how imperfect, incomplete, or humble they are." (Macnab 2012, 22) The British gallerist

Wabi Sabi:
from the Japanese *wabi*, meaning 'despondency,' and *sabi*, 'loneliness' or 'solitude.' It signifies feelings, not the physical appearance of objects. "It is a profound aesthetic consciousness that transcends appearance," as Tim Wong and Akiko Hirano affirm in the article *Wabi Sabi – Learning to See the Invisible* published in 2007. (touchingstone.net) "In early Japanese poetry, wabi meant sad, desolate and lonely, but also simple, humble by choice and in tune with nature." And sabi "the bloom of time." (Lawrence 2011) "Enduring poverty in life; I prepare fire on the hearth; and enjoy the profound touch of Tea." by the haiku poet Matsuo Basho (1644–1684) "Wabi sabi suggests qualities of impermanence, humility, asymmetry, and imperfection; principles diametrically opposed to those of the Western counterparts, whose values are rooted in a *Hellenic* worldview that values permanence, grandeur, symmetry, and perfection." (Juniper 2003, 2)
The poems of Fujiwara Sadaie (1162–1241) are said to capture the spirit of wabi sabi: "As I look afar; I see neither cherry trees; Nor tinted leaves: Only a modest hut on the shore; In the twilight of an autumn eve." (in Juniper 2003, 51)

and author Andrew Juniper in *Wabi Sabi: The Japanese Art of Impermanence*, published in 2003, attempts to explain the evolution and appropriation of the concept into western aesthetic theory:

> "Japanese art, infused with the spirit of wabi sabi, seeks beauty in the truths of the natural world, looking toward[s] nature for its inspiration. It refrains from all forms of intellectual entanglement, self-regard, and affectation in order to discover the unadorned truth of nature. Since nature can be defined by its asymmetry and random imperfections, wabi sabi seeks the purity of natural imperfection." (Juniper 2003, 2)

American design theorist Maggie Macnab, author of *Design by Nature: Using Universal Forms and Principles in Design*, published in 2012, suggested that wabi sabi found in the West a loose aesthetic interpretation in *grunge.* (Macnab 2012, 22) Which was a counterculture tendency that acted the 'let it be,' messy, dirty, and rebel attitude. A punk rock music originating in the United States in the late 1980s, featuring distorted guitar sounds and a lazy voice, with a deliberated untidy and uncoordinated fashion style of a bleak or nihilistic outlook, layered clothing and ripped jeans. And in graphic design, a chaotic breaking the rules, "nearly untethering legibility from communication" (AIGA), with the American sociologist and surfer-turned-designer David Carson, and his widely imitated work for the Ray Gun magazine. Wabi sabi and grunge are two different concepts contrary in essence. As Macnab stressed, the differences are significant. "Grunge tears down or interrupts in a reactive way, whereas wabi sabi simply appreciates the reality of the living process." (Macnab 2012, 22) Although originally, it was a "departure from the Chinese perfection," (Koren 1994, 26) hardly a comparison would be possible between these two aesthetic conceptions. Wabi sabi represents contemplation and acceptance of the "transient nature," (Juniper 2003, 121) whereas grunge insinuates resistance and dissension from the conventional behavior. In wabi sabi there is no distinction between beauty and ugliness because there is no rational characterization of natural beauty:

> "The beauty of wabi sabi is not in the realm of learned ideas of beauty and ugliness, it lies in an intuitive, nonintellectual feeling toward objects that can bring about the wabi sabi experience. The real beauty that we can enjoy in true and pure aesthetics is neither beautiful nor ugly, it is the magical state that happens before any of the concepts have found [a] voice in the intellect." (Juniper 2003, 110)

Not being judgmental about what can be considered beautiful, reveals to be difficult by the tradition of western culture. Accepting a natural (unprocessed, pure, raw, crude, unrefined, whole, wild, unbleached) beauty, and its ineluctable transiency as an intrinsic quality of everything is not a concept we have learned since we were kids, which may prove to be somehow psychologically distressful. The continuous search for perfect beauty is exhausting and inglorious.

"All around, no flowers in bloom; Nor maple leaves in glare, A solitary fisherman's hut alone; On the twilight shore; Of this autumn eve." (in Koren 1994, 55)
In *Wabi-Sabi for Artists, Designers, Poets & Philosophers* published in 1994, the author Leonard Koren writes that "originally, *wabi* meant the misery of living alone in nature, away from society, and suggested a discouraged, dispirited, cheerless emotional state." "*Sabi* meant 'chill,' 'lean,' or 'withered'." (Koren 1994, 21)

Max Dessoir (1867–1947), German Neo-Kantian philosopher, theorist of aesthetics, psychologist, and who introduced the term *Haptik* in 1892, founded and edited for many years since 1906, the *Journal for Aesthetics and General Art History* (*Zeitschrift für Ästhetik und allgemeine Kunstwissenschaft, "ZÄK"*), and published the article *Aesthetics and general art history* (*Ästhetik und allgemeine Kunstwissenschaft*), in which he formulated five primary aesthetic forms: the *beautiful*, the *sublime*, the *tragic*, the *ugly*, and the *comic*. The journal, and its multiple deliberations on aesthetics, is still being published today. (ingentaconnect.com/content/meiner/zaek)

5.2 Through Art

Aesthetics is usually associated with art, but beauty is not always assigned to art, nor was even its purpose. By allowing to be ugly, art frees itself from the critical purview of aural beauty, to arouse perplexity. American sculptor ceramist Arlene Shechet (1951–) explores ugliness intentionally to elicit restlessness on spectators. Formless or deformed, her often abstract sculptures are corporeal yet transcendent, because they are undefinable. Not that it is imperative that something without form or deformed is ugly, but it is Shechet's determination to create normative deviated objects, that she assumes being ugly.
British sculptor Henry Moore (1898–1986), known for his large-scale semi-abstract sculptures in bronze installed in public areas, told how he did not pursue beauty:

> "Beauty is not the aim in my sculpture... For me, a work of art must first have in it a pent-up energy, an intense life of its own, independent of the object it may represent. When a work has this powerful vitality we do not connect the word beauty with it." (Moore in Brouwer *et al.* 2012, 8)

To French philosopher Gilles Deleuze (1925–1995) the "intrinsic aesthetic properties of an art object" are less significant than their potentiality to "overreach the circumstances of their historical production and reception to generate further thought and response." (in Davies 2009, 234) In Heidegger's concordant opinion, works of art should aim not to be just "products of history but announce and define new historical epochs." (*ibid.*) To Heidegger, the "humanity's fundamental experience of reality changes over time," and the work of art should help "explain the basic mechanism of this historical transformation of intelligibility." (in Thomson 2010) Heidegger explains that works of art should be,

> "capable of overcoming the inertia of existing traditions [...], either giving us a new sense of what is and what matters or else fundamentally transforming the established ontology and ethics through which we make sense of the world and ourselves." (*ibid.*)

To Heidegger, "art is the becoming and happening of truth." (*ibid.*) Throughout history, art has anticipated transformative social movements, in which avant-garde artists took part, were pioneers, or even the initiators. Critically assuming a devious position from the established normative culture. Csikszentmihalyi cited a viewer describing how looking at *The Bathers* (*Les Grandes Baigneuses*), a painting by French artist Paul Cézanne (1839–1906) first exhibited in 1906, can elicit a profound feeling "that things come together:" (in Csikszentmihalyi 1990, 107)

> "A sudden appreciation of, an understanding of the world. That may mean our place in it, that may mean what bathers on the side of a river on a summer day are all about... that may mean the ability to suddenly let go of ourselves and understand our connection to the world..." (*ibid.*)

Scottish philosopher, historian, economist, and essayist, David Hume (1711–1776) uttered that ontologically, "beauty is nothing but a form, which produces pleasure, as deformity is a structure of parts, which conveys pain." (in Guyer 2005, 46)
Ugliness "is only possible through its reflexive relationship to the beautiful, in relation to which it finds its measure." (Rosenkranz 2015, 33)
In *Aesthetic Theory* (*Asthetische Theorie*) published in 1970 posthumously, German philosopher, sociologist, and composer, known for the critical theory of society, Theodor W. Adorno (1903–1969) affirms, "If one originated in the other, it is beauty that originated in the ugly, and not the reverse." (Adorno 2013 (1970), 89)

In the article *The Phenomenological Relevance of Art*, professor of Philosophy Mark Wrathall (1965–) wrote, "The power of art [...] works on us affectively, [...] not just altering our beliefs about the world, but, more importantly, our dispositions through which we encounter and evaluate the world." (in Parry 2011, 10)

In the article *The Subject of Art*, French philosopher Alain Badieu (1937–) declares, "there really is today a specific responsibility of artistic creation, which is to help humanity to find the new subjective paradigm." (Badieu in the online journal, *The Symptom* (1997–2005))

Hungarian professor and author of psychology Mihaly Csikszentmihalyi (1934–) expounds that what makes an experience genuinely satisfying is a state of consciousness he have called *flow*. Because during his interviews in 1975, people described their "flow" experiences using the metaphor of a water current carrying them along. Csikszentmihalyi got impressed particularly, by painters who would get lost in their work disregarding their need for food, water, and even sleep. To Csikszentmihalyi, flow is the mental state of being completely immersed in the moment receiving high gratification from the experience. (Csikszentmihalyi 1992 (1988))

Csikszentmihalyi identified the "unsettling physical dimension of the aesthetic flow experience, which resembles the shock a body feels when diving into a pool of cold water" from quoting someone who has experienced a work of art:

> "When I see works that come close to my heart, that I think are really fine, I have the strangest reaction: which is not always exhilarating, it is sort of like being hit in the stomach. Feeling a little nauseous. It's just this sort of completely overwhelming feeling, which then I have to grope my way out of, calm myself down, and try to approach it scientifically, not with all my antennae vulnerable, open... What comes to you after looking at it calmly, after you've really digested every nuance and every little thread, is the total impact. When you encounter a very great work of art, you just know it and it thrills you in all your senses, not just visually, but sensually and intellectually." (in Csikszentmihalyi 1990, 107)

The fruition of art happens within each one's heart and mind, to eventually grow to the whole body. Art craves to affect someone in a sensitive manner. To make one feel changed after an encounter with it. Expressed by American artist Rosalyn Driscoll, "Art is made and experienced by hand, body and heart as well as by eye and mind." (Driscoll 2013) Either affecting the heart, the brain, or both. Typically, we cannot remain indifferent to demonstrations that show similarities with us, without almost immediately feeling closeness, connection, or empathy. The exhibition *Kinesthetics: Art Imitating Life* at the Pratt Manhattan Gallery in 2013, curated by Linda Lauro-Lazin and Nick Battis,

> "explores the aesthetics of movement and includes kinetic sculptures that echo the movement of natural form and human experiences." (Pratt Manhattan Gallery)

It showed hybridized kinetic sculptures mixing life-like moving elements with mechanized parts, as wires, motors, strings, pulleys, hydraulics, and high tensile fabric, powered by hand, wind, sun, or electricity.

> "Each artist's sculpture reveals a kind of persona that evolves over time. We as viewers start to assign life-like attributes to the works and they begin to transcend their artificiality." (Lauro-Lazin, co-curator, and professor of Digital Arts at Pratt Institute, New York)

Art communicates, always. Undoubtably, "this is what art is for: transformation, communication across seemingly impenetrable barriers." (Driscoll, *Whole Body Seeing*, chap.11) In the movie *Anonymous*, directed by Roland Emmerich and premiered in 2011, portraying the life of William Shakespeare with the assumption that it was, in fact, Edward de Vere, Earl of Oxford (1550–1604), who penned Shakespeare's plays, he says in a line, — "All art is political, Jonson, otherwise, it would just be decoration. And all artists have something to say, otherwise they'd make shoes. And you are not a cobbler, are you, Jonson."

Artists are integrated into a society, which makes them forcibly political beings. Futurist artist Marinetti eloquently affirms it in a manifesto on the Second Italo-Ethiopian colonial war (1935–1936) [First Italo-Ethiopian War was in 1895–1896]:

> "For twenty-seven years we Futurists have rebelled against the branding of war as antiaesthetic... Accordingly we state:... War is beautiful because it establishes man's dominion over the subjugated machinery by means of gas masks, terrifying megaphones, flame throwers, and small tanks. War is beautiful because it initiates the dream—of metalization of the human body. War is beautiful because it enriches a flowering meadow with the fiery orchids of machine guns. War is beautiful because it combines the gunfire, the cannonades, the cease-fire, the scents, and the stench of putrefaction into a symphony. War is beautiful because it creates [a] new architecture, like that of the big tanks, the geometrical formation flights, the smoke spirals from burning villages, and many others... Poets and artists of Futurism!... remember these principles of an aesthetics of war so that your struggle for a new literature and a new graphic art... may be illumined by them!" (in Benjamin *et al.* 2008 (1935), 41)

British conceptual walking artist Hamish Fulton (1946–) asserts, "Irrespective of its appearance contemporary art is a necessary political force in society." (Fulton 2010) Cuban installation and performance artist Tania Bruguera (1968–):

> "[E]xplores the relationship between art, activism, and social change, in works that examine the social effects of political and economic power. [...] [O]ften staging participatory events and interactions that build on her observations, experiences, and interpretations of the politics of repression and control." (art21.org)

Art is politicized in the works of the American artist, geographer, and author Trevor Paglen (1974–). For he critically highlights military surveillance technology, drones activity, state secrecy, space invasion, and altered geography.
Art is crucial to develop a critical sense. To improve apprehension, to enlarge vision (Dewey in Leddy 2008), to create awareness, and convey meaning. Art is manipulation of emotions. If not, it is purely entertainment or simply decorative. An artist statement uttered by the Australian artists Marc and Gillie Schattner, known for public sculptures and the signature character hybrids *Dogman* and *Rabbitgirl*, emphatically says:

> "The world depends on contemporary artists to challenge life as we know it. We, the contemporary artists pull apart the world, so it can be put back together as something different."

Affirmed by the Russian-American painter Mark Rothko (1903–1970), "a painting is not about experience, it is experience." (in Heyrman 2005) — Art is experience. In *Truth and Method* (*Wahrheit und Methode*) on hermeneutics, first published

In *Dada Presentism: An Essay on Art and History*, published in 2016, Paris-based art historian Maria Stavrinaki recovers the Dadaist manifesto written on April 1918 by Richard Huelsenbeck: "Art in its execution and direction is dependent on the time in which it lives, and artists are creatures of their epoch. The highest art will be that which in its conscious content presents the thousandfold problems of the day, the art which has been visibly shattered by the explosions of the last week, which is forever trying to collect its limbs after yesterday's crash. The best and most extraordinary artists will be those who every hour snatch the tatters of their bodies out of the frenzied cataract of life, who, with bleeding hands and hearts, hold fast to the intelligence of their time." (Maria Stavrinaki 2016, 3)

in 1960, German philosopher Hans-Georg Gadamer (1900–2002) clarifies how is experiencing the experience:

> "The aesthetic experience is not just one kind of experience among others but represents the essence of experience. [...] [I]t suddenly takes the person experiencing it out of the context of his life, by the power of the work of art, and yet relates him back to the whole of his existence. In the experience of art, there is present a fullness of meaning which belongs not only to this particular content or object but rather stands for the meaningful whole of life. [...] The work of art is understood as the perfecting of the symbolic representation of life, towards which every experience tends." (Gadamer 2013 (1960/1975), 63)

In *Philosophers on Art from Kant to the Postmodernists: A Critical Reader*, published in 2010, British art historian Christopher Kul-Want writes, "[A]esthetics, the branch of philosophy concerned with the study of experience, and art, [...] a site of experience." (Kul-Want 2010, 1)

German philosopher Friedrich Nietzsche (1844–1900) on physiological aesthetics expresses that "All art, exercises the power of suggestion over the muscles and senses. [...] All art works tonically, increases strengh, inflames desire (*i.e.* the feeling of strengh)." (in Parry 2011, 10)

Art is a quest for multiple beauties. Art is questioning the nature or state of things. Art revolves the established.
Art investigates the laws of nature and how they can be applied, worked out, or turned inside out in an unconventional way. (Driscoll 2006) The purpose of art is to make us think differently from what we are used to. To provide us with a new perspective of the world, of ourselves, and of the others, far and around. Art should actively aim to be thought-provoking, stimulating, and inspiring. Art when concerned with questioning and bringing awareness to what might seem understated, can eventually make it explicit and reachable for a better understanding. Art can be astonishment, bewilderment, jolt, confrontation or discovery. Art can be an instant that comes from an urge to an inner expression. Art is a translation of an internal reality, and as such "every work of art makes sense of reality in its own singular way." (Elo, 2012)
To the eternal question: — What is art?! The American sculptor and land artist Jim Denevan (1961–) have answered — "It's a conversation with a man's soul. It begins in the flesh, but becomes something else." When questioned for the documentary *Art Hard*, about his large scale drawing on Lake Baikal, in southern Siberia, Russia. Directed by Meredith Danluck, and premiered in 2011.
Art is action from thought of a restless mind. An art creation often comes from an unsettled mind as an exteriorization of an inquietude, or something that needs to be called to awareness, or put in question. At times, asking the right questions can be guiding, instructive, clarifying, or even enlightening. One way to answer may be in the question. Sometimes turning difficult issues accessible to public analytical percept.

> "The perceptual act of engaging with a work of art creates multiple tensions that find resolution in recognizing similarities, discerning differences, integrating contrasts, and creating meaning." (Driscoll, *Whole Body Seeing*, chap.11)

The American philosopher and psychologist John Dewey (1859–1952), in *Art as Experience* published in 1934, upholds the intents of art:

> "The existence of art is [...] proof that man uses the materials and energies of nature with intent to expand his own life, and that he does so in accord with the structure of his organism—brain, sense-organs, and muscular system. Art is the living and concrete proof that man is capable of restoring consciously, and thus on the plane of meaning, the union of sense, need, impulse and action characteristic of the live creature. The intervention of consciousness adds regulation, power of selection, and redisposition. Thus, it varies the arts in ways without end. But its intervention also leads in time to the *idea* of art as a conscious idea—the greatest intellectual achievement in the history of humanity." (Dewey 1980 (1934), 25)

Subjectively, aesthetics deals with one's feelings to differentiated events. Feeling something is deeper and enduring than just knowing it. Feeling is fundamental for insight, as is to gain an intuitive sense of understanding that connects on a sensory and emotional level. Similar to when explaining a scientific concept; it is more significant to communicate the essence than it is to present data and facts. The various meanings of art are intended to transform us. A successful work of art is to make us feel different afterward. Yet, a parameterized beauty is not what most concerns contemporary art, but the free will of creation.
Aesthetics is a broad concept not restricted to encounters with art, as we may have multifarious aesthetic experiences from everyday sensorial interactions. Phenomenal aesthetic experiences may occur daily in nature and without any human endeavor. The notion of everyday aesthetics was paved by John Dewey in *Art as Experience*, to include "objects, events, and activities that constitute people's daily life." (in Saito 2015) Despite their differing intents, art and design connect in arousing emotions through stirring the senses.
Our corporeal existence cannot be separated from the place we are in. Referring to the built place and its integral fruition, Finnish architect Juhani Pallasmaa reflects on the aesthetic implications, and the existentialist experience of space in *The Eyes of the Skin: Architecture and the Senses*, first published in 1996:

> "Instead of creating mere objects of visual seduction, architecture relates, mediates and projects meanings. The ultimate meaning of any building is beyond architecture; it directs our consciousness back to the world and towards our own sense of self and being. Profound architecture makes us experience ourselves as complete embodied and spiritual beings. In fact, this is the great function of all meaningful art." (Pallasmaa 2012 (1996), 13)

Pallasmaa experiences art through space and its implicative effects:

> "In the experience of art, [...] I lend my emotions and associations to the space and the space lends me its aura, which entices and emancipates my perception and thoughts." (Pallasmaa 2012 (1996), 12)

Contrary to Kant's proposition, beauty to German philosopher Georg Hegel (1770–1831) is an "objective property of things." It is the "direct sensuous manifestation of freedom." For Hegel, "true beauty is the direct sensuous expression of the freedom of spirit." For "Beauty is sensuous, visible shape so transformed that it stands as the visible embodiment of freedom itself." (in Houlgate 2014 (2009)) Interpreting Hegel, "Art aims essentially at beauty, which is one way in which truth is expressed. Hence Hegel defines beauty as 'the sensuous appearance [...]' of the Idea. The Idea [...] is true [...] as Idea and not [...] merely in its sensuous, outer existence." (Hofstadter and Kuhns 2009 (1964), 380)

In *Flow: The Psychology of Optimal Experience*, first published in 1990, Mihaly Csikszentmihalyi states, "Not only great works of art produce such intense flow experiences; for the trained eye, even the most mundane sights can be delightful." (Csikszentmihalyi 1990, 107) Yet, Csikszentmihalyi proceeds, "this is true of all flow activities: without cultivating the necessary skills, one cannot expect to take true enjoyment in a pursuit." (*ibid.*, 108)

Our relation with the involving space is never dissociated from an aesthetic appreciation imbued in an embodied analytical judgment, or more prosaically of our relational existence with the surrounding and inhabitable space:

> "An architectural work is not experienced as a series of isolated retinal pictures, but in its full and integrated material, embodied and spiritual essence. It offers pleasurable shapes and surfaces moulded for the touch of the eye and the other senses, but it also incorporates and integrates physical and mental structures, giving our existential experience a strengthened coherence and significance." (Pallasmaa 2012 (1996), 13)

Architecture is the ultimate manifestation of a relational embodiment, since we exist in a forever confrontation between transformation and adaptation to a place with which we establish a concrete physicality.

5.3 Through Design

Aesthetics applied to design is directly correlated with usability or the easiness of use, and the degree of usefulness or at what level it is useful for an intended task. Which inherently, "Form follows function." American entrepreneur with German and Syrian ancestry Steve Jobs (1955–2011) used to advocate, "Design is not just what it looks like and feels like. Design is how it works." Functionality must not be devoid of aesthetic values. The inspirational and highly influential for Apple products, the industrial designer for Braun consumer products, Dieter Rams (1932–) affirms in one of his principles for design that "Good design is aesthetic." (Rams 1980s in Vitsoe) To Rams:

> "The aesthetic quality of a product is integral to its usefulness because products we use every day affect our person and our well-being. But only well-executed objects can be beautiful." (*ibid.*)

A perceived ease of use is interrelated with the beauty of a product. Beauty is alluring and what attract, grab. So much, that we desire to devote our attention to learning how it works. For the reason that "What is beautiful is usable," as asserted by Tractinsky *et al.* in 2000, referring to the aesthetics of interaction. Aesthetics is not restricted to the appearance of a product, but to the overall experience of interaction, as corroborated by Petersen *et al.* in 2004. Playfully, the American designer Timothy Prestero professes, "There's no such thing as a dumb user… there are only dumb products." The functionality of a product influences the way we relate to it, and it is not limited to its effectiveness.
In the words of the American entrepreneur, web designer, and author Jeffrey Zeldman (1955–), "Content precedes design. Design in the absence of content is not design, it's decoration." (Zeldman 2008) Design is functional content. Design is not just about how to please the eye and fill the mind, but also how it physically feels. To the Japanese graphic designer and curator Kenya Hara (1958–) it is the

design's function to offer a rich experience for the tactile senses. (Hara 2007) The way it feels when we hold it, and consequently the way we handle it, determines how we engage with the product.
Swedish professor of Interaction Design at Malmö University, Jonas Löwgren (1964–) adopted the term *pliability* to mean a sensuous quality of interaction. Löwgren suggests that "The use of a digital artifact is characterized as pliable if it feels like a tightly connected loop between eye and hand, between action and response." (Löwgren, 2007, 2) Löwgren proceeds:

> "[It] characterizes the extent to which the user perceives an interaction to be fine-grained with a tight coupling between action and outcome, a pseudo-tactile sense of manipulating a malleable digital material, [which] seems to facilitate explorative behavior and serendipitous discovery." (*ibid.*)

Löwgren asserts that "products which are essentially equivalent in instrumental terms can be quite different in experiential terms." (Löwgren, 2007, 2) And yet, concerning the performative effects, the technological products we encounter in the market have poor tactile features. They may not be devoting enough attention to stirring the senses, particularly the sense of touch. A surprising feature in a product can overcome the habituation effect that is due to the fact that people encounter many similar consumer products. (Ludden 2008) Professor of psychology Colin Martindale (1943–2008) describes (1990) this effect as "the gradual loss of interest in repeated stimuli." (in Ludden 2008) Ernst Weber affirmed that "senses are easily fatigued and tired by continuous work so that we no longer perceive differences that were obvious at another time." (Weber 1996, 127) Happening when there is a diminishing in emotional and behavioral response to a recurrent stimulus over time, increasing the development of repetitive behavioral patterns. The physiology of the senses explains that certain receptors weaken their response when a stimulus is continuous, causing adaptation. The routine creates habits that decrease the responsiveness to a sensation. Diane Ackerman (1990) stresses that "any first-time touch, or change in touch" (Ackerman 1990, 80) whether in "temperature, pressure, position, or texture," (Mileaf 2010, 10) activates our sensory receptors. Janine Mileaf specifies that "[...] sensations begin to fade if they are not renewed." (in Mileaf 2010, 9)
The experience is more intense as we use our senses to create a "fresh insight." (Dewey in Leddy 2008) Subsequently, an emotional link has a more enduring effect. An object is more "seductive" (Khaslavsky and Shedroff in Norman 2005, 111) as how much and for how long it is capable of stimulating the senses, and for that to happen "the object must be rich and complex," (Norman 2005, 111) must have distinctive characteristics "that gives rise to a never-ending interplay among the elements." (*ibid.*) Today's consumer technological objects may be clean in appearance, but are highly complex in the scope of useful possibilities. In Dieter Rams' opinion, "Good design is as little design as possible." Rams defends, "Less,

Pliability:
the quality of being easily bent or shaped; flexibility; (New Oxford American Dictionary)
changed or adjusted to meet particular or varied needs;
easily influenced, persuaded, or controlled. (The Free Dictionary)

Sensuous:
implies gratification of the senses for the sake of aesthetic pleasure.

British designer and the chief design officer of Apple Inc., Jonathan Ive (1967–), talks about simplicity, one of the core values of Apple, "[T]here is a profound and enduring beauty in simplicity; in clarity, in efficiency. True simplicity is derived from so much more than just the absence of clutter and ornamentation. It's about bringing order to complexity."

but better — because it concentrates on the essential aspects, and the products are not burdened with non-essentials." (Rams 1980s in Vitsoe) Before the advent of digital technology, objects were supposed to act for the only purpose they were designed. Now a Suisse knife, if digital, it is expected to act as a Suisse knife and have many more utilities. It may even happen to not appear like a Suisse knife. But still, an important issue is how it feels in our hands, how the objects engage our senses, and how they are surprisingly challenging. May it be because of their materials, their incredible design simplicity, their complex functioning details, or even their iconic meanings. All these attributes make us addicted to objects. Our lives become dependent on them. Mobiles use to be the size and weight of a brick, now they are small and with extended endless possibilities. Mobiles are now, portable objects of desire, social affirmation, and connection to everyone and everything. As small as they become more precise handling they demand. Text messaging requires dexterity, to handle the object with one hand and to write a message with the thumb of the same hand with velocity and accuracy.

While usability is focused on objective factors, measuring learnability, efficiency, and effectiveness of an interaction with a product or system, the user experience is concerned with the subjective characteristics of qualitative values regarding perceptions, emotions, and personal judgments, arising from the way the user relates, engage, and experience an interaction. As Jongerius and Schouwenberg urge, "Design is not about products. Design is about relationships. Good design can draw, almost invisibly, on different levels of meaning to communicate with users." (Jongerius and Schouwenberg 2015, 2) Design creates bonds through objects.

Dutch industrial designer Hella Jongerius (1963–) and design theorist Louise Schouwenberg (1954–) wrote the manifesto *Beyond the New: A search for ideals in Design*, in which they assert, "Aesthetic value is a potent means of communication. Ugliness is also a potent means of communication. Without aesthetic refinement and without friction at the boundaries of aesthetics, there can be no personal signature and no intimate relationship with the user." (Jongerius and Schouwenberg 2015, 2)

5.4 Aesthetic Touch

Since the beginning of human history that touch was being regarded as a mere utilitarian sense, and only much later it gained independence from the function to become aesthetic. Czech Surrealist filmmaker Jan Svankmajer (1934–) noted why touch was not in conformity with the aesthetic principles:

> "Perhaps precisely because touch had, of all senses, the longest utilitarian function it could not for practical reasons become 'aesthetic,' it retained primarily a certain 'primitive' connection with the world." (Svankmajer 2014)

Because touch is able to physically interact with the world, it is the only sense capable of discerning the intrinsic characteristics of objects; their depth, texture, density, weight, material, temperature. In *The world of touch* (*Der Aufbau der Tastwelt*) published in 1925, German psychologist David Katz (1884–1953) argued, "The fingers, as wielded by the hand, obtain information on the innards of objects, whereas the eye remain[s] fixed on the outer surface [...]." (in Krueger 1970, 337) The fruition and apprehension of art through another sense are possible because skin, the organ of touch, is the basis that enables every other senses.

Hegel argued, "The work of art [...] is not purely sensuous, but the spirit appearing in the sensuous." (Hegel 1998 (1975), 621) Hegel related the sensuous part of art to the two theoretical senses of sight and hearing, for "they are the least corporeal of the senses more readily disposed to abstraction." (in Danius 2002, 194) These ideal senses leave the object as it is, unconsumed. Whereas the practical senses of smell, taste, and touch, being associated with matter and its sensible qualities, are altered, consumed, which makes them unsuitable for aesthetic senses. (Hegel 1998 (1975), 38)

American artist Rosalyn Driscoll has been dedicating her work to explore the relationship between art and body. "Touching enables us to embody meaning. And meaning emerges not only from feelings, thoughts, and memories, but also from sensations and movements." (Driscoll 2006) Driscoll has discovered how touch and art share similarities, for both, are able to give us information about "the world around us and the world within us." (*ibid.*) The materiality of the object and the immateriality of the inner self is what differentiate touch. To Driscoll, this capacity to provide access to both objective and subjective realities is essential to the perceptual self and the experience of object:

> "The use of touch to explore art amplifies and intensifies our awareness of this complex interplay of self and object. The shared capacity of art and touch to fuse inner and outer conditions makes touch a deeply effective and affecting way to know art." (in Bacci and Melcher 2011, 110)

The experience of art through touch is done with exploratory will, which makes it a deliberate act. "*Aesthetic touch* is conscious, inquiring touch that explores forms, materials, and spaces for their qualities, their effects, and their meanings." (in *ibid.*, 107) Driscoll proceeds:

> [It] involves a departure from habitual recognition and functional use; attention to formal elements such as shape, space, and pattern; [a] transformation of the object or situation into alternative structures, concepts, or meanings; and openness to the emotional implications of what we perceive." (in *ibid.*)

Touch is functional, operative, enabler, perceptual, emotional, and aesthetic. "We cannot truly see something unless we have touched it." (Driscoll, *Whole Body Seeing*, chap.1) For touch imbues the qualities of objects with the impressions of the self in a particular way that no other sense is able to.

5.5 Sensuous Emotion

Sensations generate feelings that are accountable for how we experience the world around and the formation of individuality. Through the senses "we gain information about the world and ourselves." (Cole and Waterman 1995, 138) Exciting our emotional states, wherein sensing combined with the affective, cognitive, and conative faculties form our sentient self.

English neurophysiologist Charles Sherrington (1857–1952) in 1900 affirmed that "mind rarely, probably never, perceives any object with absolute indifference, that is without 'feeling.' All are linked closely to emotion." (in *ibid.*) The mind is not without being affected by what it perceives. And emotions are not devoid of cognition. American philosopher Nelson Goodman (1906–1998), in *Languages of Art: An Approach to a Theory of Symbols* published in 1968, states that "[...] in aesthetic experience emotions function cognitively." (Goodman, 1968, 248)

In the conference paper *Aesthetic Touch / Haptic Art* for Eurohaptics 2006 in Paris, Rosalyn Driscoll explicits, "Touch is unique among the senses in its compass of both subjective and objective dimensions. In perceptual terms, *objective* means that the object and its qualities seem to exist independently of the individual mind or perception. *Subjective* means the perception of the object is colored by bodily sensory impressions of the person perceiving them." (Driscoll 2006)

An art encounter through sight only can restrict or alter its meanings, writes Driscoll, (in Bacci and Melcher 2011, 110) interpreting the art critic Michael Brenson, on Swiss Existentialist sculptor Alberto Giacometti (1901–1966) about the pronounced violence of his sculptures, "When you engage Giacometti's figures with your hands, it is apparent that they have every bit as much to do with tenderness as they do with violence. To hold their shoulders, backs and heads is to ease the violence committed by the eye." (in *ibid.*)

Emotions are not dissociated of a thinking capability, as they are managed by emotional intelligence. Goodman proceeds, "Indeed, emotions must be felt—that is, must occur, as sensations must—if they are to be used cognitively." (*ibid.*) Having emotions is fundamentally stimulating the senses. Senses, the subsequent sensations, and consequently the emotions aroused by them, are relevant when designing user interfaces and products. Emotional design is directly related to stir the senses. Its effectiveness is more relevant as it is capable of affecting several senses at once. Senses are frequently used by the consumer marketing as synonymous with pleasure, associated with enjoying life in its fullness. The more appealing it appears, the more engaging it is felt. The tactility of objects can evoke different feelings, triggering memories, making the present desire and consequently a memory in the future. A sense triggering experience may become a future memorable moment. Memories connect us not only to past sensations but also to emotions.

Luscious fragrances and flavors of exotic ingredients like cinnamon, vanilla, anise, saffron, coffee, or cacao are recognized for stimulating the human senses. The 1st novel *Like Water for Chocolate* (*Como Agua para Chocolate*) written by Mexican novelist, essayist, and screenwriter Laura Esquivel (1950–) published in 1989, was reviewed as "romantic, poignant tale, touched with moments of magic, graphic earthiness, bittersweet wit — and recipes." (goodreads.com) It tells the story of Tita de la Garza, a 15 year old girl who longs to marry her lover Pedro in the revolutionary Mexico at the beginning of the 20th century. But, due to a family tradition, the youngest daughter is obliged to remain unmarried to take care of her mother Mama Elena until death. Pedro marries the sister Rosaura only to be close to Tita, who loves to cook. Expressing her love through cooking, Tita finds her way to communicate her feelings to Pedro. Her repast of quail in rose petal sauce affects the ones at the table arousing desire through lustful aroma and flavor in a quasi-mystical experience.

The enchanting movie *Chocolat*, directed by Lasse Hallström and premiered in 2000, based on the novel published in 1999 by English author Joanne Harris (1964–), tells the story of a free-spirited Vianne Rocher, a half-Indian from Central America, and her six year old daughter, that go to a very conservative French village and open the *Chocolaterie Maya*. Making beautiful, sensorily provoking, and mouthwatering chocolate treats, that entice the neighbors, tempting their senses, to ultimately change behaviors of an extremely strict moral community.

The *Bible* was the first book to be printed. Before, books were laboriously copied by a scribe on surfaces of clay, papyrus, wax, and parchment. *Letterpress* is the oldest Western printing method, after the German printer and publisher Johannes Gutenberg (1398–1468) have introduced the printing press and movable type in the mid-15th century Renaissance Europe (–19th century steam-powered press). And lately is having a comeback due to the handmade preference resurgence, and the exquisitely subtle yet noticeable relief felt with touch, that the pressure exerted by the printing plates leave on paper. (thebeautyofletterpress.com)

C-Tactile Afferents: are low-threshold mechanoreceptive afferents with slow-conducting unmyelinated nerve fibres, sensitive to a gentle stroking touch, which are suggested to innervate hairy skin (but not glabrous skin), to mediate the feeling of emotional touch, inducing feeling rather than a sensing state. (Vallbo *et al.* 1993; Löken *et al.* 2009; Olausson *et al.* 2010; McGlone *et al.* 2014; Ackerley *et al.* 2014) — Yet, these feeling states can also be achieved on the glabrous skin on palms of hands and wrists if unexpectedly stimulated by the gentle fingertips of another person.

C nerve fibers are one of three classes (A, B, and C based on their diameter) of nerve fiber in the central and peripheral nervous systems. C group fibers are unmyelinated, have small diameter of 1 µm, and low conduction velocity. C fibers are one class of nerve fiber found in the nerves of the somatosensory system. They are afferent fibers, conveying input signals from the periphery to the central nervous system, have moderate adaptation, and may reveal fatigue on repetitive stimulation. (McGlone *et al.* 2014)

The technique consists of a hard surface with raised text or motif that is inked with a viscous oil-based ink and pressed to the surface of the printing substrate to reproduce the elements in reverse and repeated production. Typically, the movable type is made of metal, but it can be wood engraving or stone block. *Embossing* is the process of creating raised texts and motifs on paper and other substrates and *debossing* of creating recessed relief, using two complementary engraved metal plates pressed together.
Commonly, the procedure consists of a raised die and another recessed die. The dies fit into each other with the paper pressed between them. The raised die forces the stock into the recessed die to create the embossed impression. A specified level of pressure is applied to the dies to squeeze the fibers of the paper, to result in a permanently raised area in the substrate. The technique can be combined with ink to create colored embossing. Embossing is the process generally applied to produce a neutral background image, that is visually diverting due to the interplay of shadows, and is alluring to touch due to the raised areas that produce tactile impressions. Debossing uses an identical procedure, but the areas of the paper are indented. The metals most used for die making are zinc, magnesium, copper, and brass.

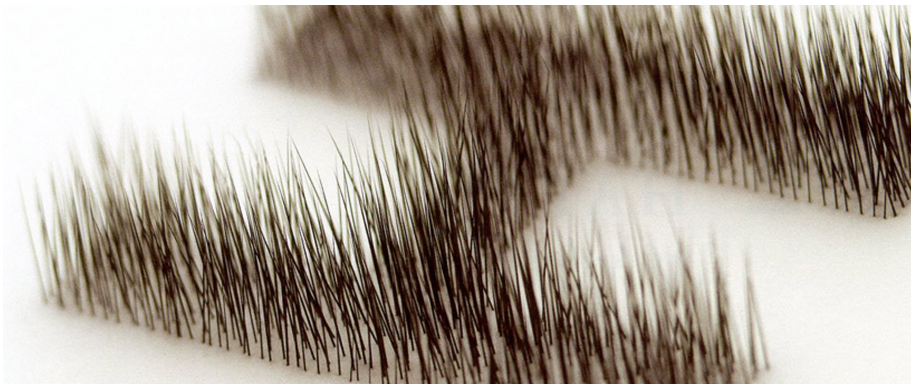


Img1. Debossed Identity and book cover for Haptic Architects, founded in 2009 with offices in London and Oslo. "Inspired by nature [with] a strong emphasis [on] the user experience." (hapticarchitects.com)

Haptic, created in 2004 by Japanese graphic designer Kenya Hara (1958–), is a typographic sign made of animal hairs on silicone, for the touring design exhibition *Haptic – Awakening the Senses* that Hara first curated in Tokyo.

in *Designing Design* published 2007, Japanese graphic designer Kenya Hara (1958–) states, "Design is not only concerned with color and form. Research into how we sense color and form, or research into the senses, is a critical subject of design. And observations of how the human senses work will give design new pointers." (Hara 2007)

The contributors were proposed to design with the premise of stimulating the senses, emphasizing touch as the basilar sense to awake all the senses. (ndc.co.jp)



Img2. *Haptic* created by graphic designer Kenya Hara in 2004.

Water Logo, created in 2009 by Kenya Hara through the Nippon Design Center Hara Design Institute and developed by Atelier OMOYA through collaborators Taro Suzuki, Ishiwata Aiko, Akagawa Tomohiro, Komatsu HiroshiMakoto, is a typographic sign for the touring Japanese fiber manufacturing exhibition *Tokyo Fiber '09 Senseware* curated by Hara. (ndc.co.jp + atelieromoya.jp)

When water droplets fall on lotus leaves, they bead up into balls. This effect occurs because of infinitesimal hairs coating the surface of the leaves repelling water. Mimicking the lotus leaf, drops of water create a sign on top of the nano-level ultra water-repellent fabric *Monert*, giving the spectators a multisensory experience. Driven by a hidden mechanism, water seeps through the fabric in groups of drops that spell out *Senseware*. The fabric slopes gently down to the front, so that whenever a drop reaches a certain size, it naturally begins to roll down the sloping surface under the influence of gravity as if appearing to be rain. Another drop of water grows up to take the place of each drop that rolls away, so the water logo is constantly being renewed.

This volumetric effect with crystalline tactile values give us an immediately will to touch the droplets and feel them changing their form under our fingertips, test the fabric water repellency, or just because we are irresistibly impelled to play with the texture.



Img3. *Water Logo* created by Kenya Hara through the Nippon Design Center Hara Design Institute and developed by Atelier OMOYA in 2009.

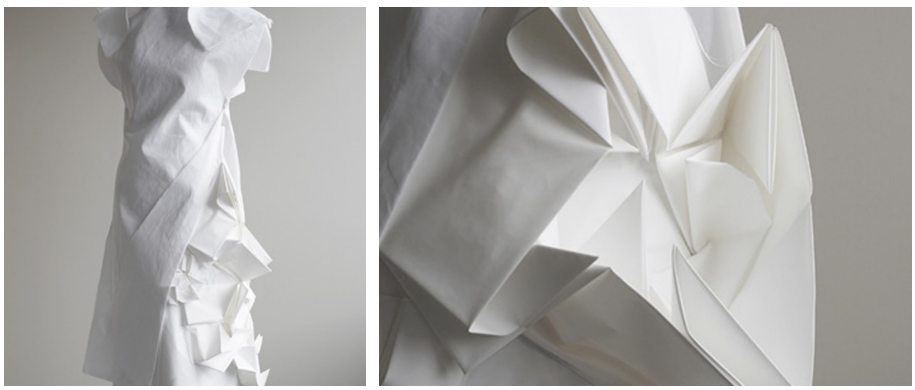
Juice Skin created in 2004 by Japanese industrial designer Naoto Fukasawa (1956–) is a fruit juice package skin series with tactile appearance and feeling, that mimics the color and texture of the fruit it contains. The package is made of nonrigid plastic with electrostatic flocking to simulate the real fruit. Fukasawa "imagined that if the surface of the package imitated the color and texture of the fruit skin, the object would reproduce the feeling of the real skin." Almost like the real piece of fruit to grasp and drink. Our sense perception can be psychologically deceived, moving our mind to an induced perception, different from reality. (naotofukasawa.com)

Japanese industrial designer Naoto Fukasawa (1956–) affirms, "Materials and means are the result of thinking of how to create sensuous effects or perplex the audience's senses." (Hara 2007)



Img4. *Juice Skin* created by industrial designer Naoto Fukasawa in 2004.

Walking City, created in 2006 by Chinese Canadian-based fashion designer Ying Gao (1973–) and developed by robotics designer Simon Laroche, is a set of three reactive dresses made of cotton and nylon that blend traditional Chinese paper folding (*Zhe Zhi*), the origami precursor, with pneumatic pumps, and electronics, to induce life-like in a virtual body. When air is infused into the garments, it inflates, appearing to be inhabited by an elusive body, producing soft movements as if virtually breathing. One of the dresses is activated by movement, incorporating a hidden compressed air system that fills the folds in the fabric with air, making them unfold. In another dress, a pressure sensor on the back retracts the folds when it is touched. The third dress is activated by blowing into a microphone, making the pleats expand. (yinggao.ca)
As a second skin, nothing is more in contact with it, all day long, than fabrics that expand and retract as we breathe in and out.



Img5. *Walking City* created by fashion designer Ying Gao and robotics designer Simon Laroche.

Incertitudes, created in 2013 by fashion designer Ying Gao and developed by robotics designer Simon Laroche, are two interactive garments based on the concept of uncertainty, made with polyvinylidene fluoride (PVDF) film, dressmaker pins, and electronics. Activated by the spectator's voice, (yinggao.ca) pins revolve slowly translating a thorny and acutely conversation full of misunderstandings, in a defensive talk, fearing hurting the other, but at times doing it. When one loses control and is taken by emotions, harsh words are thrown to one another.



Img6. *Incertitudes* created by fashion designer Ying Gao and developed by robotics designer Simon Laroche in 2013.

Untitled Sound Objects, developed in 2006 by Swiss sound artists Pe Lang (1974–) and Zimoun (1977–), who collaborate since 2004 in the sound objects series, is an installation made of 250 prepared electro hub magnets linked by wires that cover the floor, walls, and ceiling of a wooden gallery space. "Reacting to electrical impulses, electromagnetic lifts tap metal pins on the surfaces on which they are mounted." (zimoun.net/2006-250.html) Producing a reverberant acoustic room that is a constant changing environment, due to developing acoustic patterns through mechanical rhythms that are dependent on all previous events.The tactile feeling is perceived on the intense and variable vibrations of space when all magnets beat incessantly on the whole surface.



Img7. *Untitled Sound Objects* created by sound artists Pe Lang and Zimoun in 2006.

Surface Regeneration: Natural Footprint series, created since 2009 by textile and surface designer Alessia Giardino, are transformative surfaces of elaborate patterns of laser-cut wood embossed into concrete, that peel off and decompose

over time due to pollution and weathering, creating shadowy lace-like effects as they distort and bend to ultimately fall off, leaving a permanent trace on the concrete surface. And *Engraved Concrete* series are patterns engraved onto the concrete to create detailed motifs in relief. (alessiagiardino.com)



Img8. *Surface Regeneration: Natural Footprint* and *Engraved Concrete* series created by textile and surface designer Alessia Giardino since 2009.

Kumonomine [On top of the clouds], created in 1971 by Japanese potter Kato Tokuro, is a tea bowl (*chawan*) in *Shino style*, a revival of Momoyama Period (1573–1615) in post-war Japanese tea ceramics. Shino ware was Japan's first high-fired white-glazed pottery with iron-oxide brush markings. "The beautiful feldspar glazing, the perfect form, the excellent firing, the elegant iron paintings, the exceptional clay flavor, the brilliant fire color, were reborn through the work of Kato Tokuro (1897–1985) and Arakawa Toyozo (1894–1985)." (toku-art.seesaa.net)



Img9. *Kumonomine* [On top of the clouds] created by Kato Tokuro in 1971.

The Turkish Iznik (ancient Nicaea) ceramic tiles, covering the walls of palaces and mosques of Ottoman Empire in 15–16th centuries, made with quartz (a semi-precious stone) and whose process is entirely manual, were recovered in 1993 under the endeavor of Prof. Dr. Isil Akbaygil, after their production have disappeared for 400 years. (iznik.nl/handmade)

"The appreciation of Japanese tea bowls [...] is informed by the concept of wabi sabi, which finds beauty in austerity and mutability, as exemplified by old, weathered objects. The rough texture and uneven form of a tea bowl, along with the changes in color and texture that have taken place over time and the nicks and scratches it has received [...] are considered to contribute to its aesthetic and contemplative value." (Howes and Classen 2013) "Things wabi sabi can appear coarse and unrefined. They are usually made from materials not far removed from their original condition within, or upon, the earth and are rich in raw texture and rough tactile sensation." (Koren 1994, 68)

Robot Tile, created in 2007 by Japanese engineering researcher Hiroo Iwata, is a locomotion interface composed of movable tiles covered with Kuralon EC, which is a touch-sensitive conductive fabric that detects foot position. Capable of conveying information about where the pressure has been applied, to predict the position of the next step. (intron.kz.tsukuba.ac.jp)
The tiles move in all directions providing a floor for the feet. When the walker starts moving it is detected, and the tile moves. The material on top of the tile enables the system to tell where the walker is treading. The circulation of the tiles enables the user to walk in a virtual environment while maintaining the position. The tile moves opposite to the measured direction of the walker so that the motion of the step is counteracted to create an infinite walking surface. An exploration in a prototype stage, because the tiles are high, it is difficult to maintain balance while being distracted by the events in a virtual environment. Different from the commercial omnidirectional Virtuix Omni Gaming Treadmill.



Img10. *Robot Tiles* created by engineering researcher Hiroo Iwata in 2009.

Ugly Duckling Presse is a Brooklyn-based nonprofit art and publishing collective for experimental book editions, often containing handmade elements evidencing the labor and history of bookmaking. (uglyducklingpresse.org)
The Caseroom Press is a Lincoln-based independent publisher led by collective Barrie Tullett and Philippa Wood, whose work explores various book formats and printing techniques, from single limited to low run editions. (the-case.co.uk)
Mörel Books is a London-based independent publisher dedicated to limited editions of art books and booklets attentive to the feel of the book. (morelbooks.com)
Contradicting the lack of tactile satisfaction of most electronic devices of serial production, there is a return to the artisanship, to experiment the unique piece and handcrafted techniques with the characteristic irregularity that makes a handwork production unrepeatable and the handling gratifying to the touch.

Summary

Aesthetics is generally attributed to art, but it does not signify one pleasant beauty, as there are many beauties as sensibilities. Beauty is something uniquely personal. Beauty is a quality that affects our aesthetic senses. In which, aesthetic

touch means feeling affected by qualities, effects, meanings. Feeling changed at different levels and intensities. Beauty can marvel us or disturb us. As this popular saying tells, — "Beauty lies in the eyes of the beholder." A disturbing beauty for some can be a sublime beauty for a few. A created beauty is the idea in its sensitive and sensible realization, that comes from the innermost subjective in action with the objective outer, always influenced by the other. The concept of beauty may be universal, but certainly not its meanings. Lastly, it may be more fulfilling to let oneself feel touched disinterestedly by the simple and unassuming beauty.

At the beginning of art is the beginning of humanity. Art makes us more humans. Art adds knowledge, not by showing one direct way for a potential way out, but for providing stimulation for critical reflection. Art must make us think. Art must resonate in our intellect somehow at some level. Art must move us. For so, there are many designations for art. Depending on the dimension in which it operates, art can be enlightening, interventional, or playful. Art must affect our sensibilities in some way, otherwise, it will just entertain us, momentarily. Art has societal functionality; whereas functional art is design. Functionality is obtained when one intents an operative effect and its purpose is reached. Design without content and, therefore, devoid of function, is just decoration.

A similar statement can be applied to art. If art does not carry a message and does not create meaning, then it is not art, but entertainment.
And entertainment is a frivolous moment that does not ripple in our minds. It bores us after a short while, but the 'culture of entertainment' has also arrived to art. An art project can make sense and be understood, but ultimately, it will not produce a relevant meaning if it does not touch us at some level. If it does not move us, or if it does not make us think, or if it does not change us, it may not deserve a revisiting. Art that moves us or that implicates us, depending on the way it does, it deserves being revisited several times. Otherwise, the feeling is fleeting.

Chapter 6

Materials
To stir sensations

Introduction

This chapter analyzes how the means intervene and influence the quality of a sensory experience. Examining how the characteristics of materials contribute to enhancing a tactile feeling. Along with the emergent sensitive materials that offer prospective wide-ranging sensory possibilities.

6.1 Tactility

A crafty material stimulates the desire for touch. When we manually give the material a shape, the required dexterity keeps it a challenging act for perceptual haptic explorations. Material attributes, as textures, are a relevant quality for eliciting tactility. Since texture keeps active the stimulus of touch, the tactile qualities of materials influence the ensuing tactual sensations. All materials with a surface have texture that goes from smooth to rough.
Dutch industrial designer Hella Jongerius (1963–) known for fusing industry and craft, high and low-tech, tradition and contemporaneity, with appreciation for imperfection, collaborated with design theorist Louise Schouwenberg (1954–) in drawing up the manifesto *Beyond the New: A search for ideals in Design*, in which they address the materials and the manual labor of design:

> "Everyday products are used, seen, touched. The tactile and expressive qualities of materials are important means of communication, and ask

In *Understanding Media: The Extensions of Man*, published in 1964, Marshall McLuhan asserts that "tactility is the interplay of the senses, rather than the isolated contact of skin and object." (McLuhan 1964, 346), since other senses participate in handling objects besides touch.

> for a hands-on design process, an intense exploration of textures that appeal to the human scale." (Jongerius and Schouwenberg 2015, 3)

Everyday objects made of materials with a natural appearance and sensation are the ones able to more easily evoke feelings and emotions, being those of higher nostalgia triggering. (Karana 2009, 67) Such materials are cozier, providing a feeling of warmth and comfort for they look less machine made. Opposing the often cold and disengaging technological surfaces, the organic appearance and sensation seem to be more proximal to human nature. Pallasmaa asserted, "Natural materials express their age, as well as the story of their origins and their history of human use." (Pallasmaa 2012 (1996), 34) A natural material ages denoting the wear through the passage of time, to which the acquired "patina of wear adds the enriching experience of time to the materials." (*ibid.*) This transformative facet gives to materials a natural life cycle accented by time and use. In her sculptures, Rosalyn Driscoll seeks "the inner life of materials, whether manufactured, handmade or organic" (rosalyndriscoll.com) to engage the body, especially, the senses of touch. The intrinsic characteristics of natural materials are comprised of elements for perceptual involvement and aesthetic appreciation, able of stimulating the senses, captivating feelings, and eliciting emotions. Materials arousing tactility are determinant to exalt the underlying dichotomies of touch. Elizabeth D. Harvey, editor in *Sensible Flesh: On Touch in Early Modern Culture* emphasizes the enacting polarities of touch:

> "Touch evokes at once agency and receptivity, authority and reciprocity, pleasure and pain, sensual indulgence and epistemological certainty." (Harvey 2003, 2)

Yet hitherto, the consumer haptic devices are devoted to the feedback feeling, but lack the primary sensation of the material, that is usually slick and cold and not truly tactile stimulating. Driscoll pointed out the sensations and impressions elicited after an experience with materials and shapes:

> "[A] steel passage feels cold, making me fearful; a wooden area feels warm so I relax; a leather hammock is reassuring; a tight fit causes panic; a keen edge worries me." (Driscoll 2013)

The appearance and feeling of most of the technological materials are not adjustable to our nature, as they do not grow old, just become obsolete, rapidly. Besides, industrial materials are seamlessly too perfect for our imperfect making and condition. And in nature, there are no right angles, but curvilinear forms. Textiles are commonly regarded as organic materials, even though they may not be of natural origin as are cotton, linen, or hemp. The feeling of synthetic fabrics (*e.g.* polyester, acrylic, nylon, rayon, acetate, spandex, latex, kevlar) may be quite agreeable, but they are not biodegradable, which means when discarded, they do not break down in the soil, and the chemicals used in the manufacture and softening can have harmful effects on the environment.

In an era of intensive serial industrial production, the unique and distinctive handcrafted objects are increasingly being valued and preferred. (scoutmob.com) It can be suggested then, that manufactured products built to be handled could be made of materials with palpable expressions, have indentations to conform to our fingers, or innately be of resistive reactive flexibility, sustainably mixing hybrid materials of natural origin with synthetic production.
German professor of art history at Hamburg University, Monika Wagner stresses the tension between the medium and the material, alluding to the production and the reception of art:

> "Until today, the notions of medium and material seem to be in latent conflict, though the materiality of the medium and the mediality of the material may be regarded as two different functions of the same work." (Wagner 2010, 77)

To which, the material can add or subtract to the experience of the medium. As for offering compelling experiences, designers may be equally focusing on how the objects behave as on how they look.

6.2 Smart Materials

We can shape the things we use. With the advent of smart materials, objects are no longer inert, but mutable interfaces for communicative interactions. (Coelho 2013, 2) Between the developments of plastics and composites appeared the smart materials, (Harvey in Kutz 2002, 401) which are characterized as being able to respond to external stimuli or alterations in their environment, sensing, reacting, and changing reversibly in appearance or shape (*e.g.* color, transparency, index of refraction, distribution of stresses and strains, volume, viscosity). (*ibid.*, 402) A smart material is the one that has a molecular structure, is a composite, an assembly, or a system (Addington and Schodek 2005, 10) that responds in a particular and controlled way to influences upon it, which can be exerted by touch. Materials engineer James A. Harvey describes them as "materials that receive, transmit, or process a stimulus and respond by producing a useful effect that may include a signal that the materials are acting upon it." (Harvey in Kutz 2002, 401) Reported by architect Alex Ritter, these materials, substances, and products "have changeable properties and are able to reversibly change their shape or color in response to physical and/or chemical influences." (Ritter 2007, 26) (*e.g.* light, temperature, stress, acidity (pH), moisture, electrical or magnetic fields) Sustainable outcomes demand the interplay between material developers and designers. Emergent technological materials being used for design explorations are suitable within contemporary concerns relating sustainability and economy of means and resources. Developing a concept recurring to a smart material can result in a less complex system as these materials may substitute other larger, noisier, and waster components. Mechanical engineer and architect

The curve of the bottle of Shiseido's Ever Bloom white floral fragrance, created in 2015 by French perfumer Aurelien Guichard, was designed to fit in the palm of the hand, as it is advertised:
"The bottle has the density of a fine object. Its free, undulating and caressing lines make you want to hold it in your hand. Light, the symbol of inner beauty, enters the bottle and sets it aglow." (http://everbloom.shiseido.co. uk)

Designed by Sam Hecht in 2001 at the design company IDEO, the Elektex soft keyboard is made of an electro-conductive fabric in which the entire surface is able to sense the location and pressure of touch. As it was claimed, "It allows a product to have a skin that is flexible, that is itself a functioning, intelligent organ." (in Lupton 2007, 32)

Smart materials:
are functional materials, with a bi-directional property changing or energy exchanging in a dynamic and adaptive behavior to sense and react in a controlled way to alterations in their environment.
They are piezoelectric, piezomagnetic, electroactive polymers, electro and magnetostrictive [cont. ...]

Michelle Addington along with civil engineer Daniel Schodek clarify the benefit:

> "An advantage of the use of both property-changing and energy-exchanging smart materials within the context of sensor/actuator systems is that many of the actions occur internally within the materials." (Addington and Schodek 2005, 129)

Currently, sustainability issues require materials to have increased functionality and adaptive capabilities. Mimicking processes and structures from nature through biomimetics and nanotechnology, the smart materials do more and better with fewer resources and less energy spent. Characteristics corroborated by Ritter, who asserts:

> "[T]he use of [a] smart material is made necessary by the wish for more automation, for compact materials and products reacting to sensors and actuators and the increasing global demand [for] expensive energy sources and raw materials." (Ritter 2007, 7)

These materials identify an era to which designers are not indifferent. Commonly an inherent inquisitive character implies that a designer is very attentive to the surrounding critical issues. A technology-based design is representative of a time concerning economic, social, political, ecological, and cultural dispositions. Smart materials adapt well to a fast-evolving society, as "their properties are changeable and thus responsive to transient needs" as Addington and Schodek asserted. (2005, 3) These materials provide a hybrid combination of a lively behavior in a non-living substance with the convenience of having a matter with autonomous intrinsic properties, from which a creative work can be developed. The option for smart materials for creative applications is seductive due to their behavioral characteristics. Succinctly explained by Addington and Schodek, they are suitable because of the "immediacy" as these materials respond promptly. Because of the "transiency" as they respond to several environmental states. Because of the "self-actuation" as they possess an internal structure that responds to external influences. Because of the "selectivity" as they respond in a distinct and controlled way. Because of the "directness" as they respond in loco to a stimulus. (Addington and Schodek 2005, 10) Also, because of the trainability, as the shape-memory alloys and polymers, they can have memorized new shapes. Because of the structural capacity, as the shape-memory alloys and polymers, they can sustain and form an object. Because of the simplicity as they possess few components in their composition. Because of the flexibility as their components can be soft and malleable, and the most salient, because of the reversibility as they have the ability to change back to their initial state. The engineered smart materials have appealing reactive changeable properties, energy exchange capabilities, communication modes, and reversible states. With such self-sufficient dynamics, smart materials prescind from the necessity of added sensors and actuators. (Coelho 2013, 3)

[... cont.] electro and magnetorheological, magnetic shape memory alloys, ph-sensitive polymers, temperature-responsive polymers, halochromic, chromogenic systems, electrochromic, ferrofluid, ferroelectric, photomechanical, polycaprolactone (polymorph), self-healing, energy storaging, photovoltaic, dielectric elastomers, electro and magnetocaloric, thermoelectric, electroluminescent, ionic polymer metal composites, quantum tunneling composites, shape-memory alloys and shape-memory polymers.

Magnetostrictive materials change dimension when subjected to a change of the applied magnetic field, and undergoes a change in its magnetic state under the influence of an applied mechanical stress. (Buschow and de Boer 2003)

Materials acquire a behavioral reaction to surroundings, directly communicating their states. Activated through chemical, electrical, magnetic, optical, thermal, or mechanical stimuli depending on their properties, these responsive materials interact with the environment disobeying the conviction of the "hegemonic material as [a] visual artifact," that Addington and Schodek (2005, 7) have observed, defying our sensory perceptions to transformative materials. Through the transfer of technology and easier access to emergent materials, these are causing the design to acquire challenging paths, in concept, form, and function.

6.2.1 Shape-Shifting Materials

In the 22nd century, objects will excel for their transiency. The matter will have the ability to transform in an instant from one form to another completely different. American novelist Wil McCarthy (1966–) envisions that programmable matter will allow a designer to admit any desirable requirements:

> "[A] designer will simply define the shape and properties [...] — including 'unnatural' traits like superreflectance, refraction matching (invisibility), and electromagnetically reinforced atomic bonds — then distribute the configuration file to any interested users." (Mccarthy 2003, 13)

Ara N. Knaian, researcher in Center for Bits and Atoms, at the Massachusetts Institute of Technology, clarifies that programmable matter (in which are included colloidal films, bulk crystals, and quantum dots) consists of nanoscale autonomous microsystem particles, that are bound by electromagnetic forces or suspended in a fluid or gel binder. (Knaian 2008, 2) It is a "digital material with computation, sensing, actuation, and display as continuous properties active over its whole extent." (*ibid.*) For the ability to change shape under a programmable control, upon someone's input, or autonomous sensing, wherein a sheet can self-fold into a functional object and return to a sheet. (Hardesty 2010; Dickey *et al.* 2012)
Some other materials have the ability to return to their original shape from a deformed state, in reaction to alterations in their environment or influences exerted upon them. They can change shape by altering their molecular structure or liquid crystals induced by external stimuli. Piezoelectric materials generate an electrical charge ensued from an applied mechanical force, and in turn, an electrical charge produces a mechanical strain, which makes it possible to design something that bends, contracts, or expands when is applied an electrical charge.
Shape memory alloys and polymers are materials that change shape subjected to alterations in temperature to produce a thermal shape memory effect.
At ambient temperature the material is on its malleable and *martensite* phase, to gradually return to the memory temperature, the stiff and *austenite* phase when it is heated above a certain temperature. The materials that can only exhibit one change in shape undergo a one-way shape memory effect, the alloys that with the shape setting can exhibit and remember two shapes, transforming

In *Hacking Matter* published in 2003, Wil McCarthy (1966–), American science fact and science fiction novelist, science columnist for SciFi channel, and chief technology officer for Galileo Shipyards, an aerospace research corporation, dubs with his business associate Gary E. Snyder the term *wellstone*, introduced in *Once Upon a Matter Crushed* published in 1999, "to describe [a] hypothetical but quite plausible form of programmable matter." (Mccarthy 2003, 127)

Piezoelectricity: from the Greek *piezo* or *piezein*, which means 'to squeeze' or 'press,' and *electric* or *electron*, meaning 'amber,' an ancient source of electric charge, is electricity produced by pressure.
The piezoelectric effect results from applying mechanical stress to certain crystals or ceramics. It was discovered in 1880 by French physicists Paul-Jacques Curie (1856–1941) and Pierre Curie (1859–1906).

between two different molecular structures, one below and another above the memory temperature, undergo two-way shape memory effect. These alloys return to a second shape when the material cools down. Alloys with superelasticity exhibit a mechanical memory effect with great stretching capacity.
Hanabi, created in 2006 by Japanese-Canadian Oki Sato (1977–) under the brand name *nendo*, was developed using a shape-memory alloy, that opens in bloom whenever the light is turned on and the bulb heats up. *Hanabi* is the Japanese term for 'fireworks,' that derives from the words 'flower'+'fire.' (nendo.jp)



Img11. *Hanabi* created by Japanese-Canadian Oki Sato in 2006, with the brand name *nendo*. Photos by Masayuki Hayashi.

Transform, created in 2015 by Hiroshi Ishii and a team of Tangible Media Group at the MIT Media Lab, is an adaptive table comprised of three shape-shifting surfaces, that move noisily over 1,000 plastic rods mechanically up and down to make the tabletop a dynamic tangible display. (Vink *et al.* 2015)

6.2.2 Thermochromic Materials

Chromic materials have internal properties that allow them to change color, depending on alterations in one variable of their environment. An electrochromic material changes color when placed in an electric field. A photochromic material changes color when subject to variations in the UV light. And a thermochromic material is capable of changing color in reaction to variations in temperature, which can be caused by alterations in the ambient, a touch, or induced by an electric current, generating rearrangements in the molecular structure (transition temperature about 5°C) or in the liquid crystals (1°C), that change how the materials absorb and emit light, resulting in a reversible and apparent change in color. At ambient temperature the color appears in its original state but at a temperature between 27°–30°C (80°–86°F), the material becomes colorless. It changes from colored to transparent making visible the color of the material underneath. When the material cools down it changes back to the original state. Since the body temperature is normally at 37°C (98.6°F), the thermochromic material is reactive to touch, making it a sensitive material that is being used in creative propositions to change the color of printed and painted surfaces, and dyed

ShapeShift:
was a final project created in 2010 for the chair of Computer Aided Architectural Design at ETH Zürich by Edyta Augustynowicz, Sofia Georgakopoulou, Dino Rossi, and Stefanie Sixt overseen by Manuel Kretzer, as an experiment on the possibilities of architectural materialization. To explore the potential application of electro-active polymers, which are ultra-lightweight, transparent and flexible materials that convert electrical power into kinetic force with high response speed, low density and improved resilience, with great deformation potential capable of strains up to 380 percent, with the ability to change shape without the need for mechanical actuators, and can be tailored to any size or shape. (materiability.com/shapeshift; Howes and Laughlin 2012, 180)

Thermochrome:
from the Greek *thermos* meaning 'heat,' and *chroma* 'color.'
A phenomenon in which some materials change color reversibly when their temperature is changed by external influences.

fabrics at above ambient temperature or upon people's tactile inputs. Different design conceptions have been asserting a transition to dynamic behavioral surfaces prospecting a more engaging relational design, featuring materials that act as mutable interfaces.

Linger A Little Longer, created in 2011 by Australian UK-based furniture designer Jay Watson, is a black coated oak table and bench with thermochromic paint, that waives the use of coasters and alleviates the hassle of leaving marks on the surface. Table and bench respond to the heat of the tableware and body temperature with ephemeral traces of its use. (jaywatsondesign.com)



Img12. *Linger A Little Longer* created by furniture designer Jay Watson in 2011.

Design With Life, created in 2007 by Chinese UK-based communication designer Shi Yuan, includes a heat sensitive wallpaper intended to explore the concept of print design that can evolve over time. The wallpaper was printed with thermochromic ink that is heat sensitive *e.g.* to a radiator, that when on, the green vine pattern blooms pink flowers. Granting an emotive resonance the designer transforms a passive artifact into a reactive environment that seems to sense the passing of time. (yatzer.com/design-life)

Metamorphosis, created in 2010 by Philips Design, is an internal design probe report with a transformative cover printed with transient inks. The text was printed with thermochromic ink and it goes to transparent when the temperature rises. The image was printed with photochromic ink to become visible when exposed to a UV light source or the sun. When the sunlight heats the cover the image appears and the text disappears, emphasizing the unpredictability and continuous change of natural elements. The cover of this report stays unreadably blank if the ambient temperature is high and if there is not sunlight falling on the surface. (Haas 2010)

Contrary to what some suppliers advertise, only the materials that are reversible, that change back to their initial state, are smart materials.

Summary

Emergent materials with transformative properties may offer challenging design innovative prospectives. As bio-inspired materials arise, more sustainable the

designs will become. Smart materials will be able to do more with fewer resources and energy. In the future of nano-materials, surfaces will have incorporated proprieties that will respond to integrated physical changing. As "conventional materials incorporate new technologies disrupting traditional uses." (Coelho 2013)
When tactition is a premise, the selection of materials overlay visual captivation to consider the feelings and impressions that textures may elicit to the touch. A compelling experience depends on how the material will engage us in the interaction through handling. Manipulating objects with sensory stirring materials can potentially provide a tactile immediate experience that is richer and throughout conducive to a greater understanding of the intrinsic meanings.

"Art is often media art created by electronic digital means that rarely provide creations that blend craft and technology. Until recently, most of the digital art works were accessible only for screen contemplation.
After the screen sovereignty, art recovers materiality. Smart materials confer to art a dynamic tangibility, which provides a proximal physical dialogue between the viewer and the art work. With the advent of smart materials, the digital means are a physical matter with what artists give rise to aesthetic tactile explorations, altering and hybridizing the perception of the outer and inner space of the self. Interaction is all about how it makes people feel; emotionally and cognitively. As to draw meaning from content and to experience an engaging substance, people desire to interact with unintrusive contextual technologies. Art is challenged by the fast developments in technology from where new approaches, techniques, and materials arise. By using smart materials, the outcomes are not static but adaptable interfaces for communicative interactions. These materials may provide a subtle presence, seamlessly embedded in the surfaces. Smart materials confer to new media art works a dynamic tangibility, which provides renewed tactile-kinesthetic interactions. To be fully interpreted, these new media art works have to be freely touched. Haptic in art encourages people to physically engage with the art, unreservedly experiencing sensory interactions anew. Away from the fear of damaging the exhibited piece: please, do touch it!" (Coelho 2014)

Art works can benefit from the "use of recent developments in smart materials, that interact with the environment able of responding to external alterations, and the emergent sensitive technologies, as sensors and actuators become more advanced, accessible, sustainable, and affordable, permit the artists to explore challenging emergent technologies. Benefiting from the technological evolution of smart materials that can change shape in response to external stimuli, mixing an organic concept with electromechanical components, to ally the aesthetic to functional adding a meaningful inquiring purpose." (Coelho 2013)

Chapter 7

Technologies
For perceptual mediation

Introduction

This chapter gathers the technological means that are used to emphasize the senses of touch, when designing and developing interfaces for haptic interactions, with tactile perceptual meanings. Along with the technical transformations required for enhancing the haptic experiences, and the somatic adaptations to technologies.

7.1 Digitally

Digital:
"relating to or using signals or information represented by discrete values (digits) of a physical quantity, such as voltage or magnetic polarization, to represent arithmetic numbers or approximations to numbers from a continuum or logical expressions and variables;
of or relating to a finger or fingers." (New Oxford American Dictionary)
— *Two fingers of hem*, is used by seamstresses;
— *Two fingers of forehead*, means being intelligent;
Fingers guide a child reading to not deviate the eyes from the line.

The parts that the exploratory fingers accumulate when running a surface may be the sum of constituent elements, or the addition of numerical values used to measure it. A finger is semantically a number, for it aims, magnifies, intensifies, heightens, deepens, enhances, adds to realize the whole. The number creates a relational knowing within the measured phenomenon.
Fingers measure and fingers count. In *Understanding Media: The Extensions of Man*, published in 1964, in chapter *Number, Profile of the Crowd*, on anonymous individuals, as if counting heads, Marshall McLuhan considers the number a logic and fragmenting unit that stems from the touch (McLuhan 1964, 121)

> "Number, that is to say, is not only auditory and resonant, like the spoken word, but originates in the sense of touch, of which it is an extension." (*ibid.*, 124)

McLuhan proceeds, correlating arguably the written word with sight and number with touch. As if the act of writing was not a deed of the hand, or did not require any dexterity; he says:

> "Just as writing is an extension and separation of our most neutral and objective sense, the sense of sight, [the] number is an extension and separation of our most intimate and interrelating activity, our sense of touch." (McLuhan 1964, 121)

The etymology of digital is intrinsically related to touch. Coming from the Latin *digitus* meaning 'finger,' digit is simultaneously number and finger; digitally by means of digits or fingers. In Ancient Egypt, the units of measurement were elaborately made with fingers: 1 finger = 1/4 palm (1.875 cm (0.738 in)); 4 fingers = 1 palm (7.5 cm (2.952 in)); 5 fingers = 1 hand (9.38 cm (3.692 in)); 6 fingers = 1 fist (11.25 cm (4.429 in)). (Clagett 1999, 8) Digital from the Latin *digitalis*, means information represented by discrete values (digits). Digital communication uses combinations of distinct pulses or electrical signals to convey data (zero–one, off–on). Morse code, an early form of digital communication, co-developed in the 1830s and 1840s by Samuel Morse (1791–1872), is an alphanumerical method of transmitting information, in which letters and numbers are represented by combinations of telegraphed dots and dashes, or short and long light or tone signals. The 'straight key' telegraph is an entirely manual device still in use today, where the telegraphist controls with only one finger, commonly the index or middle, the length, and timing of the dots and dashes. The signal is 'on' when the knob is pressed, and 'off' when it is released.

Digital media are characterized as a mean for transmitting information through a binary system of zeros and ones, opposing the continuous or analog signals. Consequently, everything became fractionated, even our senses.

Not long ago, in the 'visual cultural era,' touch became associated with what was real, genuine, human, nostalgic, but also stale, outdated, surpassed, worn out, and definitely not digital, nor excitingly technological. Touch (or smell, or taste) did not belong to the newness of 'new media.' Yet, digital media are truly interactive if they admit touch as a mediated mean of interaction, the other way they are just audiovisual media. Finnish media archeologist, scholar, and curator Erkki Huhtamo adverted that if interactive art is not operated by touch, it is not fully experienced:

> "The idea of interactive art is intimately linked with the act of touching. As it is usually understood, an interactive artwork is something that needs to be actuated by a 'user'. If the user 'does nothing', it remains just unrealized potential — rules, structures, codes, themes and assumed behavioral models designed by the artist and embedded in a software-hardware configuration." (Huhtamo 2007)

In a time where multi-touch screens and interfaces for free gestural movements

Analogue:
is any continuous signal for which the time varying feature (variable) of the signal is a representation of some other time varying quantity, *i.e.* analogous to another time varying signal. *e.g.* In an analog audio signal, the instantaneous voltage of the signal varies continuously with the pressure of the sound waves. (Wikipedia)

Times are rapidly changing to be fully technological, yet it is of utmost importance to maintain a connection to the fundamental, so we do not lose the notion of what is till important to preserve — our essence; organic, sensory, sensitive, human. And nature stimulates our senses incomparably and irreplaceably. With or without the influence of technology it is fundamental not to lose our relation with our natural way of being, which connects us to the essence of our existence. Senses are our natural extensions to the world, whereas technology acts as an added medium mediating them, artificially augmenting them. Depending on the purpose, technology can diminish or intensify our sensibility, but never thoroughly substitute our natural senses.

are as commonly used, as were until very recently the keyboard and mouse, the consumer multisensory digital devices with haptic responsive features will increasingly be everywhere. Users will be using their entire haptic complexities, more than just the tips of fingers to press keys, move elements on the screens, tilt and shake devices, since computing will soon be embodied.

Currently, with digital media, we make things happen at the tip of our fingers, most often by switching, tapping and dragging, pinching and swelling. However, the so called consumer haptic technologies are dedicated vibration devices. These haptic devices are commonly comprised of tiny motors vibrating under the touchscreen. Yet, most certainly, there is much more to haptic feedback than making us feel a surface vibrating beneath our fingertips.

As a regular user of interfaces built to make our life easier, and a participant in experiences developed to make our life pleasanter, one could say that technology has still much to evolve to satisfy our needs and desires. Definitely, a touchscreen of a smartphone with haptic feedback that is built with a motor vibrating under the screen is strange to our fingertips and fails the purpose of enhancing an experience. The artificial vibrating response is not qualified to make us feel that we are interacting with digital simulations of physical elements. Only to alert us to their presence. Constant vibration desensitizes touch, and as such, after some time of use, it just becomes boring.

Furthermore, a film with three-dimensional appearance conceived to impose a haptic effect through an illusion of visual depth perception obliges us to wear glasses (or on top of glasses for the ones who already use glasses), restraining us from having a wide theater view screen experience. With the aggravating circumstance of causing eyestrain, headache, nausea, and disorientation (motion sickness), "especially in women with susceptible visual-vestibular system," as reported the Italian researcher Angelo G. Solimini in a journal article on *Side Effects of 3D Movies*, (Solimini 2013, 1) "that usually disappear when 3D glasses are removed." (*ibid.*, 3)

So far, technological haptic experiences lack physical quality. Haptic technologies must be more than a motor vibrating under or behind a screen, or the imposing and restricting glasses to enable us to watch movies in three-dimensions. Lately, increasing attention has been given to haptic technologies, mainly providing tactile perceptual responses, but not big advancements have been undertaken. Picking up a book, holding it with both hands, flipping through the pages, feeling the weight, density, and texture of paper, handwriting comments on the edges of the pages, or underlining lines of text, can be a truly haptic experience, more than using the tips of fingers to select portions of text or flip through the pages of an electronic book on a digital touchscreen. A screen may give us a tactile response, but grasping and handling a mouse is still more of a haptic experience. The future of haptics will challenge the interrelated complexities that integrate our senses of touch. Currently, developments on consumer haptic technologies are creating virtual metaphors to substitute real things, rather than adding to

Haptic feedback: restores tactility, confirms an action, simulates material tangibility, reassures security, stimulates the sense of touch, by applying vibrations, forces, or motions to the user, using actuators (*e.g.* motors, piezoelectrics, voice coils) to deceive the touch into sensing to be interacting *e.g.* with a real button rather than a virtual one.

Advances In 3-D May Mean No Ridiculous Glasses, was announced on the morning of April 1, 2011 as an April Fool's joke story by Jen Sands-Windsor at National Public Radio (NPR) in Washington. (npr.org/2011/04/01/135033545/3d-surgery)

"3D movies are a gimmick. They're eye candy designed to make you forget you just paid $15 to see a darker, less brilliant version of a film that its director never intended. You're paying extra for an inferior experience. That doesn't make sense." Protests Jeff Bakalar (2014) in Tech Culture for CNET, with the post *Here's why watching 3D movies is miserable*. (cnet.com/news/heres-why-watching-3d-movies-is-miserable)

Virtual: not physically existing, simulated, artificial, imitation, pretending; computer-generated.

human haptics. Irrefutably, technology offers convenience, but it may not be adding to human haptic experience. Mika Elo, professor of artistic research at the University of the Arts Helsinki, heeds, "On the basis of Aristotle, we must direct our thinking on the pathic structure of touch that evades technological control." (Elo 2012) By offering poor touch stimulation, the haptic on consumer technologies could risk being a buzzword to generally characterize a class of devices or merely a semantic appropriation.

Haptic technologies were initially developed as a safety procedure for aviation pilots, allowing them to feel simulated vibrations in the stick when stalling out was about to happen. Mechanical vibration existed naturally in older aircraft, but due to improvements in control systems, the feedback was implemented for it to be perceived. Recently, multi-touch and gestural devices have attracted a considerable interest to haptics, but generally, common consumers are not well aware of what it involves. Some who may already have heard the term associate it only with the cutaneous system. The scope and depth of its complexity are only accessible to interface laboratories and other specialized research institutions. Usually, people know very little about touch and often restrict it to sensations felt on the skin. They only know the surface of the sense of touch. What is being called kinetic technology, implying the body movements in recent consumer applications, is also part of the sense of touch, as this sense is constituted by the cutaneous, proprioceptive, kinesthetic, and vestibular sensory systems. We do not often realize how touch is implicated in the fundamental capability for producing body movement.

Due to its complexity and potentiality, the research in haptics is increasingly multidisciplinary and wide-ranging. Mandayam A. Srinivasan, founder of Touch Lab in 1990 at the Massachusetts Institute of Technology (MIT), have described the subdivision into three main areas of the development in haptics:

– Human haptics is "the study of human sensing and manipulation through touch;"
– Machine haptics is "the design, construction, and use of machines to replace or augment human touch;"
– Computer haptics are the "algorithms and software associated with generating and rendering the touch and feel of virtual objects." (Srinivasan 2005, 1)

The *PHANToM* (*Personal HAptic iNTerface Mechanism*), initiated by the engineers Thomas H. Massie and J. Kenneth Salisbury of Artificial Intelligence Laboratory at the MIT, is an arm "device for probing virtual objects," (Massie and Salisbury 1994) that "measures a user's finger tip position and exerts a precisely controlled force vector on the finger tip." (*ibid.*) Providing a "passive, three degrees of freedom gimbal attached to a thimble." (*ibid.*) Inducing the user to "manipulate a single point in virtual space." (*ibid.*) But, only the tip of one finger is constrained "to remain outside of the virtual sphere," all other fingers "can physically pass

In the article *What is Haptics?*, Mandayam A Srinivasan of Touch Lab at MIT describes, "The mechanical structure of the human hand [that] consists of an intricate arrangement of [27] bones [14 of which are the phalanges (proximal, intermediate, and distal) of the fingers] connected by almost as many frictionless joints, and covered by soft tissues and skin. The bones are attached to approximately 40 intrinsic and extrinsic muscles through numerous tendons which serve to activate 22 degrees of freedom of the hand." (Srinivasan 2005, 4)

CyberGrasp: developed in 1998 by Immersion Corporation, is a mechanical linkage with force feedback system for all fingers and hand on a lightweight exoskeleton that fits over a data glove to add resistive force feedback to each finger. Users are able to feel the size and shape of computer-generated 3D objects in virtual reality. It also allows an operator to control remotely a robotic hand and feel the object being manipulated. (cyberglove systems.com/cybergrasp)

through the volume." (*ibid.*) The mechanism has since evolved into a quasi-believable fidelity of a force touch simulation of a robotic arm attached to a pen, and is currently the most widely used haptic interface in haptics research labs:

> "[T]o perform psychophysical experiments aimed at characterizing the sensorimotor abilities of the human user and the effectiveness of computationally efficient rendering algorithms in conveying the desired object properties to the human user." (Srinivasan 2005, 6)

Still it only allows one spatial point for the haptic feedback, and the discriminative force touch technology is not yet widespread into consumer devices. The future of haptic technologies will have to deal with further developments, solving not only the dull tactile vibrating feedback, the inflexibility of the perceptual surface of touch screens, as well the kinetic devices for interpreting gestural movements. Kenya Hara sagaciously asserts that "Technology has no point unless it subtly awakens and activates the senses of its users." (Hara 2007, 145) As to counteract the condition stated by Yon Visell, director and researcher at RE Touch Lab (Re-engineering the sense of touch) that the device can sense what we are touching, but we cannot feel it. (in Marks 2010) Yet, until very recently, attempts to enhance the tactile experience have been unsuccessful. Prompting people to turn off the "annoying" vibrating haptic feedback feature whenever possible.

7.2 Force Touch

To gain interior space to contain the increasingly small electronic components, and substantially reduce the volume of devices, the elements of the hardware lose the space required for mechanical movement to become virtual simulators. In 2015, Apple has introduced the iPhone and Apple Watch with the vibrating Force Touch built into the pressure-sensitive touchscreen, and the MacBook with a Force Touch trackpad, consisting of force sensors that detect different intensities of pressure anywhere on the surface. The Taptic Engine underneath the capacitive glass surface provides a haptic feedback, enabling us to feel a single tap or varying intensities of pulses, by including customizable sensitivity to tactile response. The trackpad does not actually move downward when pressed like the traditional one used to, but it feels like it does when we press it a bit deeper. One light pressure equals to one click, and a deeper pressure, the Force Click feature, equals to the traditional mechanical Ctrl+click, which reveals a menu of contextual actions on the desktop and within apps; simulating a right-click. When gradually adding pressure to the Force Touch trackpad, it accelerates the speed to fast-forward through a movie or to zoom in on a location on a map. It has a pressure-sensitive drawing gesture feature, with which a light pressure draws a thin stroke, and a harder pressure draws a thick stroke. The Apple's Magic Mouse is also a multi-touch surface that allows scrolling in any direction and swipe through web pages with the tip of one finger.

Touch screen technologies:
— *5-Wire Resistive*, "When a finger touches the screen, the two metallic layers make contact, resulting in electrical flow. The point of contact is detected by this change in voltage."
— *Surface Capacitive*, "When a finger touches the screen, it reacts to the static electrical capacity of the human body. The decrease in capacitance is detected by sensors located at the four corners of the screen, allowing the controller to determine the touch point."
— *Projected Capacitive*, "When a finger touches the screen, the ratios of the electrical currents change, and the controller is able to detect the touch points."
— *SAW* (*Surface Acoustic Wave*), "piezoelectric transducers and receivers along the sides of the monitor's glass plate create an invisible grid of ultrasonic waves on the surface. When a finger touches the screen, a portion of the wave is absorbed. This allows the receiving transducer to locate the touch point."
— *Infrared*, "IR emitters and receivers create an invisible grid of light beams across the screen. When an object interrupts the light beam, the sensors are able to locate the touch point." (Ruterschmidt 1990–)

7.3 Electrovibration

As an alternative mean to the mechanical vibrating feature, the electrovibration is based on forces to create a perceptual illusion at deceiving the touch receptors into sensing a subtle tactile effect, when sliding the finger on the smooth surface of an insulating layer above a metal surface carrying an alternating voltage. The "charge in the finger is induced by a charge moving on a conductive surface." (Bau *et al.* 2010) The texture feels smoother when the frequency of the charge is higher. This effect of a perceived friction results from the varying electrostatic attraction between the metal and the deeper, liquid-rich conducting layers of the skin. The difficulty in developing electrotactile stimulation for the consumer is that skin conductivity is inconsistent and varies with each person, argues Ian Summers of the University of Exeter, UK. (in Marks 2010)
The *Electrostatic Vibration* initiated by Olivier Bau and team at Disney Research Pittsburgh is made with a glassplate, a transparent electrode on a clear substrate, and an insulator on top, to provide a wide range of sensations by modifying the friction of surfaces, which can be combined with "touch sensing technologies, including capacitive, optical, and resistive touch screens," (Bau *et al.* 2010) for an interface with variable vibration to stimulate the sense of touch, and without the moving parts of the constant mechanical vibration.

Electrostatic feedback: was published in 1953 in the article *Perception by the Skin of Electrically Induced Vibrations* by Edward Mallinckrodt, A. L. Hughes, and William Sleator Jr., where was reported that sliding a "finger over a conductive surface covered with a thin insulating layer and excited with a 110 V signal, created a characteristic 'rubbery' feeling." (Bau *et al.* 2010) This effect was named *electrovibration*: (Mallinckrodt *et al.* 1953, 277) "An electrostatic force is created by applying a time varying voltage between an electrode and an insulated ground plane. When a finger scans over an insulated plate with a time varying voltage, the finger works as the induced ground plane. The induced static electricity creates an electric force field between the finger and the surface." (Wikipedia)

7.4 Gestural Vocabulary

Digital literacy implies to acquire skills on a set of standardized touch gestures used to manipulate features and contents through trackpads and touch screens of smartphones, tablets, watches, kiosks, tables. These gestures comprise a language with specific vocabulary, but often denoting a lack of consistency in the gestures proposed by the different hardware manufacturers and software companies. (Nova *et al.* 2012, 53) In particular the direction of scrolling. (Norman 2011; Norman 2010; Norman and Nielsen 2010)

Tap; Double tap — Touching the surface with a fingertip initiates an action, selects links, or pushes buttons on the screen. On Apple's trackpad, a tap equals to one click, and a click or tap with two fingers executes a double click. A tap with three fingers enables *e.g.* to look up a word. A double tap with two fingers zooms in and out. On the iPhone and Magic Mouse the double tap with one finger is used for zooming.
Hold; Press — Pressing and holding the tip of the finger on the touch screen, opens a contextual menu or selects an item. (Nova *et al.* 2012, 53)
Drag; Slide; Scroll — Moving the tip of the finger over the surface without lifting it from the screen allows scrolling and drag-and-drop. On Apple's trackpad two fingers slide up or down to scroll. And three fingers are used to drag items on the screen.

Literacy: traditionally meant the ability to read and write. The term expanded to include the ability to use language, numbers, images, and other signs, to self-reliantly understand the dominant symbol systems of a culture. Currently, it includes the skills to access knowledge through technology and ability to assess complex contexts. (Wikipedia)

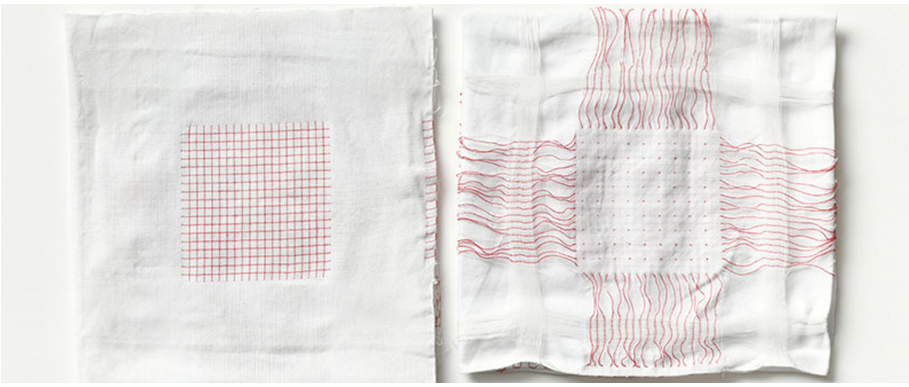
Swipe; Fling; Flicker — Used to scroll, to pan, or to quickly move objects. (*ibid.*) The finger is placed on the screen and swipe in the desired direction. On Apple's trackpad swiping left or right along the trackpad with two fingers is used, *e.g.* in Safari to navigate the previous or next page. Swiping left with two fingers from the right edge of the trackpad enables to see all notifications from the Notification Center. Three fingers swiping up on the trackpad to see everything running on the desktop. Swiping left or right with four fingers to move between desktops and full-screen apps. Swiping up with four fingers opens Mission Control, allowing access to all open windows, desktops, full-screen apps, Split View spaces making it easier to switch between them. Swiping down with four fingers allows seeing all windows of the app in use.
Pinch close; Spread — Used for zooming in, placing two fingers on the screen and moving them farther apart without losing contact with screen or trackpad. For zooming out, moving *e.g.* the thumb and finger in a pinch gesture. Pinching the thumb and three fingers together to display Launchpad, which is the fast way to find and open apps. Spread the fingers apart to show the desktop.
Rotate — On touch screens and trackpad moving two fingers around each other.

Hand gestures as shaking the device are meant to clear, reset, or refresh data. Rotating the device activates the gyroscope to give the option for a vertical or horizontal page format. Other built-in features as the compass require being calibrated frequently rotating the device in a 8 movement. (Nova *et al.* 2012, 55) Gestures to tap, scroll, swipe, pinch, rotate, press and type on digital devices became common daily actions for people who have acquired the necessary skills by everyday practice. Acting on and communicating through digital interfaces requires a symbolic gestural vocabulary that does not exist in the physical world. *e.g.* In the real world, we do not enlarge or shrink an image by placing two fingers on the image and then opening or closing the fingers while keeping contact with the surface. Our body uses a non-verbal gestural language to interact with virtual contents in digital devices. These body gestures provide uncommon somatic sensations that are proper to interact with digital interfaces.

7.5 Responsive Interfaces

The *Project Jacquard: Technology woven in* was initiated by Ivan Poupyrev and team at the Google's Advanced Technology and Projects (ATAP) department, for the wearable technologies go contrary the bulky and uncomfortable gadgets, and be barely noticeable. Producing conductive yarns by replacing strands of thread with thin metal wires or conductive polymers, that are seamlessly embedded in the fabric to create gesture interactivity in touch-sensitive textiles with integrated computerization for a natural appearance and feeling. Poupyrev notes that the structure of reticular intersection of web and mesh of textiles is similar to the squared placement of electronic components of touch-screens

in digital devices. Meaning that if replaced some of the threads in textiles with conductive threads, it is possible to weave a textile that can recognize an array of simple touch gestures. In the industrial loom, the manufacturing process combines metallic or polymeric alloys with natural or synthetic yarns for subsequent production of garments with touch-sensitive areas coupled with a small Bluetooth controller, enabling interaction with services, devices, and environments. "Touch and gesture data is wirelessly transmitted to devices to control a wide range of functions, connecting the user to online services, apps, or phone features." (Google 2015) By tapping or swiping the fingers through an area with conductive fibers inserted in the fabric, users are able to unlock the phone, answer calls, silence incoming calls, control media playback, or scroll through articles with effortless hand gestures. With discreet technologies integrated into materials and complementary electronics (connectors and circuits), the digital interfaces become seamlessly blended into clothing and home textiles to stimulate and streamline everyday tactual interactions, naturally bridging the digital with the physical in a tactile engaging way.



Img13. *Project Jacquard:* "Using conductive yarns, bespoke touch and gesture-sensitive areas can be woven at precise locations, anywhere on the textile. Alternatively, sensor grids can be woven throughout the textile, creating large, interactive surfaces." (Google 2015)

The *Project Soli* begun with Ivan Poupyrev and team at the Google's Advanced Technology and Projects (ATAP) department, to turn subtle hand gestures into digital controls for electronic devices using an unobtrusive radar-based sensor. "The Soli sensor can track sub-millimeter motions at high speed and accuracy. It fits onto a chip, can be produced at scale, and can be used inside even small wearable devices." (Google 2015) It uses broad beam radar to recognize movement, velocity, and distance. It works using the 60 GHz radar spectrum at up to 10,000 frames per second. Movements are then translated into commands that mimic touches on a screen, the while eliminating the need for knobs and buttons. Contrary to camera-based sensors like Leap Motion that capture cumbersome gestures and require additional hardware, Soli does not imply camera tracking, the chips can be embedded within objects, can capture finger movements a meter away, and hands are the only user interface needed. Tapping a finger and thumb together presses a button while selecting a song from a playlist is as simple as rubbing a finger and thumb together.

The haptic controller of the *TECHTILE toolkit* is able to generate audible audio signals (20–20000 Hz) and low-frequency vibrations (1–20 Hz) below the auditory threshold.
Here is the Link for instructions on how to develop the TECHTILE toolkit by DIY: techtile.org/en/techtile toolkit

Piezo:
is a technology that respond to an electrical charge. Different from a vibrating motor, it allows control over frequency, duration, and the onset of vibration. But, as the voice coil, it causes to vibrate the "entire touch surface" (Bau et al. 2010) where it is assembled. *Aito*, a Dutch-Finnish company is building products and solutions based on a software enhanced piezo technology (SEP), improving the localization and intensity of haptic feedback. For Aito maintains that "A product is desirable when its interaction is pleasurable." (aito-touch.com/technology)

Touchable Holography: Takayuki Hoshi and team at the University of Tokyo, proposed tactile feedback of a hovering image in 3D free space, using acoustic radiation pressure. (Hoshi *et al.* 2009; Iwamoto *et al.* 2008a; 2008b)

The *TECHTILE toolkit*, launched in 2007 by Masashi Nakatani (haptics researcher), Yasuaki Kakehi (interactive media developer), and Eisuke Tachikawa (designer) at Keio University+YCAM InterLab in Japan, combines 'TECHnology' with 'tacTILE' perception in a rapid prototyping tool for the design of haptic media to convey tactile sensations. Intending to integrate haptic technologies as the third media in the visual and audio media. The Techtile toolkit enables to record, edit, and playback tactile sensations of material properties. The kit is comprised of a haptic controller (1–20000 Hz signal amplifier), a haptic recorder (microphone), and three haptic reactors (voice-coil vibrators). A tactile signal is recorded as an audio signal when *e.g.* one attaches the haptic recorder on the bottom of a plastic cup and drops marbles in it, and attaches a haptic reactor on another plastic cup. Then hands the empty cup over to someone, and the other person will feel the marbles on the empty cup. (Minamizawa *et al.* 2012)



Img14. TECHTILE toolkit is TECHnology based tacTILE design developed by Masashi Nakatani, Yasuaki Kakehi, Eisuke Tachikawa, and collaborators in 2007.

Touché developed by Ivan Poupyrev and team at Disney Research Pittsburgh is about touch and gesture sensing on everyday objects. It uses a swept frequency capacitive sensing, that instead of sensing a capacitive touch at one frequency, it senses hundreds of frequencies to construct a complex capacitive profile, with which it detects touch events and "recognize complex configurations of the human hands and body during touch interaction." (Sato *et al.* 2012) Technology will evolve to replace the indiscriminating vibrational response into a more believable, reliable, and stimulating tactile feedback. In a distant future, surfaces will be responsive interfaces with organic forms that will adapt to our pressing tactual intents and handling actions, challenging the art making. "Since ever, artists explore, appropriate, and recreate the means. Attentive to what is happening in technical developments to adopt the ultimate technologies as their creative tools." (Coelho 2012)

Summary

The audiovisual media in our intensive technological culture have privileged the two senses neglecting the others. The digital technology is multisensory

when it involves more of our senses than just sight and hearing. Only the touch makes digital media truly interactive.
Typically, users have access to the buzz type of feedback in haptic consumer electronics, but the current vibrotactile technology does not satisfy everyone equally. The buzzing effect of the responsive vibrating feature is not an indulging option for everybody. The touch screens currently available in the consumer market are not yet flexibly reactive to touch with shape-shifting surfaces, and most of the touch sensors do not discriminately detect variable levels of pressure. As improvements in haptic technologies proceed, increasingly real interactions will be transposed as lifelike metaphors into the virtual world.

"Advances in technology predict evolution in the making of art. Art works used to be perceived at distance, untouchable, but now to be fully experienced they have to be maneuvered requiring physical interaction. To stress the need for physicality, computers of the future will have inevitably any organic form or shape demanding new ways of interaction and new body approaches to shape-shifting devices. The device will change its physical interface, sensing, and responding accordingly to real-time physical input. Organic user interfaces will transform the way we use computers. Adding the dynamic response to our physical inputs will change radically our interactions with computational devices. The objects will adapt physically to our biological nature. The dynamic surfaces will change their physical appearance and texturing when we touch or hold them. Prompting new experiential dimensions and renewed haptic relationships between the human body and its surroundings. Technology will be at our use effortlessly, changeable and controllable at our moods and desires, along digital everyday devices become increasingly complex, smaller, less obtrusive, and with minor technological appearance. Technological devices of the future will have a distinct physical appearance from today, as they will be everywhere, on any material or surface, flexible or rigid, liquid or solid. Electronic components will be assembled combined with the most disparate materials (*e.g.* paper, fabric, plastic, ceramic, glass, concrete, fluids), providing a variety of different and endless textural possibilities for tactility. Our lifeless everyday objects will soon become lively interfaces for interactions, demanding new physical relations and changing body behaviors. As touch suggests variations between activity and passivity, renewed perceptual means will give rise to the interplay between subject and object." (Coelho 2012, 172)
A largely transformed body will surpass the physical and digital dichotomy to communicate, express, and connect without restrictive barriers.

Chapter 8

Explorations
Conceived to be touched

Introduction

This chapter conceptualizes and develops empirical examples as metaphors to demonstrate the theoretical interpretations advanced by the research on how we perceive our environment through touch. Evaluating the experience of the interaction and the phenomenology of the experience, and formulating the *Theory of Aisthantic Experience* to formally analyze the quality of felt experiences.

8.1 You may touch the art

By haptic in art one infers that it is allowed to touch the exhibited pieces. With this, we may deduce that the institutional exhibition places are changing their regulations for physical constrictions in accessing the exhibited art works. But still, in many places touch is prohibited. We can use sight and ideate tactility, keeping a considerable distance from the highly valuable, original, irreproducible exhibited works, usually kept in a case of glass, or marked with a rope, on the floor with tape, a sensor that beeps, or an [cont. ...]

Haptic explorations are a set of prototypes crafted to offer haptic experiences with a statement, that haptic feedback is more meaningfully gratifying when the surface reacts, explicitly shifting its appearance, shape, or position. This may be due to the organic impression of something apparently alive. Only the fact that a robotic arm moves, it is sufficient to elicit empathetic emotions. Concordant with artificial life simulations, which intent to mimic the elementary qualities of living systems. Director of Interactive Architecture Lab, Ruairi Glynn describes the people's behavior to his kinetic installation *Fearful Symmetry*, exhibited at Tate Modern in London:

> "Our brain has neurons that mimic [the] behaviour of other people in order to gain [a] better understanding of our environment. This sort of mimesis also increases an empathy we feel for each other. The giant

> robot scans the environment, then picks up and imitates movements of an individual within the audience. As its body is very different to a human one, the movements are transformed but still mirror features of audience movement. It would randomly change its attention to different audience members, which was interesting because audience members — flattered at first by the robot's attention and then confused when confronted with its rejection — started questioning themselves and competed for the robot's attention." (Glynn interviewed by Happy Famous Artists 2012)

In haptic explorations, people get to experience a surface that instinctively and tangibly reacts to touch, another surface that changes appearance to touch, and more other volumetric surfaces non-reactive to touch.
The 1st premise is that "functionality resides in the expression of things." (in Hallnäs and Redström 2006, 166) Their unique expression is to attest the immediate reaction to a sudden touch. Emphasizing a proximal contact with a surface that promptly reacts to our touch, people may experience tactual sensations and identify the impacts they cause. Through the experience of art, it is meant to conceptually clarify our understanding of the complex sense of touch, enabling us to characterize tactile behavioral reactions. As to prompt "[...] how the fusion of touch and art transforms the experience of both." (Driscoll 2006) Experiencing anew the fundamentals of touch in its primal intuitive behavior.
In the foreword of the book *White* (*Shiro* 白) by Japanese graphic designer Kenya Hara, first published in 2008, Danish-Icelandic artist Olafur Eliasson wrote:

> "Today we seem to be experiencing a rationalisation of our senses: the art of refinement is half forgotten — detail, absorption, and slow engagement are neglected." (in Hara 2010)

In the technological era, we have been experiencing the world hastily through layers of sensory disengaging technologies.
The 2nd premise is to experience haptic through unintrusive technologies, with procedures for creating objects by hand, seeking for the corporeality of artisanal dexterity. The development processes are handcrafted — drawing, cutting, assembling, mixing, painting and sewing by hand, using traditional resources combined with emergent technological materials. Liberating our hands from the computer may enhance the shaping of concepts. As American Modernist graphic designer Paul Rand (1914–1996) keenly adverted "it is important to use your hands. This is what distinguishes you from a cow or a computer operator." (in Bader 2013, 22) There is not a technological interface between people and the haptic explorations. People touch paper and textiles with bare hands.
In the movie *In the Land of Blood and Honey*, directed by Angelina Jolie in 2011, depicting the Bosnian War, Danijel a soldier fighting for the Serbs re-encounters Ajla, a Bosnian who is now a captive in the camp he oversees. Ajla is a painter and when she is at the gallery she wants to feel the painter's gestures through the ink matter — "May I touch it? I've always wanted to touch his paintings."

[... cont.] unevenness on the floor, and guarded by a vigilant, not letting us fully engaging in a potential tactual interaction.

In *A History of Western Philosophy*, published in 1945, the British philosopher, historian, social critic, and political activist Bertrand Russell (1872–1970) awarded Nobel Prize in Literature in 1950, writes in chapter *Bergson*, on the French philosopher Henri Bergson (1859–1941) awarded Nobel Prize in Literature in 1927, "The relation between instinct and intellect is compared to that between sight and touch. Intellect, we are told, will not give knowledge of things at a distance; indeed the function of science is said to be to explain all perceptions in terms of touch. 'Instinct alone,' Bergson says, 'is knowledge at a distance. It has the same relation to intelligence that vision has to touch'." (in Russell 2008 (1945), 798)

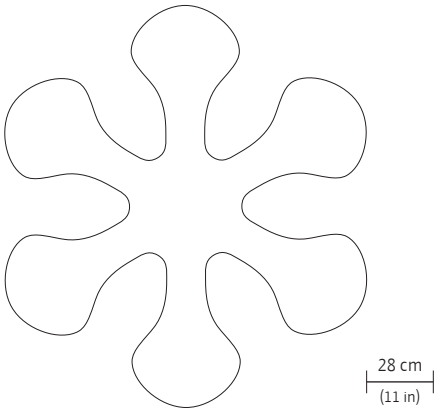
French-American artist and sculptor Louise Bourgeois (1911–2010), best known for her large spider structures *Maman* (1999), stated, "I am not what I am, I am what I do with my hands..."

Out of fear of damaging "all the artworks that could never be touched because they are too large, small, fragile, rare or valuable." (Driscoll 2013) Driscoll points out "the degree to which the prohibition has indiscriminately infused the culture of art." (*ibid.*) Contrary to most of the exhibited art works, the proposed haptic explorations are meant to be freely experienced through touch. Except for two, as a way to demonstrate to the participants the difference in the experience.

Mark Paterson, a lecturer in Philosophy and Cultural Studies, at the University of Pittsburgh, affirms, "To transfer the creative working practices of craftspeople onto the computer desktop would be the ultimate test of a haptic technology." (in Classen 2005, 433)

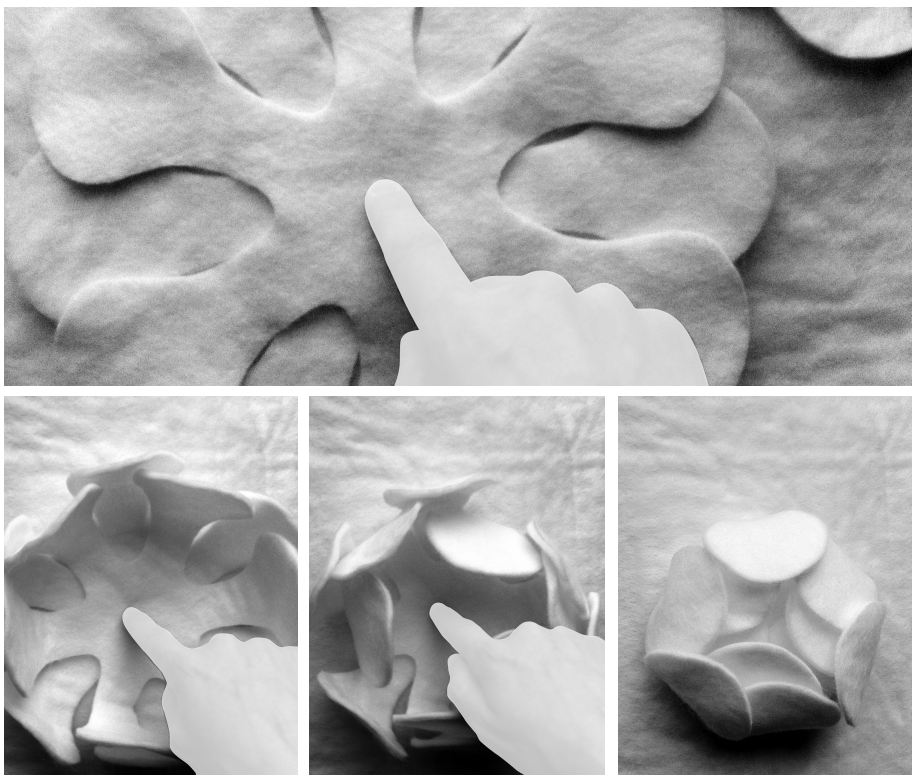
8.2 Tangere

Tangere:
Latin verb, present active infinitive of *tango* meaning 'to touch,' 'to grasp,' 'to elicit an emotional response.' Art allowed to touch without restrictions.



Diag15. Tangere pattern showing a stylized shape, much like the tropical plant *Drosera falconeri*, that is marked on the textile and cut by hand with scissors.

Drosera falconeri:
(commonly known as *Sundew*) both the botanical name from the Greek *drosos*, 'dew, dewdrops' and the English common name sundew, from the Latin *ros solis*, meaning 'dew of the sun,' refer to the glistening drops of mucilage at the tip of each tentacle that resemble drops of morning dew. In the genus *Drosera* and the eponymous species of *Petiolaris Sundew*, tropical perennial, and endemic to the Northern Territory in Australia, it is a tiny insectivorous plant with leaves of 3 cm (1.2 in) wide, bearing sticky glandular white hairs, that produce digestive juices to decompose the trapped prey. (Wikipedia; Botanical Society of America)



Img16. Tangere showing two layers of stylized leaves being activated by touch.
A simulator, because the electronic board of the animatronic surface burned. Fortunately, it burned after the assessment tests with the participants were finished.

Tangere: At the lightness of a touch is a blossoming surface project made of hexagonal stylized shapes of flattened plants, resembling the tropical plant *Drosera falconeri* with short and wide leaves.
Tangere is still a prototype aimed at becoming an immersive wall installation when the project finds the funds, or a knowledgeable, willing, and available technical team to develop it in collaboration. For when the aim is to cause a strong feeling impact, size matters. A sense of embodiment is enhanced if the project acquires greater dimensions. The transformative effect or the impression elicited when experiencing an immersive wall installation is potentially much higher than experiencing a prototype with a mere 40x60 cm (15.7x23.6 in) in size.
Tangere is meant to be an artificial semi-living surface. Metaphorically, it is the epithet of a sensory surface that gains life when it feels touched, or more prosaically it is a surface that reacts closing the petals to the center when it is touched. The two layers of the six petaled shape promptly close on the fingers of whom disturbs it, exalting a sense through a sensitive surface that reacts to our touch. The surface changes its physical appearance attempting to engage our tactual senses, comprising the exploration of tangibility in digital systems through conceptual interpretations.
For using an artificial system to simulate the tactile behavior of natural forms, it is intended to provide a perspective for the understanding of tactile behavioral reactions.

8.2.1 Concept

What apparently seems to be a flat and inert surface suddenly gains movement and changes shape as a reaction to our touch, demonstrating that things may not always be what we thought them to be, or that they do not behave the way we think they would. — What if the everyday surfaces could physically change their appearance, shape, or position by our touch, obeying to our moods, needs, and desires, mimicking a living being behavior?
Tangere is a surface whose shapes have a reactive capability to touch. When touched they react, instantly closing on themselves (it lasts 6 seconds to close fully), and opening when they are not being touched.
The concept for Tangere arose fueled by nature, particularly 'the sensitive plant' *Mimosa pudica*, which is a perennial herb of the bean family *Leguminosae/ Fabaceae*, popularly known as the 'Humble Plant,' 'Touch-Me-Not,' or 'TickleMe Plant,' because the narrow fern-like leaflets move when we tickle them. The leaves fold up when touched as a defensive mechanism against grazers. This nastic movement may set off a chain reaction with all the leaves falling on top of one another and the leaf stalk bowing, to gradually return to their original state. The leaves fold as a result of the internal movement of water. Stimuli, as touch or air movement, trigger areas of the stem to release chemicals, that cause water to move out of cell vacuoles, which leads to cell collapse.

Genus:
is a grouping of organisms having common characteristics distinct from those of other such groupings.

Eponymous:
of, relating to, or constituting an eponym. Named after something else or deriving from an existing name or word. (The Free Dictionary)

Mimosa pudica:
from the Greek, *Mimosa* meaning 'a mimic,' alluding to the sensitivity of the leaves, and the Latin *pudica*, meaning 'shy,' 'bashful,' 'retiring,' or 'shrinking.' Mimosa pudica was first formally described by the Swedish botanist Carl Linnaeus (1707–1778) in *Species Plantarum*, published in 1753.

Thigmonasty:
is the nastic response of a plant or fungus to touch or vibration. (Wikipedia)

Seismonasty:
is a nastic response to shock, referring the rapid folding of the leaflets of the sensitive plant due to changes in turgor pressure caused by vibration. (The Free Dictionary)

Nastic:
the movement of plant parts caused by an external stimulus. (New Oxford American Dictionary)

The touch-induced movements of sensitive leaves were observed and reported by English naturalist Charles Darwin (1809–1882) in *The Power of Movement in Plants*, published in 1880:

> "[T]he relation between the sensitiveness to contact of the cotyledons and of the leaves of the same plant is not very close, as may be inferred from the cotyledons of Mimosa pudica being only slightly sensitive, whilst the leaves are well known to be so in the highest degree."
> (Darwin 1880, 129)

Cotyledon:
is an embryonic leaf in seed-bearing plants, one or more of which are the first leaves to appear from a germinating seed. (New Oxford American Dictionary)

Nyctinasty:
is the circadian rhythmic nastic movement.
At night, the leaves fold and bend as reaction to absence of light.
(Wikipedia)

"Walls have ears:"
"This saying may come from a story about Dionysius of Syracuse (430–367 BC), who had an ear-shaped cave cut and connected between the rooms of his palace so that he could hear what was being said from another room."
"The *Ear of Dionysius* communicated to him every word uttered in the state prison."
Similarly, "the Louvre was so constructed in the time of Catherine de Medicis, that what was said in one room could be distinctly heard in another. It was by this contrivance that the suspicious queen became acquainted with state secrets and plots. The tubes of communication were called the *auriculaires*, and were constructed on the same principle as those of the confessionals." (Brewer 2000 (1898))

Mimosa pudica is autochthonous to South America and Central America, yet ancient Grecian writings already revealed the curiosity in a plant that exhibited movement in response to touch. (Ombrello 1983) The *Mimosa pudica*, *Venus flytrap*, *Telegraph plant*, *Sundew*, and *Bladderwort* are plants belonging to a small group capable of rapid movement caused by external stimuli.
Similarly, the *Cnidarians* are very simple life forms constituted only by muscle and nervous system. Because these animals do not have eyes, they use touch to be able to feed and protect themselves from threats. Deprived of all other senses, the possibility of existence is only achieved through the sense of touch. These touch sensitive life forms are a natural source constituted by simplified sensory systems propitious to demonstrate basic survival tactile reactions.
Tangere was inspired by looking at the minimalist design pieces from the *Haptic – Awakening the Senses* itinerant exhibition, curated by Kenya Hara in 2004 in Tokyo, where the emphasized sense of touch permeates all other senses. Unfortunately, due to their fragility and the very limited editions, people were not allowed to touch the objects presented at the exhibition. The tactile richness of their surfaces could only be vicariously gleaned by imagining the sensations felt if touched.
Tangere was also inspired by the futuristic movie *Æon Flux*, by American director Karyn Kusama in 2005, starring Charlize Theron, based on the MTV animated series created by Peter Chung from 1991 to 1995. Even though not explicitly evidenced in the movie, but through which we can envision how people will interact with spaces and reactive surfaces in the distant year of 2415. By then, walls will have overlapping layers provided with extended reactive capabilities. They may change appearance or have additional informative functionalities activated by touch.
There is an old phrase, that metaphorically attributes sensory capacities to walls: — "Walls have ears," which means a warning that a conversation can be overheard by anyone. Equally to say — "Be careful what you say as people may be eavesdropping." (New Oxford American Dictionary) Another popular expression is: — "If these walls could talk," meaning that they could tell something that someone wishes to keep for himself.
Projected to be a large wall installation, Tangere is a surface endowed with sensitive qualities. Deprived of other senses, the Tangere surface manifests its

reactive instincts only by touch. When someone disrupts its placid nature, it reacts promptly closing the round petals to the center. In the absence of a tactile stimulus, it quietly opens to a flat shape, returning to a nearly unnoticed presence on the base of the surface.
Intended to elicit a reflective interpretation of a behavioral reaction, a flat round shape changes its condition to a volumetric state in response to an unexpected touch.

8.2.2 The Nature way

The nature way means a creative outcome inspired by nature, or that mimics the structures and processes of natural elements.
Man's creative mind has never started from a blank page since everything he does is referential. American anthropologist, philosopher, and natural science author Loren Eiseley (1907–1977) eloquently asserted, "it is a remarkable fact that much of what man has achieved through the use of his intellect, nature had invented before him." (Eiseley 1998 (1970), 75) As Jean Baitaillon acutely argued, "Really we create nothing. We merely plagiarize nature." (Baitaillon in Eiseley 1998 (1970), 51) Up to now, man has developed several sensory electronic extensions based on observations made of animals much evolved and well adapted sensory capabilities. Diane Ackerman has noted a few examples:

> The electric eye is based on the motion-detecting design of the frog's eye, the mirror telescope is based on the contrast judging design of the horseshoe crab's eye, and the synchronous lenses for use in microsurgery, optical scanning, and severe vision problems is based on the double lens of copilia, a myopic crustacean that lives deep in the Mediterranean. (Ackerman 1990, 231)

Since long ago, we have been observing nature to better understand movement, self-regulation, interconnection, and learn from the extraordinary adeptness of natural beings. Biomimetic design signifies mimicking biological processes. It is the term used to identify artificial methods that draw on natural processes. American product manager and design theorist Jon Kolko defines biomimicry:

> "Biomimicry is the design strategy of noting the beauty and elegance found in nature and consciously applying these principles in the design process." (Kolko 2007, 150)

Nature is an immense library full of resources. An inspirational place to deep in for creative design processes. Design mediated by technology benefits greatly in searching for models, methods, and techniques outside its symbolic domain. Turning to nature to absorb new ways of doing, intended to acquire the know-how from the successful patterns of nature to improve design processes. Furthermore, learning from the symbiotic relation of natural systems may help

In *Art as Experience* published in 1934, the American philosopher and psychologist John Dewey (1859–1952) states that "Apart from relations of cause and effect in nature, conception and invention could not be. Apart from the relation of processes of rhythmic conflict and fulfillment in animal life, experience would be without design and pattern. Apart from organs inherited from animal ancestry, idea and purpose would be without a mechanism of realization." (Dewey 1980 (1934), 25)

English essayist, poet, and dramatist, Joseph Addison (1672–1719), stated, "There is something more bold and masterly in the rough careless strokes of Nature, than in the nice touches and embellishments of Art." (Addison 1712)

Biomimetics: from the Greek *bíos*, meaning 'life,' and *mimesis*, 'to imitate.' It was coined by the American biophysicist Otto Schmitt (1913–1998) in the 1950s, relating to, or denoting synthetic methods that mimic biochemical processes.

James Thomas Knowles (1806–1884) was the English architect, who with his son projected the Italianate Palace of Monserrate (1858–1860) for the Park of Monserrate, in Sintra, Portugal, profusely decorated with inspired vegetative motifs in the Romantic-Orientalist spirit.

Valuable lessons must be taken from nature, proclaimed the president of the Czech Republic Václav Havel (1936–2011) in *Politics and Conscience*, in 1984: "We must draw our standards from our natural world, heedless of ridicule, and reaffirm its denied validity. We must honor with the humility of the wise the limits of that natural world and the mystery which lies beyond them, admitting that there is something in the order of being which evidently exceeds all our competence." (Havel 1984)

"We flew like a bird for the first time in 1903, and by 1914, we were dropping bombs from the sky." (Benyus 2002 (1997))

In *Discourse on Method*, (*Discours de la méthode*) published in 1637, René Descartes writes, "je pense, donc je suis" translated to 'I think, therefore I am.'

solve environmental problems and raise people awareness in sustainable ways of living. We take everything from nature, from the fulfillment of basic needs to pleasurable sensations from beauty contemplation. Humans extract from nature what necessitate suppressing surviving needs and massive greed while artists and designers also obtain inspiration and insight from nature approaches for solutions in creative procedures. Access to designed elements from nature provides knowledge for solving complex human challenges. Nature stands for diversity, scalability, robustness, resilience, adaptability, resource management, energetic efficiency in variation, selection, and evolution processes. "Evolution has resolved many of nature's challenges leading to lasting solutions with maximal performance using minimal resources." (Bar-Cohen 2006) The answers to our many needs have been already resolved by nature. For 3.8 billion years, the designs of nature have been refined to respond to the hard requirements of harsh environments, and to overcome the demanding judgments that qualify for the survival of the fittest. Readily available, the designs of nature are a useful learning resource to improve design methods and products. Nature is the main source for innovative designs. (Benyus 2002 (1997)) Nature is a vast and complex wellspring where artists and designers go to get ideas for creative interpretations. Similarly, many scientific discoveries were made by careful observation of designs in nature. If it was not for nature, man alone would never come up with so many innovations. And it would take longer to finalize the ones he has conceived without the moldable materials ready to use (*e.g.* timber, clay, plaster). Nature reproductive ability creates similar structures, forms, and beings. But what prevails in nature is rarity and uniqueness. Despite the genetic similarities, each individual is intrinsically distinct. An attribute contrary to the industrially produced objects. Besides that in nature, nothing is wasted. Responsible design implies looking into nature to figure out ways to develop sustainably designed outcomes. By definition, the design is a process that natural processes may enhance. Nature inspired designs may create in us an immediate empathic desirability, capable of easing the cold medium of technology that at times makes difficult an emotional proximity. The more natural is the feeling the more proximal, appealing, and pleasant will appear.

Explorations in textural and shape-shifting surfaces of two and three-dimensional forms use simulation models of behaviors found in nature. The Tangere surface constitutes a creative form with a biomimetic expression inspired by the instinctive somatic behavior of living beings, conceived for a haptic experience as a mean of demonstrating behavioral reactions that are common to living beings when are surprised by a touch — we sense, therefore we react.

This biomimetic dynamic surface is an awareness project inspired by the sensory responsive behavior of living beings, that in an immediate encounter with others the natural reaction is to promptly close in defense or to open up demonstrating acceptance. Unlike the other senses, the sense of touch gives

and receives physical information in a critical and vital way for all living existence and survival. Because bilaterally, we communicate feelings through touch, this dynamic surface for haptic interaction uses nature as a way to demonstrate how living beings tend to react to tactile sensations of another presence. Aiming at leading to a more mindful interaction and awareness to ours and others behavioral rhythms, fears, anxieties, meanings, identity, causality, and bringing to consciousness a subtle and rich sensory interaction. It attempts to elicit an insightful reflection through a simulated nature, for the instinctive reactions to touch. As well as to explore curiosity, expectancy, interpretation, and reflection upon natural and artificial environments that are constantly changing.

8.2.3 Materials

Tangere is made with WH Nonwoven Geotextile, 100% Polyester, weight 250 gsm, for Tangere surface required a smooth and soft material to promptly captivate the sensations of touch. This nonwoven has the lightweight of paper and a light furry texture that is pleasurable to touch.
The nonwoven is a fabric-like technological material, produced by mechanical interlocking fibers of polyester or rayon in a random web or mat (or by perforating films of polyolefin), that are bonded together "with a cementing medium such as starch, casein, rubber latex, a cellulose derivative or synthetic resin." (Association of the Nonwovens Fabrics Industry (INDA) 2002) by industrial bonding methods: chemical means (adhesive/solvent), or physical means (mechanical or thermal). (European Disposables and Nonwovens Association (EDANA)) The fiber length can range from 0.635 cm (0.25 in) to 15.24 cm (6 in) "for crimped fibers up to continuous filament in spunbonded fabrics." (INDA 2002)
The nonwoven is a material that does not fray nor tear easily, is heat resistant and, therefore, non-flammable, has air permeability, liquid repellency, resilience, and stretch properties, as well as printable quality due to the even surface. Has hypoallergenic properties, it can be used on the body for it is unlikely to cause an allergic reaction. Beyond the sensory possibilities and technical capabilities, the nonwoven was also chosen for its practical characteristics, as it is malleable to work by hand, easy to mark with chalk for fabric, easy to cut by hand with scissors, and easy to sew with a steel needle and cotton thread.
The nonwoven "mimics the appearance, texture, and strength of a woven fabric." (INDA 2014) Not commonly used outside the industrial applications, the Geotextile is an alternative to the widely used nonwoven felt.

8.2.4 Color

The projects purposively created for haptic explorations are achromatic. Made all white, except two, which are black and white.

Nonwoven material kindly sponsored by the Chinese company Foshan S. L. P. Special Materials Co., Ltd.

Nonwoven:
the term is used in the textile manufacturing industry to classify materials that are neither woven nor knitted.

Bonding methods:
— Chemical bonding refers to applying adhesive binders by saturating, spraying, printing, or foaming techniques.
— Solvent bonding involves softening or partially dissolving fibers with a solvent to provide self-bonding surfaces.
— Mechanical bonding include needlefelting, stitchbonding, and hydroentangling.
— Thermal bonding implies the use of heat, and often pressure to fuse or weld fibers together at points of intersection or in patterned bond sites. (Wadsworth 2004 (Duckett 1999))

Polyester:
a synthetic resin in which the polymer units are linked by ester groups, used mainly to make synthetic textile fibers. (New Oxford American Dictionary)

The color or the absence of color is deliberated. Not using color and opting for layers of white upon white was conceived for sensory and attentional purposes. The intention was to constrain the contrasting visual expressiveness to the maximum, and take the representation to the minimum expression. For it, it was kept the original white of the textile materials, planned to take people to focus mainly on the tactility of materials, manifested in different edges and curves of shapes and textures. Otherwise, sight would be competing with touch for sensory attentiveness, and touch is the sense that matters to experience emphatically. White is the color of the braille reader book, for the reason that sight is not involved in the reading. As to increase the dramatic impact of his images, the Brazillian photographer Sebastião Salgado chooses to work in black and white, for the apprehension of his themes do not get deviated by the profusion of color, nor he gets distracted by them while producing the images. Conceptually contrary to "Impressionists, who saw no white in nature." (Kandinsky 2011 (1910), 47) Although, "the sun is glaring white in daytime." (Albers 2006 (1963), 45) Due to the reflection of the wavelengths of the visible spectrum, white is the color of clouds over the blue sky and white is the color of snow against which the white rabbit is invisible. Beaches with sand that contains high amounts of quartz or eroded limestone also appear white.

> "By means of a prismatic lens, the physicist easily demonstrates that the color spectrum of the rainbow is a dispersion of the white sunlight. With this, he proves also that the sum of all colors in light is white. This demonstrates an additive mixture." (Albers 2006 (1963), 27)

The color white is obtained by adding light. When the colors of the spectrum are mixed, it reaches the pure pungent white on the screen. The primary colors of the additive color mixing are red, green, and blue, attained through equal intensities in the RGB (255, 255, 255) color model. Whereas, by subtracting light, by way of mixing colored inks and pigments on a sheet of white paper, the white gives way to its opposite, the black. The primary colors in the subtractive color mixing are cyan, magenta, yellow, and the key black for the outlines. White is reached with CMYK (0, 0, 0, 0) color values. Yet, the response to maximum stimulation of the retina, the perception of white, depends on contrast. White is an achromatic color, a "color without color" painted on a white canvas. On the reductionism of color to the minimum, Modernist painters explored the absolute white. As Russian Suprematist painter Kazimir Malevich (1878–1935) with *Suprematist Composition: White on White* (1918). An oil on canvas exhibited in the collection of Museum of Modern Art (MoMA) in New York:

> "This austere painting counts among the most radical paintings of its day, yet it is not impersonal; the trace of the artist's hand is visible in the texture of the paint and the subtle variations of white. The imprecise outlines of the asymmetrical square generate a feeling of infinite space rather than definite borders." (MoMA)

Rayon:
a textile fiber made from regenerated cellulose (viscose). (*ibid.*)

Polyolefin:
is any of a class of polymers produced from a simple olefin (alkene). (*ibid.*)

Color:
is the property possessed by an object of producing different sensations on the eye as a result of the way the object reflects or emits light. (*ibid.*)
Expressed literarily by Charlotte Brontë in *Shirley*: "He looked up. All amongst the trees he saw moving objects, red, like poppies, or white, like may-blossom." (Brontë 1849)

Complementary colors:
"are pairs of colors which, when combined, cancel each other out. This means that when combined, they produce a grey-scale color like white or black. When placed next to each other, they create the strongest contrast for those particular two colors." (Wikipedia)

White fur:
well adapted to the environment, the Arctic fox changes the color of fur with seasons, from white in the winter to blend in with the snow, to greyish-brown or dark brown in the summer.

The American Abstract Expressionist painters Mark Rothko (1903–1970) with *Untitled 1* (1969), a minimal blue and white acrylic on canvas. Agnes Martin (1912–2004), with *The Islands* (1979), a series of twelve acrylic and graphite on canvas with the subtle expressionism of a matte white color, exhibited in a retrospective at Tate Modern in London from June to October, 2015. Robert Rauschenberg (1925–2008) with *White Paintings* (1951) of house paint on canvas. And Robert Ryman's (1930–) white paintings with *Classico 5* (1968), a series of synthetic polymer paint on twelve sheets of paper, and other experiments in white on different media, exhibited in the collection of MoMA:

> "Ryman believes that the purity of the color white best highlights the manipulation of paint. His paintings and drawings are meant to heighten the viewer's awareness of subtle variations in the substance of his materials and his brushwork. The relation of the painted areas to the edges of the support also accentuates variation and physicality." (MoMA)

White is "all colors" and "no color" simultaneously. (Hara 2010, 8) In his short book *White*, Kenya Hara embraces the essence of white as the origin upon which everything blossoms and emerges, making the white a truly special color:

> "This identity as a color that can 'escape color' makes white very special. Not only does white's texture powerfully evoke the materiality of objects; white can also contain temporal and spatial principals like *ma* (an interval of space and time) and *yohaku* (empty margin), or abstract concepts such as nonexistence or zero." (Hara 2010, 8)

In different cultures, white symbolizes light, purity, innocence, wholeness and completeness. It represents "perfection, good, honesty, cleanliness, beginning, new, neutrality, and exactitude." (Heller 2009 (2000))
White transmits an inner state: — She was white pale as porcelain. And an emotional expression: — His face was colorless with fear.
As for the tone, white is the "harmony of silence." It is the "pause that breaks temporarily the melody." (Kandinsky 2011 (1910), 47) To the Russian painter and art theorist Wassily Kandinsky (1866–1944), white "is not a dead silence, but one pregnant with possibilities." (*ibid.*, 47)
White allows breathing. White space gives the necessary intervals for things to coexist harmoniously. White means spatiality. Due to the simplicity and subtlety, the emptiness and absolute void, white surfaces induce our perception into making us feel that we are in a wider and lighter space. Therefore, a project that intends to be a wall installation will give the impression of a larger space.

8.2.5 Development

Tangere is a conceptual touch sensitive surface that changes its appearance from one physical state to another, to gradually recover the initial state when

we stop touching it. Using for this purpose textile materials combined with electromechanical components to produce movement. For this effect, it uses wires and electronic controls to acquire a semi-living presence with a behavior of its own to challenge our state of awareness and perception.
The first steps for the development of project Tangere consisted in testing the potential materials, among which, different nonwoven densities and *shape memory alloys*, the *Nitinol* wires, to find the right consistency, malleability, and performance, able of producing the required movements. The diameter of the Nitinol wire is measured in microns, which dictates its strength enabling it to move the nonwoven after being hand-stitched onto the surface. However, the Nitinol is a very capricious material, that hardly does what was intended to do, because it is difficult to shape setting a desired three-dimensional memory, and after a few cycles it starts to lose the depth of movement, up to lose it almost completely. To shape setting a memory in the Nitinol in a furnace at 500°C for 15 minutes, the tubular copper mold bent into one shape must have a form triple exaggerated from the one intended. And the outcome is hardly perceptible because the resulting movement is inconstant. A first major issue about this Nitinol wire is that when electrified it heats up to 70°C, which is too high to put a finger on it. No one could touch the wire bare hands without the risk of suffering pain or getting burned. The project had to be adjusted to that circumstance. A second major issue about this Nitinol wire is that it only has the capacity for one-way shape memory effect, which was not suitable for a project requiring two-way movements. Another adjustment was made to the project. After a very stressful and frustrating long time trying to forcibly adequate the material to the project and vice versa, it was decided not to use it. Then the project arrived at a deadlock. It was either to kill it, or to seek for an alternative. After searching for technical expertise on the Internet, it was found the name of whom worked with the British-Turkish fashion designer Hussein Chalayan in the development of his greatly acclaimed animatronic dresses. Was the British Rob Edkins and his electronic and mechanical engineering collaborators. Immediately, he was sent an email with the concept, anxiously expecting Rob's interest in developing the project in a commissioned collaboration.
A meeting was set up and he showed enthusiastic interest in getting involved with the execution. After the agreement approved, the interchanging of ideas, the explanation from the experts for why not using Nitinol but pulling wires, the several technical improvements, a change in the shape cut to answer to technical requirements, and a few months later, a reasonable Tangere prototype was finalized. Then it flew to Portugal, to be tested and experienced by touch.

Nitinol:
stands for *Nickel Titanium Naval Ordnance Laboratory*, accidentally discovered in 1959 by William J. Buehler and Frederick Wang. It is a metal alloy of 55–56% Nickel and 44–45% Titanium (changing these percentages can significantly affect its properties). The *Shape Memory Alloy* and *Superelasticity* exhibit specific properties:
— Shape memory is the ability of Nitinol to undergo deformation at a certain temperature (between -35° and +90°C), then recover its original, undeformed shape upon heating above its transformation temperature.
— Superelasticity, discovered by William A. Rachinger in 1958, occurs at a narrow temperature range just above its transformation temperature; in this case, no heating is necessary to cause the undeformed shape to recover, and the material exhibits great elasticity, about 10–30 times that of ordinary metal.
(Kauffman and Mayo 1997)

Nitinol with two-way shape memory effect exists, but it was not being commercialized. The generality of suppliers fail to provide technical specifications of their materials, and customer follow-up service.

8.2.6 Outcome

One of the main functions of art is to instill critical thinking. Art does not intend to give answers, but to pursue an insightful questioning, even so, one can find

answers through art, depending on what each one is searching for. Some find peace contemplating an art piece. Outcomes in art and design can make issues about touch explicit and reachable for a better understanding, reordering our knowledge of it. Tangere, which smoothly changes from open to closed shape at our touch, (while crossing differentiated practices, from the inquisitive art to the resolvable design, from the explainable natural sciences to the conceivable engineering) intends to be an open-ended, critical, and thought-provoking project to raise individual awareness to similar experiences of interaction involving touch. It is meant to be an analytical project for the enhancement of touch interaction, open to questioning one's perceptions, challenging each one to know oneself through touch behavioral reactions. The Tangere surface reactively closes and opens its shape smooth and quietly when it 'feels' touched, intentionally created with an inquisitive procedure as to inquire the individual sensations, when touch is the main conceptual focus.

In the article *What is Haptics?*, Mandayam A Srinivasan reminds that "Making the human user comfortable when wearing or manipulating a haptic interface is of paramount importance, since pain, or even discomfort, supersedes all other sensations." (Srinivasan 2005, 6)

8.2.7 Quantitative Assessment

The quantitative assessment aims at measuring the effectiveness, efficiency, and satisfaction attributes of the design of interaction in quantifiable results. The assessment on the experience of the interaction carried out on the prototype of Tangere aims at producing a reflective interpretation from the comprehensive data analysis, after comparing evidence from experiencing surfaces reactive to touch *vs.* surfaces non-reactive to touch. Envisioning at prompting a clear understanding on how consciously aware we are of sensory tactile dispositions. The prototype of Tangere was exhibited at a private house for an extended period of three summer months, during which 13 people (8 women and 5 men) among family, friends, and neighbors, with the average age between 27 and 73 years old interacted with the prototype, without previous demonstration and with the only instruction that they could touch it freely; pressing, tapping, or groping it at will. To assess the experience of the interaction, it was conducted an anonymous structured questionnaire with fixed-response questions and collected the answers for statistical data analysis. Drawn from a sample comprised of people with divergent cultures, educations, and practices not related to art or design making, from very little to regular use of technology. Purposively seeking for unbiased opinions, from an innocent stance and fresh eye apart from art and design domains. The questions were explained in the beginning, and again when solicited. The participants agreed to answer the questions in printed format. The close observation was carried throughout the 13 experiences. The duration of each experience plus assessments went between 45 to 60 minutes, or on a few times more, depending on the physical and mental availability of the participant. Most of them happened on leisure time on weekends, during bright daylight or at dusk. On the same moment, an interview was carried immediately after the following questionnaire:

Resistor:
is an electrical component that limits or regulates the flow of electrical current in an electronic circuit.
The electrical behavior of a resistor obeys Ohm's law for a constant resistance, however, some resistors are sensitive to heat, light, humidity, force, or chemical activity.
(WhatIs.com, Dictionary.com)

Quantitative Assessment:
collects data that can be analyzed using quantitative methods, *i.e.* numbers, statistical analysis.

Effective:
something is done.

Efficient:
something is done well.

The questionnaire is attached at the end of the thesis, in Appendices on page 203.

1. Were you expecting the surface could physically react to your touch?
   — The 13 respondents have answered NO. All the people surveyed answered that they were not expecting the surface could physically react to their tactile inputs, as they are not used to interact with surfaces that tangibly move or change shape, but only to retinal screens that have visual elements moved or changed to their touch.
   Caught by surprise, the participants instinctive reaction was to remove the fingers of the way the closing shape as quickly as possible, followed by opening the mouth in astonishment and giggling, then they waited for the shape to return to its flatten position, and repeated the action many times touching the shape to trigger the closing reaction. The participants attitude was annotated. After teasing the shape a few times, 3 curious participants (2 men and 1 woman) left one or more fingers in place to feel the shape grabbing them in amusement. While one daring participant moved his finger into and from the closing shape several times defying its reaction speed.

2. Did you realize almost immediately where to touch on the surface?
   — To all the participants were told that they could explore the surface with their hands unrestrictedly, but because they did not know what to expect, 8 respondents have answered NO; so they just explored the surface eager with the eventuality of getting some response of any kind, whereas the 5 respondents that have answered YES; they followed their curiosity to where it had taken them.
   Yet, there was a slight difference in gender attitude. Women took more time exploring, and consequently they took more time to activate the reacting movement. Initially, the participants (mostly women) started to feel the softness of the material with their fingertips. Then they grasped one edge of the shape to feel it between their fingers. And finally, with their hand open they checked the entire shape touching from the center.

3. Was it easy to find the hidden 'button' that would trigger the surface to react?
   — 8 respondents have answered NO since they were not aware of what to expect, the location of the trigger was not perceivable to them. Whereas to 5 respondents who have answered YES, the cutout of the shape drove them to the center where the trigger was located, by groping it the participants casually triggered the movement. As soon as the participants have found the trigger the shape closed promptly on their fingers. Although, not all the participants immediately correlated the movement with a triggering button. The average time for the participants to find the trigger was about 25 seconds

4. Were you willing to explore the surface with your touch?
   — The 13 respondents have answered YES. All the participants expressed their will to check the surface with touch. The captivatingly smooth material and a nature-inspired shape led the participants to explore the surface with

fingertips and open hand. Given the opportunity, the participants showed to be willing to engage more proximally with the objects they get to interact.

5. Or were you reluctant to touch the surface?
— The 13 respondents have answered NO. None of the participants felt intimidated or uneasy and avoided touching the surface. Although people are not accustomed to touching the exhibiting art works, experiencing the prototypes at a private house in an informal setting, may have freed them from difficulty, hesitation, or embarrassment.

6. Do you appreciate the surface to be tangibly responsive to your touch?
— The 13 respondents have answered YES, to feeling contented with the experience of interacting with a tangible responsive surface, because none of the participants did ever experience a surface that could explicitly react to their tactile inputs.

7. Or would you prefer the surface to be static?
— 11 of the most enthusiastic respondents answered NO while 2 answered Indifferent, and none of them have answered YES. After experiencing the emphatic reaction of a surface that physically reacts to touch, changing its shape from open to close and then to open again, a greater number of the participants want it to have movement.

8. Do you appreciate the material of the surface to be soft and warm?
— From the people inquired, the large majority of 12 respondents answered YES, to prefer the material of the surface to be soft and warm while 1 has answered to feel indifferent as to the choice of the material affecting the sensory sensations. An unsophisticated soft and warm material may evoke sensations of naturalness eliciting feelings of calmness, comfort, relaxation, and contentment.

9. Or would you prefer the material of the surface to be hard and cold?
— To this question, 11 respondents answered NO, to not prefer to experience the sensations provided by a hard and cold material, while 2 answered to feel indifferent, or insensitive to the material, and none has answered YES. Extrapolating this evidence to the everyday interaction with digital devices, it may indicate the consumer material preferences. A sophisticated hard and cold material may evoke sensations of artificialness eliciting feelings of uneasiness, discomfort, tension, and discontentment.

10. How would you classify this experience as to the level of stimulation?
— On a scale of 1–not stimulating to 5–very stimulating, the respondents were asked to rate how much the experience stimulated their senses, notably their senses of touch. Wittingly, 6 respondents answered the experience to

be fairly stimulating, and 2 respondents answered to be very stimulating to their senses of touch, as the surface seems to be defending itself, reacting physically to the participants tactile inputs. While 3 respondents answered to be stimulating, and the remaining 2 respondents answered to be mildly stimulating. No one has answered not being stimulating. Which means the majority of respondents answered the physical reaction of the surface to be sensory stimulating, engaging the senses and triggering the sensations anew, and eventually more so when the surface is big enough to be immersive.

11. How would you classify this experience as to the level of elicitation?
— On a scale of 1–not eliciting to 5–very eliciting, the respondents were asked to rate the level of elicitation; on how much the reactive surface drew out an expressive feeling, emotion, thought, or behavior from them. Deliberately, 7 respondents answered the experience to be fairly eliciting, and 1 respondent answered to be very eliciting. To these participants the experience has made them sense, feel, think, or behave expressively in response to the surface reactive closing and opening movements. Whilst 3 respondents answered to be eliciting, and as for the remaining 2 respondents, they answered to be mildly eliciting. And no one answered not being eliciting. This means that for the majority of the respondents a touch reactive surface can be sensory, emotional, or mentally eliciting. When interacting with the prototype of a touch reactive surface, 7 participants (mostly women) mentioned having thought how interesting it would be if more surfaces were physically reactive like this one, and a few proposed potential functionalities for the surfaces, like reporting the changing on weather.

12. In one word, how would you define what you have felt when you touched the reactive surface?
— Each respondent wrote one word that to their understanding would best define what they have felt; an immediate sensation they might have sensed, a meaning they might have perceived, or a value they might have attributed when experiencing a surface that is tangibly reactive to participants tactition, and the words elicited were: intrigued, interesting, amused, unusual, caught, cool, liked, smooth, inviting, appealing, nice, captivating, engaging.

8.2.8 Analysis

Tactition:
means the cutaneous senses of pressure and texture combined, excluding the senses of temperature and pain.

The sample consisted of a group of people with dissimilar backgrounds, not related to art or design practices, who agreed to answer the questions after experiencing a touch reactive surface.
With 100% of favorable answers, all the participants were willing to explore the surface with their touch, affirming that people want to be able to explore freely the exhibited surfaces. Correspondingly, all the participants expressed

their preference for surfaces that tangibly respond to their tactual intents.
Asked to rate how much the experience had stimulated their senses, 61.6% of the participants felt that their senses were stirred by the experience answering favorably from fairly to very stimulating.
To the question to rate how much the reactive surface drew out from them an expressive feeling, emotion, thought, or behavior, 61.6% of the participants have answered favorably from fairly to very eliciting.

Qualitative Assessment: collects data that does not lend to quantitative methods but rather to interpretive criteria.

The questions of the interview are attached at the end of the thesis, in Appendices on page 205.

8.2.9 Interpretation

From the rating results, it is possible to deduce in a first stage that interacting directly with responsive surfaces may elicit enhanced tactile impressions.
This quantitative assessment serves as an instrumental method to complement the following qualitative assessment.

8.2.10 Qualitative Assessment

The qualitative assessment centers on the quality of the subjective experience. For an encounter with an art work, it is a phenomenon experienced individually that is not measurable statistically.
A phenomenological assessment recurrently occurs with an interview that flows accordingly with the participants reception and acceptance.
The assessment on the phenomenology of the experience of the prototype of Tangere was made by conducting 13 individual anonymous semi-structured written interviews and collected the descriptive answers for an analysis of qualitative account. "Qualitative data are collected in the form of words or pictures rather than numbers." (Fraenkel et al. 2012, 427) A qualitative data analysis examines the non-measurable multiplicity of explicit and implicit utterances surveying the reasoning underlying a subjective behavior. Looking for potential singularities, and possible experiential similarities of phenomenological intersubjectivity, along with close observations on the participants haptic reactive behaviors. When carrying out a proximal observation, the participant observer intervenes, mildly configuring the setting, aiming at observing behavior that otherwise would not be accessible.
During the experiences an audio recorder registered the participants comments with their consent, to capture the extemporaneity of possible verbal responses, but not video for not to suppress the participants spontaneity.
The experience of Tangere surface addresses to the senses of sight and touch. Stemmed by the 1st research question — How does the tactile interaction intensify the subjective experience?; the participants were asked to experience the reactive surface in 3 different successive situations: 1st can see and touch; 2nd can see, but not touch; 3rd can touch, but not see, (with eyes closed) and

describe the feelings, emotions, perceptions, meanings, or behaviors the reactive surface may have elicited in them. It was asked the participants a set of 4 simple, clear, objective, and open-ended questions. Follow-up questions sprung up in a conversational inquiry. All descriptions were collected and analyzed, and an excerpt of nearly half were taken for report and explanation:

1. Can see and touch; how would you describe the experience of freely exploring the surface with your touch?
   — For the 1st experience, the participants were asked to explore the surface unrestrictedly. They could see and touch the reactive surface feeling freely the texture quality and the movement property. It is not usual for people to be allowed to touch the exhibited art pieces.
   The participants felt a mild astonishment that they could touch the surface and that it moved when they touched. — "It caught me by surprise, I wasn't predicting that it would move when I touched it."
   The participants experienced simultaneously, to touch and get a physical reaction as a response to their tactition. An outcome the participants could not predict if they were not allowed to explore the surface by touch. — "I touched it, and unexpectedly it closed on my fingers."

2. Can see, but not touch; how would you describe experiencing looking at the surface and not being able to touch it?
   — On the 2nd experience, the participants were allowed to see but not touch the reactive surface, to which they have described experiencing it only by half. The participants watched once or twice another person making the surface reacting to touch, but they were not allowed to touch it. Their haptic memory helped to recall the feeling. — "If it was not the previous experience, I would not know how the surface would feel to the touch." But not being allowed to touch it, have made it an impoverished experience to the sensory senses. — "It feels lacking without touch." A disappointing experience — "Not being able to make it react to my touch, have made me feel displeased." A participant voiced that this experience was not related to haptic. — "If I can't touch it, it isn't much haptic to me."

3. Can touch, but not see; how would you describe the sensations you have when you explore the surface with your touch not being able to see it?
   — On the 3rd experience, the participants could touch the surface, but they could not see where they were touching. The participants were deprived of sight, but could explore the surface freely with their hands. This situation made them feel apprehensive. — "I would not know what I was touching, if I had not seen it before, which would make me feel a bit uneasy." Again, their memory helped to recreate a mental image through their 'mind's eye.' Sight did not get to assist touch, but it also did not interfere with touch allowing the participants feeling anew shape cut-outs, overlapping materials,

textures. — "Seems it feels slightly different; as I didn't get distracted by sight I could be more attentive to how the shape felt like."

Stemmed by the 2nd research question — How does the change of a tactile stimulus enhance the sensation?; the participants were asked to describe how tangibly stimulating a reactive surface can be to enhance a sensation.

4. How would you describe experiencing a surface that reacts physically to your touch?
   — Attesting that a new stimulus has a deeper significance, the participants who were experiencing a reactive surface for the first time have confirmed that the experience exerted in them strong impact. — "This is hilarious, a fabric made thing squeezed my hand." Have felt perplexity was described by the participant who although previously aware of reactive surfaces was not expecting that this surface would physically react to touch. — "A reactive surface is not entirely new to me, but this one caught me by surprise." While other participants expressed have experienced a living like surface — "It felt like I was touching something alive." Oftentimes people feel empathy when something artificial responds in an organic way. People embrace easily a new medium if it holds a somewhat familiar element.

8.2.11 Analysis

The expression most manifested by the participants was of surprise for an unexpected reaction, as it is not common to experience a surface that tangibly reacts to touch. To most of the participants, a tangible reactive surface is a new medium previously unknown. In Tangere, the physical changes are both visual and tactile perceivable. Still, some participants have answered not being aware of the mutual influence of sight and touch.
The overall experience allowed the participants to be in straight contact with a work of art, something that rarely happens in an institutional exhibition place. After the experiences and assessments process, a great number of participants declared being important for acquiring a more comprehensive understanding of the sense of touch and art together. Evidence from the answers to the questionnaires and interviews responded by a small purposive sample, consisting of people with education and practice not related to the art or design making, affirm that people feel anew, challenged, and engaged when they get to interact with surfaces that tangibly react to their tactile inputs.

8.2.12 Interpretation

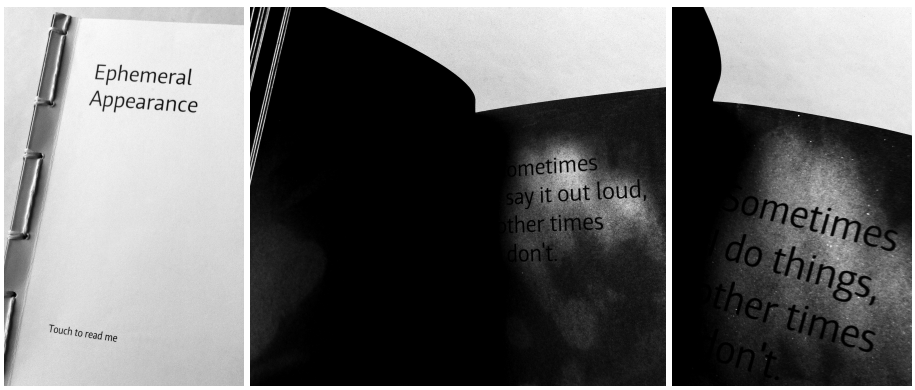
Evidence from the quantitative and qualitative assessments upon the prototype Tangere validate the arose research hypothesis: — Integrating the sense of

touch in digital creations, changes the way we interact, our perception, and consequently our behavior. Tangere is a touch reactive surface that changes its physical appearance as a reaction to a tactile input. This shape-shifting surface opposes the mechanism used in the generality of touch screen devices with haptic feedback, where the bumps, humps, and lumps are not real.
When people get to interact with surfaces that react to their touch, with differing responses than those from flat tactile screens, they testify feeling stimulating sensations, assuring that they have felt sensory engaged, perceptively captivated, and bodily connected. When perception changes behavior follows. People used the whole hand instead of just fingertips. For doing is more memorable than seeing, to be involved in an action has a stronger behavioral impact. Therefore, touch is the sense with the greater propensity to affect behavior. An unexpected reactive movement causes to a behavior alteration. Generally, we are able of identifying a sensation by contrast, opposing the present sensation with a previous one, as they are being collected in our haptic memory. It is an assessment obtained from variation. Before we know what it is that we are touching, we recognize the difference through recollection from our haptic memory.

8.3 Ephemeral Appearance



Diag17. The planning of the book Ephemeral Appearance with text formatted one sentence on every odd pages that the black thermochromic ink will cover.



Img18. The book Ephemeral Appearance with the text printed under the black thermochromic ink. One sentence hidden on every odd pages.

Ephemeral Appearance: Touch to read me is an artist book that bonds poetry, craft, and technology in a pocket format. It is hand-painted with thermochromic ink, to reveal the text upon being heated by the fingers of a reader. Changing from an overall black to colorless to let read the black printed text beneath at human temperature. Reached the transition temperature of 27°C (starting transitioning at about 24°C), the black disappears reversibly upon tactile input, or ambient temperature, to narrate something that is hidden and only appears after being touched, or influenced by an external cause (it also reacts if we blow a warm breath). At ambient temperature all pages of the book stand totally black and illegible.

8.3.1 Concept

On the nature of the human soul. Each page of Ephemeral Appearance contains a sentence that describes the ambiguity of being visible and legible, to not being anymore. In an intimate sense, the book is like a secret diary of someone confessing the difficult dichotomy of keeping a relationship with anyone, whereas, in a broad sense, it is a project on social camouflage. While some struggle for exposure, popularity, reputation, and recognition at all cost, others struggle for maintaining a healthy social life with enough space for privacy and introspection. One never knows what goes on within each one, as people only reveal what they want to reveal. It is often told that "people have two faces" for just one conflicting soul. Those sentiments are printed under the black ink:

Sometimes I'm visible, other times I'm not.

Sometimes I matter, other times I don't.

Sometimes I mean something to someone, other times I don't.

Sometimes I feel, other times I don't.

Sometimes I care, other times I don't.

Sometimes I'm a dreamer, other times I'm not.

Sometimes I'm real, other times I'm not.

Sometimes I surprise myself, other times I don't.

Sometimes I'm rebel, other times I'm not.

Sometimes I hate, other times I don't.

Sometimes I say it out loud, other times I don't.

Sometimes I regret what I said, other times I don't.

Sometimes I listen to you, other times I don't.

Sometimes I connect with your heart, other times I don't.

Sometimes I wonder, other times I don't.

Sometimes I do things, other times I don't.

Sometimes I wait, other times I don't.

Sometimes I stand up, other times I don't.

Sometimes I obey, other times I don't.

Sometimes I'm easy, other times I'm not.

Sometimes I'm intuitive, other times I'm not.

Sometimes I light up your life, other times I don't.

Sometimes I'm important to you, other times I'm not.

Sometimes I'm unpredictable, other times I'm not.

Sometimes I'm curious, other times I'm not.

Sometimes I know, other times I don't.

Sometimes I arrive, other times I leave.

Often I am, but at times, I'm not.

8.3.2 Development

The development of Ephemeral Appearance implied authoring the text to be laser printed in black ink, and handcrafting the painting and assembling the pages in a book. The black thermochromic ink was mixed in equal parts with a clear acrylic binder and applied on paper by hand with a soft rubber brayer. For resistance and substance, and to prevent the paper from crinkling, it was used a thick paper of 240 gr. All pages were arranged in a plane and held with paper tape on the four edges, a short time waiting for the ink to dry before the process being repeated on the other side of all pages. Then, the pages were measured with a ruler and cut by hand with a craft knife.
The book has a white front and back cover and 28 black content pages that were assembled and hand-sewn with a metal needle and a white paper cord. The binding was inspired by a Japanese traditional method.
The participants could handle the book, flipping through the pages freely, experiencing it without restrictions.

8.3.3 Qualitative Assessment

Some time before the end of the three summer months of being exhibited, the ink opacity of the prototype of the book Ephemeral Appearance started to lose density, and no longer could be experienced and evaluated. Due to the intrinsic properties of the thermochromic ink, a material that reacts to external stimuli is also deteriorated by them depending on the variation of ambient temperature. Unless the pages get an industrial UV film protective covering, the quality of the bare ink will not last long.

Exhibited concurrently with the prototype of Tangere, the assessment on the phenomenology of the experience with the book Ephemeral Appearance was obtained by conducting 9 individual and anonymous semi-structured interviews and collected the answers for qualitative data analysis and subsequent reflective reasoning.

The sample was comprised of people with divergent cultures, educations, and practices not related to art or design making, from very little to regular use of technology. The sample representativeness, or the possibility of transferring the evidence to another group of people, depends on the sample characteristics, not the size. Pointed out by Fraenkel *et al.*, in qualitative surveys "the number of participants in a sample is usually somewhere between 1 and 20." (Fraenkel *et al*. 2012, 103) It was asked to participants a set of 4 open-ended questions, and additional ones arose as conversational inquiry. The descriptions were collected, translated from the Portuguese and transcribed verbatim.

For the 1st research question — How does the tactile interaction intensify the subjective experience?; the participants were invited to experience the book Ephemeral Appearance, to take it in their hands and handle it unrestrictedly without previous instruction or explanation. To after being asked to answer the questions and reveal the sensations, feelings, perceptions, and meanings elicited from the experience.

Observational sample: "Researchers who engage in observation usually must choose a purposive sample." (Fraenkel *et al.* 2012, 474)

Purposive sample: "consists of individuals who have special qualifications of some sort or are deemed representative on the basis of prior evidence." (Fraenkel *et al.* 2012, 107)

The questions of the interview are attached at the end of the thesis, in Appendices on page 207.

1. How would you describe experiencing a book that requires your touch to show you the text?
   — None of the participants had ever experienced reading a printed book that conceals the text from the reader and the words have to be uncovered by touch. — "I found it very interesting, usually when I read a book I use the hands only to hold it and flip through the pages." — "I think it was exciting. I've always preferred reading printed books, but this one challenged my curiosity." — "I found it intriguing, I had never experienced touching a book like this one." Disrupting the established notion that a printed book is an inert object. — "This book is not static it reacts when I touch it." A connection with a book is personal more so it is with a diary. — "It gives a new dimension to the secrecy of a diary." It increased the intimate bond with a book. — "To me, it felt to be a private reading."

Smart materials: are the ones that sense and react to their environment shifting reversibly in color, shape, or form. In these materials may be included the shape memory alloys, piezoelectrics, electrostrictives, magnetostrictives, elastorestrictives, electrorheologicals (fluids reacting to electric fields), magnetorheologicals (fluids reacting to magnetic fields), thermo-responsives, chromic, pH-sensitives, light-sensitives (ultraviolet), polymers, gels (hydrogels), catalysts, and self-healing materials. (Harvey in Kutz 2002, 402)

2. How would you describe experiencing a book painted with a smart material that reacts to your touch letting you read the text?
   — A smart material is the one that reacts to an external stimulus shifting reversibly its appearance, shape, or position. Since it is sensitive to human temperature, it responds to exploratory touch. — "Because the ink doesn't disappear evenly, it wasn't easy to read a sentence at once, so I kept touching until it showed all the words to me." The first reaction may have been of strangeness. — "At first, I found it a bit strange, all the black pages, but then I found terrific to discover the text word by word." Then the feeling was of curiosity. — "Initially, I felt it was too dark to see much, but then I became curious about how I would be able to read it." The participants felt captivated by a non-intrusive material. — "I think this material is smart because it's easy to deal with." This question aroused curiosity on the emergent use of smart materials and the benefit for many purposes. Since the participants did not have a previous contact with smart materials, they formulated an opinion based on this experience alone.

For the 2nd research question — How does the change of a tactile stimulus enhance the sensation?; the participants were asked to describe how the transformative features of the book might have enhanced the sensations.

3. How would you describe experiencing a book that changes its appearance as you read the pages?
   — Sight assists touch in the perception of appearance, but in this case, sight needed touch for the text to appear and be visible to the eye. As the reader discovers the text on each page, he or she feels defied by the transformative features. — "I felt it was defying me, and I thought how interesting it was for doing it." The book shows the reader one facet at a time. — "I felt intrigued, and doubted that I could ever read it, but I did." The participants soon found that the appearance reversed in an instant. — "Although the text seems to disappear rapidly, I managed to read it through."

4. How would you describe experiencing a book that plays hide and seek the text with your touch?
   — The participants revealed that there was a kind of interplay between them and the book. — "The book piqued up my curiosity as it kept hiding the text." The participants have found stimulating to read a book that does not show the text immediately, but it has to be sought by touch. — "It's refreshing to have a book that plays with me, but at first, I kept searching for more text until I realized there was only one sentence on each page. I thought it was hiding more from me than it actually was." While another participant declared to find it tempting. — "I felt tempted to go right away through all the pages to find what was that it was hiding."

8.3.4 Analysis

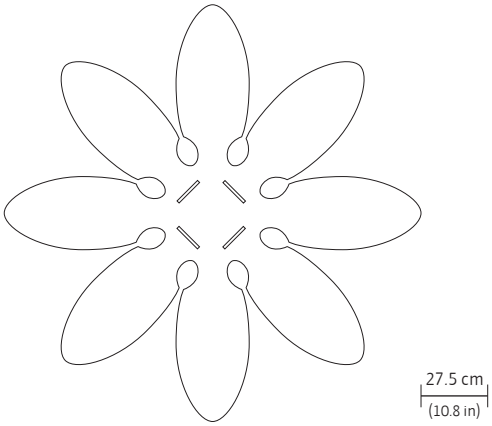
The participants embraced this experience with the prospect of a sensory and perceptual stimulating moment. In the end, they expressed their enthusiasm with the experience of handling a book that seems to hold a secret well kept under the black thermochromic ink, a smart material that reacts to touch, or more accurately to ambient or human temperature. The secretive Ephemeral Appearance uses a palpable technological material that is seamlessly blended in a familiar object. Alluded by a participant, a book is not a lifeless object, it contains space, time, senses, feelings, emotions, thoughts, essence, and touch intensifies the connection with it.

8.3.5 Interpretation

It is commonly told that information is widely available and easily accessible, but inevitably, it has to be acutely searched with fingertips and wisely handled. In the digital era, people are increasingly using touch gestures to access anything digitized, but they are not accustomed to having to use similar gestures in the physical world. The experience with the book Ephemeral Appearance challenged the participants to use their fingers to access the information contained therein. Applied metaphorically as a confluence of a corporeal finger and the digitized digit, in an analog medium through two opposing, discrete, and binary states: hidden *vs.* exposed, private *vs.* public, protected *vs.* vulnerable, elusive *vs.* obvious, imperceptible *vs.* palpable. Similar to a digital medium that is packed with layers upon layers of information, a layer of solid ink covers the text printed underneath that is only revealed if touched by a reader. Ephemeral Appearance waits mute until a reader breaks its silence quietly with touch. Its voice is then made audible upon a reader's peeping touch.
Since intrinsically, touch is exploratory, revealing, expressive, and "slow, linear, intimate, direct, connective and creative," (Driscoll 2013) getting to experience a book through touch alters our perception of handling a book to read its contents. Furthermore, adding touch to the experience of art allows people to grow their understanding on touch and art, and of themselves.

Haptic explorations consist also of six tangible non-reactive surfaces in different non-woven materials, and more two video projections, for people to experience touching and feeling touched unrestrictedly. On two surfaces, the experience happens through an intermediating transparent vinyl plate simulating a touch screen or a big interface button.
The qualitative assessment consists in producing reflective interpretations from the comprehensive data analysis, comparing evidence from experiencing surfaces reactive to touch *vs.* surfaces non-reactive to touch.

8.4 Octal Flower



Diag19. Octal Flower pattern showing the shape and interlocking holes.

The pattern is placed on top of the stretched textile and is marked with a tailor's chalk. Each pattern is marked adjacent to the previous one, heeding the less waste of material, and only after several rows of patterns have been marked on the textile that each shape is cut by hand with scissors. The process is repeated for each modular surface. All modular shapes were cut by hand. All surfaces are manual labor.

The Nonwovens utilized in the projects are industrial textile materials developed for other functional purposes than art production and art fruition.

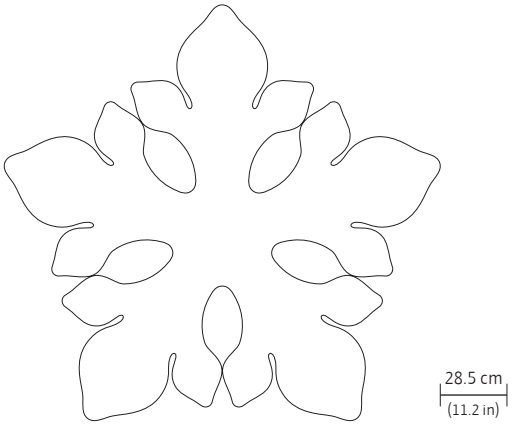
Nonwoven material kindly sponsored by the Japanese company Kuraray Kuraflex Co., Ltd.



Img20. Octal Flower surface that can grow in any direction.

Octal Flower is a modular surface comprised of 31 individual shapes that are interlocked, and together they form a volumetric surface, that participants could build and change the direction to where the surface grows.
It is made with the Nonwoven Felibendy NL M5, 100% Polyester, weight 0.05 g/cm^3, and 4mm thick. The material is smooth and mildly soft. The participants could touch freely and remake the surface at will, conferring a high level of tactition. This surface requires dexterity to be able to do the interlocking.

8.5 Moving Foliage



Diag21. Moving Foliage pattern.

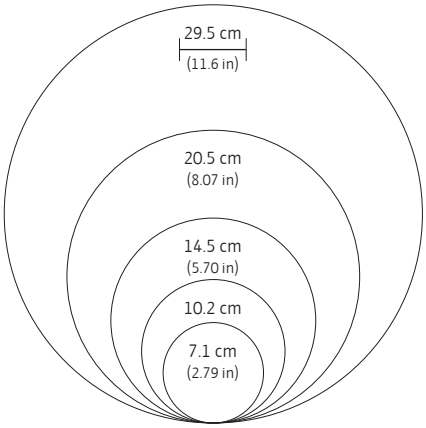


Img22. Moving Foliage surface with shapes positioned randomly.

The movable surface *Moving Foliage* is composed of 23 pentagonal shaped leaves randomly placed in a base of the same material. The leaves are held with Velcro by the center of each shape, which can be repositioned. The WH Nonwoven Geotextile, 100% Polyester, weight 250 gsm is a smooth, soft, and very malleable material. Highly pleasing to the touch. The participants could experience the surface freely moving the shapes position and orientation, giving a volumetric height to the surface. Or they could simply feel the frugal tangency that occurs upon a gentle tactile contact.

Nonwoven material kindly sponsored by the Chinese company Foshan S. L. P. Special Materials Co., Ltd.

8.6 Protuberant Polyps



Diag23. Protuberant Polyps patterns showing shapes and sizes.



Img24. Protuberant Polyps surface.

Like coral polyps, the palpable surface *Protuberant Polyps* has protuberances formed by volumes of different heights that are tangibly perceptible when handled. It is an artificial metaphor to the living polyps found in coral reefs. The shapes are made of a light, smooth, fluffy, and hairy material, the Needle Punched Nonwoven Geotextile, 100% Polyester, weight 140 gsm, and the base is a WH Nonwoven, weight 350 gsm, very soft to the touch. The dimension of the surface is 65x155 cm (25.5x61 in). The participants could freely feel the volumes and the materials properties of smoothness and softness.

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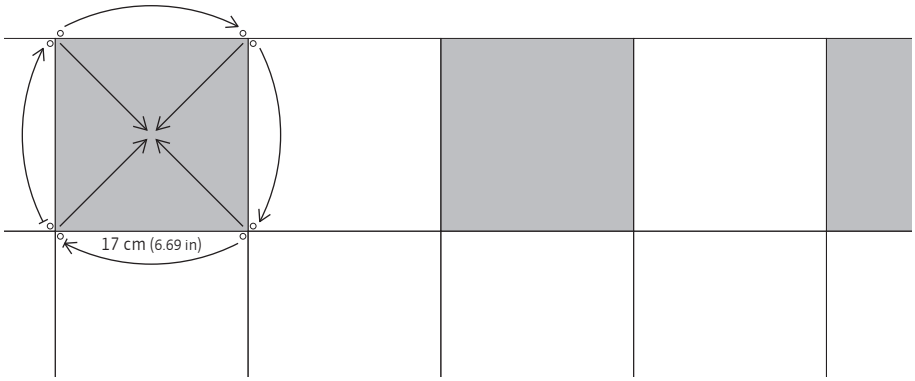
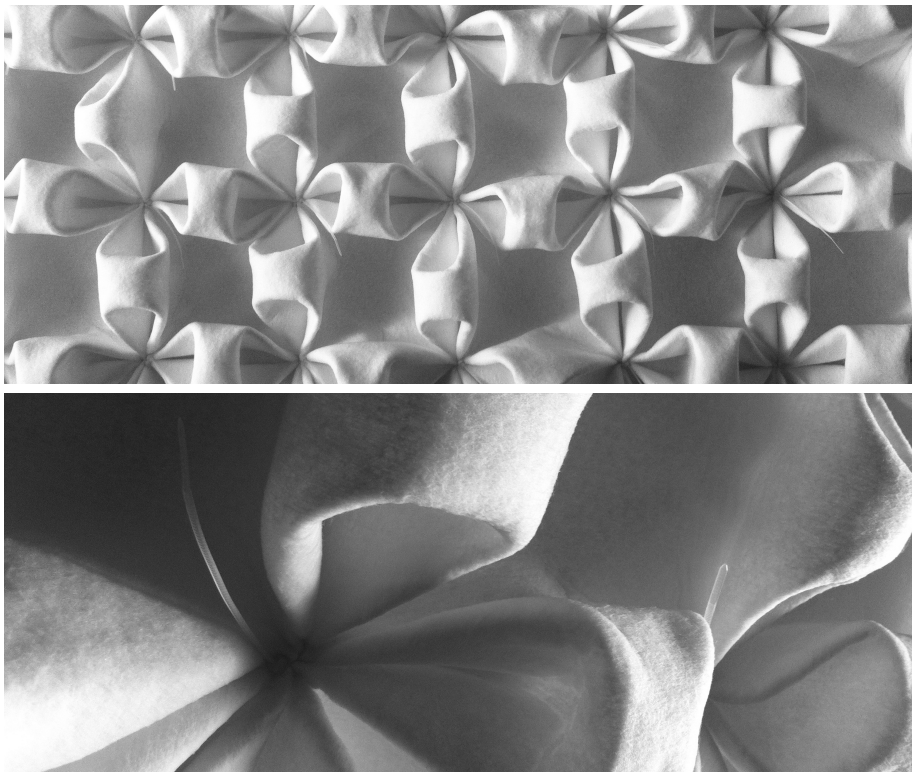
8.7 Folding Flower



Diag25. Folding Flower planning measuring 111x319 cm (43.7x125.6 in) for 27 folding squares.

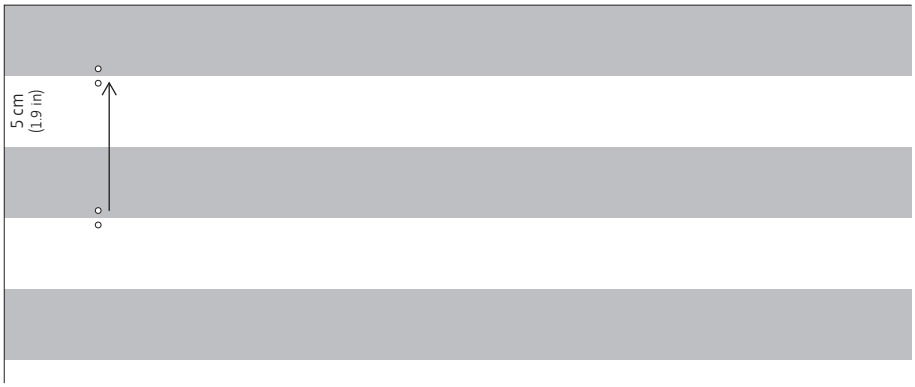


Img26. Folding Flower surface with a regular arrangement of 27 folded flowers.

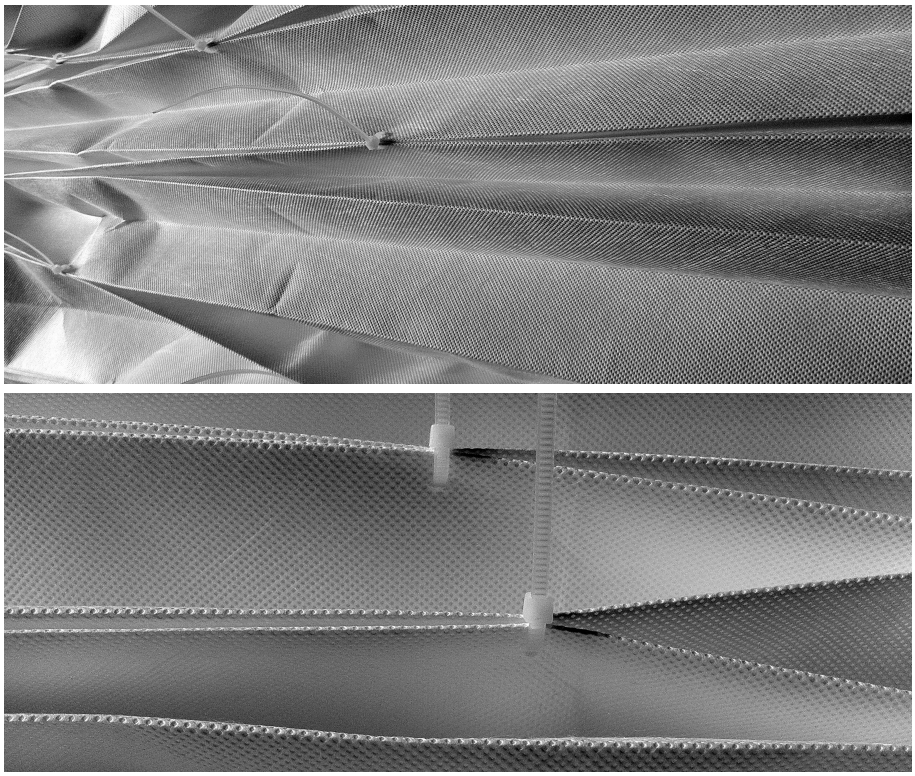
Folding Flower is a volumetric surface adapted from the traditional craft technique Canadian smocking made with the Nonwoven Felibendy SL M7, 100% Polyester, weight 0.05 g/cm^3. The folds are created by joining four points of a square, tied together with transparent plastic cable ties measuring each 0.28x15 cm (0.11x5.9 in). After folding the 27 flowers (distributed in 3x9), the surface measures 55x160 cm (21.6x62.9 in). The material is smooth and mildly soft. The participants could touch and press, and freely feel the volumes and the texture of material under the palm of their hands. Some participants passed the hand over the entire surface, feeling the shapes giving in to hand's pressure. While the plastic cable ties were felt like thorns.

Nonwoven material kindly sponsored by the Japanese company Kuraray Kuraflex Co., Ltd.

8.8 Terraced Rice Fields



Diag27. Terraced Rice Fields planning with 150x150 cm (59x59 in) for 15 horizontal foldings.



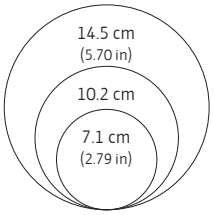
Img28. Terraced Rice Fields showing the surface relieves.

Sistelo is a village in the north of Portugal, located in the Serra da Peneda 20 km (12.4 miles) from Arcos de Valdevez, which is dominated by terraces built 300 years ago on the mountain slopes supported by stone walls, once used to grow corn and potato.

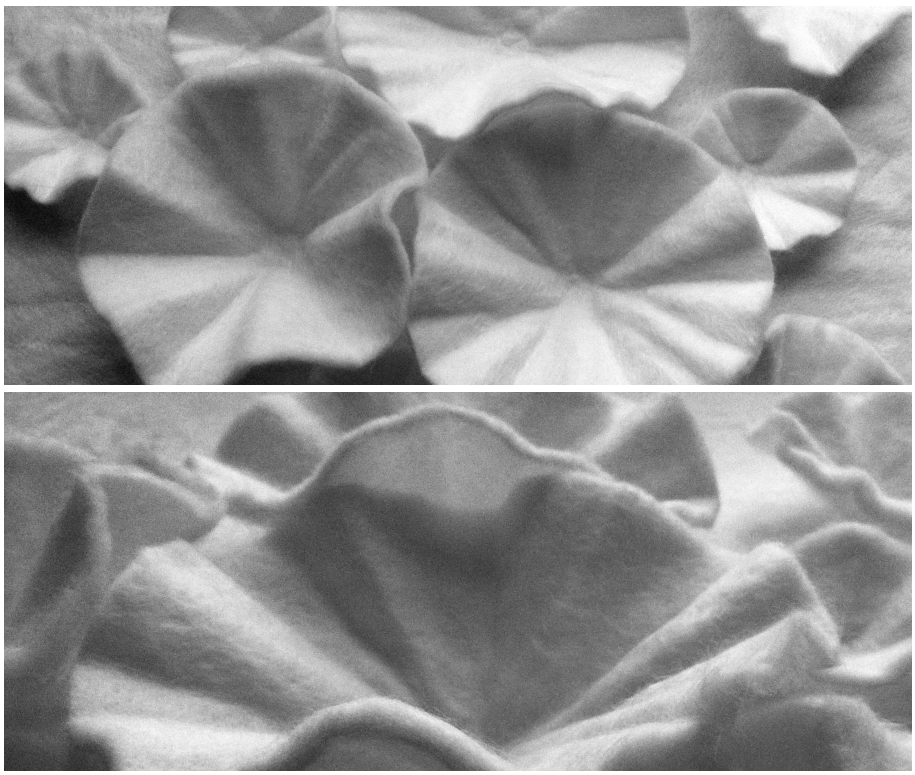
Nonwoven material kindly sponsored by the Chinese company Foshan S. L. P. Special Materials Co., Ltd.

Terraced Rice Fields was inspired by *Mu Cang Chai* in Vietnam created by the *H'Mong* ethnic community. It is a surface made of horizontal relieves developed by grabbing folds of material, tied together with transparent plastic cable ties measuring each 2.8x150 mm and positioned randomly.
The Polypropylene Spunbonded Nonwoven, 100% Polyester, weight 120 gsm, is a paper-like material, smooth, but cold and mildly stiff. The surface is to be experienced at a distance by sight. The participants were not allowed to touch it directly. They could experience the surface through a 24x24 cm (9.44x9.44 in) white transparent acrylic plate, simulating an interface screen similar to handling an electronic device with a multi-touch screen.

8.9 Nasturtium Leaves



Diag29. Nasturtium Leaves patterns showing the circular shape and sizes.



Img30. Nasturtium Leaves surface showing the shapes and their position in space.

Nasturtium Leaves is a surface containing variable circular shapes inspired by the Nasturtium plant of round leaves with a central stem. It was made with WH Nonwoven Geotextile, 100% Polyester, weight 250 gsm, which is a smooth, soft, and hairy material, but to be experienced without touch and by sight only. The participants were not allowed to touch it. They could experience the surface through an acrylic plate, held in the researcher's hand and shaken when the participants touched it. Loosely resembling the screen of a device with vibration with digital elements projected under or behind the window not tangibly assessable. The participants understood the irony and purpose of the analogy. They commented that this restriction has diminished their feeling of involvement due to the acrylic plate have separated them from the potential sensations of tactition. Although sight impacts greatly the somatic senses, not being able to touch the surface directly has impoverished significantly the participants *aisthantic* experience.

Nasturtium:
from the Latin *nasus tortus*, meaning 'twisted nose,' referring to the reaction on a person's face for biting into the tangy, peppery, bittersweet flavor of the leaves. The richer the soil the more bite in the leaves. Native to Peru on the Western coast of South America, both leaves and flowers are edible.

Nonwoven material kindly sponsored by the Chinese company Foshan S. L. P. Special Materials Co., Ltd.

Introducing in this research the neologism *Aisthantic experience*: from the Greek *aisthanthike*, which means 'felt' experience through touch.

8.10 Punching White

The *Punching White* project is a bright white light produced by electronic means and projected on a white wall at about three meters away. There is no real physical contact, but if we keep staring, the white is very strong and makes our eyes hurt. The plain bright white projection makes us feel physical discomfort. Like the white of snow for which we use glasses for protection, or when rays of sunlight hit the water forcing us to immediately look away. Without exception, all the people who experienced it complained feeling deeply affected by the intense light. We do not need the proximity of a physical contact to feel touched.

8.11 Hitting Light

The *Hitting Light* project is a high-intensity flashing white light with white noise produced by electronic means and projected on a white wall at about three meters away. Light hits us without making a physical contact, and we cannot look for too long without feeling dizziness and headache. (Project accompanied by a warning to stare with caution, alerting people of the extreme seizure effect.) The participants could not stand the experience more than five seconds straight without feeling uncomfortable. When Laura Marks (2002) elaborates on haptic cinema, she is not referring to the vibrating chairs in movie theaters, but to sensations caused by the images ability to hit the viewers physically at a distance.

8.4–11.1 Qualitative Assessment

Close observations and annotations from the informal conversations, voluntary comments, attitude, and recurrent actions, were the methods adopted to assess the haptic experiences on non-reactive surfaces by the surveyed participants. Aiming at producing a reflective interpretation from the comprehensive data analysis, contrasting evidence from experiencing volumetric surfaces reactive to touch *vs.* surfaces non-reactive to touch.

Followed by the assessment carried out on the reactive surface Tangere, and again taken by the 1st research question — How does the tactile interaction intensify the subjective experience?; the participants were invited to experience the non-reactive surfaces in 3 different successive situations: 1st can see and touch; 2nd can see, but not touch; 3rd can touch, but not see, and express how these experiences may have affected them.

And for the 2nd research question — How does the change of a tactile stimulus enhance the sensation?; the participants were requested to comment on how the non-reactive surfaces can be tangibly stimulating to enhance a sensation. Except for two surfaces, the participants were not allowed to touch directly, but through an acrylic plate positioned between the surface and the participant.

8.4–11.2 Analysis

Since non-reactive surfaces do not have movement, the participants highlighted the texture of materials as the fundamental element for the haptic experiences. The differing textures of the fabric-like materials provided the participants varying tactual responses. Even small variations in the material properties altered the sensory stimuli. The experiences subjectively shaped how the participants perceived the materials and forms.
The contrary experience was perceived when the participants were prevented from touching directly the surface material, and could only do it through an acrylic plate. A tactile sensation identical to using a multi-touch screen of an electronic device. The participants commented the acrylic surface was stiff, slick, cold, and comparably unwelcoming.
Cross-checking evidence from experiences with volumetric surfaces reactive to touch *vs.* surfaces non-reactive to touch, the participants attested that the reactive surface adds a perceptual meaning that is sensory engaging. Participants have mentioned feeling captivated by the organic-like quasi-instinctive behavior of the touch reactive surface.

8.4–11.3 Interpretation

The touch reactive surface replies to our tactual intents stirring a captivating sensation of empathetic connection. An embodied dialogue that communicates through gesture. In the book Ephemeral Appearance, the surface changes on touch even though those changes are not tangible but visually perceptible.
The responsive movement of the touch reactive surface to a kinesthetic touch makes it more sensory appealing than the non-reactive surfaces, as "movement produces sensations in the body, it can draw attention to the inner dimensions of being." (Driscoll 2013) The functionality of a surface lies in the expressiveness of form, as it moves reversibly to our touch. Touch allows a particular perceptual awareness, in that it provides "a different way of knowing than seeing." (*ibid.*)
Contrary to the detachment and distance of sight, the experience of touch is concrete, intuitive, deep, and meaningful. Touch makes a subjective experience intimately particular. For the reciprocity of touching and feeling touched creates a dynamic interaction. An impression enhanced by the tangible responsive movement of the surface. Albeit we are capable of feeling in the body without contact, when there is contact the feeling is intensified.
Combining the experience of touch with art allows inquiring the inner sense of self on the outer sense of being, through what place us, relate us, and connect us to the world. An art work that is created with the fundamental premise of touch enables interaction and perception not achievable by sight alone.
The material, form, expression, and interaction are determinant to influence the quality of an *aisthantic* experience.

In *Job's Body: A Handbook for Bodywork*, first published in 1987, the American massage therapist Deane Juhan (1945–) wrote, "Tactile experience tells me as much about myself as it tells me about anything that I contact. I am constantly using the world to explore my reactions just as much as I am using my reactions to assess the world. My sense of my own surface is very vague until I touch; the moment of contact, two simultaneous streams of information begin to flow: information about the object... and information about my body ...We could even say that this role of the tactile senses in establishing a fuller and fuller sense of self is their primary function." (Juhan 2003 (1987), 34)

Introducing in this research the neologism *Aisthantic experience*: from the Greek *aisthanthike*, which means 'felt' experience through touch.

8.12 Theory of Aisthantic Experience

The inductive *Theory of Aisthantic Experience* is a set of principles introduced in this research, proposing to formalize the analysis of quality of felt experiences through touch, unmediated, and mediated by something that stands between the skin and a touchable surface, which may be a wearable device, a handling interface, or a touch screen with or without vibration. The *extrinsic hapticality*, refers to feeling touched at a distance, external to the body and without contact, from a light, sound, image, scent, taste, a written or spoken word, wherein touch is mediated through other sense organs, the brain, and efferent neurons:

— The *unmediated aisthantic experience* is a direct felt experience through active touch having nothing standing in between the bare skin and the touched surface enabling a natural and immediate sensation:

1. Surfaces may have ridges and grooves that are stimulating to touch, and the materials may provide a sense of well-being when touched.
2. The sensation can be renewed at every touch since the hand has freedom of movement and the pressure may be variable.
3. The experience may be enhanced by the intrinsic characteristics of objects and textures of materials.
4. Materials may have integrated properties that make them responsive to touch.

— The *mediated aisthantic experience* is an indirect felt experience where the exploratory touch is intermediated by something that prevents an engaging and prolonged sensory impression:

Interacting with a wearable device:

A wearable device may constitute a barrier that prevents a stimulating tactual sensation:

1. Like when the hand is inside an electronic glove it is in straight contact with the material, therefore, the tactual sensation is not renewed since it is caused by a sustained sensory input.
2. Conversely, like wearing a piece of clothing, a technological device should not be intrusive, and should become almost imperceptible to the cutaneous sensory receptors.

Interacting with a handling interface:

1. The surface may be slick and cold and unwelcoming to touch.
2. A mechanical handle may have force feedback, but the hand has restricted freedom of movement, and a prolonged use can cause strain or discomfort.

Interacting with a touch screen without vibration:

1. The surface of a screen is often cold and passive and not truly tactile stimulating.
2. The digital elements shown on the screen can be moved, enlarged, or altered, but their forms and material features are not palpable.

3. When using the on-screen keyboard, the keys pressed are not tangible.

Interacting with a touch screen with vibration:
1. The vibration may be indicative of a key being pressed or of the existence of a digital element, yet it does not discriminate what key or element is being touched.
2. The vibration that does not vary the frequency after a short while it will desensitize touch.
3. The force touch technology through vibration is always felt deceiving.

8.12.1 Applying the theory

When applying the Theory of Aisthantic Experience to the haptic explorations of this research, one may infer that the projects Tangere, Ephemeral Appearance, Octal Flower, Moving Foliage, Protuberant Polyps, and Folding Flower can be classified *unmediated aisthantic experiences*, since they provide a direct bare skin interaction with the materials and their affordances.
In particular, the touch reactive surface of the Tangere project has a stimulating tactile trigger, that enables it to tangibly react when it is touched, challenging the participants tactual intents. The participants could relate this project's moving ability to a reactive living organism.
While the project Ephemeral Appearance is also reactive to touch, the changes are not tangibly perceptible. And because it is a text printed book covered with a temperature reactive ink, the project is mind stimulating through an intrigued kinesthetic touch.
The projects Octal Flower, Moving Foliage, Protuberant Polyps, and Folding Flower are surfaces non-reactive to touch, meaning that although the materials can be directly felt through exploratory touch, these will not have an intrinsic conspicuous reaction to the participants tactual intents. Instead, the projects Octal Flower and Moving Foliage can be manually altered and remade on site at the participants will. The other projects Protuberant Polyps and Folding Flower can be experienced by pressing the forms to feel their resistance in obeying as they return to the original formation after being released.
Whereas, the projects Terraced Rice Fields and Nasturtium Leaves are classified *mediated aisthantic experiences*, because the interaction with the surfaces is intermediated by a white transparent acrylic plate preventing the participants from having a direct contact with the materials and their potential affordances. The participants could experience both projects by merely touching the acrylic plate, simulating the interaction with a multi-touch screen of an electronic device with and without responsive vibration.
And through the projects Punching White and Hitting Light, the participants could experience *extrinsic hapticality* for feeling somatically affected with physical discomfort or pain, caused by a persistent bright white light and a flashing white light with white noise both projected at a distance on a white wall.

Theory of Affordances: states that the world is perceived not only through object shapes and spatial relationships but also by means of object possibilities for action, the affordances. Perception drives action, realized by the American psychologist James J. Gibson (1904–1979), who introduced the term in the article *The Theory of Affordances*, published in 1977. Gibson's work on visual perception led him to question: — "How do we see the world as we do?" (Gibson 1979)

8.13 Qualitative Research

The qualitative research intends to understand a phenomenon described from the first person point of view of those who have experienced it. Qualitative research examines how people respond to a stimulus or behave before a situation, how people perceive and feel an experience, and the meaning and value people give to it. Qualitative researchers inquire upon a phenomenon as it occurs in a natural setting with minimum intervention. Asserted by sociologist Quinn Patton (2008), the qualitative research centers on the "naturalistic inquiry:"

> "Studying real-world situations as they unfold naturally; nonmanipulative, unobtrusive, and noncontrolling; openness to whatever emerges — lack of predetermined constraints on outcomes." (in Fraenkel *et al*. 2012, 428)

Phenomenon:
in philosophy, it is the object of a person's perception; what the senses or the mind notice. (New Oxford American Dictionary)
It is a fact or situation that happen or appear to us in different forms of conscious experience. (Smith and Smith 1995)

Behavior:
is the way in which one acts in response to a particular situation or stimulus.

Mixed Methods Research:
"involves the sequential or simultaneous use of both qualitative and quantitative data collection and/or data analysis techniques." (Currall in Johnson *et al.* 2007, 119)

The qualitative research assesses the quality of an experience, not with statistical measurements as happens with quantitative research, but rather with subjective descriptions. Data collected for qualitative research is according to Patton (2008) "detailed, thick description; [an] inquiry in depth; direct quotations capturing people's personal perspectives and experiences." (in *ibid.*)
Data may be collected from innumerable methods, as noted by Fraenkel *et al.*:

> "The kinds of data collected in qualitative research include interview transcripts, field notes, photographs, audio recordings, videotapes, diaries, personal comments, memos, official records, textbook passages, and anything else that can convey the actual words or actions of people." (Fraenkel *et al*. 2012, 427)

Data are validated by cross-checking several sources. Sourcing evidence from the quantitative and qualitative methods of questioning, interviewing, observing, conversational inquiring, note taking, and audio recording a purposive sample, assists in "triangulating" (*ibid.*, 426) the findings, seeking the convergence of a "single understanding of the underlying phenomenon." (*ibid.*, 584) Triangulation helps to determine how "solid, coherent, and consistent" is the evidence in supporting the findings, ascertaining their "substantive significance." (Patton 2002, 467) Appropriately, using methods from distinct research paradigms for collecting, analyzing, and interpreting data to assess the measures of interaction and values of experience for a comprehensive understanding of a phenomenon. Zuber-Skerritt (1992) characterized the two philosophical research paradigms (in Laws and McLeod 2004, 3), here extended with contextual definitions in brackets:

Quantitative Research Paradigm	Qualitative Research Paradigm
Natural Science (determinist)	Human Science (voluntarist)
Quantity (measures)	Quality (features)
Traditional (structured, predetermined)	Alternative (flexible, emerging)

Experimental (correlative)	Naturalistic (observational)
Prescriptive (predictive)	Descriptive (meaning)
Reductionist (a few isolated variables)	Holistic (contextal)
External (objective)	Internal (subjective)
Nomothetic (discovering general scientific laws)	Ideographic (discovering particular scientific facts and processes)
Normative (from a standard or norm)	Interpretive (explaining the meaning)
Positivist (factual)	Non-positivist (phenomenological)

Nomothetic and Idiographic are terms introduced by Kantian German philosopher Wilhelm Windelband (1848–1915) to describe two distinct procedures to knowledge:

Nomothetic: from the Greek *Nomothetikos*, meaning 'regulated' and *Nomothetes* 'lawmaker.' It is based on what Kant described as a tendency to generalize. Pertaining to, or involving the study or formulation of general or universal laws. In psychology, it describes the study of classes or groups of individuals.

Idiographic: from the Greek *idea* + graph. Is based on what Kant described as a tendency to specify. In psychology, it describes the study of the individual, or the effort to understand the meaning of contingent, unique, and often subjective phenomena.

Positivism: "just the facts." The philosophy of Auguste Comte (1798–1857), who published *Philosophie positive* in 1830. For the positivist procedure, knowledge obtained using the scientific method is objective and measurable.

The differences between quantitative and qualitative research stand on the philosophical paradigms according to assumptions that guide how investigations are conducted. These differences were summarized by Fraenkel *et al.* (2012, 429):

Assumptions of Quantitative Research	Assumptions of Qualitative Research
There exists a reality 'out there,' independent of us, waiting to be known. The task of science is to discover the nature of reality and how it works.	The individuals involved in the research situation construct reality; thus, realities exist in the form of multiple mental constructions.
Research investigations can potentially result in accurate statements about the way the world really is.	Research investigations produce alternative visions of what the world is like.
It is possible for the researcher to remove himself or herself — to stand apart — from that which is being researched.	It is impossible for the researcher to stand apart from the individuals he or she is studying.
Facts stand independent of the knower and can be known in an undistorted way.	Values are an integral part of the research process.
Facts and values are distinct from one another.	Facts and values are inextricably intertwined.
The proper design of research investigations will lead to accurate conclusions about the nature of the world.	The initial ambiguity that occurs in a study is desirable.
The purpose is to explain and be able to predict relationships. The ultimate goal is the development of laws that make prediction possible.	The purpose is an understanding of what things mean to others. Highly generalizable 'laws,' as such, can never be found.

Main procedural characteristics that distinguish the quantitative from qualitative research methodologies were edited and added to the summarized comparison made by Fraenkel *et al.* (2012, 426):

	Quantitative Methodology	Qualitative Methodology
Problem formulation	Precise definitions stated at the outset (pre-specified, outcome-oriented).	Definitions in context or as study progresses (open-ended, process-oriented).
Hypothesis testing	Precise hypotheses stated at the outset.	Hypotheses emerge as study develops.
Type of data	Data reduced to numerical scores.	Narrative descriptions.
Reliability	Much attention to assessing and improving reliability (consistency) of scores obtained from instruments.	Assuming that reliability of inferences is adequate.
Validity	Assessment of validity (accuracy) through a variety of procedures with reliance on statistical indices.	Assessment of validity through cross-checking sources of information (triangulation).
Sampling	Random techniques for obtaining meaningful samples.	Expert informant (small, purposive) samples.
Instrumentation	Precisely describing procedures.	Narrative descriptions of procedures.
Control of variables	Statistical control of extraneous (unrelated) variables.	Logical analysis in controlling or accounting for extraneous variables.
Control of bias	Specific control for procedural bias.	Primary reliance on researcher to deal with procedural bias.
Type of analysis	Numerical estimation, statistical inference	Narrative description, constant comparison.
Analysis of data	Breaking down of complex phenomena into specific parts for analysis.	Holistic description of complex phenomena.
Procedure	Manipulation of aspects, situations, or conditions in studying complex phenomena.	No tampering with naturally accruing phenomena to understand, explain, or interpret the people and situations investigated.
Reasoning	Deductive, objective, causative.	Inductive, subjective, meaning.
Findings	Precise, numerical.	Comprehensive, detailed description, holistic.
Researcher	Detached.	Immersed.

The researcher is an integral element throughout the qualitative methods. Denoted by Patton (2008), the researcher's position is of "emphatic neutrality:"

> "Complete objectivity is impossible; pure subjectivity undermines credibility; the researcher's passion is understanding the world in all its complexity — not proving something, not advocating, not advancing personal agendas, but understanding; the researcher includes personal experience and empathic insight as part of the relevant data, while taking a neutral nonjudgmental stance toward whatever content may emerge." (in Fraenkel *et al*. 2012, 428)

Recalling Janesick (2000), the researcher must draw meaning out of evidence:

> "Simply observing and interviewing do not ensure that the research is qualitative; the qualitative researcher must also interpret the belie[fs] and behaviors of participants." (in Patton 2002, 477)

There is no possibility of apprehending the world without a perceiving mind, and because perception is subjective, there can be no objective facts, but "interpretations," as expressively asserted by German philosopher Friedrich Nietzsche (1844–1900):

> "Against that positivism which stops before phenomena, saying "there are only facts," I should say: no, it is precisely facts that do not exist, only interpretations." (Nietzsche 1954, 481)

Concordantly, Martin Heidegger (1889–1976) "argues that all description is always already [an] interpretation. Every form of human awareness is interpretive." (in van Manen 2011) The participants have perceptually interpreted the experiences. The researcher reflectively interprets the interpretations of participants.
As no research is devoid of some degree of subjectivity, another researcher may interpret the data differently, just by being attentive to other particularities.

8.14 Phenomenological Research

The phenomenological research intends to objectively study topics generally regarded as subjective: consciousness and the content of conscious experiences such as perceptions, emotions, and impressions.
Husserl described phenomenology as the "intuitive appreciation of phenomena as they are perceived." (Smith and Smith 1995) Husserlian phenomenology correlates the essence of phenomena with levels of consciousness. Canadian educationist, Max van Manen characterized the nature of a phenomenological understanding:

> "Phenomenological understanding is distinctively existential, emotive, enactive, embodied, situational, and nontheoretic[al]; a powerful phenomenological text thrives on a certain irrevocable tension between

Phenomenology: from the Greek *phainómenon*, meaning 'that which appears,' or 'is seen,' and *lógos*, 'study,' is the philosophical study of the structures of experience and consciousness. The practice of carefully unfolding and describing what is given to perception, for knowledge is rooted in the subjective experience.
From its formulation by German philosopher Edmund Husserl (1859–1938), phenomenology has since been elaborated to respond to distinct dimensions, namely ethical with Max Scheler and Emmanuel Levinas; existential with Martin Heidegger, Nicolai Hartmann, Gabriel Marcel, Maurice Merleau-Ponty, and Jean-Paul Sartre; hermeneutical with Martin Heidegger, Hans-Georg Gadamer, and Paul Ricoeur; linguistical with Jacques Derrida, Jacques Lacan, Roland Barthes, and Michael Serres. Evolved to reveal the phenomenological structure of perception addressing the body with Maurice Merleau-Ponty.

Consciousness is the medium through wich anything is known.

what is unique and what is shared, between particular and transcendental meaning, and between the reflective and the pre-reflective spheres of the lifeworld." (van Manen 1990, 346)

Van Manen listed the main characteristics of phenomenological research (van Manen 1990, 9), here summarized:

- Phenomenological research is the study of lived experience; of the lifeworld as we immediately experience it pre-reflectively. Phenomenology attempts to gain insightful descriptions of the way we experience the world. It aims at gaining a deeper understanding of the nature of meaning of our everyday experiences.
- Phenomenological research is the explication of phenomena as they present themselves to consciousness. Anything that presents itself to consciousness is potentially of interest to phenomenology, whether the object is real or imagined, empirically measurable or subjectively felt. Consciousness relate[s] us to the world. To be conscious is to be aware of something in the world.
- Phenomenological research is the study of essences. Phenomenology is the systematic attempt to uncover and describe the internal meaning structures of lived experience. The essence may only be intuited or grasped through a study of the particulars or instances as they are encountered in lived experience. The essence or nature of an experience has been adequately described in language if the description reawakens or shows us lived quality and significance of the experience in a fuller or deeper manner.
- Phenomenological research is the description of the experiential meanings we live as we live them. Phenomenological human science is the study of lived or existential meanings; it attempts to describe and interpret these meanings to a certain degree of depth and richness.
- Phenomenological research is the human scientific study of phenomena. For Husserl, phenomenology is a rigorous, human science precisely because it investigates the way that knowledge comes into being and clarifies the assumptions upon which all human understandings are grounded. (van Manen 2011) Phenomenology is the systematic, explicit, self-critical, and intersubjective study. A human science since the subject matter of study are the structures of meaning of the lived human world.
- Phenomenological research is the attentive practice of thoughtfulness, which means to be immersed, to feel empathic, to have ethics, to act reflectively, and to respond responsibly.
- Phenomenological research is a search for what it means to be human. Researching the possible meaning structures of lived experiences to infer what it means to be in the world.

Lived experience: from German *erlebnis*, meaning 'experience as we live trough it.' To phenomenologists as Husserl, or Merleau-Ponty, "it announces the intent to explore directly the pre-reflective dimensions of human existence." (Given 2008, 616)

Felt experience: for a research in haptic art this designation is more accurate as to feel is often used when referring to touch: to be aware of something through touching or being touched; to be aware of something happening through physical sensation; to examine or search by touch; to be capable of sensation; to give a sensation of a particular physical quality when touched; to find one's way by touch rather than sight; to experience an emotion or sensation; to be emotionally affected by; to have a specified reaction or attitude, especially an emotional one towards something; to have a belief or impression; to hold an opinion. (New Oxford American Dictionary)

Aisthantic experience: from the Greek *aisthanthike*, means 'felt' experience through touch.

– Phenomenological research is a poetizing activity, in such a way that to summarize a poem to present the result would destroy the result because the poem is the result.

American psychologist Amadeo Giorgi (1931–) developed in the early 1970s, the *Descriptive Phenomenological Method* in psychology, reclaiming Husserl's transcendental phenomenology (in van Manen 2011):

> "Phenomenological inquiry should be a descriptive method, since it is through analysis and description of how things are constituted in and by consciousness that we can grasp the phenomena of our world." (in *ibid.*)

Giorgi specifies that the position of researcher should be of "empathic immersion," and the descriptions of experiences should be unbiased by researcher's early interpretations. To Giorgi, phenomenology is a "way of seeing" the data. Reflective interpretations should follow the descriptions and not interfere with the lived meaning of the participants' experiences. The researcher must ensure:

> "The results reflect a careful description of precisely the features of the experienced phenomenon as they present themselves to the consciousness of the researcher." (Giorgi, 2009, 130)

The researcher should intuit what is essential to the phenomenon being studied, focusing on and being sensitive to the concrete, subjective, and pre-reflective dimensions of the lived experience. Giorgi emphasizes that it is the meaning of experience, as it is lived in the body, rather than the objective interpretation of behavior that is essential to phenomenology. (*ibid.*)

> "But the simple fact that constitutive activity is rooted in the body implies that it is unconscious of itself and not the means of access to feeling." (Dufrenne 1973 (1953), 388)

Transposed to a *felt experience*, particularly in the context of an art encounter, the descriptive phenomenological method is the way by which the participants describe experienced phenomena and what these may have elicited in them, entailing how the empirical data are reported, analyzed, and interpreted. Descriptions are undertaken consciously aware of the phenomenal experiences, to inquire into the sensitivity to a sensation; awareness of the sensation; giving it a perceptual meaning, and granting a value to the meaning. An *aisthantic* experience transcends corporeality to connect the body with the mind. There is no possibility of perceptual interpretation without the consciousness of inner and outer self experiencing the phenomenon:

> "The notion of consciousness itself is clearly meant primarily to designate the fact that the subject knows about, is informed about, or in other words is aware of, the phenomenon." (Varela and Shear, 1999, 3)

Transcendental Phenomenology: Husserl's phenomenology deepened from descriptive to transcendental. This was accompanied by two methodological clarifications through the concepts of *epoché* and *reduction*. Epoché is a methodological shift in one's attitude from naively accepting a certain dogmatic beliefs about the world to "bracketing" or suspending those beliefs in order to discover their true sense. When one brackets the natural attitude, they are in essence, bracketing its common place validity in order to discover its meaning. Reduction describe the thematization of the relation between subjectivity and the world. In its literal sense, to reduce one's natural experience is "to lead back" one's attention to the universal and necessary conditions of the experience. Both epoché and reduction are important features in freeing oneself from naturalistic dogmaticism in order to illuminate the contribution that subjectivity plays in the constitution of meaning. Transcendental phenomenology is often called constitutive phenomenology. (New World Encyclopedia)

The participants must be informed that they are about to participate in an *aisthantic* experience without revealing the research intents, that is to assess their state of expectancy.

8.15 Interview Method

The interview method is a personal face to face inquiring dialogue, where the interviewer asks questions to obtain perceptions, feelings, and impressions from the interviewee. Interviews, either spoken or written, are a fundamental method of phenomenological qualitative research. Spoken and written interview forms imply different levels of reflectiveness.
If the participant interviewee is given the possibility of expressing impressions in written form, the statements may vary from impulsive to intuitive pre-reflective interpretations. Since from mind to hand takes longer than from mind to voice, the participants may put more effort in the written form as the oral expression is most often impulsive. If the participants are given the space and time to interpret intuitively, and not to voice the first thought that impetuously and disregarding may come to their mind.
French psychologist and psychotherapist Pierre Vermersch developed in 1994, the *Explicitation Interview Method* (*l'Entretien d'Explicitation*) to enable people to gain access to their pre-reflective, inner experience, to recall, and intuitively describe it. (in Maurel 2009) French philosopher, Claire Petitmengin observed that most of the subjective lived experience unfold in pre-reflective consciousness:

> "Whether we are touching, seeing, listening, imagining, remembering, understanding or deciding, whether we are performing a concrete or an abstract activity, a large part of our experience, although 'lived through' subjectively, is not immediately accessible to reflective consciousness and verbal description." (Petitmengin 2009, 9)

Petitmengin states that the difficulty we have in describing lived experiences is due to our attention that is usually directed to the 'what' object and not to the 'how' it make us feel. "Our attention is absorbed into the object, we lose contact with the immediate visual sensation." (*ibid.*, 8) If we center our awareness only on the phenomena happening outside the body, we miss how the experience affects implicitly our somatic senses. Canadian philosopher, Evan Thompson elaborates on making explicit the implicit feeling:

> "In seeing, I attend to features of what there is to see. But I can also attend to how seeing feels, to what the activity of seeing is like for me, and to the ways it feels different from freely imagining and from remembering. In attending to experience in this way, I can become aware of features I do not normally notice (attend to), precisely because they usually remain implicit and pre-reflective." (Thompson 2007, 286)

Constitutive:
forming an essential element of something.

Intuition:
from the Latin *intueri*, meaning 'to gaze at,' 'to contemplate.'
In philosophy is a phenomenon of the mind. It describes the ability to acquire knowledge without inference or the use of reason. As Albert Einstein puts it: "The intellect has little to do on the road to discovery. There comes a leap in consciousness, call it intuition or what you will, the solution comes to you and you don't know how or why."
German *anschauung*, can be translated to both 'intuition' and 'perception.' While the East values intuition and emotion-based decision making, the West prefers clarity and logic due to deference for science. (Juniper 2003, 48)

Elicitation:
from the Latin *elicitus* 'drawn out,' past participle of *elicere* 'draw forth.' It means to educe, evoke or bring out, to give rise to (a response, answer, or fact) from someone in reaction to one's own actions or questions. (New Oxford American Dictionary)

Explicitation:
French *explicitation* means 'to make explicit.'

A sensation happening in the body or adjacent to it is perceived as feeling in the mind, and through the mind, a feeling is already an interpretation of a felt experience, to which we give a meaning. A perceptual interpretation does not necessarily means reflecting upon an experience. As French philosopher and aesthetician Mikel Dufrenne (1910–1995) wrote in *The Phenomenology of Aesthetic Experience* (*Phénoménologie de L'expérience Esthétique*, published in 1953), there is not feeling if there is not reflection on an experience affecting the body:

> "Reflection prepares the way for and then clarifies feeling. Conversely, feeling first appeals to and then guides reflection. This alternation between reflection and feeling designates a dialectical progress toward an increasingly complete comprehension of the aesthetic object. It is entirely possible that feeling is what is given first and that all perception begins in feeling, since it may be true that we perceive forms first and that feeling is the soul of form, the principle of unity for a perceptual diversity, or, as it were, the first instance of a meaning which still adheres to bodily presence" (Dufrenne 1973 (1953), 423)

An intuitive reflection enables the awareness of feeling, which in turn becomes a reflected state of consciously felt experience. As Dufrenne similarly stressed:

> "Reflection not only prepares for but also ratifies feeling, since feeling can, in turn, become the object of a reflection which aims to explicate and justify feeling." (*ibid.*, 422)

Van Manen emphasizes that while living through the experience, and although aware of the experience, it is not possible to simultaneously reflect on it:

> "A person cannot reflect on lived experience while living through the experience. [...] Thus, phenomenological reflection is not introspective but retrospective. Reflection on lived experience is always recollective; it is reflection on experience that is already passed or lived through." (van Manen 1990, 10)

Considering an aesthetic felt experience as an occurrence affecting the senses, it is not devoid of emotion, cognition, and the ascription of meaning and value. To describe a pre-reflective sensation it is unavoidably, to reflect intuitively upon it, as there is no other way to translate into a symbolic language of an alphabet a non-reflective statement. While one can learn to become aware of sensations, it is not possible to write about those sensations without reflecting on them.

Feeling:
from the Latin *sentire*, meaning 'to feel.' The term was first used in English to describe the physical sensation of touch through either experience or perception. It is also used to describe intangible experiences, and of sentience in general. Phenomenology provides some basis for knowledge of feelings. In psychology, it is usually reserved for the conscious subjective experience of emotion. (Wikipedia)

Felt sense:
was introduced in 1963 by Austrian-American philosopher and psychotherapist Eugene Gendlin (1926–), who attributed the phrase to the unclear, preverbal sense of the inner knowledge or awareness experienced in the body that has not been consciously thought or verbalized. (Gendlin 1982 (1978), 10) Arising from the "body and mind before they are split apart." (in Prendergast 2015, 41)

American Abstract Expressionist painter Agnes Martin (1912–2004) stated, "Everything, everything is about feeling." (in Popova 2014 (Gruen 1976))

8.16 Observation Method

The observation method centers in collecting directly observed data in a purposeful and holistic way to fully understand a phenomenal experience.

The observation method implies close attention to the non-verbal cues given by the observed participants. Inferring from their intuitive and pre-reflective actions and reactions, postures and attitudes, facial expressions and gazes, hand positions and gestures.
The participant observer entails that a researcher is immersed in the experienced phenomenon witnessing attentively the participants expressions, positions, and movements. As it intends to seek the potential idiosyncrasies that may possibly emerge from the subjective felt experiences. For no data is trivial, the observer is exhaustive in detailing annotations obtaining both explicit and implicit data in field notes, reflexive journals, and interviews.
Observation in qualitative research is exploratory. It is done in a natural setting, in an informal way, and in an unstructured form. The observer must avoid early interpretations, and should be aware to not lead the observed to behave in a different way from they would normally do. The familiarity of the observed with the observer helps that observed react more at ease. However, the observer is never sure if the observed would behave the same way if they were not being observed. In addition to memory and annotations, the observation method is usually supported by instrumental techniques, such as video or audio recordings, and photography. The researcher must take into account that image recording can disrupt and prevent the spontaneous behavior of the observed participant. In any case, the observed must be consulted if image or audio recording is consented, and be informed that observational annotations will be applied. Because observations happen in voluntary sessions, the observer should be attentive to the motivation of those observed. Since the variables are not controllable, the observer must be receptive to the emergence of new data. Subsequently, the data collected are transcribed to be presented, analyzed and interpreted.
The participant observer is engaged in a phenomenal experience, which means a somatic circumstance, where not just sight and hearing are involved.

Summary

When an art work is created to be primarily experienced by touch, the tactile characteristics of materials and forms, and the absence of profusion of color, gain relevance over the visual ones. And the subjective impressions of a felt experience acquire different dimensions as the tactile interactions prevail. This immediacy allows readings of reality that impacts strongly our perceptions, as touch opens bidirectional pathways to and from our inner self.

The reactive surfaces renounce the immateriality of virtual digital media for they react physically to our tactual intents. A reactive surface is not the window of a screen where data are displayed, but is the surface of a material where touch gets tangible responses to tactual intents. There is not an intermediating

transparent layer separating and disembodying our somatic dispositions to digital contents. The touch reactive surfaces simulate living-like features of sensitivity to external phenomena. For every living being instinctively reacts to sensations. Decoding the vital instinctive reaction to events sensed by touch. Touch is the sense that connects any living being to the world where he inhabits. Haptic explorations present conceptual alternative and prospective outcomes to elicit potentially dissimilar perceptions of haptic reactive behaviors.

The quality of touch impressions is highly dependent on the expectancy of a stimulus, the type, and term. Having an experience one time is different from having similar experiences several times. If the experience is agreeable or not so, it influences our judgment and future reactions to other experiences of the same kind, as we will carry a perceptual set consisted of learned expectations that are based on personal, social, or cultural experiences. These may change or bias perceptual behaviors.

Haptic explorations serve contextually the research premise of proving and demonstrating the concept through the experience of art. Defying the participants to be attentive to touch sensations and the subtle differences of touch stimuli through materials, while offering alternative tactual sensations from the ones felt when interacting with a multi-touch screen of an electronic device.
The participants could touch the surfaces unrestrictedly except for two projects. In these two moments, the researcher was directly involved in the experiences, doing performative actions, being immersed in the events with the participants, asking them to touch the surfaces through a transparent acrylic plate, and shaking it slightly. Simulating a multi-touch screen that vibrates when touched, and detaching the participants from the textile materials.

Using for experiential assessments, phenomenological methods for qualitative research adapted from Psychology to the specificity of eliciting felt experiences, interpreting the participants descriptions of sensations, feelings, perceptions, impressions, emotions, meanings, values, and expectations.
Since the descriptions are the participants impressions of individually felt experiences, the validity and reliability sought, refer to inductively finding answers to the research questions and attest the veracity of the hypothesis. The qualitative results can hardly be replicated as the evidence is the outcome of subjective impressions from a purposive sample. However, the procedures are easily replicated.

Introducing in the research the phrase *Aisthantic Experience* from the Greek *aisthanthike*, meaning 'felt' experience through touch, and formulating the inductive *Theory of Aisthantic Experience*, proposing to formalize the analysis of quality of felt experiences.

Conclusions

Touch is sincere, expressive, emotive, connective, primal, vital, and it is also intricate, entangled, equivocal, concealed, and ulterior — Touch is our core. It enables us to be, feel, connect, relate, communicate.

This thesis provides a reflection on the phenomenological experience of touch through art. It explores touch and its relation to other senses. Its vital importance and the extensive broadness. And how we deal with touch in our everyday lives and through technological interactions. For it, the digital media were approached not from the digits of discrete values or figures, but from the digits fingers. As it is in the physical interaction through touch, that media can be truly interactive.

This thesis inquires touch through the experience of inner touch and by outer touch. Meaning, being conscious of the self and aware of the being. Since touch allows us, the double experience of sensing and feeling, of touching and feeling touched. It is through the feeling of the inner self that we experience sensing the outer being. Which is further analyzed by three fundamental segments: The attention we put on the event for it to be experienced; the expectancy of what might happen; and the fulfillment of feeling satisfied with the experience.

One premise of this research was to examine the fundamental human qualities of touch before technology has taken over the term haptic. Another premise was to resolve a disquietude pressing the quality of felt experiences when dealing with multi-touch screens with or without response to touch.
While rediscovering the sense of touch, experiencing it more attentively, and being aware of the frightful implications of its absence, one may conclude that the widespread multi-touch screens of consumer digital technologies do not yet offer stimulating tactile sensations, for the force touch still feels a deceiving feature under our fingertips.
Experiencing touch through a digital screen can at times be boring or annoying for preventing a fulfilling sensory involvement, where the sensation of touch is either neglected or mechanized. Yet, sensation matters.

This research aimed at developing considerations based on crossing disparate epistemologies related to the sense of touch, intervening and raising awareness for this sense that we so often overlook. Along the way, conceptualizing and developing haptic surfaces that change their physical appearance and reading expression when we touch them. Following the inquiry into tactile sensations when interacting with tangible media, on how to enhance the physical experience between users and digital interfaces. Since the tactile sensations obtained from the haptic technologies entail deceiving the touch receptors using technical effects to create a perceptual illusion.

For the research methodology it was used a qualitative approach, as it was intended to infer the quality of subjective tactile sensations and individual behavioral patterns. Inquiring the quality of tactile sensations through the experience of art and phenomenological research.
To assess the phenomenology of the experience were applied qualitative research methods, conducting interviews, performing close observations, and being a participative researcher. The experiences and assessments happened in an informal setting. Taking the time to find purposeful participants, while being able to stay long enough with each one.
Surveying a purposive small group of people asking them to describe individual experiences, with questions directed to identify specific features of each experience. The questions were purposefully directed to the tactile sensations being experienced.
Since commonly, artists and designers are known for being highly sensitive to their surroundings, as corroborated by Elaine N. Aron in her research on the *Highly Sensitive Person*, the sample was comprised of people from outside the creative domains in an attempt to assess the participants attentiveness to tactile sensations.
Using assessable phenomenological descriptive methods of psychology adapted to felt experiences. The research methodology was supported by the *Descriptive Phenomenological Method*, that works on ways of participants to describe experienced phenomena and what these may have elicited in them. Resorting to the *Explicitation Interview Method* intending to enable the participants to gain access to their pre-reflective, inner experience, to recall, and intuitively describe it.
The participants described in spoken and written forms immediately after the experiences had occurred. Spoken commentaries were recorded, but no images were registered during the experiential assessments, for not to break the participants spontaneity. The Interviews were done individually in separate occasions to assess the level of expectancy of each participant.
Closely observing experiential behaviors looking for phenomenological particularities and commonalities. The participants were informed of the experiences, but not instructed in their use. They could touch and explore the surfaces unrestrictedly except for two projects, where the participants could touch the surfaces through a transparent acrylic plate simulating a multi-touch screen.

On the outcome of the research of touch trough art were collected the findings, which may corroborate the findings of other disciplines, that touch receptors are extremely sensitive to material properties with impact on behavior.
The properties of surfaces impact our affective dispositions towards materials. Typically, we use the tips of fingers when touching multi-touch screens, but tend to use the whole hand when exploring materials.

Touch receptors are highly sensitive to changes in stimuli. In particular, our fingertips are profusely endowed with nerve endings, which make them highly susceptible to subtle variations.
Touch receptors adapt fast to a continuous stimulus rapidly desensitizing them. If a stimulus persists the sensitivity to the stimulus will decrease and touch receptors will cease from detecting it.
Touch sensations are perceptually conditioned and easily deceived. A perception built through exploratory touch is done by summing parts of a whole. Perception is consequent of a mental construction that is easily deceivable through tactile illusions.
Touch makes possible the inner existence of self into the outer experience of being. It is through the integral touch that we have an elemental felt sense connecting our inner and outer worlds.

This study is of significance as to enrich the apprehension of somatic sensations through art experiences. The notion of a veracity attained by tactile feelings through an art encounter experience contributes to what the art historian Bernard Berenson alluded of "life-enhancement." This perception happens from the awareness that touch is vital for our body and mind existence, and that from this consciousness we may feel strengthened.
To decontextualize touch experiences making us mindful of specific sensations. While transposing experiences to another medium we may become aware of sensations not previously noticed.

As for the contributions it can be highlighted, the bringing into awareness the vital importance of our touch sensory system. As we are not commonly aware of the significance of touch for our survival, and often put touch in the lowest position of the sensory hierarchy.
To provide an enriched comprehension of our self through the integral touch. Touch is the sense that provides an inner unifying sense that is integral to our sense of being. Senses act interrelated giving us the consciousness of a pathic corporeal existence that fully integrates us in the world.
To enhance our everyday somatic experiences and relational interactions. Technological rationalization is making us feel disconnected and desensitized by objectifying our senses. As technology becomes progressively more pervasive and immersive, we become increasingly more detached from the physical reality, which impacts the way we sense the world around. Benevolence happens when we are in tune with our somatic vibes, in a body we feel connected to or in touch with.

The reflections arising from the research resulted in the *Theory of Aisthantic Experience*, introducing the term *Aisthantic* to characterize a felt experience through touch, etymologically derived from the Greek *aisthanthike*, meaning

'felt.' A neologism in the English language and in the research domain. Similarly, the term *Haptic* derives from the Greek *haptikos*, meaning 'of or relating to the sense of touch.' The Theory of Aisthantic Experience enables to formally analyze the quality of felt experiences. It evolved inductively as a result of the research process, proposing to examine the distinctive elements of touch experiences, through the essence of the medium and the sensations it conveys.
The theory is constituted by three main principles:

1. The *unmediated aisthantic experience* is a direct felt experience through active touch having nothing standing in between the bare skin and the touched surface enabling a natural and immediate sensation.

2. The *mediated aisthantic experience* is an indirect felt experience where the exploratory touch is intermediated by something that stands between the skin and a touchable surface. Preventing an engaging and prolonged sensory impression of stimulating and renewed sensations of touch, from the varied cutaneous cues the finger pads detect when directly touching an object.
Which is subdivided into different experiences of interaction:
   – Interacting with a wearable device.
   – Interacting with a handling interface.
   – Interacting with a touch screen without vibration.
   – Interacting with a touch screen with vibration.

3. The *extrinsic hapticality* refers to feeling touched at a distance, external to the body and without contact. Since experiences through touch can happen in many ways from various sources. We may feel somatically affected by touch not exclusively by contact, which can cause us physical impressions (goose bumps, wobbly legs, dizziness, headache, ...), from a light, sound, image, scent, taste, a written or spoken word, wherein touch is mediated through other sense organs, the brain, and efferent neurons.

This study has topical application as touch impressions are fundamental for a deeper connection of our own understanding. As there is no possibility of a sustainable life without feeling in touch through our interiority with what and who surrounds us, which ultimately impacts the relation we nurture with the objects we handle. And, the touch sensory system is crucial to human-machine interactions. As developing an interactive system requires the involvement of touch. Attention must be given to the intrinsic particularities and mechanisms of the sense of touch. For the accomplishment of an interactive technological experience is in providing rewarding touch sensations. But, it often happens that when addressing the digital media is put more emphasis on the means of production, than in the fruition of the experience and the quality of sensations.

Recently and increasingly, we will be hearing the term haptic in consumer multisensory devices. The sense of touch is finally regaining the due attention. But still, we know very little about its dominance and the seriousness it is of not having it working properly. In knowing touch thoroughly, we can intensify the way we use it and the way we intend to interact with creations in art and design involving touch. In describing what touch is, revealing how it works, as well as to tell what we are able to do with it, and how to intensify the experiences with it, more critically involved we may become.

While aiming to find answers to the research questions and validity of the hypothesis through the interpretative inductive reasoning, it is not intended to end with narrow conclusions, but rather it is aimed to be an open-ended, critical, and thought-provoking research to raise individual awareness, and preferably to raise further questions. Meant to be an investigation through explorations in the inquisitive art, it is open to questioning one's perceptions, challenging each one to know oneself through the sense of touch while claiming for meaningful sensations of touch when interacting with haptic technologies. In the hope that this thesis will inform artists and designers of the scientific rationale required for their haptic creations and research.

The human sensory faculties are fundamental for the successful creation of digital interfaces, where the immediacy of interaction is more gratifying and lasting if they allow the physical involvement. Wherein the interaction with digital interfaces is embraced as if it were an embodied extension of the user's body. Progressively, the 21st century promises to be a more body centric.

Future Work

Recognized its potential, the next phase of this research is to continue making efforts to develop the *Tangere* prototype into a wall sized project.

To develop further in an essay, the *Theory of Aisthantic Experience* in its fundamental principles, and reflect on how we are somatically adjusting to the technologies we deal with daily.

To investigate the materials and electronics for wearable technological art, exploring potential conceptual possibilities to experience a body that extends capabilities through wearable technologies. Applying the *Theory of Aisthantic Experience* to analyze the quality of embodied experiences, wherein touch can be augmented by an added interface skin layer, while interpreting the somatic implications of embodying technologies.

A future work may come as a proposal for a materials science laboratory to develop in collaboration a material different than the conventional glass, that could move organically and react to our tactual inputs instead of vibrating. Through a resistive circuitry, a single compound positioned underneath, or the material molecular properties, that could make the surface expand or shrink to become concave or convex in response, providing a more natural force reactive surface.

The study of a topic never runs out in one investigation, so that as much one goes holistic about a subject many other intertwined or adjacent studies could be undertaken. As such, further research is needed to proceed inquiring critically the tactile sensations provided by interactive technologies. Considering that the quality of haptic technological experiences depend on how the technical effects are applied to create perceptual illusions deceiving the touch receptors.

Short Biography

Sandra Coelho (Mónia) is a Portuguese communication designer, media artist, researcher in digital media, walker, vegetarian and activist.

She is a member of the Research Group in Art and Intermedia (NAi) from the Research Institute in Art, Design and Society (i2ADS), at the Faculdade de Belas Artes, Universidade do Porto (FBAUP), Portugal, and a member of the Society for Artistic Research (SAR) in Bern, Switzerland.

She holds a five years Degree in Communication Design – Graphic Art, and a Master in Multimedia Art, from Faculdade de Belas Artes, Universidade do Porto, with the dissertation *0 1 1 2 3 5 8 13 21 34 55: Arte Generativa*.

She holds a Professional three years Course in Fashion Design from CITEX, Porto (currently MODATEX Professional Training Center for Textile, Clothing, Apparel and Wool Industry). She was invited by VIDA, a company based in San Francisco, which is a Google Ventures-backed fashion e-commerce platform, to be one of their designers. VIDA is a collaboration between designers and makers around the world.

She creates experiences loving the beauty of simplicity of artificial things and the complexity of natural beings.

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Appendices

Quantitative Survey: The experience of the interaction

Haptic Interfaces

Vibrating under the screen

This questionnaire was developed for a research thesis and aims to verify the experience of the interaction of using haptic interfaces. It is anonymous and confidential and will not be used for other purposes.
The estimated time for answering the questions is about 2 minutes. Please answer the following questions.
Thank you:

1. Are you familiar with the term haptic?

(if the answer is no, please jump to question 4)

Yes
No

2. Do you know what haptic means?

Yes
No

3. Do you know that haptic refers to your sense of touch?

Yes
No

4. Did you know the term haptic before the advent of consumer haptic devices?

Yes
No

5. Are you familiar with tactile screens?

Yes
No

6. Are you familiar with tactile feedback screens?

Yes
No

7. Do you usually use tactile feedback screens?

Yes
No

8. Do you find the vibrating tactile screens a satisfying response to your sense of touch?

Yes
No
Indifferent

9. How much is important for you to have a tactile feedback screen?

(1-not important, 2-mildly important, 3-moderately important, 4-fairly important, 5-very important)

Not important 1 2 3 4 5 Very important

10. Would you prefer a different tactile feedback than vibrating?

(1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree)

Strongly disagree 1 2 3 4 5 Strongly agree

11. Would you prefer the device to have another type of responses?

(1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Movement	1	2	3	4	5
Texture	1	2	3	4	5
Temperature	1	2	3	4	5
Light	1	2	3	4	5
Color	1	2	3	4	5
Sound	1	2	3	4	5

12. Or would you rather prefer to have a surface screen that changes its shape?

(1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree)

Strongly disagree 1 2 3 4 5 Strongly agree

13. Would you prefer a different material for the screen than the glass or plastic?

(1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree)

Strongly disagree 1 2 3 4 5 Strongly agree

14. Would you prefer a soft and warm material for the screen?

(1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree)

Strongly disagree 1 2 3 4 5 Strongly agree

15. Or do you prefer a slick and cold material for the screen?

(1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree)

Strongly disagree 1 2 3 4 5 Strongly agree

Quantitative Survey: The experience of the interaction

Tangere

At the lightness of a touch

This questionnaire was developed for a research thesis and aims to verify the experience of the interaction with Tangere installation project. It is anonymous and confidential and will not be used for other purposes. The estimated time for answering the questions is about 2 minutes. Please answer the following questions. Thank you:

1. Were you expecting the surface could physically react to your touch?

   Yes
   No

2. Did you realize almost immediately where to touch on the surface?

   Yes
   No

3. Was it easy to find the hidden 'button' that would trigger the surface to react?

   Yes
   No

4. Were you willing to explore the surface with your touch?

   Yes
   No

5. Or were you reluctant to touch the surface?

   Yes
   No

6. Do you appreciate the surface to be tangibly responsive to your touch?

   Yes
   No
   Indifferent

7. Or would you prefer the surface to be static?

   Yes
   No
   Indifferent

8. Do you appreciate the material of the surface to be soft and warm?

   Yes
   No
   Indifferent

9. Or would you prefer the material of the surface to be hard and cold?

Yes
No
Indifferent

10. How would you classify this experience as to the level of stimulation?

(1-not stimulating, 2-mildly stimulating, 3-moderately stimulating, 4-fairly stimulating, 5-very stimulating)

Not stimulating 1 2 3 4 5 Very stimulating

11. How would you classify this experience as to the level of elicitation?

(1-not eliciting, 2-mildly eliciting, 3-moderately eliciting, 4-fairly eliciting, 5-very eliciting)

Not eliciting 1 2 3 4 5 Very eliciting

12. In one word, how would you define the sensation you had when you touched the reactive surface?

Qualitative Survey: The phenomenology of the experience

Tangere

At the lightness of a touch

This interview was developed for a research thesis and aims to infer the phenomenology of the experience with Tangere installation project. It is anonymous and confidential and will not be used for other purposes. The estimated time for answering the questions is about 20 minutes. Please answer the following questions. Thank you:

1. Can see and touch — how would you describe the experience of freely exploring the surface with your touch?

2. Can see, but not touch — how would you describe experiencing looking at the surface and not being able to touch it?

3. Can touch, but not see — how would you describe the sensations you have when you explore the surface with your touch not being able to see it?

4. How would you describe experiencing a surface that reacts physically to your touch?

Qualitative Survey: The phenomenology of the experience

Ephemeral Appearance

Touch to read me

This interview was developed for a research thesis and aims to infer the phenomenology of the experience with the Ephemeral Appearance book project. It is anonymous and confidential and will not be used for other purposes. The estimated time for answering the questions is about 20 minutes. Please answer the following questions. Thank you:

1. How would you describe experiencing a book that requires your touch to show you the text?

2. How would you describe experiencing a book painted with a smart material that reacts to your touch letting you read the text?

3. How would you describe experiencing a book that changes its appearance as you read the pages?

4. How would you describe experiencing a book that plays hide and seek the text with your touch?

For a brief instant, I have experienced what it is like to lose touch with the ground. Once, I was very busy and sleeping only 4 hours a night for months in a row, when one afternoon I was walking on the street, and suddenly I looked to the right because something had caught my attention when it happened. I kept walking, but with a terrifying sensation of not feeling the ground under my feet. Not sure of what really happened.

Colophon

Haptic is a sans serif typeface created in 2008 by German typographic designer Henning Skibbe. (henningskibbe.com/haptic) Besides the obvious reasons for the preference, this font was chosen because it "emits visual warmth and draws sympathy. The rounded, slightly broadened stem-heads were adopted from the common ink bleed when writing by hand with ink and pen," (Skibbe 2008) which inherently presupposes an expressive but accurate haptic interaction with the paper.

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The internet addresses were verified to be correct at the time of publication, but due to the dynamic nature of the medium, it is not guaranteed that all web pages are still active.

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