The Phenomenology of Tactile Perception for Design

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Abstract: For design, tactile perception is a crucial dimension of the user experience. Design disciplines can find an essential body of knowledge in the tradition of the psychology of perception. This article first introduces the physiological aspects, starting from receptor differences and leading to the tactile representation in the brain. Consistent with the phenomenological perspective, it is argued, however, that the reductionist approach provides an understanding of physiological mediation, useful for knowing the functioning of the organism, but not sufficient to make the user's perceptual-tactile experience immediate. The perceptual-tactile experience extends to the dimension of the self and demonstrates that the bodily self extends beyond the boundaries of the physical body. For the designer, therefore, scientific knowledge of the tactile experience derived from experimental phenomenology, developed from Gestalt psychology, is a priority.

Keywords: Tactile perception, Experimental Phenomenology, Gestalt Psychology, Intermodality, Design.

1. INTRODUCTION

Although the skin can be defined as the “outer covering of the human body,” more commonly, humans experience their skin as an integrated part of their body. It is considered the most significant perceptual intimacy. One reason for this sense of intimacy lies in the fact that in tactile perception, unlike sight and hearing, proximal and distal stimuli coincide: the physical object, the source of sensory stimulation, is in direct contact with the receptors. There is no mediation, such as light for vision or air for hearing, between the physical object and physiology. However, this innocent observation conceals a compromising theoretical contamination.

Describing tactile perception based on a distal physical object that triggers sensory stimulation assumes a causal theory of perception. According to this theory, perception is defined by a world thought of with a physicalist assumption: the metaphysical origin of perception would be the physical data, the physical data would activate sensory data, the sensory data would be processed by the mind (for the dualist scientist) or by the brain (for the monist scientist), and, for a mystery that no one has ever explained, the percept would eventually arise, which is the phenomenologically experienced perceptual data. It is no coincidence that one of the most influential publications on visual perception in the last twenty-five years, by the American scholar Stephen E. Palmer [1], is subtitled: “Photons to Phenomenology.” A metaphysical assumption is legitimate, but it must always be kept in mind that it is theoretically binding. It means it constrains our way of knowing: it conditions both how we look at and think about things and how we design them.

The skin has the specificity of mediating the tactile perceptual experience through a widespread network of receptors belonging to the so-called somatosensory system. The purpose of this paper is primarily to present the functioning of this system and to demonstrate how receptor physiology, which is an important stage of the causal theory of perception, does not fully explain tactile perception [2].

For this reason, it is essential to introduce a phenomenological perspective capable of accounting for the lived perceptual data, instead of an intellectualistic definition of proximal stimulation, which is nothing more than a hypothetical construction of a transphenomenal world, qualitatively different from the immediate experience that the recipient, the final stage of every designer’s project, actually has.

From this initial conclusion, I will subsequently proceed to consider the body surface beyond the skin: from the somatosensory system to the phenomenal extension of the corporeal self. This extension finds exemplification in a very common experience: when one wears a glove that prevents proximal stimulation, in other words, when the receptor physiology of the skin is blocked, the experience is not that of having the hand enclosed in a covering fabric;

instead, there is a psychological sense of extending the somatic self onto the surface of the glove itself. In fact, if one is touched on that covering, the reaction is as if the person themselves were being touched. The glove becomes, in essence, the "sensitive" skin of the individual. However, before delving into this psychological issue, it is necessary to introduce the physiological system that mediates tactile perception, and then clear the field from misleading physiological biases that can hinder the designer's project horizon.

2. THE SOMATOSENSORY SYSTEM

The somatosensory system (for an extensive discussion see, for example, Kandel & Schwarts [3]) functions to process stimulation of the body surface, commonly referred to as "the skin." To be precise, this system also receives stimulation from deep tissues and organs. However, this second type of stimulation will not be examined here. It is essential to immediately distinguish four sensory modalities of the system: 1. tactile sensations, activated by mechanical stimulation of the skin; 2. proprioceptive sensations, activated by muscles and joints; 3. thermal sensations, i.e., cold and hot; 4. painful sensations, activated by harmful tissue stimulation. These four sensory modalities have four distinct types of receptors that function to specify the quality of the stimulation. Three different receptor classes respond selectively to specific stimuli. These are nociceptors, thermoreceptors, and mechanoreceptors.

The nociceptors respond to harmful stimuli to the tissues, such as sharp objects, temperatures above 45°C, or other forms of chemical damage. The phenomenological experience of pain, corresponding to different nerve fiber physiology, can be categorized into two types: a rapid and piercing pain or a slow and burning pain. Cold thermoreceptors activate with intensity proportional to the decrease in temperature (the optimal range is between 30°C and 10°C); conversely, heat thermoreceptors are excited up to a temperature of 45°C, after which the response to heat is mediated by thermal nociceptors. Finally, mechanoreceptors are physiologically responsible for the tactile sensation. Two classes of mechanoreceptors are distinguished based on their response to stationary mechanical stimulation. The first, called slowly-adapting, activates continuously; the second, called rapidly-adapting, only discharges energy at the onset and sometimes at the end of the stimulation (see figure 1).

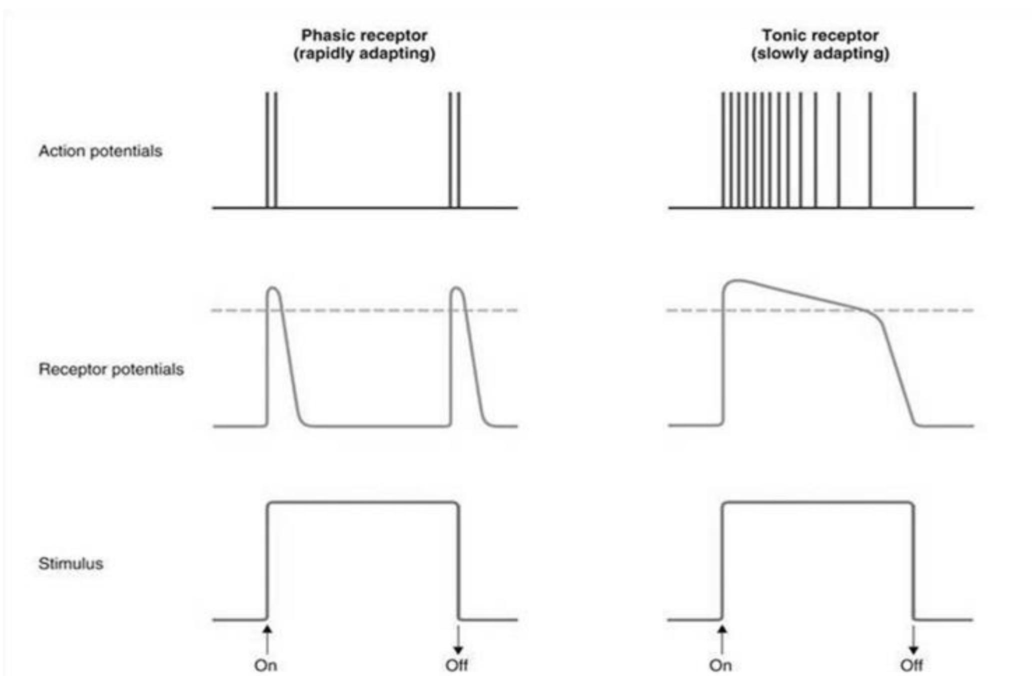

Figure 1. Slowly-adapting and rapidly-adapting

In the glabrous skin, there are four types of receptors, each with a specific response. Meissner's corpuscles and Pacinian corpuscles are both rapidly-adapting, meaning they quickly adapt to long-duration stimuli, saturating rapidly. However, they differ because the first type of receptor is more superficial, located near the dermal papillae, while Pacinian corpuscles are found in the subcutaneous tissue (see figure 2).

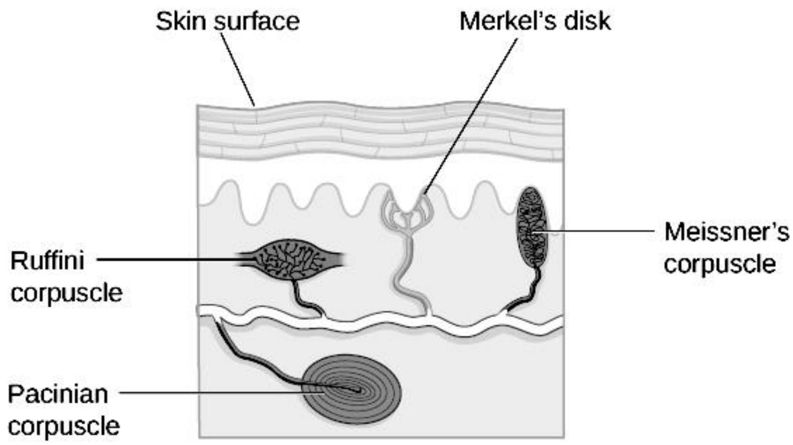

Figure 2. Four types of receptors.

Due to this adaptation type, these receptors primarily respond to vibrations and changes in position and stimulus velocity. Merkel receptors and Ruffini corpuscles, on the other hand, are slowly-adapting: after contact, they provide the sensation of steady compression. Their response specifically pertains to pressure and shape stimulation. Merkel receptors are localized in the dermal surface, whereas Ruffini corpuscles are situated deeper. The difference in localization affects the receptive field size. Surface-located receptors have a smaller receptive field and are therefore better suited for fine spatial discrimination, contributing to the perception of object microstructure. These receptors are also present in the extensive surface of hairy skin, except for Meissner's corpuscles, which are replaced by hair follicle receptors with equivalent physiological properties.

Another selectivity of receptor response is determined by the frequency of the stimulus. The Meissner's corpuscle selectively responds to low-frequency mechanical stimulation, perceived as a gentle skin tremor. In contrast, the Pacinian corpuscle responds to high-frequency mechanical stimulations, creating diffuse and localized perceptual impressions in the deeper regions of the skin, resulting in a buzzing or deep vibration effect (see figure 3). Their deep localization makes these receptors more sensitive to coarse discriminations, such as the overall qualities of an object.

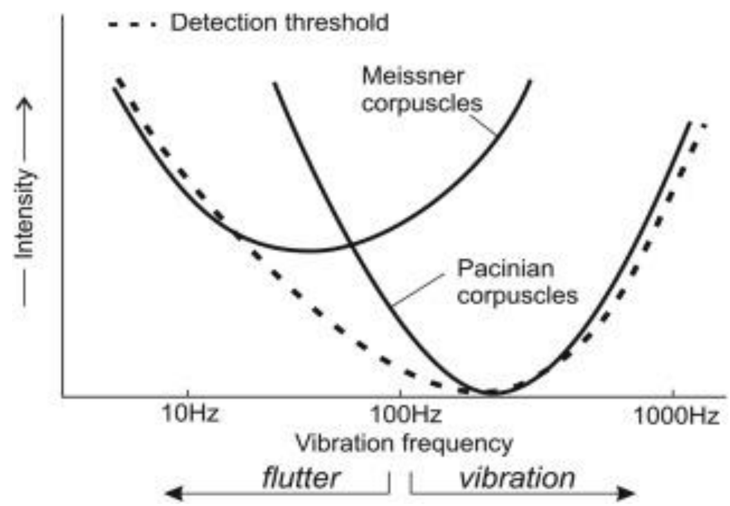

Figure 3. Receptor response.

A significant characteristic of the somatosensory system, as proposed in these pages, is the different receptor distribution on the body's surface, both quantitatively and qualitatively. For example, considering the hand, it's observed that there is a higher density of mechanoreceptors on the fingertip of the index finger compared to the palm. Additionally, the same fingertip of the hand has a different distribution of receptor types (see figure 4). For this reason, natural stimuli typically activate various classes of receptors, causing different parts of the body to respond quite differently to the same stimuli.

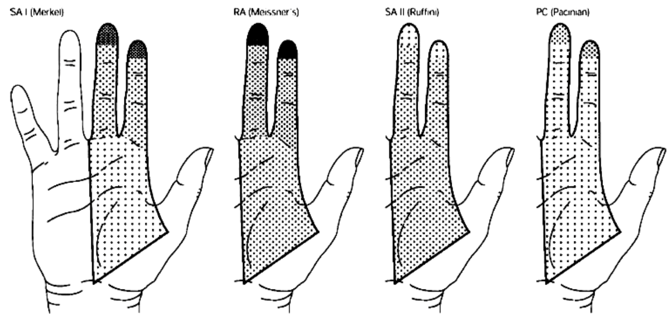

Figure 4. Different distribution of receptor Types.

After peripheral receptors are activated, the electrical information follows a path that travels through nerves up the spinal cord to the thalamus and then to the cerebral cortex (see figure 5).

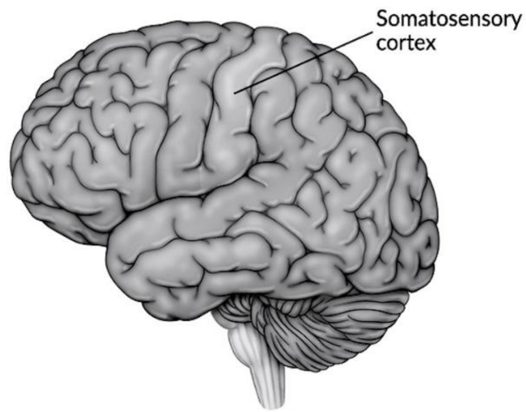

Figure 5. The somatosensory cortex.

In the central nervous system, there is a representation of the body's surface, meaning somatic sensations are localized in specific areas of the cortex. However, these brain areas are not proportional to the corresponding parts of the body. In the coronal section of the postcentral gyrus of the parietal cortex (see figure 6), the map of the body's surface is somewhat distorted: the tongue, lips, and index finger, which have high tactile sensitivity, correspond to a large area in the brain; conversely, the ankle and knee, less sensitive, occupy a smaller cortical surface. Notably, when two lovers share affectionate moments, they seek contact with hands or lips, not elbows. The brain mapping of sensitivity is graphically represented by the somatosensory homunculus.

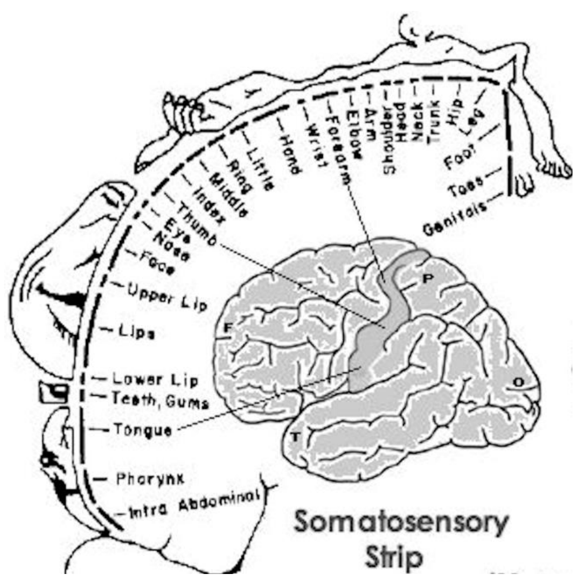

Figure 6. The sensory distribution along the cerebral cortex.

The homunculus is a representation that serves to emphasize once again that the body's surface, for various physiological reasons - as we have seen -, responds in a highly differentiated manner to the same stimulus. This difference is mirrored in the phenomenal experience. One prime example is the so-called Weber illusion, named after the German physiologist of the same name [4]. The experience involves touching a subject's fingertip and then their forearm with an open compass set to the same width. The subject consistently reports a greater distance between the two compass points on the fingertip. This illusion precisely demonstrates that discriminative sensitivity differs across different parts of the body.

3. THE PHENOMENOLOGICAL VIEW

This detailed discussion has served to establish that the skin is a part of a physiological system upon which tactile experience depends. This dependence is not generic but influences even the subtlest perceptual nuances. In other words, even at the receptor level, there are significant perceptual differences that are maintained in the realm of phenomenal experience. From all this, one could peacefully deduce that if physiology were solely responsible for our tactile perception, we should have a very different perception of the same object when touched with different parts of the body, just as the Weber illusion seems to suggest.

However, this is not the case, as demonstrated by the phenomenon of perceptual constancy. When manipulating an object with consistent surface characteristics, such as a perfectly smooth sphere, tactile differences are not perceived due to the varied receptor distribution on the hand (see figure 4). Manipulating the sphere makes it feel smooth. Wearing a long glove that covers the entire arm, made of uniform fabric, does not yield a heterogeneous tactile perception, as if the fabric touching the fingertip were different from the fabric on the elbow. In all cases, the constancy of tactile properties of the object is perceived. This phenomenon also holds true for other sensory modalities. An illustrative example in the realm of vision is the size constancy. As an object moves away from the observer, its retinal projection consistently decreases (see figure 7). Therefore, retinally speaking, one would expect to see an object that progressively becomes smaller. However, perception reveals an object that remains of constant size while receding in depth. In general terms, perceptual experience does not correspond to the immediate physiological stimulation - in the latter case, the image on the retina, or in the case of tactile perception, the activation of skin receptors - but rather organizes itself by maintaining certain object characteristics coherently within a specific perceptual context [5].

Furthermore, even the different representation of body parts in the somatosensory cortex does not entirely mirror tactile phenomenal experiences. Some researchers reconsidered the measurement of the Weber illusion with an experimental variation [6]. They asked subjects to observe their forearm through a magnifying lens for an hour. After this visual treatment, the measurement experiment was repeated. Interestingly, the tactile distances on the forearm decreased. This result demonstrates that the phenomenal body image, rather than the tactile representation in the somatosensory cortex, constitutes the metric reference system for evaluating tactile distances. In other words, tactile sensitivity does not precisely correspond to the proportions of the homunculus.

If objects and perceptual qualities do not exclusively depend on physiological stimulation, what should be attributed to our perception? Neuroscience, like cognitive science, explains perception within a functionalist framework. Here, “functionalist” refers to the theory of a system or machine that processes, manages, and analyzes information received through sensory organs. This implies a psychophysical chain of successive causal stages: it begins with the distal object, defined in physical terms, which causes proximal physiological stimulation (receptor activation), which in turn causes brain areas to activate through neural pathways.

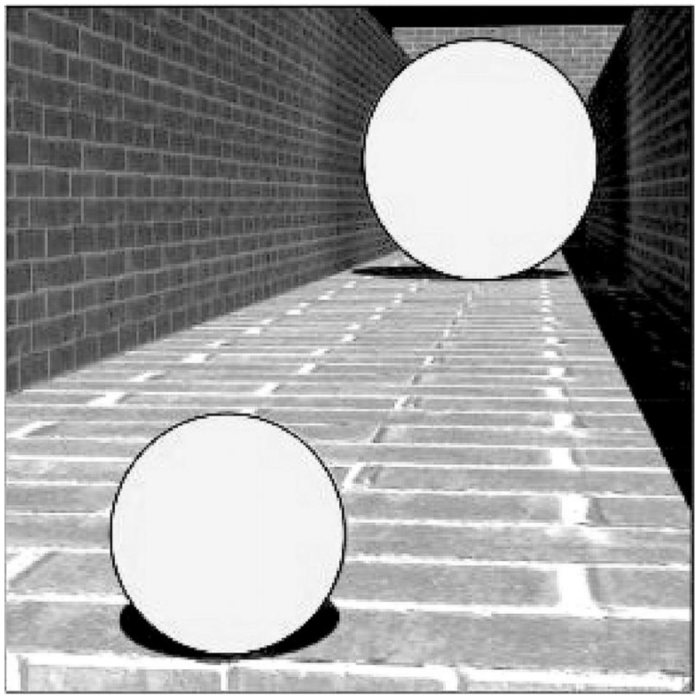

Figure 7. Size constancy.

Finally, the brain (or, for dualist scientists, the mind) is responsible for generating perception. While the brain's functional activity in correlation with perception is undeniable, there is an ontological leap here that nobody has clarified. No one has justified the leap from neural or mental processes to perception, despite the exciting advances in neuroscience. This is not the place to delve into ontological criticism, but it's important to emphasize that the functionalist explanatory approach aims to infer models of brain or mental mechanisms that process input from different senses, integrated with subliminal activity. The goal is to understand the system's functioning rather than the phenomenology of perceptual experience. Understanding and explaining perceptual experience is the specific focus of scientific phenomenology [7]. There is a long tradition of research in this disciplinary field that began systematically with a psychologist from the Göttingen School, David Katz, particularly with his essay "Der Aufbau der Tastwelt" (The Structure of the Tactile World) published in 1925 [8]. Katz advocated for a phenomenological-experimental approach fully consistent with the theoretical paradigm of Gestalt psychology.

This methodological approach prescribes bracketing the biases of natural science, knowledge about the physical world, experimental findings about the physiological system, and asks the researcher to orient themselves to the qualities of the phenomenal world as they appear in immediate and direct experience. Simultaneously, this approach is scientific in that it systematically controls experiments manipulating phenomenal variables to observe their effect on other phenomenal variables. The ultimate goal is to formulate general laws about the qualities of objects in the phenomenal world – the actual, visible, concrete, and tangible reality of everyday objects, rather than the intellectual reality of atoms, neutrinos, bosons, and abstract particles discussed in physics, which no one can directly see, hear, or touch. This phenomenal world, at first glance, cannot be simplified by an atomistic theory.

The atomistic theory, indeed, has been primarily established through the analytical method of 19th-century science, which studied physical and chemical properties by attempting to isolate minimal components, such as the atom. The underlying idea was that by knowing the minimal components, one could understand the structures, complexes, and objects. This theory has transformed into a prejudice criticized by the phenomenological approach [9], which advocates an opposing holistic conception with the strength of undeniable perceptual evidence. Max Wertheimer's laws of perceptual organization (1923) are precisely the evidence that units, structures, and gestalts are entities distinct from the simple arithmetic sum of parts – just as a melody is different from the individual physical notes that compose it. These laws (see three examples in figures 8a, 8b, and 8c), initially conceived for the visual and auditory modalities, have been shown to hold true in the tactile field as well [10].

The methodological prescription of phenomenology, besides the holistic approach, also denies possible influences of unconscious mental processing in the study of observed phenomenal qualities. In other words, Katz, like all other Gestalt psychologists, excludes cognitive integration in perception and therefore studies direct perception. Katz's phenomenology of perception thus distinguishes qualitative specifications within the tactile field that are entirely absent in the physical or physiological description. These specifications differentiate, for example, three types of tactile experiences:

1. Superficial touch concerns the experience of the two-dimensional surface of an object, characterized by being continuous and extended. An example could be discriminating the roughness of a table's surface.
2. Immersive touch, on the other hand, is an experience such as moving one's hand through a fluid substance, where there is no perception of the shape of an object and no specific spatial orientation.
3. Volumetric touch, finally, pertains to the experience of the object's shape, how an object is structured in the spatial dimension. This last experience can be exemplified by cases where the hand is covered by a glove, thus reducing the perception of surface characteristics, or by medical palpation, where the surface of the patient's body is touched to explore deep organs.

With these specifications, Katz laid the conceptual groundwork for a phenomenology of tactile experience and built a substantial body of experimental results. It wouldn't be appropriate or feasible to summarize all the contents of his beautiful classic text. Instead, let's provide examples of perceptual experiences where both receptor physiology and the physical definition of the distal stimulus become unnecessary stages in the psychophysical chain to fully understand tactile experience.

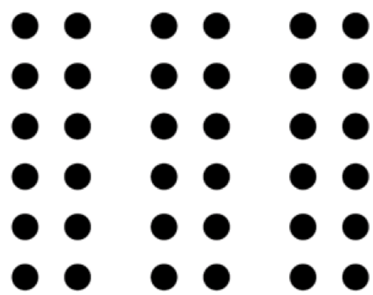

Figure 8.a. Law of proximity.

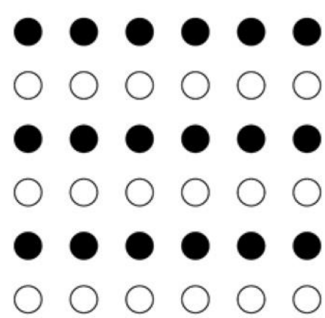

Figure 8.b. Law of similarity.

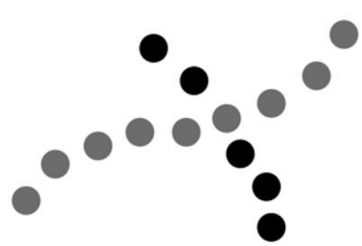

Figure 8.c. Law of good continuation.

Many scholars agree that the characteristics of the body play a decisive role in defining the ontogenetic core of the self. Body image, that is, the phenomenological experience with one’s own body, is critical for self-awareness [11]. As mentioned in the introduction, the skin is not merely a covering of the body; it’s also a significant component of the bodily self [12]. One could even go so far as to argue that the skin largely coincides with the somatic self, in the sense that bodily identity is conferred by the external surface of the body. Similar to how when we look at the sea, we attribute the essence of “Sea” to the surface – more or less vast, more or less turquoise, more or less rippling – despite everything hidden from phenomenal perception, like the water underneath, the seabed, and even the fish, algae, wrecks, etc. However, one rarely experiences, if at all, the sensation that the skin is subjectively distinct from the internal parts of the body. Normally, the body is experienced as a psychological unity, although different parts and organs can easily be differentiated within it.

This psychological unity doesn’t exhaust the self – the concept of which is far more dynamic and complex, encompassing personal and social adaptation aspects as well as material ones [13]. Nonetheless, it constitutes the bodily self. This bodily self is by no means static or monolithic; it undergoes significant changes over time and in social contexts, generating psychologically flexible experiences of adjustment. Consider, for example, a part of the body that is inherently insensitive, lacking sensory receptors: hair. When a stranger deliberately touches another person’s hair in a public setting, such as on the street, the latter reacts with displeasure because not only is their personal space violated [14], but through physical contact, they feel connected to another bodily self. This experience forms a gestalt unity that transcends the mere sum of its parts (in this case, the two individuals) and has, due to the dynamic field laws of gestalt [15], the psychological power to generate a compelling sense of belonging to a higher entity, to which a portion of identity is ascribed. Physical contact, on the other hand, isn’t critical in forming psychological unity. In environments with high population density, the self-retracts, and, as in the case of buses, to a certain extent, physical contact is accepted. Conversely, it’s also common to experience a scenario where one is at a hairdresser or barber, and the hair, once cut and fallen on the floor, is nonchalantly brushed into the trash, without causing significant distress. Even though a while ago, that hair was a part of one’s body. There’s no internal conflict because the self is dynamic.

Similarly, the bodily self can extend beyond the boundaries of the physical body. To illustrate this phenomenon, one can refer to Descartes’ famous passage from “Dioptrique,” in which he explains the role of light in vision: “Therefore light is nothing more, in bodies called luminous, than a certain movement or a very quick and vivid action, which passes toward our eyes through the medium of air and other transparent bodies, just as the movement or resistance of bodies, which is felt by the blind man, passes through his stick to his hand.” [16] The tip of the stick thus becomes the ultimate termination of the sensory system. This termination constitutes a part of the bodily self that dynamically adapts to the environment, enabling the blind person’s mobility.

James Lackner conducted a research study demonstrating this phenomenon experientially [17]. He described a striking perceptual illusion that shows how the bodily self doesn’t have boundaries coinciding with the physical body’s boundaries. Experimental subjects were asked to close their eyes and hold their right arm semi-flexed. Lackner stimulated the muscle spindles, i.e., receptors in the biceps, with vibration. These receptors are typically active when the biceps muscle is stretched. The subjects, having only proprioceptive experience, reported feeling their arm extending. Based on this effect, Lackner designed an interesting experimental variation. He asked subjects to touch the tip of their nose with their index finger. When the vibration was applied, subjects not only felt the illusory extension of their arm but also felt that as their hand moved away, their nose elongated. This perceptual inconsistency, due to the hand moving away from the body while the finger maintained constant pressure on the nose, resulted in a phenomenal extension of the bodily self.

This phenomenon of bodily self-extension is also responsible for all those experiences in which our body becomes an integrated part of a functional system. When, for example, driving a car, the expansion of the bodily self to the car’s boundaries is not limited to perceiving that if someone touches or hits the external body of the car, it feels like a personal touch has occurred (it would be interesting in this regard to develop a psychology of automotive space, based on the observation that intruding into personal space often leads to heightened irritation towards other drivers, and this excess is psychologically justified or at least explained by the regulation of proxemic distances of intimacy rather than purely physical distances). There’s also an extension that involves a synergistic relationship with the car’s functioning. This kind of bodily self-extension is highly relevant in cases where the skin becomes the site for placing technologies (such as subcutaneous chips) that provide information about the body's state or its interaction with the environment.

Finally, it's worth mentioning the phenomenon whereby phenomenal extension leads to an out-of-body experience [17]. This type of experience has been examined in recent studies. Experimental subjects saw an image of their own body displaced to a different location in space using a virtual reality system. During the experiment, researchers touched the subjects' backs, creating a perceptual contradiction: subjects felt they were touched where they were physically, but they saw themselves being touched in the virtual reality location. At the end of the immersive session, all subjects reported being touched in the virtual location. These experiments unequivocally demonstrate that the bodily self can extend far beyond the physical body's boundaries.

4. CONCLUSION

Having said that, we can now move on to the conclusions. Every designer, in various stages of design, necessarily makes choices that depend on a theory, whether consciously or unconsciously, which may be explicit or implicit. In any case, if a designer were to adopt an inadequate or unfounded theory, they would be led to create a project that, at best, would overlook some relevant factors.

In this sense, for a designer working with the skin, it would be a mistake to adopt a perceptual theory that reduces the entire tactile sensory experience to physiology. The physiological system allows us to have an advanced understanding of sensory response and the overall functioning of the sensory organism. In designing with the skin, knowledge of the somatosensory system is relevant, as seen earlier, because it enables an understanding and prediction of receptor functioning. This knowledge is useful in clarifying some aspects of tactile phenomenology. However, it does not explain phenomena like perceptual constancy that broadly govern the perception of objects in the natural world. Additionally, the dimension of the bodily self, which redefines the perceptual experience of the skin in a more complex manner, diminishes the explanatory functionalistic approach. This approach is based on the assumption of a psychophysical chain that extends from the distal object described in physical-metric terms to a physiological system that functionally processes the physical data and produces the phenomenological result. A redefinition of tactile experience, in light of the bodily self, even empties the distinction between the distal physical world and proximal physiological stimulation of its meaning. Extracorporeal experiences demonstrate that even that which lies outside the physical body can fully reenter the phenomenal field. This can be achieved without renouncing ontological realism and without abandoning an operational definition of the physical object, which can be conceived as a plane of hypothetical abstraction (just as the measurative abstraction in physics translates the dimensions of immediate experience into numerical terms, that is, symbols).

Behind this conclusion, there remains a noteworthy theoretical knot yet to be clarified. As explained by the Gestalt psychologist Köhler, the processes occurring within the brain, where mechanisms related to perceptual experience take place, are transphenomenal processes, not directly observable in immediate experience [19]. These processes remain transphenomenal even if the neuroscientist, who opens the cranial box, finds perceptible events, namely, phenomenic events. A conceptual distinction must be made between the body, which is a phenomenal entity, and the organism, which is a transphenomenal entity. Our tactile perceptions, as with all our perceptions, depend, to some extent, on processes occurring within the organism, both at the peripheral level, that is, the receptor system, and at the cortical level. All these processes are transphenomenal, and thus, of a hypothetical nature, even if they can have indirect anatomical-physiological confirmation. Conversely, when referring to the phenomenal world, one can distinguish an "outside of me" or an "inside of me" that take place within the immediate perceptible in reference to the phenomenal body. Thus, the perception through the exploration of the tongue that a tooth is broken occurs within the phenomenal body; the perception of being touched when the hand is covered by a glove occurs on the phenomenal body; and finally, the perception of being touched, identifying with a virtual image located in a space different from the actual one, once again concerns the phenomenal body. This is the body that a designer interested in the tactile dimension must primarily consider for a project truly oriented towards the tangible recipient.

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