

Tactile-Kinesthetic Interactions: Interdisciplinary Technological Materials Challenge Design Innovation

Sandra Coelho

PDMD

Faculdade de Engenharia, Universidade do Porto

Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

NAi-i2ADS

Faculdade de Belas Artes, Universidade do Porto

Av. Rodrigues de Freitas, 265, 4049-021 Porto, Portugal

sandra.coelho@fe.up.pt

Abstract: Design faces challenging prospects afforded by the fast developments of tools and techniques. Exploring unusual ways for creative productions, designers collaborate with scientists and engineers working interchangeably with materials science, natural sciences, and engineered systems. To research at the interface of design and society mediated by emergent technologies, converging differing disciplines for a growing consilience contributing for design innovation. Committed in a common search and influencing each other, creators and technologists may produce contaminated outcomes that would not be possible if done unconnectedly. Technologies initially developed in scientific disciplines aimed to be used with specific ends, end up being conceptually explored by designers. Experimenting materials not intended for creative uses may ultimately provide challenging outcomes for the partnering disciplines. The stimulating interaction between divergent disciplines may cause to prompt defiant advances. Designers absorb the ultimate interdisciplinary technological advances to extend their creative possibilities. Designers develop, modify, and use technical means and tools to stir social awareness and renew aesthetic experiences. The new means encompass the interchangeable intersection of materials science, computer technologies and electronics, natural and social sciences through aesthetics and creativity for public information and cultural innovation.

Key words: interdisciplinary means, emerging technologies, technological materials, smart materials, interaction design, engaging design, design innovation

1. Introduction

Driven by the will to captivate and stimulate, designers improvise and incorporate innovative means to better communicate their intents. The curiosity of creative minds leads them to absorb emergent materials. Between developments of plastics and composites, happen the smart materials [8]. Since long ago developed for science and engineering, the employment of smart materials is relatively recent to creative domains.

Characterized by functionality and mostly used for health instruments, security devices, enhanced ergonomics, solar radiation control, illumination, ventilation, power generation, and waste reduction, the smart materials are the ones that are capable of responding to external stimuli or alterations in their environment, sensing, reacting and changing reversibly in appearance or shape (e.g. color, index of refraction, distribution of stresses and strains, or volume [8]), adding meaning to means for interactive design. These interdisciplinary technological materials

are somatically challenging as they hold touchable performative behavior that grants design a tempting haptic interaction with the beholder. Focused on offering engaging experiences, contemporary design is centered on how it behaves rather than on the way it looks.

In a digitally driven world, with a growing range of interaction modes, the computer is being integrated, gradually dissolved into the environment and into our body to be operated by tactile-kinesthetic active inputs. This implies significant cultural mutations in our eagerly demanding societies. This paper proposes considerations on the cultural transformations revealed by interdisciplinary technological materials for innovation in design. Emphasizing the implications of technological materials for the creation and reception, rather than focusing on the technical state assertions as previously published studies have done. Along referring some examples of materials and their applications by designers, to finally register the answers that two designers posted to an interview.

2. Emerging Technologies on Cultural Transitions

Design is challenged by the fast advancements in technology and in science from where new processes, techniques, and materials arise. Through transfer of technology and easier access to emergent materials, these are causing design to acquire challenging paths, simultaneously in concept, form, and function. The integration of design, technology, and science, is not only providing that design has an indispensable function for the prosperity of individuals in society, but also that design may contribute to the development of science and technology, meaning that without borders between them, designers, technologists, and scientists may contaminate each other in pursuing vital ways for solving prevalent issues.

We can shape the things we use. With the advent of smart materials, the designed objects and surfaces are not inert outcomes but adaptable interfaces for communicative interactions.

Smart materials are the ones that sense and react to their environment through visual and tactile dynamic behaviors shifting reversibly in appearance or shape. In these materials may be included the piezoelectric, electrostrictive, magnetostrictive, elastorestrictive, electrorheological (fluids reacting to electric fields), magnetorheological (fluids reacting to magnetic fields), thermo-responsive, pH-sensitive, light-sensitive (ultraviolet), polymers, gels (hydrogels), catalysts, shape memory alloys [8]. A smart material is the one that has a molecular structure, is a composite, an assembly, or a system that responds in a particular and controlled way to influences upon it [11]. Described by Ritter [12] “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, [e.g. light, temperature, pressure, magnetic, or the application of an electrical field].”

Sustainable outcomes demand interplay between material developers and designers. After many tries on prototypes and material improvements, the challenges are in adequate the design concepts to reconcile the material capabilities and constraints. Working with new materials resources implies to do a series of iterative assessments for different possible combinations, pursuing an outcome that is able to insure preservation and durability. 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. Addington and Schodek [1] explain that, “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.” 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 [12] asserting that “the use of 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 on expensive energy sources and raw materials.”

These materials identify an era to which designers are not indifferent. Commonly an inherent inquisitive character implies that a designer is very attentive to critical issues that surround him or her. Technology-based design is representative of its 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 [1] asserted. 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 [1], 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 a molecular 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. Also, because of the trainability, as in case of shape-memory alloys and polymers they can have new memorized shapes. Because of the structural capacity, as in case of 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.

Materials acquire a behavioral reaction to their surroundings, directly communicating their states to their beholders. Activated through chemical, electrical, magnetic, optical, thermal, or mechanical stimulus depending on their properties, these responsive materials interact with the environment in which we intervene disobeying the conviction of the “hegemonic material as visual artefact” that Addington and Schodek [1] correspondingly claimed, defying our sensory perceptions to transformative material surfaces.

With the discovery of reversible behavior from combinations of materials long ago known [8], the materials became smarter with intrinsic characteristics able of adjusting to specific needs. As sensors and actuators become more advanced, accessible, sustainable, and affordable, and materials gain additional properties it permits the designers to explore innovative technologies. A consilient transferability of resources and techniques open channels and defy means for creative possibilities. The use of innovative materials taken from disparate disciplines challenge design development processes and procedures. Interdisciplinary technological materials forge interchangeable meanings derived from differing interpretative applicability of the means.

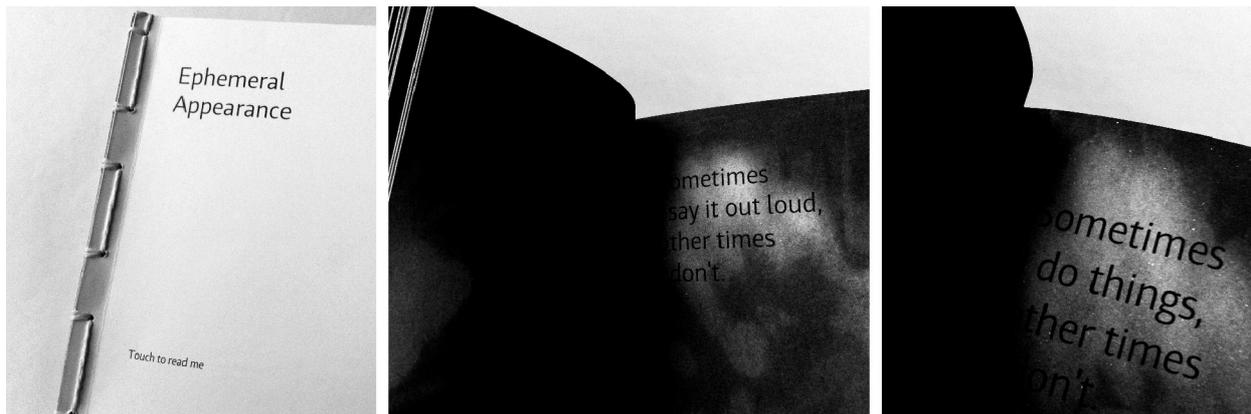
A few unusual composite materials have been arising, which prompt in designers the will to explore and expand playfully the accessible means and fabrication processes. Some examples of responsive materials are *conductive paint and ink* that can conduct electricity, spreading the application surfaces from metal, plastic, and

paper to the human skin. *Bare: Skin Safe Conductive Ink* [9], is a nontoxic and temporary conductive ink that can be applied directly onto the skin with a brush, stamp or spray. This material allows the creation of customized electronic circuits that can be interacted through movement, gesture, and touch, in a body unencumbered from wires. Bare is intuitive and non-invasive that allows the development of flexible and stretchable electronic circuitry. *Spray-on Fabric* [6] is a nonwoven fabric-like material comprised of a liquid suspension that is sprayed using a spray gun or an aerosol can. The nonwoven is formed by cross-linking fibers, which adhere to one another to create an innocuous material that allows the creation of an instant second skin directly on the body. Easily sprayed on to any surface, the wearer is able to customize a garment in infinite combinations of colors, shapes, sizes, and textures in varying degrees of thickness. With protective, healing, and stimulating properties, the material science innovations in smart fabrics incorporating nano-technology offer possibilities previously unimaginable, allowing instantly binding, lining, repairing, layering, covering and molding. Self-healing materials have the intrinsic ability to repair damage by use expanding their lifetime. *Electrotextiles* are conductive fabrics, threads and yarns that have the ability to be electrically conductive. *High Relief ink* is a substrate to which is applied a coating that when dried and subjected to temperatures between 120-130°C expands or inflates forming a high relief effect sensitive to touch. *Magnetic paint* is a water-based emulsion paint that contains a very fine iron powder allowing magnets to adhere to it. *Magnetic paper*, which is a polymer-based material with the thickness and flexibility of thin card, contains a magnetic medium that makes it stick to any ferrous surface. *Metal paper* is based on 0.02 millimeters gauge aluminum foil with a matt polymer coating both sides, hybridizing a feeling and behavior between metal, paper, and plastic. *Shape memory materials* are made of a compound of two or more metals or polymers able of changing reversibly their shape due to transitions in temperature. Mostly requiring an external actuator to return to their original shape because of the single-usable shape memory. These materials are malleable in cold phase and become stiff when hot, during the memory state. *Thermochromic inks and dyes* change color with temperature. Reached the transition temperature the color appears and disappears reversibly. The available variation of activation temperature can go from about -25°C to 70°C but the most sought are between 15°C and 31°C, which are being used to change the color of printed surfaces and dyed fabrics at above ambient temperature or upon people tactile inputs. *Photochromatic ink* is invisible under normal light conditions and appears reversibly by action of UV light source or sunlight. The *phosphorescent ink* is almost invisible under conventional light, but under the UV light or sunlight it has the ability to store energy. In the dark, after exposed to light for at least 30 minutes, this energy is liberated in the form of light lasting up to 8 hours. *Fluorescent pigments* have colors that seem to glow. The active ingredient is a dye that absorbs light (electromagnetic radiation) at one wavelength and emits it at a different wavelength producing a bright appearance. The *iridescent ink* or *pearl luster ink* changes its appearance displaying a rainbow effect when observed at different angles, or it goes from invisible to visible with a brightness effect depending on the incident light. The ink contains transparent pigments consisting of a thin film deposited on tiny mica flakes. Mostly conceived for security applications these materials are increasingly being used in printed graphic materials and designed products for embodied interactive surfaces. Opposing what some suppliers advertise, only the ones that are reversible and change back to their initial state are smart materials. With the irreversible ones, one can work with them smartly as Harvey [8] would suggest.

Different design conceptions have been asserting a cultural transition to dynamic behavioral surfaces prospecting a more engaging relational design. Some examples featuring materials that act as interfaces are *Linger A Little Longer*, from 2011, by Jay Watson [14], which is a black printed oak table and bench with thermochromic

ink that waives the use of coasters and alleviates the hassle of leaving marks on the surface. The table and bench respond to the heat of the tableware and body temperature with ephemeral traces of its use. *Metamorphosis*, from 2010, by Philips Design [11], 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 temperature rises. The image was printed with photochromic ink to become visible when exposed to UV light source or the sun. When the sunlight heats the cover surface the image appears and the text disappears, emphasizing the unpredictability and continuous change of natural elements. The cover stays unreadably blank if the ambient temperature is high and if there is not sunlight falling on the surface. *Alex Trochut. More is More*, from 2011, by Dani Navarro [10], is a retrospective book filled with personal and commercial work done by the typographer and illustrator Alex Trochut, with a cover printed with phosphorescent ink that displays a monogram in the dark. *Chronos Chromos Concrete*, from 2004, by Christopher Glaister, et al. [7], is industrial design engineered with an embedded system that is able to dynamically display graphics, text, and numbers through concrete surfaces. It uses thermochromic ink mixed with concrete and nickel chromium wires set beneath the concrete surface, which heat up when electric current passes through them. The area above the wires changes color when it reaches a transition temperature. Applied to home design products or large-scale architectural installations the composition of these wires beneath the concrete enable the display of customized information. *Zoe*, from 2012, by Laura Villasenin [13], are fashion brand Miista iridescent bright coated leather shoes complied with the iridescence and holographic trend emerging in fashion design for SS13 (Spring/Summer 2013) collections of clothing and accessories. The metallic futuristic look of the technological material conveys the playful sheening hue variation for a colorful season, which combines iridescent yarns, holographic foils, and metallic sequins to create dazzling effects and textured surfaces. *Design With Life*, from 2007, by Shi Yuan [15], includes 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 creates transforming inert passive artefact into life-like reactive environments that seem to sense the passing of time. *Not-So-White Walls*, from 2004, by Dario Buzzini [3], are interactive wallpaper design that apparently seeming plain surfaces are interfaces that act as displays. Printed with thermochromic ink, the back of each wallpaper is covered with a matrix of sensors, conductive materials, and resistors hooked up to a PC (Personal Computer) to allow showing low-resolution images and text messages. A physical interaction allows dimming lights, turning on home appliances, reading emails on the wall, or viewing pictures taken with a mobile phone camera. A version of the wallpaper acts as a barometer, changing color according to the level of humidity levels detected in the environment. *Pulp-Based Computing*, from 2007, by Marcelo Coelho, et al. [5] proposes building pervasive computing that behave, look, and feel like paper, combining traditional papermaking techniques, with smart materials, and printing. Developing electronic paper composites by embedding electroactive inks and conductive threads in the papermaking process to create sensors and actuators. Leveraging the physical and tactile qualities of paper while simultaneously conveying digital information. *Touch Me*, from 2005, by Zane Berzina [2], is a reactive wall covered with manifold stripes of thermochromic paint that changes color in response to body heat. People touch it and create patterns with their hands, which remain visible on the surface until it returns to ambient temperature. Interaction is all about how it makes people feel. To draw meaning from the content and experience an engaging substance, people desire to interact through unintrusive contextual technologies.

Combining poetry, craft and technology, I created *Ephemeral Appearance: Touch to read me*, which is an artist book in 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 people's tactile inputs or ambient temperature. The thermochromic ink used is a mixture of pigment in equal parts with a clear acrylic binder that is applied on paper by hand with a rubber roller. The binding is hand sewed inspired by the Japanese traditional method.



Sandra Coelho, *Ephemeral Appearance: Touch to read me*, 2013.

3. Overviewing Designers Experiences

Optimizing the creative utilization of smart materials is dependent of their contexts. Currently, not all smart materials conveniently respond to the designers' requests, but encouraging consilience and hybridizing procedural tasks one hopes that material developers and designers will produce outcomes that actively correspond to the demands and expectations.

In a request for an interview sent by email to several designers with the intention to have a practical overview of the experiences that designers have when using smart materials for their creations, their interpersonal work interactions among disparate fields, and what they know about people's acceptance, Isabel Lizardi, designer and co-creator of *Bare: Skin Safe Conductive Ink* [9] and Jay Watson, designer of *Linger A Little Longer* [14], kindly accepted to answer thoughtfully to a few questions.

When using smart materials, which challenges (conceptual, technical, or other) do you usually face?

Isabel Lizardi: As designers, there are two main barriers that we tend to encounter when working in the field of smart materials. On one end, the problem tends to be conceptual, and lies in the difficulty of getting people to understand an innovative or challenging proposition for how a material can be used by individuals or society. This can relate to totally new materials, or existing materials used in new contexts. On the other side there is the technical challenge, which lies in being taken seriously as an innovator in the field of material science. When coming from a design background rather than a material or chemical engineering background, it can be quite difficult to gain credibility in these industries.

Jay Watson: Technical issues are always important to resolve in the most efficient way as possible. In my experience managing clients expectations can also be important.

How do you manage to solve the issues that come with those challenges?

Isabel Lizardi: The conceptual challenge can really only be solved by providing clear examples that illustrate the proposed application. Through the years we have realized that the best way to make people understand a concept is by creating a physical or visual representation that people can interact with. The challenge here lies in not being too limiting or prescriptive when a concept is larger than one example, but what we find is that even one example is better than an idea that is too big to grasp. At least demonstrations provide a way to direct the conversation in a certain direction.

As for the credibility issue, the only real way to deal with this is to demonstrate a clear technical understanding of the technology. When we presented Bare Conductive Paint in highly technical or industrial circles, we had to learn to pitch the material in a different language so that it didn't come across as a design project, but rather as a solid technology that could be built into a range of specific applications.

Jay Watson: Research, experimentation and testing.

At what extent do you feel you have to compromise the design concept to adjust the material behavior?

Isabel Lizardi: Perhaps because our project was developed hand in hand as concept and material, this question is somewhat irrelevant to our particular story. In a way there is very little use to a concept if you can't make the technology match it, just as a technology is useless without a specific attribute that can be exploited. I think this is oftentimes what differentiates design projects from real-world applications. Sometimes it is the material development, which needs to be compromised for the concept.

A perfect example is our own material. When we were students we started our project envisioning a skin-safe conductive paint, but upon presenting this material and concept to the world, discovered that the real demand lay in the value of the paint as a non-toxic material, rather than a cosmetic one. Some people think our concept was compromised by the material's chemistry, but it was actually that the stronger concept was not what we'd originally envisioned, so the material had to change to match the better concept.

Jay Watson: Without materials we are left with only concepts. Most of my concepts are material or process led.

In what ways do you think that smart materials can add to the design concept?

Jay Watson: Smart materials provide function.

Do you usually engage in scientific or technical lab residencies to collaboratively develop design products?

Isabel Lizardi: A lot of our work focuses on building a community of users and makers that are engaged with our technology and curious to generate and discover more applications for the material. Because of this we find that collaborations tend to come to us via people who are using our paint in interesting ways, or proposing new interesting applications. When people make great projects with the paint we reach out to them and help them develop these further as best we can.

What do you take from the other scientific and technological disciplines?

Isabel Lizardi: We make a point of constantly engaging experts in as wide a range of fields as possible as we believe that this is a great way to discover more uses or ways of thinking of the material. Whether it's through conversations or collaborations, we make sure to listen to how people in other fields are thinking of the material so that we can keep all this knowledge and use it to our development.

In what ways do you feel that your creative skills contribute?

Isabel Lizardi: I think that our design background is most useful in understanding the context of how our material will be used and understood in the world. Although it may sound strange, developing a material is the easy part. If you don't understand exactly where the material will add value, or how people looking for it as a solution will find, or use it, then the material can exist for years without ever being taken up by the market. I think as a material developer, the key is in showing people how they can use a material, and giving them the tools to do so. Otherwise they may never be bold enough to try it out.

Jay Watson: Every designer connects the dots in different ways some even dare to discover new dots.

And when (in the procedural stages) do you feel that your creative skills contribute?

Isabel Lizardi: I don't think there is a single stage at which they don't. Creativity can be found in the way spreadsheets are laid out to output information in the most effective way. It lives in the research and brainstorming stages as much as it does in the stock management, product development, branding, and sales. Creativity isn't about design or art, but about the range of ways you can imagine using the tools at your disposal for any given objective.

Jay Watson: Whenever you are doing something you've not done before.

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. What is your opinion on this subject?

Isabel Lizardi: Although I think there is incredible potential in smart materials being used for specific applications in order to reduce waste, or take economy of resources into account. I think thinking of them as the end-all solution is somewhat naive. Currently most smart materials of this sort are incredibly expensive or difficult to manufacture, and it will take a long time for them to reach a stage at which they can begin to replace existing means — however unsustainable these may be.

I think the danger in thinking of this as the solution in the short run is that a smart material is only as good as the context it lives in. There are many materials that have been developed to degrade in an environmentally friendly way, but the developers behind them have not taken into account the realities in which these materials will be used. Oftentimes this means that the materials don't actually behave as they were designed for because the context they're being used for isn't appropriate.

Jay Watson: That would depend on the smart material concerned and the application. I wouldn't take that as granted.

In your experience, how do consumers perceive new products that make use of these emergent technologies?

Isabel Lizardi: I think consumers are eager and excited to embrace technologies that they understand to be better engineered for their life-cycles. I think that if it exists, resistance from the market is probably due to disenchantment linked to the realization that the materials aren't actually fulfilling their potential because of the limitations in the system.

Jay Watson: It is difficult to say, as the consumer doesn't usually have the same points of reference. I have found managing expectations important.

How can designers create products so that consumers will evaluate them positively?

Isabel Lizardi: When developing new materials designers need to carefully consider the whole life-cycle of the product these live in, and make sure that there is a system in place that will allow users' journey to be as simple as the one they are currently accustomed to. It is very few people who are willing to change their lifestyle for the sake of a product or cause, therefore sustainably-minded enterprises need to be designed to fit into peoples existing expectations.

I think a big mistake that designers make when developing these processes is that they think of their market as "consumers" when actually materials' and products' life-cycles involve many stages before and after the user. To be a true success, materials have to be developed thinking about the people manufacturing, packaging, shipping, purchasing, using, disposing, and disassembling them. Serious resistance in any one of these areas could mean product failure.

Jay Watson: Design with the consumer in mind and ensure it performs as they expect it should.

With the advent of smart materials, the designed objects and surfaces are not inert outcomes but adaptable interfaces for communicative interactions. How do you envision the near future?

Isabel Lizardi: I think interactivity and information will exist all around us, allowing us to engage with the world in a far more specific context than we have up to this point. I think the interesting thing will be to see all the niches that arise and what people decide to monitor or track via all the available information. I imagine the range of interests and specificity of information that people are attuned to has the potential to diversify dramatically.

Jay Watson: Given the current economic situation and peoples naturally conservative nature, not much different to now. I think most smart materials will be incorporated into mundane everyday items, for which they will provide extended or improved function.

4. Prospecting an Engaging Relational Design

Design defies contemporary social and cultural dispositions, and developmental state of its means and mediums. By converging differing disciplinary materials, a growing consilience contribute to design innovation and reciprocally to technological and material innovation. Prospective innovation in design is in connecting familiar things with innovative materials that are technologically silent, smooth, and almost invisible. Because technology should not ever get in the way, smart materials are capable of acting effectively and unintrusively, balancing harmoniously an intuitive event and its consequent effect on the beholder. The use of smart materials may provide a subtle presence, seamlessly embedded in surfaces and objects. Smart materials confer to design a dynamic tangibility, which provides renewed tactile-kinesthetic interactions. By using smart materials, the means for design production become tangibly active as materials acquire physical behavior. New technological materials are active and participative. Conventional materials incorporate new technologies disrupting traditional uses. By combining materials and technology for enhanced sensibility and enriched sensory experiences, the transposition of emerging technologies into traditional materials are prompting design to face new and exciting possibilities.

Natively immaterial, the digital is being increasingly blended with material structures. Combining tradition and technology for reinvented concepts, forms, and functions, the renewed materials creatively hybridize analogue with digital metaphors. Metamorphosing from one state into another, the emergent technological materials provide

organic kinetic behavior that is evolutive and shape changing, carrying biodynamic features of synthetic methods that mimic biomechanical processes informed by biology.

Objects and spaces adjusted to somatic behaviors are able of providing sensorially enhanced experiences. As briefly referred by Coelho and Maes [4] “looking at body language, gestures and our human interactions, objects and spaces can learn to adapt to their different conditions of use and respond with just-in-time affordances”. Brought from consilient proveniences the reinterpreted means translate the immediacy for adaptable interfaces with clear interaction affordances that provide straightforward gestural controls. People desire specificity and fluidity with effective and affective resonance.

In a world pervasively digital with manifold interactions, people are increasingly expecting immediate and fulfilling replies to their inputs. As people got used to interact with *on-the-go* interfaces, designers are defied to look for the dynamics of engaging relational interactions for everyday designed objects and environments. Responsive materials imply procedural challenges where “the design choices lie in picking the right computational metaphors and parametric delineation which physically describe and encode an object’s intelligence in its materials and mechanics” as Coelho and Maes stressed [4]. Emphasizing the behavior of means, behavioral design creates physically adaptable interfaces. Behavioral design is not only focused on broaden people’s behavior but also in creating the objects and spaces that help them do it.

Overcoming the lack of material and physical expressiveness, the behavioral responsive materials with their inherent properties will transform interfaces dramatically. By joining design, engineering, science, and biotechnology, the computational devices will soon have an organic shape, demanding new ways of interaction and new approaches between body and shape changing devices. The device will change its physical interface, sensing and responding accordingly to real time physical inputs. Organic user interfaces will transform the way we use computers. Adding dynamic responses to our physical inputs change radically our interactions with computational devices. The changing corporeality of things will give us a clear state of their conditions, which will boost new relational possibilities. 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, while our everyday digital devices become increasingly complex, smaller, less obtrusive, and with minor technological appearance. The technological devices will have distinct physical appearance from today, as they will be everywhere, in any material or surface, flexible or rigid, liquid or solid. Electronic components will be assembled and embedded in the most disparate traditional materials (paper, fabric, plastic, ceramic, glass, concrete, fluids), providing a variety of different and endless textural possibilities for tactility. Kinetically adapting to wear, use and context, our lifeless everyday objects will soon become lively interfaces for interactions, demanding new physical relations, and changing our body behavior. As touch suggests variations between activity and passivity, renewed perceptual means will give rise to interplay between subject and object.

Unusual substrate combinations will prompt new behavioral composite materials that seamlessly juxtapose input and output systems. Flowing interchangeably between information acquired and displayed that favor rapport of a corporeal interface that is consistent with the surrounding space. Translated into a hardware simplification that harmoniously connects us to the real world. Natural expressiveness and connectivity come directly from the simplicity of dedicated features that smoothly provides us unbroken perceptions. As sensors and actuators

technologies evolve, progressively being integrated into the environment and into our body, new references, directions, meanings and implications arise to human-computer interactive communications.

New forms of individualized interactions emerge reinforcing that designers have to create with the people rather than for the people. Listening carefully interpreting and managing people's expectations and paying attention to the behavioral hints that are brought to designers non-verbally by the users. Focusing in enhancing relational interactions prioritizing experiences over technological means. Design does not just follow the change, but allied in consilience, design directs the turn to more human centered technological interfaces.

5. Acknowledgments

To artist and curator Dr. Patricia Flanagan for exhibiting the book *Ephemeral Appearance: Touch to read me*, from May 27 to June 6, on the Haptic InterFace pop-up exhibition, at Vivid Sydney 2013, Australia.

To designers Isabel Lizardi and Jay Watson for their availability answering the questions of the interview.

To Fundação para a Ciência e a Tecnologia (FCT) of Portuguese Ministério da Educação e Ciência (MEC) for funding this research (SFRH/BD/33952/2009) through the UTAustin–Portugal partnership for the joint Doctoral Program in Digital Media by Universidade do Porto (U.Porto) and Universidade Nova de Lisboa (UNL)

6. References

- [1] Addington, M., and Schodek, D. (2005) *Smart Materials and New Technologies: For the Architecture and Design Professions*, Architectural Press, London
- [2] Berzina, Z. (2005) *Touch Me* [Online Portfolio]. Available at <http://www.zaneberzina.com/touchme.htm> [Accessed 12 March 2013]
- [3] Buzzini, D. (2004) *Not-So-White Walls* in 4dspace: Interactive Architecture. Helen Castle and Lucy Bullivant (Eds.). AD- Interactive Architecture (Architectural Design), vol. 75, no. 1, John Wiley & Sons Ltd., UK
- [4] Coelho, M. and Maes, P. (2008) *Responsive Materials in the Design of Adaptive Objects and Spaces*, in the Interactive and Adaptive Furniture Workshop. Aarhus, Denmark
- [5] Coelho, M., Hall, L., Berzowska, J., and Maes, P. (2007) *Pulp-Based Computing: A Framework for Building Computers Out of Paper*, In Proceedings of Ubicomp 2007
- [6] Fabrican (2000) *Spray-on Fabric* [Online Post]. Available at <http://www.fabricanltd.com> [Accessed 15 March 2013]
- [7] Glaister, C., Mehin, A., and Rosen, T. (2004) *Chronos Chromos Concrete* [Online Post]. Available at <http://www.innovation.rca.ac.uk/718/all/1/Chronos-Chromos-Concrete.aspx> [Accessed 11 March 2013]
- [8] Harvey, J. A. (2002) *Smart Materials*, In Handbook of Materials Selection, Myer Kutz (Ed.). John Wiley & Sons, Inc., New York
- [9] Johnson, M., Lizardi, I., Pilditch, B., and Nelson, B. (2009) *Bare: Skin Safe Conductive Ink* [Online Archive]. Available at <http://www.rca.ac.uk/Default.aspx?ContentID=505478&CategoryID=36646> [Accessed 15 March 2013]
- [10] Navarro, D. (2011) *Alex Trochut. More is More* [Online Portfolio]. Available at <http://www.forma.co/es/alex-trochut-more-is-more> [Accessed 11 March 2013]
- [11] Philips Design (2010) *Metamorphosis* [Online Blog Post]. Available at <http://designprobes.ning.com/profiles/blogs/transforming-book-cover> [Accessed 11 March 2013]

- [12] Ritter, Alex (2006) *Smart Materials in Architecture: Interior Architecture and Design*. Basel, CH: Birkhauser Verlag AG
- [13] Villasenin, L. (2012) Zoe [Online Shop]. Available at <http://miista.com/shop/zoe-iridescent-silver> [Accessed 11 March 2013]
- [14] Watson, J. (2011) *Linger A Little Longer* [Online Portfolio]. Available at <http://www.jaywatsondesign.com/portfolio/furniture/linger-little-longer> [Accessed 6 March 2013]
- [15] Yuan, S. (2007) *Design With Life* [Online Portfolio]. Available at <http://www.yatzer.com/Design-with-life-Shi-Yuan> [Accessed 12 March 2013]