



## **Interactive Media as Fields of Transduction**

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## FCJ-124 Interactive Environments as Fields of Transduction

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### Introduction

Digital and interactive technologies have evolved dramatically as the traditional desktop computer has given way to ubiquitous computation. Computation is now an integrated part of many people's everyday lives, a question of experience more than simple use, as John McCarthy and Peter Wright have argued in their seminal book on the subject *Technology as Experience*. Yet while all this might be a simple given, accounting for and working with the reality of newer interactive technologies is less straightforward. Ubiquitous computation provides a digital layer that can be added to almost anything, offering radically new contexts of use and technological possibilities (McCullough, 2004). This changes the way one can—and must—imagine the design of digital and interactive technologies. Design is often now for what Terry Winograd has termed 'interspaces', in a move away from more traditional screen-based interfaces (Winograd, 1997: 161). In addition, design for living with ubiquitous digital technologies needs to consider the experiential qualities that come into play in interactive environments. This will be the central concern of this article. The exploration of experience in this context has so far been based on a wide range of humanist and artistic theoretical foundations and projects that supplement the existing vocabulary used in interaction design (see Dourish, 2001; McCarthy and Wright, 2004 and 2010; Petersen et. al, 2004). Here we will draw on the work of French philosopher Gilbert Simondon to add a different perspective to the exploration of experience of interaction design within interactive environments.

Many approaches that address the significant changes shaping the relations between humans and technology tend to leave these two domains apart. For these approaches, technologies might become ubiquitous, and ever more subtle in their presence and effects, but they remain separate to human experience. In this article, however, we explore a way of thinking the design of interactive environments that blurs the clear difference between human experience and its technological milieu. We reframe design thinking via Simondon's thought. Simondon's concepts allow us to outline a mode of thinking and practicing interaction design that begins to break away from the binary logics of man and machine.

At the same time, we need to emphasise that contemporary design might balance this new approach with established approaches. Essentially, we are content with an antimony—a necessary contradiction between partial perspectives (see Gil, 1998:5)—within the contemporary moment of interaction design. In this article we underline the creative shift that Simondon allows us to propose within design. Yet we also understand the need to continue to work with some of what remains of the divide between human and technology, even as we overcome this divide. For us, this has two very practical reasons. First, we need to take into account the actual design and design assumptions that are currently part of designed experience. Second, the binary assumptions in current debates on the design of interactive technologies can be very productive, even for our breaking away from them. In sum, we conceive of the human-technology binary as a stimulating problem from which to propose potential transformations of design practices.

In fact, interaction design is an intrinsically open discipline. There is, within interaction design, a growing interest in developing a philosophical understanding of, and a vocabulary to describe, interactive environments' shaping of our lives in experiential terms. Here we mobilise Simondon's concepts of individuation, in-formation, the preindividual, and the associated milieu in the context of interaction design. Simondon helps us to think of designing interaction in terms of process and becoming rather than product and being. We conceive of this as designing for the dynamics between fields of transduction and fields of experience. Fields of transduction and experience are overlapping parts of each event. They offer particular conditions of emergence that are relationally dependent but not predetermined. We turn to Simondon because we believe his ideas enable lines of thought that work on the level of emergence and immanence within these fields. Such ideas allow us to consider interactive technologies as metastable—as in continuous negotiation with their environments. Simondon's theory of individuation also offers a way to think about the relation between humans and technology without pre-determining either of their capacities for the creation of interactive experiences (see among others Adrian Mackenzie, 2002; Isabelle Stengers 2002 and 2004; Brian Massumi, 2002, 2008 and 2009; and Erin Manning, 2009).

As Adrian Mackenzie has underlined, however, the thought of transductive processes must itself be transductive (Mackenzie, 2002: 18). This calls for a theoretical approach that incorporates the processual dynamics of the object of study; an approach that in itself creates new fields of potentials, new experiences and relations. It is this modality of transduction that we deem most important in the context of interaction design. At the same time as, in our thinking about design, and our design practice, we generate transductive materials and events, these materials and events weave themselves back into our thinking and design practice. The result is something like an eventful or processual “thinking-design”. How do we account for the transductive nature of each interactive environment and simultaneously consider the transformation of our own thinking by such environments?

In this article, we propose two interrelating trajectories by which to negotiate the ways in which Simondon can be used to enable new processes of thought in and with interaction design.

The first trajectory involves a theoretical mobilisation of a range of Simondonian concepts, framed by an overarching interest in uncovering processual richness and complexity. Based on the tension between expression and experience, we use the foundations of Simondonian thinking to propose an analytic understanding of interactive environments in terms of the fields of transduction and fields of experience they produce. This moves the emphasis of the analysis from preformed and predetermined entities to processual conditions, and to the emergence of relations. These processual and relational conditions of emergence are best defined by Simondon’s concept of the associated milieu. This concept allows for a re-thinking of the relation between man and machine/technology, where neither should become a blueprint for the crafting of the other. Following Erin Manning, we argue for an experimental approach to interaction design, now understood as a form of technogenetic emergence. In the final section we show how this kind of technogenetic experimentation must always be effectuated within the preindividual and affective aspects of experience.

The second trajectory presents two examples that shed light on how fields of transduction and experience arise. We consider first Rafael Lozano-Hemmer’s piece *Voz Alta* from 2008 ([http://www.lozano-hemmer.com/voz\\_alta.php](http://www.lozano-hemmer.com/voz_alta.php)). Here we will investigate the different layers of interaction and expression in a large scale urban installation, one affectively charged with the event of the 1968 student massacre in Tlatelolco, Mexico City. The second project considered is the interactive installation the *Impossible Room*, developed by the authors as a proof of concept as part of the *SenseStage* workshop at Concordia University, Montreal in 2009. The *Impossible Room* experiments with bodily and affective capacitations for interaction as these co-emerge with an interactive system. The installation interlaces fields of transduction and fields of experience. It does so via the relations between an algorithmic and dynamic sensor

system for interaction on the one hand, and embodied spatio-temporal experience on the other, all within a space that appears impossible to navigate.

Finally, we outline directions for future experimentation with a Simondonian approach to interaction design.

## Mobilising Simondon: Fields of Transduction, Fields of Experience

To mobilise Simondon's concepts within interaction design is a challenging endeavor. Each concept in Simondon's theory of individuation is accompanied by an entire swarm of conjunctive concepts. In the following section we will outline the main Simondonian concepts that nurture our own conception of interactive environments as fields of transduction.

Two aspects of interaction are crucial to the conceptual adventures that will follow: expression and experience. Expression is that intensive force, or affective shock, which strikes the body first, before any ordering of that force can emerge as content (Masumi, 2002a: xvii). Expression therefore defines the event of affective tendencies at the verge of actualisation. It stretches affect into an actual occasion. Yet affect and expression are to a certain extent autonomous with regard to the actual occasion. In their autonomy they function as attractors via which an event may engage with an embodied experience. As autonomous, affect and expression are forces of generative relation in the constitution of an event. Their autonomy provides the necessary freedom for an event to evolve as novel and not predetermined. The generative relation involved comes before any differentiation into subjects and objects.

To address the relational layer of an event, before it is unfolded into subjects and objects or humans and technology, we use the notion of a field. Here we discuss both fields of experience and fields of transduction. Fields of experience describe embodied experience: sensations and perceptions. What we call experience might be better understood through William James' concept of pure experience. Pure experience indicates a plain unqualified actuality, 'as yet undifferentiated into thing and thought' (James, 1904/2003: 39). When we navigate through the conceptual landscape of Simondon's theory of individuation then we always do so to address modes of expression and experience in their very coming-into-presence, and as zones of openness for experimentation.[1] Fields of transduction are the relational

meshes through which events that arise between humans and interactive technologies come into presence. Transduction names the very process of interlacing physical, vital, mental and collective strata as part of each individuation within which experience in turn emerges. Interaction is seen here as part of the processes of transductive individuation. These occur interstitially. Thus, although as always we have to consider processes of interaction with respect to what an interactive environment can do, we need to do so in a way that emphasizes the interstitial fields within which expression and experience emerge. Deleuze points out in his lecture on Spinoza: “[When w]e define things by what they can do, it opens up forms of experimentation’ (Deleuze, 1980). In this article, we are interested in further opening up those forms of experimentation.

## Individuation and Ontogenesis

The concept of a field enables us to discuss both potential tendencies in their incipience and processes of actualisation in their effects. Both are part and parcel of each individuation which is the central focus of Simondon’s work. Individuation is the very process of becoming of an individual. Although the term individual might be misleading. Simondon attributes the status of “individuality” to every process of expression, seen as a becoming, yet there is no essential individual as it is sometimes conceived. On the one hand, the process of individuation precedes any individual. On the other hand, each “individual” is an open-ended construct of transductive (as well as affective and expressive) forces. In short, individuals are processes of ongoing individuation. According to Simondon, individuation is the very motor of existence, an “existence” which becomes constant perpetuation and transformation. Each individuation is marked out by the various tendencies it holds in play, in relation to the environment or “milieu” in which it individuates. Each individuation is not only in flux but relies on a collective unfolding with its material and immaterial environment. In the case of interactive environments, individuation happens across all layers, from digital materials and processes and the sensing human subject to processes of thought.

In developing a theory of individuation, Simondon introduces a shift in the way things (subjects and objects) are understood to come into presence and endure. Individuation foregrounds process over products or fixed entities. It fosters becoming over being. Simondon underlines this point by conceiving of his overall mode of investigation as ontogenetic (Simondon, 2005: 23). Different from an ontology primarily concerned with ‘being,’ ontogenesis accounts for becoming. It conceives of individuation as a perpetual process of forces negotiating their future composition. Considered from this point of view, the notion of interaction undergoes a crucial transformation. Interaction is not a mere connection between pre-determined states of affairs. It is the process of relations producing individuations, as they

individuate. The produced individuations (and the terms with which we come to understand them) only endure as long as the relations hold them. Considering interaction as a relational concept in this way allows us to ask: how can one compose relations that open up experimentation within fields of experience?

According to Simondon technical objects (among others) are continually individuating through processes of transduction. Transduction is the “mechanism” driving individuation. One way it can be understood is as any transfer of information across an interstitial field, in which it becomes a kind of propagation. The concept denotes a process ‘... – be it physical, mental or social – in which an activity gradually sets itself in motion, propagating within a given area, through a structuring of the different zones of the area over which it operates’ (Simondon, 1992: 313). Transductive processes are individuations in progress. Transduction—with its ongoing transformation and gathering together of forces—therefore operates at the level of becoming. These processes unfold as relational events that create new conditions of becoming and generate ‘novelty’. Simondon’s transductive conception of becoming describes the motor that allows different registers of being or becoming, namely the physical, vital, mental and collective, to generate relational events conjunctively.[2] It enables forces to become relational, to constitute an event of experience. The interplay between transduction and experience is what makes each interactive environment at the same time physically, vitally and mentally intertwined. This is what, in this article, we describe as the intersection of fields of transduction and experience. There is perhaps further complication in addressing these fields. To address processes of transduction in the design of interactive technologies often means addressing the very forces that lead to experience before they individuate.

## In-formation and the Preindividual.

The concept of information is key for Simondon’s understanding of processes of individuation as transductive and ontogenetic. Yet information in this context is understood very differently to the “content of transmissions between sender and receiver”, as it is well known in traditional communication models. The notion of information here can be better understood as in-formation; the coming-into-form or a certain structuring of a prior state of disparity. According to Simondon, the process of individuation is a process of dephasing (*déphaser*) from a phaseless state of potential, that is, the preindividual (Simondon, 2005: 25). If individuation is a process of becoming, this is becoming as dephasing, which involves the contraction of disparate tendencies and potentials into an individuation. To allow disparate potentialities to actualise relationally, in-formation is required. In-formation is precisely that which provides a process of dephasing to happen conjointly between different tendencies. Rather than the content of a transmission between pre-defined terms, such as sender and receiver, in-forma-

tion emerges at the moment when an individuation appears out of disparate fields of potentials. The emergence of in-formation is therefore a crucial aspect of individuation.

In-formation is not predefined but it nevertheless constitutes a field for resolution from disparate tendencies, taken up here as a constructive problem. This problem-resolution dynamic is of course perpetual. Or, one could say that a logic of perpetual resolution requires a primordial disparity. Problems are necessary. It is this primordial disparity that Simondon calls the preindividual—his term for the state of disparity from which a dephasing as individuation unfolds. If there are overall processes within this primordial disparity, for the resolution of problems, that is, the beginnings of processes of individuation, these are perhaps what we call fields of transduction. The transductive nature of individuation can allow the processes of individuation to traverse entire fields, ranging from matter, to vital beings, to abstract thought, in order to yield multiple resolutions. In these transductive fields, in-formation functions as the shock of expression when disparate tendencies contract into actuality. At the same time, in-formation provides an excess of the actual event that feeds back into the realm of the preindividual, thus allowing for novelty within both the preindividual and more general fields of transduction. Throughout all this, in-formation, due to its immediate character, cannot be predefined. However, it might be able to be carefully orchestrated in larger processes of individuation.

Let us sum up the recent points. The preindividual as a concept has a particular function in relation to individuation. The preindividual is that field from which an initial problem takes off. By problem we have to understand a creative force that generates an individuating process. An individuation is the seeking for and attempt at resolution of that problem. [3] Another way to think of this is to imagine the preindividual as a charged and tensed field that is able to produce new individuations from past and present events. It does this by drawing a potential future into the present. The preindividual facilitates the potential of a future becoming (it gives events a durational quality) and this allows individuations to become, transductively. The preindividual level of experience is the potential and not yet actualised part of each particular individuation. At the same time, the preindividual itself maintains its autonomy. This allows it in a sense to push and pull an individuation to seek a resolution, and to yield a new problematic attached to that resolution that is “given back” to the preindividual. In all this, the crucial aspect of the preindividual is its capacity to generate collective individuations. As Simondon points out, the preindividual being, as a complete being, is always more than one (more than unity) (Simondon, 1992: 312). An individuation that transduces more than one individual is collective. So all individuation is collective. For this collective individuation to emerge the preindividual tension has to express a certain force.



## Affect and the Associated Milieu

The force that makes individuations evolve collectively and endure can be named affect. As Simondon points out, 'it is affectivity that expresses a preindividual charge in a becoming and supports the collective individuation' (Simondon, 2005: 252). At this point we can direct attention to the perceiving and experiencing body as that through which certain individuations become collectively through affective forces. However, if a collective facilitated by a preindividual becomes affectively, this changes our concept of the body. The body can never be a simple containment. It is instead an open system allowing collective individuations the potential to happen. The same applies to technology, as itself a kind of series of perceiving and experiencing "bodies" which are never entirely exterior to other bodies. If each engagement with technology (and bodies) is affective, this means that each engagement creates individuating collectives of various kinds. Interaction design, as the engagement between technology and bodies, therefore has to question which levels of a collective individuation might be of importance when it comes to yielding an enhanced notion of experience. Yet this has to be qualified perhaps, as this is not a question merely of an experience that can be predetermined but of a pure experience, where affect and the transductive field of a collective individuation become sensible. In interaction design terms, for each actualisation there is a particular collective set of affordances that allow for the event to exist, although via Simondon we have rethought the nature of affordances, events and existence.

As the dephasing of a preindividual field, an actualisation always produces more than an individual (even this individual in its potential is expressed through excess—its preindividual charge). Or, seen from another perspective, an actualisation always also produces an associated milieu, in relation to the individuation. The associated milieu is that dense zone of potential, which shifts with each becoming of the individual. The relation between associated milieu and individuation always emerges from the middle of events. In their relational bond, individual and associated milieu define the intensive zone of interplay between transduction and experience. The preindividual is a third factor, immanent to each individuation and its associated milieu. With the notion of the associated milieu we now can approach more clearly the particularity of the complex nexus between preindividual, transduction/information and individuation.

Following Simondon, we have to consider experimental environments for interaction with digital technologies as always transductively co-emerging with the process of interaction itself. This can greatly contribute to the design of interactive technologies. If we conceive of interactive technologies as fields of transduction that relate to fields of experience through shared associated milieus, the emphasis shifts away from designing controlled environments and interactions. Instead, there is an opening towards radically experimenting with the way

we might live and co-evolve with technological assemblages. This changes the very conception of experience within interaction design. A Simondonian theory of interaction design would be concerned with unfolding the idea of these technological assemblages and associated milieus. Both would be understood as transductively emergent phenomena, at the same time conditioning and constructed through the interaction. Interaction in its turn must be considered in terms of processes of individuation unfolding as an experiential field in relation to particular fields of transduction. These fields emerge through the interaction and cannot be pre-determined by either system or user.

## Technical Objects, Invention and Affective Engagement

Mobilising Simondon in relation to the design of open interactive environments is particularly interesting due to the rich, isomorphic vocabulary proposed to describe the relations between humans and technology. These concepts go beyond describing technology as finalised machines. Instead, they focus on the relations that emerge from the transductive encounters between technical elements and their socio-cultural milieu.[4] This allows for an understanding and description of interactive environments in open-ended and processual terms. Further, it goes beyond a focus on whether a given design should be built in the image of either man or machine, cutting directly through discussions of usability and user-friendliness in present day interaction design. According to Simondon's thought, interaction design should be neither human- nor machine-centered but transductive, challenging how an interactive experience might become.

One of the central claims made by Simondon is that it is not possible to constitute a symmetrical relation between man and the technical being. This would be devastating to both the values of the individual and those of the technical being (Simondon, 2005: p. 519). In Simondonian terms technology is more than prosthesis, more than a tool, and man is more than a cog wheel in the technologically crafted system. The relation between man and machine functions as a double assimilation and has a real value of being (*valeur d'être*) (Simondon, 2005: 521). Man is completed by the machine, and the machine finds unity in its relation to man: man and machine are mutually in-forming each other. Yet this double participation or relation is a chiasm between two universes that stay separated. In other words, man and machine are not separable in the relations they maintain but at the same time they have distinct modes of entering and leaving a relation. An individuation, for instance an interactive media art installation, only happens in the moment where the interaction-as-individuation takes place. Such interaction has little to do with cyborg phantasies since, according to Simondon, not only is the human body permeated by the machine but the machine is permeated by the human body. Further, Simondon argues that if man has ultimately created

machines, this is to develop and produce new relations (Simondon, 2005: 522). It is in this sense that we have to account for Simondon's insistence on regarding human-machine relations as their own mode of individuation.

Neither the human nor the machine preexist their particular expressions on the plane of experience. They both individuate conjunctively (in an individuation). The environmental conditions in the form of associated milieus are part of the individuation of technical objects, which is the condition for technical progress. In other words, the individuation is '... made possible by recurrent causality in an environment that the technical being creates around itself' (Simondon, 2007: 207). Of course, the invention of technical beings is not only a question of the man-made. Neither should it be seen as the invention of a fully determined and closed system. Brian Massumi has argued that the invention of technical beings is to a large extent self-conditioning emergence (see Massumi, 2009: 40). In this self-conditioning emergence, the associated milieu does not only provide the environment for a technical being to become in conjunction with a subject; the subject itself also co-constitutes the associated milieu through its actions. Or rather the technical being and the subject both co-emerge together in the process of invention. Invention here then is defined as the self-conditioning emergence of novelty, cutting transductively across the individual and its associated milieu. An invention is an act of a widening of potential in the realm of experience. As such, interactive environments might enable a transductive field for inventive creation involving both technologies and experience.

With a renewed concept of interaction as a relational force we can reconsider the question: through which kinds of individual-milieu couples might novel experiences emerge? By 'novel' experiences we mean embodied states that challenge the habitual modes of perception and sensation of our environment—in other words, a widening of the scope of what a body can do. Interaction design is here reconceived. It is not only a practice interrelating technologies ready to be encountered by human perception but also a potential technique to make fields of transduction felt on the plane of experience. Such interactive experiences always happen at the threshold of, or in the interstice between, affect (potential) and emotion (effect).

In Simondonian philosophy, technical individuation is conjunctive with psychological individuation. According to Simondon, affectivity and emotivity are the utmost transductive forms of the psychic individual. Affectivity is what relates the preindividual to the individual (the actualised) through transductive charges, that is, in-formation (Simondon 2005: 252). Here Simondon has a rather particular conception of affect: affect is the preindividual capacitation of an emotion to be captured in experience. On the other hand, theorists like Brian Massumi stress the importance of affect as the potential (read: virtual) capacitation and intensive charge in an event of experience itself. For both Massumi and Simondon however,

if in their different ways, affect is necessary for any event to be experienced and endured. We can perhaps sum this up by suggesting that it is only by means of affect that we are able to relate to other individuals through felt intensities—often at the cusp of becoming emotion (where emotion is already individualised affective force, see Massumi 2002: 61).

It is through affective capacitations that a relational event of experience can conjointly emerge with a field of transduction. As shown above, an individual always individuates co-extensively with its associated milieu. This double-mode of becoming enables in-formation to give an event a certain outline without exhausting or determining the event's potential for future becomings. If emotion is, as Massumi argues, 'a recognised affect,' then it provides an actualisation with a charge that can be captured experientially (Massumi, 2002: 61). Importantly, such an individualised event of experience still maintains its transductive nature. It re-potentialises the event, opening it up onto its relation to the preindividual plane of potentiality. Interaction considered as the relation between technologies and human beings as pre-defined entities would not allow for a re-potentialisation of the interactive event. However, interaction understood through the notion of affect not only allows us to consider the transductive nature of any individual-milieu couple as open-ended and emergent. This also allows us to consider the drawing into experience of a sense for future (not yet actualised) becomings. Interaction design is constantly concerned with the question of how to create environments for future unactualised becomings. Yet interaction needs to function affectively to enter the zone of the interstice between transduction and experience which has been discussed in this article.

In sum, affectivity and emotivity are both necessary for an experience to actualise and open onto preindividual potentialities. We could add that affect, as well as the preindividual, do not come before emotion and experience (i.e. action) but are immanent to them.

## Designing Interaction as Technogenesis

We have outlined the importance of affect and emotion in the event of experience for our general argument concerning interactive environments as fields of transduction. Affectivity and emotivity are the 'transductive forms par excellence' of the psychic individual precisely because they both maintain the necessary tension between expression through experience and re-potentialisation through in-formation (Simondon, 2005: 247). We have also argued that a Simondonian take on interaction design would be concerned with thinking the design of interactive environments as transductive. This means we have to conceptualise the prein-

dividual as enabling affective and experiential interactions via the relations emerging in technological assemblages and associated milieus. In sum, a Simondonian approach necessitates thinking affectively about interaction design. In this article we have suggested that this means emphasising the interdependence between transduction and experience.

One way of thinking about interaction design in this way is to give accounts of interactive environments that allow for the complexity of technologies' capacity to engage people affectively and create particular experiential fields. To work with affective engagements is to foreground a mode of interaction in which experience becomes the zone where transductive forces are felt in embodied states of perception. Again, neither the human nor the enabling technology can be understood separately in these affective and transductive assemblages. Conceived as an individual-milieu couple, interaction always requires a relational thinking in order for the primordial emergence of any experience to be rendered palpable. If one considers the process of design as partly self-conditioning emergence, one has to orchestrate events of interaction to the extent that interaction becomes an event yielding novel experiences—through an attentiveness to the affective engagement of an experience.

The question of how to account for and design such affective engagements on the basis of transduction has rarely been addressed in contemporary literature. One exception can be found in Erin Manning's recent book *Relationscapes*. Here she builds on Simondon to unfold the concept of what she terms technogenetic experiences. According to Manning, technogenetic experiences recompose the body through a multiplicity of techniques understood as '.... technolog(ies) of emergence (an ontogenetic technology or a technogenesis) through which new complex systems are composed' (Manning, 2009: 71). These techniques are associated milieus of potential, '.... compositional matrices for the machinic body, in-forming the body through transductions that open the body-becoming to the metastability that provokes it to become in excess of its organism' (Manning, 2009: 71). What Manning calls technogenesis is the interstitial process of becoming, through the associated milieu, from which a particular mode of being emerges. Manning takes up Simondon's particular account of the human-machine relation to regard machines as techniques of relation (Manning, 2009: 87). She points out: 'The machine operates ontogenetically through "(...) concretising invention creat(ing) a techno-geographic milieu ... that is a condition of possibility for the functioning of the technical object"' (Simondon, 1958, translated in Manning, 2009: 87-88). Technogenetic individuations account for the becoming of a technology by means of the techniques of relation they can develop in a relational event with other individuals (be they physical, human, vegetal, or mental).

The transductive aspect of a technogenetic individuation merges with the field of experience in the expressive event that is interaction. In other words, during the process of invention the

self-conditioning attribute of the machine feeds into the field of experience by means of a shared associated milieu of the machine and the human. This relational nexus between associated milieus and their different individuations is particularly interesting if we deal with the question of how technologies designed to be interactive influence the way an experience actualises. This question can be explored by working with the relational bonds between transductive fields and fields of experience. Working with these, we continuously move along the threshold between the actual and the virtual of such events of experience.

Manning argues that if digital technologies want to truly contribute to this technogenetic transduction they must work at the level of perceptual emergence, making transduction felt affectively (Manning, 2009: 72). This perceptual emergence can be sought out by tapping into the body's rhizomatic networks of actuality and virtuality. Such a tapping-into functions through sensation/experiencing amodally. Amodal experience is a key way to activate the body's relation to the world. Amodal experience opens the body to its technogenetic potential by addressing its affective experiential field.

In sum, so far we have suggested that the value of Simondon's thought for the design of interactive environments lies in the inseparable relation between technologies and humans as part of a shared technogenesis. The propositions at stake foreground both the force of relationality that underlines transduction and the expansion of potential through affectively engaged embodied experience. In the following section we will outline two examples that operate transductively between body-becoming (what a body-becoming can do) and the techno-geographic milieu. As we will see, in both cases a transductive mode of thinking enables an interlacing of manifold layers of experience that are usually treated separately.

## Loud Voices and Impossible Rooms

This preliminary conceptual tour has brought to the fore a range of concepts and directions of thought that we believe can enrich the critical discourse on the design of interactive technologies and environments. So far the theoretical development has been grounded in an exploration of concepts. In this section, we seek to show how the concepts work in the analysis of two different but related technological assemblages, namely *Voz Alta* by Rafael Lozano-Hemmer and the *Impossible Room* which was developed in part by the authors on a proof-of-concept level during the *SenseStage* workshop at Concordia University, Montreal (<http://sensestage.hexagram.ca/workshop/>).

Although the two projects are not typical examples of interaction design, they are both artistic experiments with the crafting of technological assemblages that foster new interactive experiences. As Bolter and Gromala have argued, it is possible to regard digital art as a series of radical experiments in digital design (Bolter and Gromala, 2003:7). We will argue that the analyses of Voz Alta and the Impossible Room enable a re-thinking of the nature and extent of experiential concerns and relational events we might be able to explore through the use and design of digital and interactive technologies.

The analysis will show how the two installations can be conceptualised as fields of transduction and experimental, experiential fields of technogenetic emergence. We will demonstrate how the installations, in differing but still complementary ways, function as associated milieus for transversal exchanges. The installations can be considered as individuations occurring between humans and technology. By creating conditions of emergence for affectively engaging interactions these individuations ontogenetically tap into the preindividual through fields of transduction. The analysis is not intended to validate the conceptual development. Neither is it supposed to validate the quality of the presented projects. Instead, the point of the following section is to make the concepts and projects resonate in a mutually beneficial way, keeping thoughts in motion as a conceptual feed-forward into further experimentation and invention in interaction design.

## Voz Alta

Voz Alta (translated as 'Loud Voice', the project also has the subtitle Relational Architecture 15) is a commemorative, technological in(ter)vention in urban space by interactive artist Rafael Lozano-Hemmer. The installation was built in 2008 to mark the 40th anniversary of the student massacre in Tlatelolco, Mexico City. [5] In the massacre, which took place on October 2nd 1968, hundreds were killed. However, the event is not very well described or documented and the subject is still a taboo in present day Mexico. Lozano-Hemmer's web site described the piece in the following terms:

*In the piece, participants speak freely into a megaphone placed on the "Plaza de las Tres Culturas", right where the massacre took place. As the megaphone amplifies the voice, a 10kW searchlight automatically "beams" the voice as a sequence of flashes: if the voice is silent the light is off and as it gets louder so does the light's brightness. As the searchlight beam hits the top of the building of the Ministry of Foreign Affairs, now Centro Cultural Tlatelolco, it is relayed by three additional searchlights, one pointed to the north, one to the southeast towards Zócalo Square and one to the*



*southwest towards the Monument to the Revolution. Depending on the weather, the searchlights could be seen from a 15Km radius, quietly transmitting the voice of the participants over Mexico City. Anyone around the city could tune into 96.1FM Radio UNAM to listen in live to what the lights were saying.*

*When no one was participating the light on the Plaza was off but the three lights on the building played back archival recordings of survivors, interviews with intellectuals and politicians, music from 1968 and radio art pieces commissioned by Radio UNAM. In this way the memory of the event was mixed with live participation.*

*Thousands of people participated in this project, without censorship or moderation. Participation included statements from survivors, street poetry, shout-outs, ad hoc art performances, marriage proposals, calls for protest and more.  
([http://www.lozano-hemmer.com/voz\\_alta.php](http://www.lozano-hemmer.com/voz_alta.php))*

As can be seen in a video of the installation on YouTube, it is clear that people had numerous reasons for participating: voicing their opinion on the current state of freedom and democracy in Mexico, bearing witness to the event, demanding that people responsible for the killings should go on trial – and the people participating did so in a variety of ways, either spontaneously, in groups, reading up statements or just sending shout-outs to their friends. [6] Participants who talk about their experience with the installation emphasise the strange and powerful feeling of seeing their ‘voice in photons’ or their ‘voices becoming light (and) enlightened thoughts become words’. The installation is simultaneously described as artistic and political, emphasising the accessibility and non-elitist approach to art that it demonstrates. One participant in the video underlines the fact that the installation lets ‘people believe they have a voice that can actually make a difference.’

## Megaphone–Light–Radio

In her book *Materializing New Media: Embodiment in New Media Aesthetics*, Anna Munster describes Lozano-Hemmer’s approach to what he himself has termed ‘relational architecture’. This means working with interfaces as active fields of relations requiring negotiations between body, building and imaging technologies (Munster, 2006: 147). Munster argues that Lozano-Hemmer’s work is located at the very core of contemporary affect and experience. His work shifts the experience away from the interface as a thing in itself, making it ‘...a kind of quality that emerges in the experience of (these) relations in information spaces.’ (Munster, 2006: 148). Munster’s proposition to move towards the interface as a shared and



distributed set of tendencies and intensities aligns with our proposition for interactive environments as fields of transduction. According to Lozano-Hemmer himself, he is actually not creating interfaces, but situations. Drawing on Brian Massumi, Munster points out that Lozano-Hemmer's work addresses the way in which technologies can be twisted away from pre-existing forms and functions and toward operating directly as technologies of emergent experience (Munster, 2006: 148 from Massumi, 2002: 192). In their operation as technologies of emergent experience the modes of interaction involved play into the field of experience in their own particular ways.

The different technologies used in Voz Alta create a technological assemblage that allows people to tap into the field of transduction provided by the installation through different experiential gateways. The megaphone can be conceptualised as the most situated part of the technological setup. It demands and creates attention, offering people a means to amplify their voice to an extent which makes an actual difference to them. This activity very manifestly modulates the general feel of the place by actualising a range of virtually present and really lived stories relating to the site. The experience of seeing your voice as pulses of light creates an affective surplus effect that exceeds the audiovisual. It spills its excess literally and manifestly all over the city. There is no way you can not engage affectively with Voz Alta; for a start the installation forces you into the role of a performer via the technological setup. Further, the immediately situated experiential field provided by the installation has an impact on the general feel of the city. In a very obvious way, the technology is being used here to alter a range of basic relations; to the act of voicing your opinion in public space, to the reach of this act, and between the past, the present and the future of Mexico City. Enabling a field of transduction, the technical object also enables a relational field of experience.

It is clear that the light emission is more than illumination, or at least that the light illuminates more than buildings. The emission of light is directed towards places that are historically and symbolically connected to the massacre, literally tying the stories being told to the physical manifestations of the people and civic institutions connected to the tragedy. As stated before, the light functions to grab attention, but it also becomes more-than-visual as people develop a connection to the setup. It is clear that the light must have an impact on the affective experience of the city; it draws people into the sphere of the installation by reminding them about what is going on. The light, then, highlights the experience of the city, offering ways to engage with the installation and the historical setting. Via the light beams, spoken content becomes pure expression generating new potential in-formations of a new transductive register. Light transduces in-formation across different registers (the technological, urban, personal, historical, political) to generate altered states of experience. In this respect, the technical object and its associated milieu broaden the experiential relations between humans and the city. The installation as a field of transduction enables a widening of the field of potential for acts of expression. Voz Alta demonstrates, then, in a very elegant way, not only how a technogenetic becoming can concern different registers of being or

matter but also the way time, in such a technogenetic becoming, can become multiple, with many intersections across past-present-future.

The radio station works differently since it is not tied to a particular location or action and can be experienced anywhere in the city regardless of whether anybody is actually talking into the megaphone. The radio functions as the contextual framing of a range of situations and relational events, mainly tied to the performances carried out on the Plaza de las Tres Culturas. It is plausible that knowing their voice will be broadcast on the radio as well affects the people voicing their opinions in the public space. Finally, it is crucial to note that the megaphone is not only emitting visible light but also invisible electronic pulses, creating its own hertzian space to be explored (Dunne, 1999). As such, it perturbs already existing associated milieus of communication and interaction.

The transductive nature of Voz Alta becomes extremely apparent in the different modes of entering a formerly contained or rather shunned event. In the use of the megaphone different modulations take place. These generate different modes of expression that enable other relational events between experiencing bodies and expressive technologies. Interaction is distributed across the transductive field of the entire system, from radio waves, to voices heard to photons flashing throughout the city. Crucially, through each engagement with the system, both the engaging subject (or individual individuating) and the associated milieu of potential expressions shifts and re-organises itself.

The different interfaces presented in Voz Alta thus alter the relations between, among other things, social arrangements, environmental conditions, historic repression and public awareness. Voz Alta is an example of how to design strong, situated, relational events where embodied experience and technical objects mutually shape the emergence of fields of transduction. In Simondonian words, Voz Alta works ontogenetically to create a situated, technogeographic milieu to be simultaneously explored and further developed.

## Infrastructural Emergence

A range of relational events emerge from the associated milieu created through the interactions surrounding Voz Alta. There is a strong link between the situated performances and the stories that are told, where the setup stages and alters the conditions for acting out the story in public. There is a strong relational retro-activation of the physical site, and of the narrative

of the massacre, through the interaction with the installation. More than just functioning as a medium to speak up or aloud, or to communicate messages and memories, Voz Alta opens up a register of politics that is intrinsically technogenetic and affective. Through the technical system and its modulating processes (voice into light or radio waves) the experiencing subject is challenged not only in terms of what it can do but in terms of how to make different levels of experience conjunct in creative and novel ways. In this way, the politics of the event are an immanent part of the way the system is open for affective engagement. Each individuation that emerges from this affective engagement is touched by what becomes a political field. In sum, the transductive distribution of politics enters the field of experience through the different modes and modulations of expression.

From an interaction design perspective Voz Alta can be conceptualised as pure infrastructure, form without content— in-formation, individuation. All the content is provided by the people who interact with the installation (except for the excerpts on the radio station). Instead of describing the events that took place, the installation becomes a “living memorial” where people can re-live the historical event. What is existing virtually, as part of the ambiance and pastness of the city, the people, and the place, is actualised by the participants. The idea of using the technological setup to “give people a voice” creates the potential for strong affective ties by capacitating (or empowering) people. Thus the installation ‘bridges’ the affective with emotivity, emotions, narratives and communication. All these thresholds of the experiential continuum are somehow activated and distributed in the physical, social and affective spaces the installation creates. Instead of just making historical material public, Voz Alta provides a field of transduction that allows multiple and ongoing individuation. Each engagement with the megaphone transforms the relation between the technical object, the individual speaking, the city, time and memory. More generally, this interplay between individual and associated milieu allows us to conceive of the technical object as a relay for the individual to participate in acts of invention. Such inventions happen via a becoming-attentive to the preindividual realm of potential that might be taken up and actualised in a future event.

Not only does Voz Alta empower people to speak up, it shifts the way the political is rendered active.

## Impossible Room

The interactive installation the Impossible Room brings into play a contextual setting that is different to Voz Alta. The installation was developed by the authors in a laboratory setting as part of a range of experiments carried out during the SenseStage workshop at Concordia

University, Montreal. SenseStage is an interactive performance system developed by Marije Baalman, Harry Smoak and Chris Salter. Technologically, SenseStage is a wireless sensor network, built for immediate use in interactive performance environments. Building on this network, we experimented with the design of a particular experiential field, exploring affective capacitations and bodily engagement in a controlled setting.

The Impossible Room itself is a darkened room filled with smoke. It invites the visitor to enter and experiment with the responsiveness of its augmented environment. The room appears to have a life of its own and offers different zones for interaction. The ambiance is enhanced by a pervasive soundscape and by visual events that provide cues for movement. In the room, sensors are distributed on the floor (floor sensors activated when stepped upon), on the walls (distance and IR sensors activated when approached) and in an object lying on the floor (an accelerometer activated when moved around). All sensors are visualised with a blue light to attract attention and this subtly choreographs the visitors' movement around the room. The underlying algorithmic structure is based on the notion of impossibility; whenever a visitor responds to a cue, there is a cue countering the prior one—the sound moves from one end to the other of the room, the lights change. The room attracts attention only to re-direct attention to the opposite end of the room. The process is built on (modulated) binaries like left/right, or up/down, facilitated by the sensor setup.

The soundscape consists of an ambient, deep drone complemented by a bird's singing in a dissonant, highly pitched and distorted way. The sound is activated when a visitor enters the room and would be overwhelmingly loud and disturbing. However, the more the visitor agitates the room, the more the visitor tries to figure out how to respond to the cues in the room, the more activated the room becomes—and the more appeased the soundscape gets. In the end, after "performing" the room, the sound changes to a bird's natural singing. The light changes to a red, sun-set color, creating a relaxed ambiance. The impossibility of the room consists in demanding actions with no particular goal. These actions are demanded because the experiential field is saturated in the immersive setup of distorted audio-visuals. The agitation of the visitor is inversely proportional to the mood of the room. Another way to put this is that the room inversely performs the visitor and vice versa. The whole setup is always on the verge of impossibility.

In sum, the setup fosters an over-cued and disturbing ambient environment. This seems insurmountable and hostile at first but changes character through interaction. In an extension of the setup, the room might continue to provide contradictory cues for action unless you actually knew how to appease it, making it possible to "play" the room like an instrument. For this to happen, an evolutionary and adaptive algorithmic backend is required, radically experimenting with the different sensors' abilities to choreograph the room spatially in ac-

cordance with the audiovisual setup.

The installation was only available to the people attending the SenseStage workshop for a short period of time. At least 20 people tried the room. The feedback was generally positive. Many of the people who visited the room gave accounts of strong affective experiences created by the ambiance and interaction. Some followed the cues provided in a straightforward and linear way, whilst others simply drifted along in the room, thus activating it in a less intentional way. Most people did achieve the intended appeasement of the room. Those who did not still spoke of an intense experience. Based on the feedback we received we believe that the interactive setup created an experiential field worth exploring, fostering different kinds of relational events of technogenetic emergence—as regards the technology, the physical setup, the audiovisual ambiance, and the people themselves.

## Operating Impossibility

The Impossible Room works directly—and explicitly—on a preindividual, affective level. The interactive setup constantly modulates the affective experience of being in the room through all people's interaction with the distributed technological infrastructure. At the same time, in the Impossible Room, the field of transduction resonates with different thresholds of experience as it is modulated by the underlying algorithmic structure. The design of the installation attempts to effectively condition the way visitors perceive and act in the room without forcing upon them an exact outcome. This is effectuated by oversaturating the room with different cues that catalyse perceptual changes in the experiential field. The aim is to tap into the very conditions for experience and orchestrate these, but technogenetically.

The Impossible Room is very different from *Voz Alta* as it experiments with a highly constrained and determined field for interaction. The interesting aspect of such a constrained field is the experiential precision one can evoke. As Andrew Murphie has explained in regard to the potential of Virtual Reality environments (e.g. immersive mediascapes and the like), VR (both as practice and as a concept) '... allows us ... to shift the gears on the threshold of perception, operation, and expression more powerfully than ever before' (Murphie 2002: 188). According to Murphie, virtual reality implies not a virtualisation of reality but an increase of 'our ability to operate the virtual' (2002, 192). The emphasis on operation is crucial in this context. Instead of constituting modes of representation, confined interactive environments such as the Impossible Room foreground the operational quality of an experience. The very notion of operation is broadened. It accounts for how things come into presence in terms of 'what they do.' However, the experimental nature of the Impossible Room adds a further

concern to operation: it investigates what things ‘can’ do, their potential capacities, not only ‘what they do.’

Operation, as described above, also plays a central role for Simondon. It is a key part of transduction. For Muriel Combes, writing on Simondon, operation—similarly to information, affect and expression—is autonomous of the terms it relates in its unfolding (Combes, 1999: 22). So to investigate the operational level of interactive environments means to develop techniques of experimenting with this autonomy, in other words with preindividual potentials. The Impossible Room provides a zone of experiential experimentation that aims to make its relational nature palpable in an embodied experience. The environment of the Impossible Room taps into the field of transduction and enables its emergence without fully prescribing the interaction. Instead, interaction is turned into a field of potential, continuous variation.

When the Impossible Room experiments with the distribution of technology it affectively engages and spatially choreographs the physical boundaries of the room. For many people these boundaries are dissolved and they find themselves interacting with the invisible layering of digital processes and algorithms. There is an overload of cues and multiple ways of relating to the interactional setup, including the option to simply ignore them, which does not, however, mean they do not have an effect on what you are doing or experiencing. The work creates a distributed ecology of sensing, of sense and sensation across human and digital strata. In other words, the Impossible Room deals with the question of how to design an interactive environment that dynamically experiments with the relation between experience, embodiment and interaction.

The design of the Impossible Room also begins with the idea that technologies can be sensible and flexible in their operational nature, to the extent that they change the way we perceive different spaces in a remarkable way. The work seeks to explore and expand the specific capabilities of a range of sensor technologies—floor sensors for extensive, horizontal space, accelerometers for intensive movements, IR-tracking for vertical displacements. Inviting people to take part in forming a mixed and relational interactive ecology with the expanded capabilities of technologies, the Impossible Room also experiments with our perceptions of ourselves. The technologies that are becoming a part of our everyday lives now make the felt experience of the technologies tangible in a disturbing and creative way.

Such a mode of experimenting with preindividual potentials requires an ethical awareness. To shift the point of action from effects to affects and from expression to transduction also means to orchestrate becoming for the better or worse. Alongside this the political undergoes a shift, from an explicit order to a virtual immanence within each event. In sum, inter-

action design has to address the experiential, experimental and political dimension of its practice. Here we consider the moving relation between individuation and associated milieu by means of transduction as a crucial aspect of such practice. Of course, many questions remain. For example, how do we enable a field of experience through fields of transduction without rendering the range of potential too narrow or too wide? This is one paradoxical challenge each design process has to balance. Or, as *Voz Alta* and the *Impossible Room* experiments ask, in their different ways, how do we bring together digital and analog strata in a way that allows for novel qualities of experience to emerge while traversing the edge of the (im)possible.

## Conclusion

The analysis of two different interactive environments brings to the fore the complexity of current technological assemblages. To regard technologically enhanced media environments such as *Voz Alta* or the *Impossible Room* as fields of transduction allows us to understand a layer of interactivity that is often overlooked in more traditional conceptions of interaction. *Voz Alta* is a designed environment that offers conditions of emergence for activating pre-individual fields of becoming ontogenetically. *Voz Alta* makes the transitions and transductions from the virtual to the actual felt through the associated milieu conditioning and created through the interaction. *Voz Alta* alters the affective experience of the cityscape, of the historical facts behind the setup, of the interactive situation itself and of the possible relational events that might emerge from the interaction. Time travels through the people engaging with the interaction. The collective pastness enters the present, and the users themselves become a kind of 'memorial' of the event. It lives on. It is retro-activated through their engagement and interaction with the installation. The conditions of emergence offered by the installation activate people possibly creating new capacitations and relations, qualitatively altering or qualifying the experience—of *Tlatolelco*, of the history of the student massacre, of the user herself, of the technology used in the setup, of technology in general.

Compared to *Voz Alta*, the *Impossible Room* unfolds in a much more controlled environment. Unlike *Voz Alta*, the *Impossible Room* does not aim to modulate the affective experience of a given location or retro-activate a historical context. Instead, the installation simply effects a transformation of the room it occupies. In doing so, the *Impossible Room* tries to make the relations between the human and the technology felt more intensely. The algorithmic infrastructure and the interactive setup that unfold through people's interaction is always processual, always different from the last time, although the conditions of emergence remain largely the same. The interaction can be more or less intentional or volitional, and the transductions offered by the experiential and technological field can be felt more or less



affectively—but the complexity of engagement is virtually present at all times. As such, the Impossible Room allows for collective individuations to potentially unfold in what are simultaneously technogenetic and experiential space-times.

Voz Alta and the Impossible Room provide different takes on the question of how to activate fields of transduction and experiential fields of becoming using interactive technologies. They offer different conditions of emergence giving rise to a multitude of relational events that take on a life of their own through interaction. In Manning's words they both involve the constitution of a form of technogenetic emergence that changes experiential space-time, recomposing and in-forming the body through transductions. Such a transformation is more immediate in the Impossible Room, which arguably affects the users' bodies more directly in the interaction than Voz Alta. On the other hand, it is obvious that Voz Alta more clearly activates a range of different experiential levels, adding emotivity, emotion and narrative or communicational expressions to the interactive setup in an extremely engaging and touching way.

We are aware that the Impossible Room operates at a totally different scale of impact and execution to Voz Alta. However, we argue that both installations are genuine inventions in a Simondonian sense. It would be interesting to look into the way digital and analog technologies are at play in the two installations since Voz Alta can be said to experiment more with an analog setup whilst the Impossible Room is certainly diving into a world of the digital. It should be made clear, though, that the associated milieus are neither solely analog nor solely digital but a zone of in-mixing.

The mobilisation of a Simondonian vocabulary makes it possible to unfold this zone of in-mixing, in part because Simondon's concepts allow us to see interaction very differently. We can then work actively with this in-mixing in the analysis of interactive installations. Just as importantly, we can work with this in-mixing in the development of new interactive experiments in design practice. Introducing Simondon in interaction design paves the way for thinking the invention of technological assemblages and beings as an integrated part of our contemporary culture. Instead of maintaining clear lines between humans, technology and the world we have to conceive of technological individuation as cutting transductively across all strata of life.

In Relationscapes, Manning suggests that the potential within the technogenetic lies in further explorations of preindividual potential and affective experiences. This in turn allows for explorations of alternative and experimental configurations of people and technologies. As we have briefly begun to suggest, such explorations always carry ethical implications



with them. One of these is the question of how experience might unfold, if it does so within a collective ontogenetic process. This is a central question within the contemporary ethics of interaction. Yet, if fields of experience are transductive and collective, and if all instances of an individuation emerge relationally, then we have to account for interactive technologies, systems and experiences differently. Here we have suggested that the concept of a field of transduction enables us to reconsider what we mean by affectively engaged interaction, environment and the relation between thought and experience.

Throughout the article we have proposed a mode of thinking and practice of interaction design which carefully considers the relations between fields of transduction and fields of experience. We believe that interaction design can function as an experimental laboratory for this. Designing technologies that focus on working with an associated milieu as self-conditioning emergence radically shifts the role of the designer. The designer becomes a “helpmate to emergence” in processes of technogenetic individuation (Massumi, 2009: 40). Bodies, technologies and concepts have to maintain an open-ended character to further participate in the process of technogenetic invention. We understand fields of transduction as an open-ended interplay of these disparate tendencies folding into fields of experience. Working at the junction of these fields means working with the body as open to experience in its pure state, where affects take precedence over emotions and feelings over consciousness. A design process that mobilizes such work always has to experiment with operations that lure bodies into experimentation. Both of our examples demonstrate how an ethics of interaction might facilitate an affectively engaged mode of interaction that does not pre-determine experience but invites experimentation. Interaction taken as an interstitial event makes the field of transduction palpable and at the same time allows one to maintain an open relation between bodies and technologies. The fields of transduction can feed into designed processes themselves, as well as more generally demanding an open practice of experimental interaction design research.

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## Notes

[1] The concepts of expression and pure experience take on an important role in relation to different discursive receptions of Simondon's work. Expression and pure experience emphasise the role of a perceiving and experiencing human body that engages with interactive technologies in our essay. Hence, this body is not predefined but co-constitutive with its technical environment. Expression and pure experience allow us to account for the perceiving body on an affective plane without predetermining the human body as phenomenological, as hermeneutic readings of Simondon tend to do.

[2] If one wants to align the concept of transduction with another concept in Deleuze and Guattari, then the notion of machinic might be the most appropriate. Even though both Deleuze and Guattari use the two notions independently. (See *A Thousand Plateaus* 1987, 404-415; Guattari 1995, 33-57).

[3] Simondon's use of the notion of problem correlates with Deleuze's remarks on stating a problem as inventing, as proposed by Bergson. (see Deleuze, 1988: 15)

[4] In this section, while maintaining these distinctions, we will primarily hint at how the vocabulary can be used in order to re-think the practice of interaction design, working with digital technology.

[5] [http://www.lozano-hemmer.com/voz\\_alta.php](http://www.lozano-hemmer.com/voz_alta.php)

[6] <http://www.youtube.com/watch?v=87SCyQ2O8wY>

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