when shape does not induce function: why designers must not loose the big picture (of use)

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WHEN SHAPE DOES NOT INDUCE FUNCTION: WHY DESIGNERS MUST NOT LOSE THE BIG PICTURE (OF USE).

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ABSTRACT
Shape does not induce function. That is what this paper first tries to demonstrate. Affordances must be *perceived* to link a structure to a function, to make an object look like what it is designed for. It takes palaeontologists the understanding of a hybrid socio-technical context to interpret the structure of an artefact. A brief backward look at historical simple optical systems bears it out: structure must be replaced in a larger network to understand why it is like it is, why rivet spectacles had no sidepieces.
Then if function has a systemic nature, if it has never been inscribed on shape, but on the socio-technical context of objects, it necessary has implications for design. Recommended methods as value analysis involve socio-technical networks in function identification; they follow designers in building a compulsory and *forecasted* set of connections to surrounding actants, embodying concepts in *unspoken* scripts of use. Still, what this paper illustrates is the enormous significance given to those implicit and hardly discussed representations. Mentioning the case of axiomatic design, it is shown how then functions are translated into functional requirements, distinct design parameters, and independent teams: unspoken scripts are behind product's and organisation's structures, behind 'indisputable' dominant designs. Moreover, original 'big pictures of use' fade out during the breakdown, creating numerous short-sighted (and still implicit) models of use.
What this paper suggests is the need for intermediary objects (scenarios?) that could consider use representations as an influential parameter of design, and maintain throughout the design process *shared*, *partially-explicit*, and *discussed* visions of socio-technical contexts where artefacts are imagined.

Keywords: Function, structure, affordance, representations of uses, dominant design, scenario-based design

1 INTRODUCTION
The issue of artefacts' shape and functions, even if it is seldom formulated as a discussion of their links, is central to current stakes of engineering. In a widely recognized context of intensive innovation [which is particularly-well described by the numerous papers of Le Masson, Hatchuel and Weil since 2001, on the shift from R&D to RID and more recently on CK theory (their latest book sums their works on these subjects up; see [1])], the development of dynamics of objects' identities seems prominent in firms' innovation strategies. Behind that expression hides a need for innovation teams to get out of dominant designs, to explore innovation fields and products' values. Stands out from *innovative design* the will to question objects' value spaces, to define new needs from customers, new partitions of users, new uses. The systematic stop on marked out structures challenges innovation and the development of new functions (uses). Dominant designs (which are obviously more than artefacts' shapes) seem to restrict the thought in terms of functions.
Generally speaking then, design has been seen for ages, more or less implicitly, as a Cartesian series of translations from functions to shape (structure) – with functional analysis as a figurehead. From functional requirements (FRs) meant to render users' needs (and therefore a certain representation of the use / the activity) shall emerge design parameters (DPs), which are then the inputs of the mapping

towards the physical domain. Requirements management secures this chain of translations whose operators make up design's core. That is incidentally this chain of translations that is drastically changed during breaks of dominant design. All the implicit gallops up to the surface and perturbs this sequence that once made sense.

Still, seeing design as a bijection from functions to structure is certainly a simplification of the complexity at play here. Suh describes design as a zigzag between functional requirements and design parameters [2]. The trouble that information systems have in representing at the same time the Product Breakdown Structure (PBS) and the Functional Breakdown Structure (FBS) shows things are not that simple. Design could eventually be seen as an attempt to build a relationship of equivalence (between functions and structure), that depends on a given context. Users could then handle the device "as if it were the most natural thing in the world". We hypothesize that design is not a one-way process, that the way back matters (from structure to functions, but also from structure to DPs, from DPs to FRs, etc.). Besides, what is this way back to tasks? We suggest it could be no less than users' contribution. Then thinking about the mapping from shape to functions could give designers a hand, helping them to represent uses. Anyway what are participatory design and user-centred design, apart from an attempt, symmetrical to requirements management, to further a backwards reasoning?

If design is a mapping from functions to structure, it is certainly not exempt from a rearwards questioning. Incidentally, in one way or the other, are those links really obvious? Discussing them is the main objective of this paper. We will begin to study the way which is the oddest for design, because it is also the one from which there is the most to learn; that is the link from shape to functions. Therefore we will take design process "on the inside out", and that is where this paper got its (puzzling) name. In that purpose, a look at some social sciences studies and notions will be worth the detour. In particular, we will start with a glance at a concept which CHI-web designers are very familiar with: the notion of affordance. They indeed use it left, right, and centre as a way to indicate how a precise form implies its use… Then, in a second time, it will give us new insights into the way of reasoning functions and structures, within the scope of design.

2 FUNCTION IS NOT INSCRIBED ON SHAPE

2.1 The misinterpretation of the concept of affordance: when affordances distinguish from *perceived* affordances and conventions; when they do *not* argue for a causal relationship between structure and function

When we first began to doubt the causal relationship between shape and function, asserting that structure did not induce function, and therefore that designers would experience great difficulty in building objects from their mere technical functions, we were regularly asked doubtfully if that would mean denying Gibson's and Norman's concept of affordances [3, 4]. Indeed designers told us, from the basis of Norman's "Psychology of Everyday Things", that the appearance of the device could provide the critical clues required for its proper operation [3]. Its shape would *afford* (suggest, invite) its particular use. Then designers would just have to put relevant affordances here and there to allow the users to find naturally the use of the device. Then people at The Coca-Cola Company® must have put wrong affordances on their original bottle, seeing in which diversity of uses (excluding being a vessel) Kalahari inhabitants imagine it! (See the movie directed by Jamie Uys, 'The Gods must be Crazy', 1980). Anyway usability notions have operationalized the idea of affordances to a point where uses seem to be "automatically" inferred from shape. When supplied with the right affordances, they say, no period of apprenticeship is required for a user to properly handle the device.

Still, we went back to Gibson's original definition of affordances: *actionable* properties between the world and actors, that exist naturally, and *do not have to be visible, or even known*. Affordances are "simply" relationships; they exist independently to what is visible or actioned. No evidence of any causal link between structure and function here. On the contrary, according to Gibson, "If the affordances of a thing are perceived correctly, we say that it looks like what it is. But we must, of course, *learn* to see what things really are – for example, that the innocent-looking leaf is really a nettle or that the helpful-sounding politician is really a demagogue. And this can be very difficult." [4, p142]. It is the *perception* of affordances, and therefore a learning and cognitive process, that connects a shape to an appropriate use. Obviously Norman could not have missed that point. His efforts from 1999 to differentiate affordances from *perceived* affordances and *conventions* show it. "My fault: I was really talking (in "Psychology of Everyday Things") about perceived affordances, which are not

at all the same as real ones. (…) Don't confuse affordances with conventions. Affordances reflect the possible relationships among actors and objects: they are properties of the world. Conventions, on the other hand, are arbitrary, artificial and *learned*" [5]. He makes explicit the fact that under the term *appearance* of the device (which provides critical information for an adequate use) he meant the *perception*. "(…) affordances are of little use if they are not visible to the users. Hence, the art of the designer is to ensure that the desired, relevant actions are readily perceivable" [5]. That is to say, designers must managed conventions and both the broad and complex cognitive process that makes an affordance a *perceived* affordance to achieve their objectives. The structure of an object is therefore really a single element of a wider system (a social and technical context) that must be thought as a whole to be understood.
A Coke bottle affords "containing liquids", drinking, handling the bottle, but it also affords playing music by blowing or hitting, cracking nuts, hammering, rolling dough out… So it can be used by drinking, playing sounds, fighting, cooking, tilling the soil, etc. What makes it immediately a bottle to us is not its shape, but the perception we have of it, i.e. our industrial and economic context, the facts that every one of us knows the brand and what it sells, that we have all ever seen the dominant design of a bottle… To be honest we all could nearly guess the bottle from its cap. We are used to the economic, social, technical system of a soda bottle; it is the knowledge of this global system that makes a Coke bottle looks like what it is designed for.

2.2 Palaeontologists and reverse design: guessing function from shape…

Then, to our great relief, we found out empirical studies we were agreeing with. These were works from François Sigaut, head of the History of Techniques department at EHESS, Paris. These papers, in the end, became our richest resources dealing with the issue of the link between shape and function. Yet there were still bridges to build to cross from palaeontologists works to those of designers! Because Sigaut's most influential paper on this subject, a controversial – if not at first puzzling – article entitled "A knife is not used *for* cutting but *by* cutting" [6], is precisely a discussion from works of palaeontologists, such as Leroi-Gourhan. He therefore focuses on the matter of functions' identification of the artefact found, taking part in what can be called a *reverse design*.
Distinguishing function (the whole set of ends for which the artefact is put to use) from functioning (the way the object works or is worked), he argues for *the impossibility to go back from the structure of an artefact to its function* [6]. "Because the function of an object is what links it to a system of which it is only one element. Therefore if I do not know the system, how could I give any sense to the element? What will a bit or a stirrup mean to me if I know nothing about horse-ridding? (…) There is no direct connection between shape (or structure) and function. They only exist when mediatized by the functioning" [6]. He is indeed in agreement with the conclusion of the previous part, that is the inability to understand the element outside from its system. "Searching what [a knife] is exactly for is the only means to understand how it cuts, and therefore why it is what it is." [6, p31] The understanding of the structure of an artefact thus comes from the knowledge of its whole socio-technical (and historical, and ecological) system: contexts of use, surrounding objects, intentions of the users, representations they have of what they are doing, every ends for which the artefact is put to use (the function according to Sigaut)… Concerning a plough, that means knowing if the plough is for ploughing or harrowing first, but also who ploughs or harrows, and why. That means knowing what is the ploughing for (oat, barley, wheat?), if it is a single ploughing or one for fallowing, what are the intentions of the farmer, what he thinks a good ploughing is, etc. All of this (and even more) makes the function of a ploughing tool [6, p24].
To mention another example from Sigaut, you will only know what a dagger is for when you place it into its *historical* and *action* context, among its surrounding *interacting artefacts*. Once its function has been identified (to *pierce* the chink of an *armour*, in *a hand-to-hand fight*), the structure of the dagger is explained and its affordances are perceived. The lineage of the dagger differentiates from the one of swords and knives.
Then, the *ecological* context and its affordances matter too. Sigaut once again made it clear, a few years later. Taking the notion of affordance up, in the original and strict sense of Gibson, he showed how "the fact that grains are hulled or naked is a factor without which the history of machinery and of industry cannot be fully understood" [7, p422], because the different affordances of the grains took part in the production of various cultural traditions, types of agricultures and machines. For instance, "with an economy based on hulled grains (…) the Chinese had every incentive to contrive a machine

for winnowing (…). On the other hand, with an economy where wheat and bread became more and more dominant, the Greeks and Romans were interested in other machines, especially the flour-mill; they also made significant innovations in oven-building, for instance" [7, p422]. The functions of those tools, too, are inseparable from the structure of the grains [7].
Function is not inscribed on shape, but on the historical, ecological, social, technical, and economic context of artefacts. This wide framework is needed to interpret an object's structure.

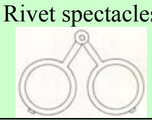
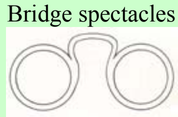
2.3 (More) empirical evidence: the history of eyeglasses: various functions at constant shape.

Thirdly, we re-investigated an earlier work [8] to illustrate our point from another perspective. As we were underlining in previous parts the historical dimension of the "functional context" (a systemic view of the notion of function), we thought that a rereading of a history of such a common and simple object as eyeglasses, with in mind the issue of the shape-function link, could provide us with more and new empirical data on this particular topic (We guess the object does not really matter though). What we suggest here is by no means a social or technical history – it has from "historic" only the age of the artefacts and of their users; this is a one-page long backward look to some single-lens optical systems, looked through so as to see better. It will be focused on this paper specific interest.

The intuition of a lens, which, when suitably smoothed, could facilitate reading by magnifying the letters (Alhazeni), was to remain theoretical until the second half of the thirteenth century, when a technical framework (Venetian glassmakers) and a social group (Venetian monks) 'interested' [9] in *magnifying writings* (and not correcting eyes' defects) emerged together. From the local Venetian network, the reading stone appeared. This was a glass plane-convex lens, larger than half a sphere, used by the monks in their works of writing, illumination, and reading. Its use reveals its status as a magnifying glass: positioned flat on a book in the necessary place, this 'stone' was a genuine book accessory. Used as and when necessary, the reading stone enhanced the precision and meticulousness of the monks' work rather than improved their eye defects, which were a result of their human condition; a holy gift that, if corrected, would have been deemed an act of heresy.
The *Opus Majus* by Roger Bacon (1267) produced a new reading of Alhazeni's ideas. At the same time, it started a long process of transformation of the status of the artefact itself, *even if no alteration in the form of the object was yet palpable*. Bacon indeed suggests that 'such a device [the lens described by Alhazeni] will be useful to *longsighted* old men who will be able to see a letter, no matter how small it may be, at a decent size'. He establishes a link between the artefact and the eye, thus illustrating the very progressive change of paradigm taking place with respect to the main function of reading stones. Moving from a utilitarian purpose – enhancing the human ability to perceive smallness – Bacon gradually adopted a humanistic logic based on correcting presbyopia (which opens up the artefact to a potentially wider audience, even if at that stage the only two activities for which optical lenses were used were reading and writing). The artefact had been anchored to the paper, but Bacon senses a change in focus towards the eye, without the contexts of use of the object actually being reconfigured. From a practical point of view, the elderly who could read were just a subset of monks.
This ascent of the reading stone, from the paper to the eye, (up until then only conceptual) will be made concrete few years later, with a technical and empirical observation noted by the monks themselves: the fact that reading stones are much more effective when they are thin stretches of globe, rather than half a sphere or more. In concrete terms, the lens stones had to undergo a slimming process in order to make the ascent towards the eye possible in terms of weight, size and comfort. Stones were now somehow thinner, and moved between the book and the eyes.
At the very end of the thirteenth century, reading stones, slimmed down into convergent lenses, underwent the necessary mitosis in order to embrace the binocular nature of human vision. These were called 'rivet spectacles' owing to the rivet that joined both ends of the sidepieces that held the thick circular frame wrapped around each lens. Rivet spectacles were never *worn*. They were still a *moving reading- and writing-only aid*: sometimes held by the rivet, sometimes by the edge, sometimes in front of the eyes, sometimes halfway between the book and the face, sometimes in the hand waiting to be used, over a book, for individual or collective[1] use.

[1] See especially Martin Schoengauer's painting, 'The Virgin's death'.

The elimination of the pivot joint (XVth century) between the two lenses enabled to stiffen the structure giving it a rounded bridge; it also extended the scope of possible materials used and thus the object's final shape. In this way the moving aid was able to reach a milestone in terms of weight and thinness. Yet its functional context seems unchanged.
Finally, as the short-sighted nobility began to use eyeglasses, not for reading but for hunting (end of the XVth century), and the lens curve was changed, eyeglasses finally broke away from their status as a magnifying glass anchored to the book and embraced their destiny as optical devices correcting ametropia and centred on the individual. The use of divergent systems (correcting myopia) puts us in front of a radically different object. This difference stems from its anchor (the individual), its users (nearsighted persons), as well as its potential contexts of use (huge diversification of use situations).
This backward look at few simple optical systems can be summed up according to the following table (Figure 1):

Users	Old monks			+ scientists + painters		+ nearsighted nobility
Context of use	Writing, Illumination, Reading			+ manual labours		+ hunting, outside activities
Anchor	Book	Between book and eyes				The individual
Frame	/		Rivet spectacles 		Bridge spectacles 	
Glasses	Reading stone (convergent)		Convergent lenses			Conv. or divergent lenses
(Applied) Science	AlHazen	Bacon / a technical observation: thin stretches of globe are much more effective.				Printing
Paradigm	Enlarging the particular object of vision					Towards correction

→ *time*

Figure 1. A backward look at few simple optical systems

From these short account and figure can be illustrated the systemic nature of socio-technical hybrids (more than mere technical artefacts). Artefacts' shape appears to be only a single element of a bigger picture, which is *not* understandable from that particular piece of the jigsaw. Indeed many contemporary observers of rivet spectacles wondered why they had no sidepieces: 'From the moment they were invented, glasses posed a problem that wasn't solved for almost 350 years: how to keep them on!' [10]. That is exactly the kind of reasoning one will *not* do when replacing shape in a larger system. Because then appear the hesitation of the device between the book and the eyes, its goal of magnification rather than correction, its sometimes collective use, its very punctual use, dedicated to specific activities, etc. There is no way the rivet spectacles could have sidepieces in that system. Shape is out-of-reach without a representation of this global picture.
Furthermore we clearly see that artefacts, of a constant shape, are confronted with various contexts of use, users, anchors, paradigms, and thus distinct functions, as underlined by Sigaut. How could we then deduce functions from shapes?
For instance bridge spectacles with convergent lenses have quite different functions depending on the period in history. Before the use of divergent lenses, they still acted as intermediaries between the support (the book) and the eyes; they aimed to magnify, were a moving object and could be used collectively. Following the use of concave glasses, and although they had exactly the same shape, they acted as an individual means of correcting eye defects, and were held still or almost in front of the eyes (by the bridge). Once again, an understanding of the surrounding socio-technical network seems to be necessary to interpret (or design, should this happen) the structure of the artefacts.

2.4 Conclusion: Design needs an understanding of artefacts' surrounding socio-technical networks to go from function to shape.

The conclusion of this first part should be pretty clear by now: we tried to show, from different trades (psychology, design, palaeontology, history) and different perspectives, that (i) shape was a single piece of a complex jigsaw; (ii) the global picture of the puzzle cannot be caught from one single element.
It is the *perception* of affordances, and therefore the knowledge of a far-reaching and complex system, that makes an object looks like what it is designed for. It takes the palaeontologists an understanding of a historical, ecological, social, technical, and economic context to interpret the structure of an

artefact. A device that was never used, that had no interaction with anyone or anything (outside from its making), is a complete mystery. Shape is not enough; it does not induce function. Structure must be replaced in a larger system to understand why it is like it is, why rivet spectacles had no sidepieces.
All in all, knowledge of artefacts' surrounding socio-technical networks is required to *interpret* their structure. What is now most interesting is to know whether, *within the scope of design*, this knowledge is needed to *design* devices, and if so, how it is or can be mobilized in innovation processes.

3 REPRESENTATIONS OF USES AS WORK TOOLS

3.1 How functional analysis includes socio-technical contexts to design functions

A minimum of knowledge of design methods will be enough to tell that they of course tend to introduce models of socio-technical contexts (i.e. representations of uses, scripts of uses) in the design process. If there is no direct bond between structure and function, as we tried to show, one of the designer's roles is then precisely to build a set of connections embodying the concept, so as to create the "functional context" in which shape makes sense. The assumption that we made – that designers involve socio-technical contexts in their work – is therefore quite easy to check. Still, seeing design tools' involvement of socio-technical environment as an opportunity to link shape to function and take into account its systemic nature is already something.
The requirements analysis phases of design processes are the time when these representations are built. Of course those are only *representations* because nothing is fixed at that early stage of the process, where there is no object, use, context of use, or user. As Johan Redström pointed out by underlining the object-centric perspective of the notion of 'user', there must be something there to use in order for people to become users [11]. Then the term 'user' becomes an obvious misuse of language at a point where only wide open concepts are worked out; as it refers to heterogeneous representations of users' figures *built by designers*.
Involving users' spokespersons (such as marketing experts, senior designers, or potential end-users – participatory design) as representations of end-users' needs is suggested. Then requirements lists are in some ways models of designers' predictive uses. It could be noted that the choice and segmentation of potential end-users are already a strong sign of the influence of designers' representations of uses in the innovation process.
Those models of predictive uses are functional models, where the device is described as actions it has to perform. Some of them focus on the identification of functional requirements, and involve some aspects of socio-technical contexts of use as well. In the value analysis method for instance, functions are identified as *interactions between external elements and the device*. The environment diagram (Figure 2) is precisely suggested to explore the relationships between the artefact and its environment. There are as many functions as links between the artefact and the environment (Constraint Function) or connections that go through the artefact from an external element to another (Use Function).

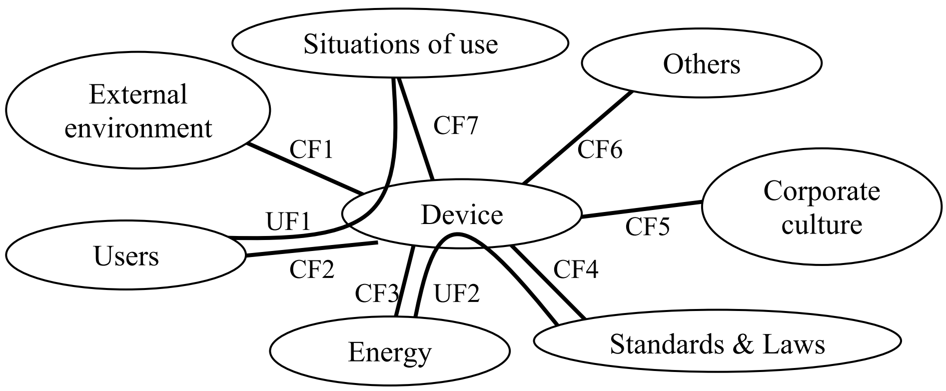


Figure 2. The environment diagram

It illustrates well, from the first part of this paper, the systemic and plural nature of function, and the need for designers to build that system to embody a concept and then design an object. Still, the point remains to think *ahead* those socio-technical networks within which technical devices will come. As far as breaks in dominant design are concerned (and required!), building relevant representations of

those networks could be an issue. If design has to go through the integration of scripts of use in objects, it seems crucial that those *likely* scripts (because they are anticipated) could be discussed, managed, and do not remain at a stage where they are implicit, integrated in everyday methods and where they are missing their purpose.
Other methods, such as life cycle analysis, suggest focusing on the different steps of the device's life (in stocks, in transport, during installation, use, maintenance, recycling). The expectation here is once again to take into account (and formalize) the various situations of use of the product in order to identify the functions that the device has to perform. The team tries to build an exhaustive list of requirements, *based on their own representations of the artefact's uses*.
Requirements analysis, through those diverse tools, approaches the environment as an object-centred method. Functions, although they are characterized through different tools, aim to be defined by *parameters that can be measured*. They guide the breakdown of the product into sub-systems, then the search for technical solutions. Therefore they are the basis of the artefact's architecture (SADT & FAST diagrams).
One other intervention of use representations in design that is worth noting takes place during the qualification process of the object. Its validation is actually based on models of forecasted situations of use (normal, occasional or extreme situation). The *load cases* used in mechanical analysis are perfect examples of such models: anticipated contexts of use are the basis of the modelling of constraints or limit conditions. Use situations and environmental elements are translated into load cases, i.e. quantitative data that lead the qualification of the object through numerical simulation or physical test of prototypes [12].

If the involvement of environmental socio-technical elements in recommended design tools confirms the need to consider (imagine) a wide and hybrid system to design the structure of artefacts, it also points out the issue of the relevance of such anticipated systems (especially in case of breaks in dominant design) and the critical role left to designers' representations of uses. Furthermore, those representations are implicit in the work of designers, quickly hidden behind numbered parameters, and therefore rarely discussed or put in balance again, outside of a reassessment of the function's value. When you know how various use representations of designers can be [13], and what they are linked to (Darses and Wolff show the different kinds of users mobilized, according to the types of meeting that were hold.) you may legitimately consider those representations as an influential parameter of design, that one should know how to build, change, reconfigure, or diversify.

3.2 Losing the big picture…

Yet those implicit representations are diluted in numerous functional requirements, that condition (restrict) sooner or later the perception of use. Incidentally, in the case of complex and well-charted products, use representations of designers are even often limited to the vision of the technical parameter(s) they are in charge of. A major difficulty is therefore that with this kind of design management the breakdown of the object into several sub-systems blurs the global vision of the product to a point where only design parameters remain. To quote John M. Carroll, "(…) the switch to enumerating features and functions can cause them to lose the big picture. Listing isolated design elements can capture attention; it can become a task unto itself, diminishing attention to how those elements might work together to address the user needs that were originally identified" [14, p30]. Among the identified risks are a local optimization that does not take into account the interactions between components; and a growing difficulty to re-question dominant design, to get out of local increments.
That is why the relationship between functional requirements and the structure of artefacts is one of the main stakes of design. Several models have an idea on how this must be done.
According to Suh's axiomatic model [2], design can be seen as the mapping from functional to physical domain. The choice of the right design parameters should indeed be made in order for the matrix [functional requirements x design parameters] to be diagonal. In other words, while defining design as a continuous return from functional requirements (FRs) to design parameters (DPs), Suh suggests that effective design should respond to the following equation:

$$(FRs) = (A).(DPs) \qquad (1)$$

It advocates uncoupling functions so that each functional requirement corresponds to a single design parameter. The old-fashioned tap, with its two cold/hot settings, can be therefore labelled as sub-optimal design (according to Suh's model), as the rotary motions control both the heat and the flow of water. Those two design parameters are uncoupled in modern mixer taps, where horizontal (vertical) rotation sets the heat (the flow). Those will undoubtedly be Suh's favourites.

Anyway this theory of reliability, which breaks user needs down into independent functional subsets, then separate design parameters, and then distinct design teams, aims to minimize coordination needs, while smashing the big and complex picture of use. It configures an organization which is therefore dedicated to the local improvement of design parameters. It advocates in favour of teams able to manage modules' interfaces rather than to integrate multiple systems. It gives a gigantic significance to the 'original big picture of use', initially developed to identify functional requirements (and therefore behind product's architecture / organization's configuration); and then endeavours to hide this macroscopic representation behind partitioned systems. Numerous examples of complex systems come to mind.

Yet let us take the instance of eyeglasses (such a simple device…) back. Looking for a high index plastic that does not scratch is definitely different from looking for a high index plastic that tolerate the anti-scratch coating. The first suggests integration, whereas the second seeks coordination, according to Suh's logics. The current product's and organisation's structure of ophthalmic glass manufactures follows the last path. Each element has its proper function: the plastic corrects, and then comes the stack of functional coatings: anti-scratch, anti-reflection, polarised, etc. This produces high-performance but highly-specialized modules. Each one is linked to a team that refers to a specific and partial representation of uses (teams' representations are potentially contradictory). On one hand, 'anti-scratch teams' will develop a representation of uses where spectacles are unlikely worn: always here and there, put on desks and tables, jumbled up in bags… On the other hand, 'correction teams' or 'anti-fatigue coating teams' will get an opposite view of the product: worn (incorporated) from dawn to dusk… If this breakdown remarkably translates the plurality of uses, it also asks several questions: Why keeping these representations implicit and unshared (partitioned)? Why should not they be confronted between teams? Are people scratching their glasses not potentially the same as those wearing them all-day long? Who is in charge of discussing the biggest picture? Is it not out of reach here, bound to remain the same old big image (dominant design)?

Future scripts of use are conditioned by current partitions (of product, of uses, of organisation). The impossibility to discuss the big picture from independent teams is obviously a major trouble for innovation. The case of research teams or departments that take advantage of a promising emerging technology to both release from current structure (organisation) and discuss alternative scripts of use [15] speaks volumes in that particular sense. Technological breakthroughs both imply unusual representations of the product and of its uses (the new technology does not fit the current structure / architecture) and benefit from a development of marginal pictures of uses, as it releases the new technology from established stakes and brings out logics of coordination with existing modules *and* logics of integration.

To end this part, it is worth noting that the mapping from functional requirements to artefacts' structure is not Suh's privilege. Among others, functional analysis and allocation [16] focuses, during systems engineering, on the translation from customers requirements to functions and their partition into building blocks. This last particular step corresponds to the definition of the product's architecture. Ulrich and Eppinger, as far as they are concerned, [17] define architecture as the scheme where functional requirements are organised into subsystems and physical components. All in all, the partition of forecasted functional systems into independent subsets does not further the sharing of a global vision of a product and of its uses, neither its discussion. The big picture of use, behind the architecture of products and the configuration of organisations, fades out behind design parameters.

3.3 Conclusion: Managing relevant and explicit representations of socio-technical networks: big pictures at all stages.

The structure of artefacts must be replaced in a large socio-technical system to be understood; that is what we claimed from the first part. Function has a systemic nature; it has never been inscribed on shape, but on the historical, ecological, social, technical, and economic context of objects. A look at some well-known design methods bears this rationale out: they involve socio-technical environment in the identification of functions (a function, according to value analysis, is an interaction between the

device and external elements); they follow designers in helping them building a set of connections to surrounding actants, embodying concepts in scripts of use.
Still, if design tools integrate the systemic nature of functions and commit designers to project the object in a likely (because anticipated) script, they give an enormous significance to implicit and hardly discussed representations. Because then functions are translated into functional requirements, then distinct design parameters and independent teams (cf. Suh's matrix): unspoken scripts are behind the structure of products and organisations. Yet original big pictures of uses fade out during the breakdown. Tools like value analysis are performative: they create the partition that they suggest. This takes place at various levels: organisational (distinct teams), architectural (structure of products), and representational too (teams develop their own partial or 'short-sighted' vision of uses).
Losing the big picture of use could be much of a trouble for innovation; totally implicit and therefore hardly questionable, it stands as the only possible way. However, at the same time the product's architecture and the organisation's structure convey a particular unspoken dominant design, the partition they form creates numerous and heterogeneous models of use, potentially contradictory and implicit as well. From concepts creation and analysis to prototypes tests (example of load cases) thrive many tacit and short-sighted models of use, whose relevance never seems to be addressed.
What we are suggesting here is that use representations could and should be, particularly in a context of intensive innovation and of dynamics of objects' identities, an influential parameter of design, that one must know how to build, discuss, reconfigure, or diversify. Beyond requirements management, which consists in keeping traceable the series of intermediate translations from customers' needs to technical specifications of subsystems, the issue is here to keep a shared and partially explicit vision of socio-technical contexts where designed objects are imagined, throughout the design process. How global vision must be reintroduced without removing design parameters? We identify here the need of intermediary objects, which would enable to mobilize the user (his representation) and his requests at different stages of the design process; and to explicate designers' representations of their product. But what are the relevant intermediary objects to simultaneously represent the big picture and the requirements of products?

4 CONCLUSION: USE SCENARIOS AS BIG PICTURES?

Carroll's approach [14], and generally speaking scenario-based design, seems well-positioned to us to tackle that question. Indeed tracks like scenarios could be particularly fitted to give an embodied vision of innovative products, making explicit the unspoken scripts of use, and providing an intermediary object of discussion between and within teams. Therefore we think scenarios should not be seen as prospective tools, but rather as design work objects, able to make designers' perceptions of uses move about at a global level, upper than their design parameter. They should be seen critically, as ways to overcome dominant designs, rather than expected places to go.
The characterization of scenarios (by extension to the representations that they formalize) as an influential parameter of design, as a means of explicating, sharing, and discussing unspoken scripts of use, as ways to destabilize dominant designs, and as essential tools for intensive innovation, is an original depiction. It goes further than the purposes usually mentioned in the literature, i.e. providing context for trial use as well as for feed-back to designers [18]. If "the role of usability changes [with recent works] from being an activity that "approves" of a computer application, to an activity that takes responsibility for the product and its future use" [18, p62], we suggest an even more fundamental integration of these tools to the activity of design: scenarios, in our opinion, could help to maintain big pictures of use despite the breakdown (the partition) of the product and the organisation. Scenarios would then be responsible for keeping the link between function and shape; they would act as representations of the "systemic functional context". The scenarios that we are describing are then obviously centred on all the socio-technical networks within which the product plays (rather than product-centred). If scenarios are constructions made with a *purpose* [18], then it is crucial to take this one into account.
The research we are currently leading in a three-year exploratory program subsidized by French Research Ministry on ambient intelligence, and the interviews we are holding with partners' R&D teams make us believe this is a rich track, as there is a real demand from designers for this kind of contextualization of the concepts and technologies they are handling everyday. Yet questions remain: implicit use models are everywhere in design (not just in concept design); do scenarios have to be present throughout the process, or at precise times? The breakdown of products leads to different

levels of subsets; how far do scenarios have to go? How big (small) must the picture be? What is the adequate zoom for a team working on a truck's engine's sparking plug? The use of sparking plugs, of engines, of trucks, of vehicles? Must scenarios be closed or open-ended? Whereas critical scenarios, developed to allow perspectives to be confronted with one another [19, 20], seem more appropriate than scenarios based on typical situations, may those two types work together? Our future works should allow us to examine those questions in more detail.

One of the main issues – we have already mentioned it – may be that scenarios could freeze possibilities, instead of opening them. This point is incidentally qualified by Carroll as one major risk of scenario-based design [14]. That is why competing scripts are vital. They open up new horizons to R&D actors. They renew their vision of uses. Designers are then able to re-work on their implicit representations, to discuss them, individually or collectively.

That is what this function – shape connection's story is all about: building intermediary objects allowing designers to keep a global representation of the product and of its values; building as global and complex representations of problems as those of solutions. Scenarios could be an additional approach to requirements management, aiming to give an existence to the representations of imagined socio-technical networks.

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