The Body in Ideas: Implications of Embodied Cognition for Design

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ABSTRACT

Our paper discusses the role of human body in the design practice, drawing from cognitive science contributions. we discuss the role of the bodily dimension in design projects starting from Norman's seminal book on Emotional Design, to then review the most recent research on embodied cognition. We conclude by discussing two implications for design, concerning the role of embodied knowledge and the importance of designing for diversity.

Keywords: Embodied Cognition, Interaction Design, Emotional Design, Individuation

INTRODUCTION

Design has been considered as a means to solve problems. A good designer analyzes the problem space, tries out different solutions, and iterates till the problems are addressed. Designers transform intuitions and guesses into objects, into products. *Form follows function*, meaning that design gives shape and form to needs. If we are to adhere to this motto, designers translate abstract ideas about "what is needed" into products. They are the ones that give body and substance to the world of ideas.

In this paper we aim to complement this idea of design with insights coming from research on cognitive psychology, to show how ideas already possess a body. Designers do not only perform the work of "embodying" abstract concepts into objects. Ideas are borne with a body, so designers need to act directly on that body as well.

"DESIGN IS GETTING FROM HERE TO THERE"

The sentence in the title is derived from Petroski's book on the evolution of useful tools (Petroski, 1994). Petroski describes how the current form of the paper clip is the product of a slow evolution, where different solutions were proposed for the same problem (keeping sheets of paper together). The same for utensils like forks and knives, which evolved in parallel with different societies' customs and habits, to cook food, slice meat and serve it to guests,

bring the food to the mouth (spoons).

The design processes described by Petroski are not driven by an abstract idea of a potential solution. They start from the practical us of a tool in a situation to *do something*. Whenever the tool proves to be less than useful, design comes in to adapt it, to modify its form. For this reason, Petroski proposes the motto “form follows failure”. Every tool is a solution to a problem. Whenever the solution turns out to be less than effective, designers strive to conceive a new solution and give it a form. In this conception, design is a way to get things done, to “go from here to there”.

Petroski clearly opposes the idea of the solitary thinker, who by hard reasoning finds the best solution. He shows the incremental nature of design, and how new design ideas are borne by using objects. Design is new forms following old forms.

EMOTIONAL DESIGN

To complement this conception of design, we may refer to the work of Donald Norman on emotional design (Norman, 2004). In Norman’s book, design is seen as developing on three levels: visceral, behavioral, reflexive. Two of these three levels are about the body sensations.

On the visceral level, shape and size matters, the weight does. The object needs to appeal sight and touch. At this level, the physical features of an object are of primary importance: look, feel, and sound. These features are automatically interpreted at the visceral level, where we perceive an object as beautiful, or a sound as pleasant. Visceral design requires the skills of industrial designers, of visual and graphical designers.

The next level described by Norman is the behavioral one. This level is about the use we make of a tool, about the results that we can achieve with it. The behavioral level is concerned with performance, with function rather than form. Good examples of behavioral designs are objects that perform a function and fulfill needs. Most of the times is hard to uncover what the real needs of users really are, but this is exactly what is at the core of this design level: finding out what people really need, making it easy to use the first time, and then after. The four main components are: function, understandability, usability, and physical feel (for material objects).

The third level of design is the reflexive one. It concerns the meaning we attribute to an object, the values, motivations, and objectives that we project onto it. It is about us seeing more than there is in an object, projecting meaning and values on it. But it is also about the message that an object sends to others, about itself and about us (as users). About how we think others are going to perceive that object and us, the users. In this category, one may also have objects with no functionality, impossible objects, that prompt the user to reflect on conventions, or on abstract ideas.

Norman proposed this division in three levels to enrich a purely function-oriented conception of design. The behavioral level is about accomplishing things with objects, with the other two levels accounting for the experience of using an object. Design is about targeting the three levels, balancing their importance. In a well-known example, Norman discusses the qualities of three teapots. The different sensations that Norman derives from the use of each one of them can hardly be explained by their function alone. Basically, they serve to prepare tea. But their material aspect, the way one has to interact with them, triggers totally different experiences, that are described by Norman as “appealing”, “complicated, but practical”, unusable”, efficient”, “simple”, and so on.

Figure 1. Two of the three teapots described by Norman.

DESCARTES' ERROR

The importance of body and matter in design is not a surprise. To further our discussion, we move to cognitive science and to the analysis of decision-making processes. It has been shown that decision-making is deeply affected by body sensations. The neuroscientist Antonio Damasio has proposed that body markers (i.e. sensations and emotions) are our key tools to assess different alternatives and options (Damasio, 1995). Without a body, we would not have emotions. Without emotions, we would be unable to make even the most trivial decisions.

In his book, Damasio tells the story of a very interesting brain lesion, the one happened to a man named Phineas Gage. During railroad construction works in the USA, Phineas suffered a major injury, with an iron bar entering his skull and damaging a brain part. What was really surprising was that Phineas not only survived such an extensive lesion, but that he appeared to have preserved his cognitive capabilities. He remained able to understand language, he could speak, perform logical and mathematical operations, apparently to the same level as before the injury. But he became a different person. He became aggressive, incapable of self-regulating his behavior in social occasions. There were also more fundamental changes: he changed his attitude towards life, becoming a dissolute man, while before he was very responsible. To summarize, he would not know how to behave in everyday situations, he could not make the right decisions at the right moment, whenever he was confronted with concrete daily situations (and not with abstract problems).

The clinical diagnosis for his disturbance is named anosognosia: it is the lesion of part of the somato-sensitive cortices on the right side of the brain, resulting in the incapability of perceiving one's body sensations. It is a deficit of self-awareness, where the person seems unaware of her/his physical condition.

What has such a lesion to do with Phineas' behavioural problems? The hypothesis put forward by Damasio is that those body sensations are key to orient our behaviour. We can differentiate among different choice alternatives, because our body anticipates how it is going to feel in one, or the other case. We anticipate the outcomes of the various choices by feeling them in our body. These body markers help us to discard some options as unpleasant, while only acceptable options get to be consciously assessed. The sensations rooted in our body are fundamental decision mechanisms, driving decisions that would otherwise appear as purely "cognitive", brain-related.

EMBODIED COGNITION

The same strong relationship between body and mind is currently being much discussed by the approach named "embodied cognition" (Wilson & Foglia, 2011). According to this approach, our body plays a key role in giving shape to cognitive processes. It mediates the interaction with the world, it constraints the mind shape and contents, it regulates how the mind has to act in space and time. Glenberg mentions four main arguments to support the embodied cognition perspective (Glenberg, 2010). (i) Cognitive processes evolved to ensure each organism's fitness to survive. Such fitness is linked to a close interaction with the external environment, that only happens through the body. For this reason, it is unreasonable to ignore the body to understand cognitive processes. (ii) Cognitive processes need to be aligned with one's own body capabilities. Our thinking needs to consider what the body can do, and what cannot do. This implies a close co-evolution of the two. (iii) The body is a constant presence in life. It is there from birth to death. It is unreasonable not to consider it to understand cognition. (iv) The experience of the surroundings is at the basis of our thinking and it comes from our senso-motory systems. The key claim of the embodied cognition approach is that most (if not all) of our cognitive processes are affected by physical, perceptual and motory characteristics of our body, by its morphology and by the characteristics of our senses.

In a recent paper by Caruana e Borghi (2013), the authors maintain that the various approaches to embodiment have in common a shift of emphasis from cognition as happening in the brain to cognition as being closely linked either to perception or to action. Perception-based embodiment are usually grounded on phenomenology, with perceptual sensation having a primacy on cognition (Gallagher & Zahavi, 2008). Action-based approaches claim that human

behaviour has to be studied in relation to the function it fulfils for the individual. Gibson's well-known ecological psychology (Gibson, 1979) shares similar tenets. Human perception is primarily a means to guide action, thus the individual will not perceive the external environment as an objective reality. She would rather selectively take in only the elements that can be used to act, seeing the environment through its "affordances" (i.e. possibilities for action), not as a collection of undifferentiated objects.

Caruana and Borghi also propose to distinguish three different conceptions of what embodiment is. The first one maintains that body parts have a clear influence on cognition, for instance via mental images *standing for* body sensations, or as the main means to give form and substance to cognitive processes. An example drawn from the field of robotics is the iCub robot. This robot was created starting from the hands. Researchers do not directly implement its intelligence in order to have it acting in the world. On the contrary, its mind is empty at first, and gets populated as the robot interacts with the world (Metta, Sandini, Vernon, Natale, & Nori, 2008). The second perspective studies the interplay between body sensations and cognitive processes, not dissimilarly to Damasio's book. Another example could be the *priming* effect (Bargh, Chen, & Burrows, 1996), where facial expressions influence how funny we perceive a joke to be or, vice versa, where the activation of mental thoughts about being old causes study participants to walk slower than they would normally do. The third, more disruptive, conception blurs the distinction between cognition (traditionally seen as the manipulation of abstract symbols) and thinking as achieved through body images. An example of this line of study can be found in (Kirsh, 2010) on coordination and learning processes that take place in a company of modern dance. In this case, the type of knowledge being studied is directly embodied, as it is a mental representation of complex body movements. Kirsh analyses the process to learn, develop, memorise, share, and discuss this knowledge among fellow dancers. It is a study on how to develop and learn embodied knowledge about the body.

Tacit Knowledge

If we contextualise the above discussion into the design field, we see that embodied knowledge is definitively close to what has been known since the sixties as "tacit knowledge" (Polanyi, 1962). Tacit knowledge relates to the *know-how*, to practical applied knowledge. We know how to do something, but it is hard (or impossible) for us to verbalise how we do such things. This form of knowledge derives from practice; it is connected with practice and makes our performance smooth and effective.

According to the above discussion on embodiment, we can further break down Polanyi's tacit knowledge into two types of knowledge. One type is the highly automated one, knowledge we can use without consciously paying attention to it. But this knowledge type is not embodied by necessity. It may have started as "normal" declarative knowledge (how to read, how to multiply numbers) and have become tacit only after a process of internalisation. Now our eyes know how to read and we do not have to pay any attention at all to do that. If we were asked to describe how we do that, it is likely that we have forgotten how we learnt. We cannot tell, because we cannot retrieve from the memory the intermediate steps of a complex sequence that now appears to be just one action. The second category is actually the embodied knowledge as discussed above, as it refers to the sensory-motor knowledge. We know how to do things, with our body, our hands, and with fine eye-hand coordination.

As compared to the first type of tacit knowledge, this type of knowledge is impossible to break down. You can show and demonstrate how you do that, but you cannot simply describe it in words. While a good teacher would be able to tell in plain and simple words how to read. This second knowledge type is slow to acquire, it requires long periods of practice but, once learnt, it is never forgotten. It is very robust to disruptions and interference, lack of practice. It lasts long.

EMBODIED COGNITION IN ACTION

The above discussion tells us that there are forms of knowledge closely connected to our body, to the way we think with our hands and movements, and that we are often unaware of these skills, even if we exploit them in our daily life. Two clear examples of the importance of these skills can be found in the work of David Woods and Erik Hollnagel.

In the first one, they describe how nuclear power control room operators were observed to rely on auditory cues

when monitoring the system. Specifically, they were picking up changes in clicking sounds made by mechanical counters, indicating the position of the control rods as they moved in and out of the reactor.

"It turned out that activity of the automatic rod control system was indicated by the sounds made by the mechanical counters as the control system moved the rods to regulate reactor power and to shut down the reactor if faults occurred." (Woods & Hollnagel, 2006, pp. 15-16)

What is remarkable about this example is that the operators could pick up the clicking sound without disrupting their action flow. Their attention moved to the rod control system only when necessary. This knowledge is tacit in the sense that the operators were not aware of it, nor were they aware of using it. They recognised this knowledge when someone directed their attention to, but normally they would use it without a conscious process of analysis or decision-making. The process of acquiring this knowledge was also typical of the embodied knowledge. There was no dedicated training; this knowledge emerged from practice and from an established link between perception and action.

Another example relates to the cues that aircraft cockpits provide to pilots when there are changes in the autopilot mode. On modern cockpits there are multiple automation modes that can handle vertical navigation, horizontal navigation, power management and other tasks in different ways. Cockpit design often provides only weak cues when the autopilot transitions from one mode to the other, making detection of changes very difficult for pilots. As a result, automation surprises can cause pilots to lose track of how automation is flying the aircraft, until they detect some unexpected behaviour of the aircraft. To increase the salience of these transitions, Sklar and Sarter employed the haptic modality for notifying pilots of mode changes, comparing this method with visual cues in the context of a realistic flight simulation (Sklar & Sarter, 1999). The results indicated that performance was never perfect with visual cues, and it dropped off significantly in high workload. On the contrary, with haptic feedback pilots detected all of the mode transitions, even during peak performance and workload.

Haptic feedback shows a remarkable feature. Pilots do not need to pay any attention at all when the mode change is expected. And in fact there are not distracted at all, as shown by the performance during high workload periods. It is instead noticed when the mode change is unexpected. Pilots then modify their behaviour accordingly, to fit the new automation mode. Visual cues are instead distracting even when there is no relevant information, or transitions are missed when they should not, especially in moments of high workload.

We mention these cases because they both show the power of embodied knowledge and how this form of knowledge can translate into effective action without the need for what we normally call reasoning.

These forms of embodied knowledge are particularly important in stressful situations. In these situations, our brain "shuts down" the areas connected to more advanced thinking (i.e. pre-frontal cortex) and relies on the thinking that gets done in its most primitive structures (the striatum and the sensory-motor cortices). Oversimplifying for clarity's sake, in stressful conditions we do not stop and think, but we trust our body in order to react in the fastest possible way, thus relying on embodied cognition rather than on declarative knowledge (Arnsten, 2009).

IMPLICATIONS FOR DESIGN

What are the consequences for design if mind and body are so closely interconnected? How can we exploit this form of knowledge if we are often not aware of possessing it?

There two implications for design that we can draw from the above discussion. One is about the need to train and develop this form of knowledge. The second one is related to the methods and tools we would need to deploy to address this aspect.

Training for Embodied Knowledge

Compared to declarative knowledge, the processes to develop and learn embodied knowledge are different. This form of knowledge is characterised by resistance to change and it is hard to forget. On the other hand, it is also extremely plastic, not rigidly defined, and can be customised for many applications. Training and learning for this type of knowledge requires a careful balance among seeing others performing, doing, reflecting on what has been

done.

Jon Kolko tackled the issue in an article appeared on *Interactions* (Kolko, 2011), where he claims that the designer work shares many similarities with craftsmanship, considered as a balance of hand dexterity and practical intelligence. This remains true for designers that are mostly involved with digital products. Kolko advocates that designers should be exposed to a wide range of craftsman-like activities, where they have to pay special attention to aspects, like for instance colour, shape and form, texture, and so on. He then lists four main characteristics for these activities. First, they need to require designers to use fine sensory-motor skills, both to observe and to design. Second, details matter. So the designer should be asked to work as much as possible on minor details. Each one taken on its own is not important, but all the details together convey a message of thoroughness, of wholeness of the underlying design idea. Third, all the works should be shared and commented within the community, to establish a social paradigm of what is a good piece of work, to preserve an open attitude to learn and self-criticise. Fourth, these activities should foster a slow and methodical pace of working, where the designer stays focused on the work to be delivered.

According to Kolko, these training activities remain important for interaction designers, dealing with digital products. They are important because they help producing high quality work. One aspect that is specific to interaction design craftsmanship is the capacity to work on the meaning of a product. Interaction designers do so by learning how to tell stories, to highlight the users' needs and motivations, to tell the context in which the product will be placed. This ability is hard to teach, it is a tacit one. A designer has to connect the idea as she sees it, to a narrative presenting it to other persons, carefully balancing the details that she is providing on all the constituting elements, i.e. persons, behaviours, goals, technologies, interactions.

Tacit knowledge is seen as a key designer's asset by Kuutti, too (Kuutti, 2009). Design teaching should not focus on methods and tools, but on developing "impossible to formalise" perceptual and motor skills. Design a good product is not about applying a method and obtaining the same results, as another designer would do. It is about cultivating one's own capacity to assess what is "good design", to recognise it at first glance, by expert intuition.

To sum up the discussion, the knowledge required to be a good designer is in our eyes and hands. It is in the assessment that relies on fine perceptual skills for the details, on what is recognised by everyone as "good" even if no one can define what makes it so good in words.

Individuation

The second implication is that every design idea (even a very abstract one) already possesses its "body". A design idea is about a physical context, it concerns the interaction between a specified person, her/his body, and specific tools. Design is not only about giving form and shape to ideas, it is also about understanding the form and shape that the idea already possesses. But if body matters, then every user is going to be different, every situation of use is going to be unique. Designing for embodied users increases the variety of users and contexts of use to be considered by design processes, asking for methods and tools to design for diversity.

How do we understand such complexity? How do we deal with the intricacies of each specific situation? Our proposal would be to adopt the strategy of individuation, that is to understand specific users, delving into the complexities and intricacies of single users' interactions, into the minute details that differentiate one user from the others. This approach has been captured in psychology by the opposition between the nomothetic and the idiographic approach (Cronbach, 1957, 1975; Hancock, Hancock, & Warm, 2009). The nomothetic approach studies events and persons as examples of some general law. Its aim is to identify the general features of psychological processes, to describe the "average behavior" across individuals, and to establish rules applicable to the largest possible number of persons. On the other hand, the idiographic approach studies events and persons as unique cases. Its aim is to understand specific instances of behavior, related to one single individual and her/his interactions with the context.

It is not only a problem of analysis, but also of results communication. As well put by Hancock: "Quite simply, how does one illustrate individual differences that are truly unique to each individual? This means, how does one plot and communicate the findings from studies of true individuation?" (Hancock et al., 2009). In the same work just cited, Hancock suggests that inspiration should be sought in visual and media arts, because of their mastery in telling individual stories (note the similarity with Kolko's argument).

The focus on individuals can be used to support two design directions: (i) Incremental: specific use situations and individuals are studied to gain more in-depth knowledge on a specific issue; (ii) Breakthrough: specific use situations and individuals are studied and exploited as catalysts of innovation (Pozzi & Bagnara, 2013).

In the case of incremental innovation, the knowledge on complex problems is advanced by a throughout study of a specific individual. Focusing on one individual enables the collection of a more extensive data set, often covering very intensive (i.e. 24 hours a day) and extensive (i.e. even years) periods of time. A famous recent case is the one being carried out by Deb Roy at the Massachusetts Institute of Technology under the name 'The Human Speechome Project'. The project sets out to understand how children learn the meaning of words, and is recording approximately 10 hours of audio and video per day of Roy's child in his first three years of life. Such an extensive data gathering is meant to avoid the pitfalls of previous research on the same topic, largely based on surprisingly sparse and incomplete data, and mostly focused on later stages of child development.

The second strategy targets more radical innovation (i.e. breakthrough), changes of technological paradigm, which is sometimes referred in the design literature as "the creation of new meanings" (Verganti, 2009). While the analysis of existing users (the first case just presented) does not question existing meanings but rather reinforces them, breakthrough innovation focuses on the creation of new meaning. In this case specific situations of use are not analysed because they are in some way similar to other situations, but to "*detect* the whispers in the current socio-cultural models, *identify* the weak voices likely to grow stronger in the future" (Verganti, 2007, p. 167). Specific individuals and situations of use are valued as precursors, or as catalyst for emerging innovations, in order to create new meaning for existing human activities or products.

CONCLUDING REMARKS

In this paper we aimed to show the importance of considering the bodily dimension in design projects and to discuss two implications for design, suggesting approaches to address them. To elaborate on why body is so important, we relied on key works from design and on the increasing interest that embodied cognition is receiving in the field of cognitive sciences.

What are the consequences for design if mind and body are so closely interconnected? The first one is that every design idea (even a very abstract one) already possesses its "body". This requires a specific mix of theoretical-methodological-practical training for designers, in order for them to be able to appreciate design features that typically connect with embodied knowledge. The second implication is that if body matters, then every user is going to be different, thus requiring methods and tools to design for diversity. We discussed how study of individuals can be used to feed design, both for incremental and for breakthrough innovation.

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