The Origin and Design of Intentional Affordances

Antonio Rizzo
Università di Siena
Via dei Termini 6, Siena, IT
rizzo@unisi.it
+39057748263

ABSTRACT
Gibson's seminal concept of affordance could have real design power if it could be adequately explained as a phenomenon that happens within the scale of human lifetime. Today there is a growing number of neurophysiological and behavioral studies that shown that the intuition of Gibson was just a starting point for a more elaborated theory of affordances.

Author Keywords
Affordance, Interaction Design, Action, Intention.

ACM Classification Keywords
H5.2, I5.2

INTRODUCTION
The original concept of Affordance, as proposed by Gibson [4], does not provide adequate support for deliberate design of affordances. In Gibson's theory, the establishment of affordances is accounted for by learning in an evolutionary sense, through the history of the whole species. Gibson's account does not yield sufficient insight for affordances that are culturally determined through individual history. Indeed, when Gibson tried to address this issue, he suggested a concept that is barely distinguishable from any other concepts of human learned knowledge. The Affordance notion lost its emergent and relational ontology. Gibson's seminal concept of affordance could have real design power if it could be adequately explained as a phenomenon that happens within the scale of human lifetime. This has been the attempt of cognitive approaches [5] and activity theory approaches [1,2]. However, even though they helped manifest the heuristic power of the Gibson's intuition for interaction designers (the cognitive approach), and set a proper direction for the theoretical discussion (the activity theory approach), these attempts fall short of providing a rationale for the genesis of the ontogenetic creation of affordances.

Affordances are opportunities for actions available in the environments for individuals with proper sensory-motor abilities. They do not belong to the environment neither to the individual, but to their relationships. Affordances are emergent phenomena between distribution of energy in the environment and potential agents' behavior that produces privileged interaction modalities among the myriad of possible relationships. Notwithstanding the relational ontology of affordances, once established, they exist by themselves independently from their perception by an individual, from the attention someone could put on them and even from the availability of signs that point out their existence. However, according to Gibson, the notion of affordance rests on the idea of a direct link between perception and action: perception is a means to action and action is a means to perception. This perspective maintains the impossibility of drawing a sharp line between *acting* and *perceiving*, the distinction between perception and action is considered deceptive. Today there is a growing number of behavioral and neurophysiological studies that demonstrate that perception and action have a common coding.

The first evidence was the discovery at the University of Parma of sensorimotor neurons located in the ventral part of the monkey premotor cortex, that is the coexistence within the same neuron of motor and sensory properties. Fadiga et al. [3] postulated that the motor system not only executes actions but also internally represents them in terms of 'motor ideas'. Indeed, the visuomotor neurons fires when we grasp an object with the left hand, with the right hand, or with our mouth. These neurons do not codify movements but goals - they codify grasping. When they become active, their firing tells to the individual: "grasp". The existence of these neurons gave to goals the same ontological dignity than that of visual experience produced by physical reality, such as the perception of vertical and horizontal bars in the visual field. They also provide the neurological correlate of the Gibsonian affordance but raise sensorimotor process to ideomotor activity.

INTENTIONAL AFFORDANCES
Thus, in our brain exist neurons deputed to the coding of objectives. But, for how astonishing was this discovery, it was nothing in respect to the next step made by the Rizzolatti's group, that is, the discovery that some of these neurons does fire not only when the animal perform grasping, but also when they see another individual grasping. These neurons do not tell if the goal-oriented action is carried out by the individual they belong to or by another individual, they are sensible just to the goal that has to be pursued. Rizzolatti named these neurons "mirror neurons" [6]. More recently, it was found that a subset of these mirror neurons also respond when the final part of an action is hidden and

DIS 2006, June 26–28, 2006, University Park, Pennsylvania, USA.
ACM 1-59593-341-7/06/0006.

can only be inferred, however when the action is seen in its entirety this part is crucial in triggering the response. Therefore, specific neurons in this region respond to the representation of an action rather than to the action itself. Ongoing work by this laboratory extends this idea by showing that some neurons in the same region display mirror properties between motor sense and other modalities such as audition. This demonstrates that single neurons are concerned with some actions regardless of the modality through which they are inferred, and suggests that it is the consequence of the action that is represented. Such neurons are not restricted to the premotor cortex but have also been identified in other areas of the brain, notably in the posterior parietal cortex in relation to actions performed with objects.

The current interpretation is that mirror neurons allow an animal to understand what other individuals are trying to do. When mirror neuron fires in a "passive" way they signal to the organism the same action that they signal when it is actually carried out. In this way an individual who observe someone else put herself in the boots of the real actor of the scene. I understand what another does since this give rise in me a close neural activity to the one I produce when I perform that action. The mirroring process mediated by these neurons allow us to know the world through the actions we can perform in the world, and such performance would be defined by the intentional states we learn to generate along our social life, from birthday forward. When children observe other people using cultural tools and artefacts, they often engage in the process of imitative learning in which they attempt to place themselves in the "intentional space" of the user—discerning the user's goal, what she is using the artefact "for." By engaging in this imitative learning, the child joins the other person in affirming what "we" use this object "for": we use hammers for hanging frames, a vacuum cleaner to make mommy happy, a refrigerator to prepare dinner. As children are involved in such intentional mirroring process they start to perceive objects and artefacts as elements that evoke, beyond basic sensory-motor affordances, another set of affordances, the intentional affordances, as named by Micheal Tomasello [7]. *Such affordances rest upon the understanding of the intentional relations that other persons have with that object or artefact—that is, the intentional relations that other person have to the world through the artefact*. Thus, we claim that human affordances have a double nature that can be mutually supported and that is nested in the history of the artefacts, in their socio-historical evolution, as well as in the ontogenetic development of each individual. Intentional affordances are produced by the communication of intentions and the establishment of a shared intentional space. It happens in a triadic interaction between people and objects, they are a bridge between the minds of people. Sensory-motor affordances are a necessary but not sufficient conditions to built a shared intentional space.

AFFORDANCE PRODUCTION

This was just the issue we explored in a series of experiments with young children of 12–18 months. At this age children are able both to manipulate light objects and to understand communicative intention. In the talk we will focus on two of this experiments, the first aimed at exploring the establishment of an affordance among artefacts the second to the transfer of an affordance to other artefacts. In the first experiment is explored the critical matter of how affordances of interaction among objects are established. This is an issue that is not accounted for by the Gibsonian notion of affordance. Many of the objects we manipulate are designed and used not in isolation but in relationship one to the other. Do children exposed to a pair of objects designed to offer opportunity for actions will use basic sensory-motor affordances phylogenetically established to combine the objects? And if not, how they can perceive and use these opportunities and how long it will take? In the second experiment we address the issue of how easy and fast is the process of extending a given perceived and used affordance to objects that offer similar opportunities for action. Will children apply the privileged modality of interaction to similar objects in spite of multiple opportunities for interactions available in these new objects; and what will happen to these other opportunities? The results of the experiments provide data that corroborate the hypothesis we formulated to answer the previous questions, thus supporting the notion of intentional affordance and the related cultural-historical framework.

Finally will be presented the application of these theoretical positions to the design of artefacts for ambient intelligent solutions dedicated to the furniture and installations on the central street of a small village in Tuscany

REFERENCES

1. Albrechtsen, H., Andersen, H.H.K. Bødker, S. Pejtersen, A.M. Affordances in Activity Theory and Cognitive Systems Engineering. Tech Rep: Risø-R-1287(2001).
2. Bærnstein, K.B. & Trettvik, J. An Activity Theory approach to affordance. NordiCHI 10/02. New York: ACM. (2002) pp. 51-60.
3. Fadiga L., Fogassi, L., Gallese, V., Rizzolatti, G. Visuomotor neurons: ambiguity of the discharge or 'motor' perception? *International Journal of Psychophysiology* (2000) 35, 165-177.
4. Gibson, J.J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.
5. Norman, D. A. (1988). *The Psychology of Everyday Things*. New York: Basic Books.
6. Rizzolatti, G. and Craighero, L. The Mirror-Neuron System. *Annual Review of Neuroscience*. (2004) Vol 27: 169–192.
7. Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, Mass.: Harvard University Press