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# On Distinguishing Sensorial and Eliciting Epistemic Actions and on the Relationship between Perceptive Structure of Body and Cognitive Processes

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## Abstract

The present article is the fruit of part of an ethnographic research that I have carried out at an Italian hospital in order to analyze how cognition goes on in a surgical team. The paper has two main points: the distinction between two kinds of epistemic action specifically devoted to construct representations in interaction with the environment and a reflection about the possible influences on cognitive processes of a change in the perceptive structure of human body. These two points are treated by means of two case studies: medical semeiology and laparoscopic video-surgery, respectively. The aim of the article is to try to demonstrate the hypothesis that representations used in human cognitive processes arise from more or less structured physical interactions between human and environment and that a change in the perceptive relationship between body and environment may mean a change in the representational codes used in reasoning.

**Keywords:** Distributed Cognition; Embodiment; Epistemic Action; Perception; Teleoperation.

## Sensorial Epistemic Actions and Eliciting Epistemic Actions

### Theoretical Analysis

Kirsh and Maglio (1994) make a fundamental distinction between two kinds of action: pragmatic actions and epistemic actions. According to their analysis, pragmatic actions are “actions performed to bring one physically closer to a goal” (Kirsh & Maglio, 1994, p. 513), whereas epistemic actions are “actions performed to uncover information that is hidden or hard to compute mentally” (p. 513). In other words, pragmatic actions are actions by means of which an agent changes the world in order to create a state of affairs that brings it physically closer to the goal that it wants to reach. Epistemic actions, instead, are actions by means of which an agent changes the world in a way that may even be disadvantageous for reaching the physical goal, but that allows the agent to detect previously unavailable information or to save internal cognitive effort.

I maintain the basic definition of epistemic action; however, I propose a further distinction, within the category of epistemic actions, between two fundamental kinds of epistemic action. In addition, in my analysis I present a strict correlation between the notion of epistemic action and the notion of representation.

The first kind of epistemic action that I take into account is the one in which the cognitive agent structures her own sensorial action in order to receive from the environment a feedback structured sensation that carries information. I call this kind of epistemic actions *sensorial epistemic actions* (SEAs). The second kind of epistemic actions that I consider

is the one in which the cognitive agent performs a non-sensorial structured action upon the environment in order to find previously unavailable data that are later examined. I call this second kind of epistemic actions *eliciting epistemic actions* (EEAs).

In the case of a sensorial epistemic action, the cognitive agent gives a structure to its own sensorial action so that the environment gives the agent itself a sensation that is structured as well and that contains information. By means of its own sensorial action, the cognitive agent constructs a sensorial representation that carries information. Therefore, we can say that a sensorial epistemic action has, as its counterpart, a sensorial representation. The distinctive feature of a sensorial epistemic action is that, in a sensorial epistemic action, the action that creates the representation is the same identical action that explores it. We can say that a sensorial epistemic action explores the sensorial representation by creating it (see the illustrating scheme in Figure 1).

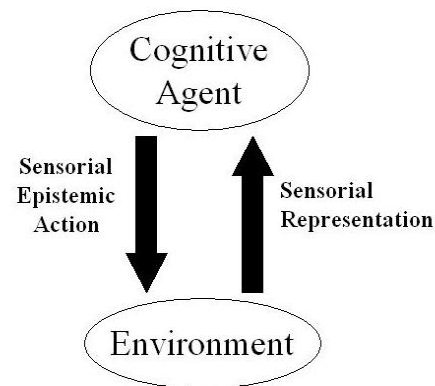


Figure 1: Illustrating scheme for sensorial epistemic action.

In the case of an eliciting epistemic action, the cognitive agent performs actions that are devoted to change the configuration of the world or to stimulate the world in such a way that it gives previously unavailable information. This kind of action is not sensorial; it is an action that gives the environment a new configuration or provokes a reaction in the environment. This new configuration or this reaction are later examined as if they were representations that carry information. Therefore, the counterpart of an eliciting epistemic action is an examination-independent representation. Unlike sensorial epistemic actions, the distinctive feature of an eliciting epistemic action is that, in an eliciting epistemic action, the action that creates the representation is separate from the action that explores it. The cognitive agent manipulates the world and elicits a particular configuration or a

particular reaction that can count as representation and, then, it explores such representation by means of a more or less structured sensorial epistemic action (see the illustrating scheme in Figure 2).

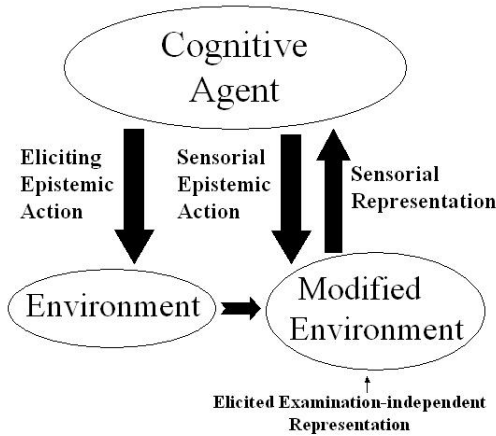


Figure 2: Illustrating scheme for eliciting epistemic action.

In order to give support to the theoretical analysis illustrated above, in the next subsection I take into account a real case in which the distinction between sensorial and eliciting epistemic actions is evident.

### A Case Study: Medical Semeiology

Semeiology is the medical discipline that studies the correlation between signs and pathologies and the adequate gestures to detect the pathological signs themselves. After the collection of the case-history related to the patient, the physician begins what is called objective examination. This examination follows the four principles of physical semeiology and these principles are: inspection, palpation, percussion, auscultation (DeGowin & DeGowin, 1969; Swartz, 2002). In this subsection, I will illustrate such principles by taking into account the example of the examination of the abdomen aimed at detecting signs of surgical pathologies and I will propose a cognitive analysis of the various kinds of actions at work in an objective examination by tracing a specific connection between the actions performed by the physician and the information representations that she obtains in the direct contact with the environment constituted by the patient's body.

The analysis has a primary goal: to show that the representational code of the representations actually used in cognitive processes has a deep and direct origin in the interaction with the environment and, therefore, that human cognitive agents use different types of representational code and not a single internal one.

**Inspection** During the inspection time of abdominal objective examination, the physician directs her eyes toward specific parts of the patient's abdomen in order to catch specific visual clues that give diagnostic information. We can say that the physician structures her visual action in order to receive structured visual inputs. In this case, the physician is

using a sensorial epistemic action, which we can call *visual epistemic action* and the result of this epistemic action is a *visual representation*.

But, at the same time, the physician not only uses inspection alone, but also asks the patient to change her own position or to profoundly breathe and then observes specific data in this new settings. So, we can notice that there are also eliciting epistemic actions. These eliciting epistemic actions are of a particular kind in that they are in fact performed by the patient; however, the patient performs such actions under the instructions of the physician. Therefore, we can define these eliciting epistemic actions *interpersonal eliciting epistemic actions*. The representation that they generate is an *interpersonally structured representation*.

Such results related to inspection are schematized in the following Table 1:

Table 1: Epistemic actions and representations for inspection.

| Epistemic Action   | Representation                            |
|--|---|
| Visual Epistemic Action (SEA)                                      | Visual Representation                     |
| Interpersonal Eliciting Epistemic Action (language-mediated) (EEA) | Interpersonally Structured Representation |

**Palpation** When the physician touches the abdomen of a patient to detect diagnostic signs, she is using palpation gestures that have a specific structure depending on the sign that the physician wants to detect and on the features of the abdomen itself. Physician is performing a tactile technical action which will give her specific tactile inputs. This time, the sensorial representation that the physician receives is a *tactile representation*, which she has obtained by means of a sensorial epistemic action that we can call *tactile epistemic action*. Therefore, the physician is handling a representation that exhibits a representational code which is different from the one of the representations collected during inspection.

As in the case of inspection, also during palpation the physician asks the patient to take specific physical positions in order to be able to detect otherwise unavailable diagnostic signs. Therefore, also in this case there are interpersonal eliciting epistemic actions that generate interpersonally structured representations. But, besides this kind of eliciting epistemic actions, in the case of palpation there is another important kind of eliciting epistemic actions, which generates a specific elicited representation. This kind of eliciting epistemic actions is constituted by the gestures through which the physician provokes a pain reaction in the patient. This kind of epistemic actions, that can be defined as *pain-eliciting tactile epistemic actions*, stimulate the patient's body in such a way that the patient has a pain reaction that the physician evaluates. So, we can speak of a special kind of representation that is constituted by a behavior of the patient and that can be defined as *elicited behavioral representation*. Table 2 shows the connections between epistemic actions and representations that refer to palpation.

Table 2: Epistemic actions and representations for palpation.

| Epistemic Action   | Representation                            |
|--|---|
| Tactile Epistemic Action (SEA)                                     | Tactile Representation                    |
| Interpersonal Eliciting Epistemic Action (language-mediated) (EEA) | Interpersonally Structured Representation |
| Pain-Eliciting Tactile Epistemic Action (EEA)                      | Elicited Behavioral Representation        |

**Percussion** During the percussion moment of the objective examination, the physician beats on the patient’s abdomen with percussive technical gestures in order to generate acoustical reactions that can give important diagnostic information as to the conditions of the internal organs and tissues. Therefore, in this case, the semeiological action, performed with the hands, is devoted to stimulate previously unavailable acoustical signs that are later evaluated by the physician’s ear. This means that the percussive semeiological gesture is an eliciting epistemic action, which can be defined as *sound-eliciting percussive epistemic action*. The main representation that it creates is an *elicited acoustical representation*, that is, a representation that exhibits still another representational code.

But the percussive semeiological action shows the property of generating, at the same time, another kind of elicited representation. When the physician detects an area in which an anomalous sound is heard, she has to percussively mark the boundary of such area. To mark the boundary of the area, the physician moves from the first found acoustically anomalous point and percussively searches for the close acoustically anomalous points until she has found all of them. This movement of her own hands attracts the visual attention of the physician toward the points that constitute the boundary of the area under examination. Therefore, the physical movements of the physician’s hands draw an *elicited visual representation*. If we want to do a more detailed analysis, the hand movement draws the boundary of the area to be examined and, therefore, elicits an external configuration. At the same time, this same movement of the physician’s hands attracts the physician’s visual attention making her perform a guided visual epistemic action.

In addition, also in the case of percussion, the physician asks the patient to change her position in order to percussively evaluate if an acoustically anomalous area changes with the patient’s different positions. Therefore, there are again interpersonal eliciting epistemic actions. The scheme for percussion is shown in the following Table 3:

Table 3: Epistemic actions and representations for percussion.

| Epistemic Action                                  | Representation                            |
|---|---|
| Sound-Eliciting Percussive Epistemic Action (EEA) | Elicited Acoustical Representation        |
|   | Elicited Visual Representation            |
| Interpersonal Eliciting Epistemic Action (EEA)    | Interpersonally Structured Representation |

**Auscultation** Among the four semeiological times of physical semeiology, auscultation shows the particular property that it involves the use of an external instrument, the stethoscope. Stethoscope can be viewed as an external sensorial support that increases the physician’s auditory capabilities. In this sense, there is a distribution of the sensorial action in that the physician places the stethoscope on the patient’s abdomen to listen to the internal sounds and the stethoscope amplifies these sounds.

The semeiological action that is performed by the physician in the auscultation moment can still be viewed as a sensorial epistemic action, because the physician structures her own auditory action, which is, note, a hand movement and not an ear movement on the patient’s abdomen, so as to obtain a feedback auditory sensation that carries diagnostic information. This action can be defined *auditory epistemic action* and the representation that it creates can be defined *acoustical representation*. But, if we want to do a detailed analysis, in this sensorial epistemic action there is an eliciting component constituted by the amplifying action of the stethoscope, which gives the physician’s ear a transformed sound. However, I consider auscultation as a sensorial epistemic action, because the action performed by the physician is completely devoted to listen to the diagnostic sounds and the eliciting action is, instead, performed by the external instrument. What is interesting is the distribution that takes place.

A series of actions that are, instead, genuinely eliciting epistemic actions are the ones that the physician performs, during auscultation, when she beats the abdominal wall with repeated small strokes or rubs and pinches the skin or gently massages the abdomen in order to stimulate the peristalsis. These actions cause reactions inside the patient’s abdomen that can be perceived as sounds that give diagnostic information. Such actions can be generally defined as *sound-eliciting tactile epistemic actions* and the related representation is an *elicited acoustical representation*.

For the auscultation time, we have the following Table 4:

Table 4: Epistemic actions and representations for auscultation.

| Epistemic Action                                       | Representation                     |
|--|------------------------------------|
| Auditory Epistemic Action (stethoscope-mediated) (SEA) | Acoustical Representation          |
| Sound-Eliciting Tactile Epistemic Action (EEA)         | Elicited Acoustical Representation |

### A Change in Embodiment, a Change in Mind: Laparoscopic Video-Surgery

An important aspect that emerges from the analysis conducted so far is that cognitive processes cannot be restricted to internal manipulations of symbol structures of a single language that take place only inside the head of the individual agent (Fodor, 1975; Newell, 1980), but they include specific physical manipulations of the environment devoted to gather from the environment representations of different formats and structures. What seems to emerge is a perceptual origin of the material by which representations are con-

stituted (Barsalou, 1999) and a direct, analogical influence of the environment on cognitive processes (Shepard, 1984). In this new perspective, many cognitive processes appear to be embodied, in the sense that the body becomes the means to perform actions that carry out a deep epistemic function.

If we consider the term “embodiment” as referring not only to bodily actions that have a strong epistemic value, but also to the specific structure of the boundaries of human body, we may well hypothesize that a change in embodiment can cause a change at the level of cognitive processes.

In order to evaluate this hypothesis, I take into account the case of laparoscopic video-surgery, where the surgeon finds herself to work in a setting and with instruments that are completely different from the setting and the instruments that are present in traditional laparotomic surgery.

In more detail, laparoscopic video-surgery is a minimally invasive surgical technique in which the surgeon intervenes on the anatomical structures contained into the abdomen without opening the abdominal cavity (Kremer, Platzer & Schreiber, 1995). The operating field is observed by means of an optical probe endowed with a videocamera that sends the visual inputs to a monitor screen. The surgical instruments are longer than the laparotomic ones, they are introduced into the abdomen through small holes and are handled from outside the abdomen.

On the basis of these considerations, laparoscopic video-surgery can be defined as a case of embodiment change. In the analysis that follows, I will try to point out the cognitive consequences that this embodiment change causes at the level of sense of control and at the level of diagnostic information processing, both with respect to vision and with respect to touch.

## Vision

**Sense of Control** It can be said that one of the targets of laparoscopic video-surgery is to give rise to a minimally invasive surgery by means of technological appliances that reproduce an operating situation which be, at the sensation level, as similar as possible to the operating situation that the surgeon encounters in laparotomic surgery. From this point of view, the appliances that support a laparoscopic surgical operation would aim at becoming “transparent technologies” (Clark, 2003), that is, tools that are so well integrated with our own lives, with our ways to confront problems, with our ways to interact with the rest of the world that they become almost invisible while we use them.

It cannot be ignored that this aspect of transparency of technological devices that try to give the surgeon the impression to operate in a situation similar to the laparotomic one is actually present in laparoscopic video-surgery and it is due, especially, to the video system that allows the surgeon to see the results of her own actions. The surgeon acts upon real anatomical structures by means of the surgical instruments, but she observes what she is doing on the monitor screen and this certainly constitutes a change in embodiment that creates a completely different physical behavior in the surgeon. But, if the surgeon, thanks to the images of the video system, can have a good control upon her own gestures and, consequently, upon the anatomical structures,

she is likely to find herself in a situation similar, at the level of sensation, to the one that she encounters in laparotomy.

However, the transparency of the technological devices used in laparoscopy is not complete. The video system, which is the instrument that allows the surgeon to maintain a control of the situation similar to the one that she has in laparotomic operations, is also the element that creates difficulties as to the control of the gestures involved in a surgical operation. The main problem that can be found in laparoscopy is a gap between surgical gesture and vision: the image on the monitor screen is managed by a videocamera and, for this reason, such image gives sensations of dimension and depth that not always correspond to the real situation and that may create problems in the adjustment of the surgical gestures. In other words, the surgeon acts on the basis of the images on the monitor screen; these images visually reproduce the operating field with dimensions that are different from the real ones, but the surgeon is physically acting upon the real anatomical structures and this causes difficulties in adapting the surgical gestures to the real anatomical situation. It is necessary for the surgeon a repeated training in order to adapt herself to this new embodiment in which she has to bring into coordination actions performed upon anatomical structures that she does not see directly with visual information about those anatomical structures observed on a monitor screen. After adequate training, however, this gap between gesture and vision is overcome and the coordination between visual inputs and gesture tends to become very similar to the one that takes place in laparotomy.

What we have said so far is summarized in some assertions made by the surgeon that was my first informant during my in-the-field research and that I call here “The Fox”. The assertions I am referring to are the following ones<sup>1</sup>:

Me: What are the differences between an operation in laparoscopy and an operation in laparotomy?

[...].

“The Fox”: [...]the differences are basically the ones of putting a filter between oneself, one’s vision, and the object and the more connatural this filter is with the gesture, the smaller the refractive differentiation will be that can take place[...], in the sense that we have a difference between what we see and the gesture that we do, but[...]the better this sort of gap between vision and gesture is bridged, the more natural and almost normal it will become in the end[...].

Me: Almost like a laparotomy, at that point?

“The Fox”: Almost like a laparotomy.

**Diagnostic Information Processing** The optical probe that is used in laparoscopic video-surgery allows the surgeon to execute a visual exploration of the abdominal cavity which is more accurate than the visual exploration that can be performed in the case of a laparotomic operation. This is due to the fact that the laparoscopic optical probe can explore abdominal zones that the human eye cannot reach or cannot see very well, it can arrive nearer the anatomical structures than the human eye, it may offer different vision angulations

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<sup>1</sup> My English translation from Italian for this and the other quotations in the paper.

according to the type of lens, allowing the surgeon, this way, to have a wider view of the abdominal cavity and to explore hidden areas; finally, the videocamera mounted on the optical probe allows the image to be enlarged by means of the zoom system.

From a cognitive point of view, the new embodiment constituted by the laparoscopic optical probe and, in general, by the video system used in laparoscopy changes and improves the surgeon's visual epistemic actions and, consequently, the visual representations that the surgeon collects in her own interaction with the operating field. In laparoscopic video-surgery, surgeon obtains new, clearer visual representations of anatomical structures that she had not been able to see well in laparotomy or that she had not seen at all and she had only been able to touch. Once again, there is a strict relationship between epistemic actions and representations: an improvement in visual epistemic actions generated by an external artifact brings to an improvement in the visual representations of the same identical information.

A demonstration of this fact and of the fact that different representations of the same information may bring a cognitive agent to different cognitive processes and to different decisions about what to do in a particular situation (Zhang, 1997, Zhang & Norman, 1994) is that, in some cases, it happened that some surgical mistakes were made in laparoscopy because of the fact that the operator could see in a clear way anatomical structures that could not be seen very well in the laparotomic version of the same operation or that could only be felt by touch. For this reason, the operator could not recognize those anatomical structures in the laparoscopic surgical operation and this was at the basis of the surgical mistakes:

“The Fox”: [...]where video-surgery has mostly spread it is in those kinds of operations in which the video-endoscopic vision is better than the open one.[...].[...]the success that laparoscopic cholecystectomy has obtained is because you see it well, very well, you see it better. That is, you can see structures of which you usually catch a glimpse or that you feel with your fingers, to the point that there were even mistakes of a surgical type with respect to the cholecystectomy, because you could see[...]certain structures so well that certain structures were bound that didn't have to be bound: when common bile ducts were bound and cut, sectioned[...]because[...]you see them, even if you see them you don't recognize them in terms of habit, of experience and they were bound.

So, such mistakes are explained by a contrast between an internalized representation of anatomical structures that has been generated through the experience in a laparotomic context and a new visual representation of the same anatomical structures that is encountered in a laparoscopic context. This contrast makes the mechanism of recognition difficult or impossible and may bring the surgeon to make mistakes.

From the point of view of vision, in laparoscopic video-surgery the surgeon becomes an augmented cognitive agent thanks to the presence of an external video system that modifies and improves her capacity of capturing visual inputs. Laparoscopic video-surgery, in this sense, demonstrates that a change in epistemic actions (in this case, sen-

sorial epistemic actions) causes a change in the representations used in cognitive processes and that human cognitive agents find themselves in front of different representations of the same information and, in addition, it demonstrates that the boundaries of our mind are deeply intertwined with the boundaries of our body and that the boundaries of our body are flexible.

## Touch

**Sense of Control** In laparoscopic video-surgery there is a deep change in the tactile sensations that the surgeon feels while performing surgical actions during a surgical operation. The impact with the anatomical structures is different from the one that the surgeon has in laparotomic surgery and this is due to the fact that the surgeon uses longer instruments that drastically reduce the tactile sensation that is generated by the contact between surgeon and anatomical structures. This change in embodiment that causes a reduction in tactile sensation has important consequences on the sense of control. The surgeon sees what she is doing through the monitor screen, but not always she has a tactile sensation of what she is doing, not always she physically realizes that she is touching anatomical structures and this can reduce the sense of control that the surgeon feels.

On the basis of “The Fox's” personal communications collected through interviews, I have found that it is possible to distinguish two situations of tactile sensation, on the part of the surgeon, of what the surgeon herself is doing during a laparoscopic surgical operation. The point of departure of my analysis are these important statements made by “The Fox”:

[...]I have realized that, at the moment in which you do the usual gesture and you do the thing that, perhaps, you have learned to do, instead, with the traditional gesture, you can acquire your jump in quality, the jump in quality, in my opinion, at the moment in which, besides seeing, which has its own importance and you see what you do and, therefore, you can correct the gesture, *you also have, with the surgical instruments, the sensation of what you are doing*.[...]not in all of the gestures you can understand that you are touching the tissues, but in certain gestures you can[...]. It is not always easy; some times you have such a light sensation that you don't have...*you see it* (the anatomical structure) *and it seems to you to feel it*, but there are certain moments in which *you indeed feel too what you are doing* and then, at that moment, the capacity arises[...]of having an impact with the tissues you are handling, which does not have to be, thus, only a virtual that you see, if possible, but also a real sensation[...].

On the basis of these statements, I analyze from a cognitive point of view the two situations that emerge from “The Fox's” words.

The first situation is the one in which the surgeon has the impression of feeling an anatomical structure because she sees on the monitor screen her own surgical instrument touching that anatomical structure. This can be defined as a virtual tactile sensation induced by a visual representation: the visual representation on the screen shows the image of a physical contact and the surgeon has the impression of feeling that physical contact. This is an interesting case from a

cognitive point of view, because the surgeon uses only one real sensation, the one given by the external visual representation and, on the basis of the specific features of this sensation, creates a tactile representation that does not correspond to any real tactile stimulation. It can be said that the surgeon cognitively works with two completely different representations, one constituted by a sensation generated by a contact with a particular stimulus and the other internally constructed with a sort of synesthetic process on the basis of the features of the sensation that constitutes the first representation. We can assume that the second representation, that is, the tactile representation, is constituted by tactile components that the surgeon has internalized through the experience in laparotomic surgical operations. The virtual tactile sensation is used to reinforce the control on what the surgeon is doing.

The second situation is the one in which the surgeon has not an impression of feeling an anatomical structure she is touching, but she really feels that anatomical structure. In this case the tactile representation is not constructed on the basis of a visual representation, but it is generated by a tactile stimulus and, in particular, such tactile representation is no longer constituted by internalized tactile sensations, but by a new tactile sensation, in which the sensation is mediated by a surgical instrument which is longer than the laparotomic ones. The surgeon is using, in this case, a new tactile representational code, she is experiencing a new tactile impact with the anatomical structures.

**Diagnostic Information Processing** One of the most important consequences of the setting in which the surgeon finds herself to operate in laparoscopic video-surgery is that she no longer can use her own “naked” hand to touch the anatomical structures. Direct palpation, which has a crucial importance in traditional laparotomic surgery, disappears in laparoscopic technique. It is vision, an improved vision, as we have seen, that, in laparoscopic video-surgery, holds the main role at a diagnostic level. The surgeon mostly uses a visual semeiology:

“The Fox”: [...]there can still be and there must be tactile sensations; they certainly have less space than before, that is, now[...]you have a visual semeiology, that is, you see and decide.

Notwithstanding this, palpation at a diagnostic level is still present in laparoscopy, but it is mediated by special instruments, that is, metal bars that are introduced into the abdomen and are pushed against anatomical structures in order to evaluate their consistence or are used to touch behind an anatomical structure in order to test the presence or the absence of some elements that cannot be seen.

Once again, we are in presence of a change in embodiment that causes a change in sensorial epistemic actions and, consequently, in the sensorial representations that are used in cognitive processes. In laparoscopic video-surgery there are, at a diagnostic level, new tactile representations generated by new tactile epistemic actions. In particular, these new tactile representations are less accurate than the ones that can be obtained in laparotomic surgery and, for

this reason, as we have already said, vision acquires a greater importance.

## Conclusion

On the basis of the case studies illustrated in the present article, some important cognitive conclusions can be drawn:

- 1) Human cognitive system is not confined to the individual agent, but it includes individual, material environment and technological artifacts;
- 2) Human cognitive agents do not use, in their cognitive processes, only one single symbolic internal language, but they make use of several different representational codes, each of which influences in a different way their cognitive processes;
- 3) A fundamental role as source of these representational codes is played by human-environment interaction;
- 4) Cognitive processes are deeply dependent on the way human beings organize their perceptive contact with the environment and a change in the structure of the boundaries of body may mean a change in the structure of human mind.

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