A Developmental Perspective to Studying Objects in Robotic Surgery

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Abstract. Drawing on interventionist activity theoretical approaches, this paper describes a method of self-confrontation as a way in which to study objects in technology-mediated practices. In addition to research interests, the aim of examining the objects is to develop the capacity of professionals and organizations to work and learn better in complex technology-mediated work. The method was applied in robotic surgery, in which instruments are tele-operated by a surgeon. The robot offers better, collective visualization of the area under surgical operation than previous techniques. In particular, the paper shows how objects were revealed and new objects emerged during the intervention. We suggest that activity theoretical developmental interventions such as self-confrontations may help understand the complexity and evolution of objects, and thus contribute to studies of technology and organizations.

Keywords: developmental intervention research · object · robotic surgery · activity theory · self-confrontation.

1 Introduction: The Developmental Perspective

The focus of sociomaterial assemblages is on agencies such as actors and objects, which have saturated each other so thoroughly that previously taken-for-granted boundaries have now dissolved [1]. According to a relational ontology, entities – whether human or technological – have no inherent properties; they acquire their form, attributes and capabilities through their interpenetration. The notion of "sociomaterial" attempts to signal this ontological fusion [1] (p. 456). Similarly, Annemarie Mol [2], in discussing the way out of the dichotomy between the knowing subject and the objects-that-are-known, suggests spreading "the activity of knowing widely over tables, knives, records, microscopes, or other things of habits in which it is embedded" [2] (p. 50). Instead of subjects knowing objects, we may

come to talk about enacting reality in practice [2]. The view that objects are enacted in practice, for Mol, suggests that something is enacted only there and then, in the act. Although activities take place, the actors remain vague [2].

Sociomaterial assemblages are important in their consideration of humans and other living entities such as technologies and other materials, and have many advantages in terms of science and policy. The concept of sociomaterial assemblages implies that concrete practices or activities are important in the assemblages" enactment (or becoming). However, we argue that we must not lose sight of the human in these practices: first, because even the naming and meaning of a practice, or any entity, are human endeavours: a building may be a hospital to us, but not necessarily so to a fly on the wall. Second, because most changes through time are triggered and driven by the human actors in or outside the systems under study at a given historical time. Although it is important to acknowledge the distributed nature of agency involved in sociomaterial assemblages, it may also be useful and interesting to study them precisely from the human perspective. To investigate sociomaterial practices as dynamic and evolving interpretations of humans in these practices does not necessarily mean a return to an individualist stance of agency. Nor does it lead to denial of the material world. On the contrary, it may lead to the transformation of the sociomaterial assemblages at stake.

Our suggestion for a research encounter with technology and organization is developmental interventionist research, based on a dialectical ontology. We refer to an article by Charles Tolman [3], which contrasts dialectics with the metaphysics of properties and the metaphysics of relations. According to Hegel's dialectical thought, things do not pre-exist, and cannot be independently conceived of their relations with other things [3]. This is similar to relational ontology [1], which dissolves the analytical boundaries between technologies and humans. However, dialectics proposes more than this: it advocates seeing temporal movement as part of interconnections and relations [3]. It is thus interested in change, development and the "becoming" of both human and non-human entities. For dialectics, a concrete understanding of a thing is an understanding of it in its interconnections and dynamic movements. Movement and change is reality itself [4].

Developmental intervention is defined as a purposeful action by an agent to create change [5]. Kurt Lewin, already in 1947, advocated harnessing science in the service of intervention rather than observation [5]. Practices are bombarded with both deliberate and incidental interventions, also without research [6]. Within a developmental intervention, the focus at least partly shifts from discovering how things are to exploring how things may evolve. The interventionist approach focuses not only on how researchers interpret the object of study, but also on how research intervenes in practices in which objects and entities are enacted [7, 8, 9]. Because it supports professionals' new interpretations and object formations, interventionist research is, we believe, a possible way in which to renew our understanding of technologies in organizations. In addition to practical outcomes, interventionist research can advance theories (see e.g. [10, 11]).

In this paper, we describe, quite practically, the method of self-confrontations in the Activity Clinic approach, as elaborated by a French cultural historical psychology group [12, 13], and based on a dialogical interpretation of the indirect methodology of L.S. Vygotsky [14, 15, 16, 17]. The assumption is that this method helps understand and enhance an interpretive way of working [18, 19], which is needed in increasingly complex, technology-mediated and uncertain work activities. The second author of this paper is a member of the community of the Activity Clinic, whereas the first author has worked extensively with another activity theoretical approach, namely Developmental Work Research [20, 21]. These approaches look at technology and organization from the perspective of activities [22], and they share a similar concept of the object [23] to that which we apply in our study.

In this paper we will describe, first, how the method of self-confrontations was used in a study of robotic surgery. Secondly, we will identify the different kinds of objects that were present and that emerged in the three-step process of the intervention, by analysing a situational action in robotic surgery. Before presenting the method and the empirical analysis, we will take a look at robotic surgery.

2 The Robot in Surgery

Technological advances in optics, digital video equipment, computers and robotics have opened up new possibilities in surgery. Robotic-assisted surgery is the most recent such advancement. One device, called the da Vinci Surgical System (Intuitive Surgical® Inc.), first introduced in 2000, has become significant in the field of urology. By sophisticated technology at the tips of robotic instruments, a surgeon can operate on the human body with the facility of a human wrist. As in laparoscopy, the operation is performed via tubes (trocars) inserted into the patient through small incisions. This "minimally invasive" technique is different from open surgery, which requires a longer incision. In robotic surgery, the instruments are teleoperated by a surgeon, using a separate console that provides a 3D-vision stereo view [24]. Properties such as tremor abolition, motion scaling and 3D vision can substantially improve the dexterity of the operation, especially in suturing within the patient's body [25]. Compared to open surgery, robotic surgery is more beneficial in terms of shorter hospital stays, decreased blood loss, fewer complications, decreased pain and better outcomes for patients [26].

Our empirical data are about radical prostatectomy, a surgical operation in which a cancerous prostate gland is removed entirely. Although surgery is the primary treatment choice for localized prostate cancer, other treatment modalities also exist. The rationality of surgery depends on the patient's general condition, the type and extensiveness of the cancer, and the patient's expectations and preferences. The patient needs to know the potential benefits and risks of surgery compared to other treatments before making a decision. When surgical treatment is correctly chosen and the patient is well informed, the results of the therapy are excellent.

The main objective of this robotic surgery operation is to remove the cancerous prostate gland from the patient's body. We can divide the procedure into three phases: (a) exposure, (b) dissection of the prostate, and (c) sewing anastomosis, which means reconnecting the urethra and the urinary bladder (Figure 1). Exposure of the prostate is unavoidable, because the gland is located deep in the male pelvis and is not visible at the beginning of the operation. The most challenging phase is the dissection of the prostate. The surgeon must be careful not to damage important adjacent structures, such as erectile nerves, the neck of the urinary bladder, the muscles affecting urinary continence, and the rectum. However, if the surgeon dissects the prostate too near the prostate surface, there is a risk that some cancer may remain. The correct dissection plane is estimated by preoperative studies, such as blood tests, radiological images and prostate biopsies. The functional and oncological outcomes are measured at follow-up visits.

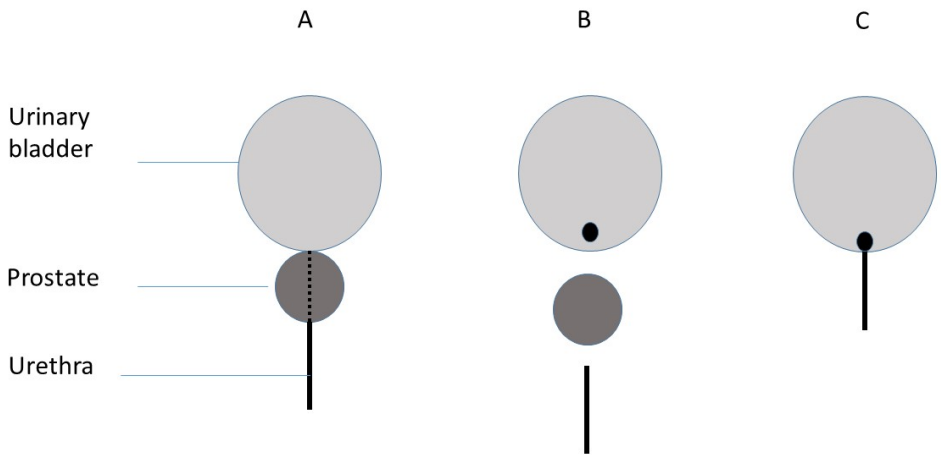

Fig. 1. A rough sketch of the radical prostatectomy. (A) Original location of the urinary bladder, the prostate and the urethra that goes from the bladder through the prostate. (B) In the operation, the prostate is separated and removed. (C) The urethra is reconnected to the urinary bladder (Simplified from [27])

The operative team often consists of two surgeons, two assisting nurses, an anaesthesiologist and an anaesthesia nurse (Figure 2). The whole team mediates the control of the robot and the surgical operation [28]. The robot also changes the quality of communication, as it inhibits face-to-face interaction, thus reducing the ability to anticipate without explicit demands [29]. This is different to conventional laparoscopy.

Most importantly, robots offer better visualization than other technologies [26]. All members of the team in the operation room see the operation on-line, and can anticipate forthcoming tasks. In contrast to open surgery, surgeons need to see or induce visual indicators to guide their operation, because there is no tactile (haptic) feedback from the robotic device. This may be one of the biggest challenges as compared to open surgery. Therefore, the surgeons and the operating room team need to create and constantly maintain a good visual view by, for example, positioning the camera correctly and keeping the lens clean. The acts of pulling, poking and pushing play a significant role in tissue identification via the visual sense [30]. With extensive experience, surgeons can develop a combined sense, sometimes called "visual haptics" [31].

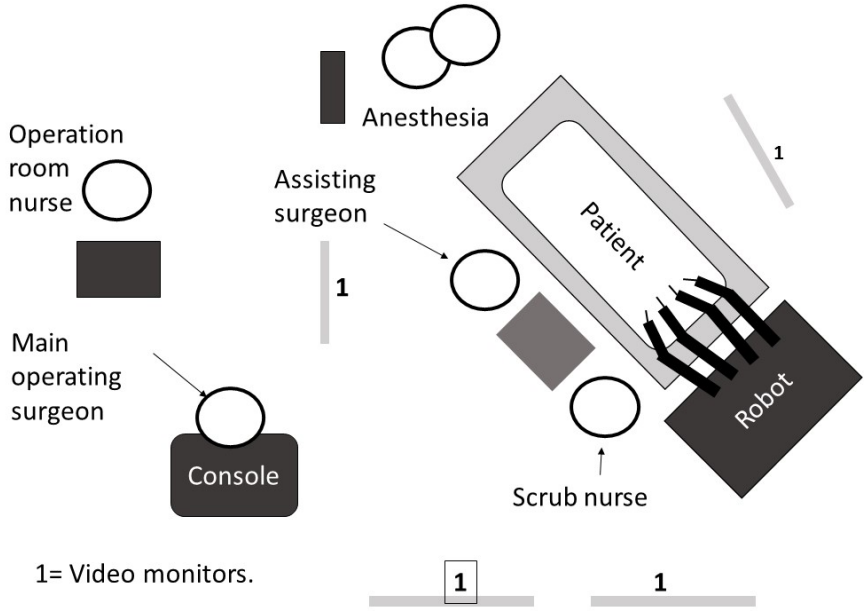

Fig. 2. Sketch of operation room setting during robotic-assisted surgery of prostate. One robotic arm transmits camera view from inside body on-line to console and to four video monitors (1).

As the robotic system, and especially the camera, transforms the activities of the surgeons and nurses, it may also induce opportunities for learning and developing. The operations are routinely video-recorded, which means they can later be watched, evaluated and reflected upon. Robotic surgery videos are already being used in the global community of surgeons in scientific conferences and medical journals, and in the training programmes of the company of the robotic surgi-

cal device. Operating manner and skill is sometimes described as a surgeons' own handwriting, and this can be seen in the videos. Next, we turn to the developmental method used in the research on this surgical activity.

3 The Developmental Interventionist Method and the Concept of Object

This paper is part of a research project that investigates interpretive practice as a promising mode of action for coping with dynamism, complexity and uncertainty at work. Studies of nuclear power plant operations carried out by Leena Norros and Paula Savioja found that even in this highly regulated and proceduralized work, the operators' actual work practices vary considerably [18, 19]. The behaviours that reflected the operators' own interpretation of a situation; questioning the observed phenomena, dialoguing within the team, anticipating the system state, and using various information sources, were labelled "interpretive practice" [18]. This paper's exploratory investigation of objects aims to support the study of interpretive practice. Moreover, we hope to contribute to the research project's aim of outlining a method for enhancing the interpretive way of working in robotic surgery.

If interpretive practices – as continuous learning that makes new connections between phenomena – are increasingly needed in work, we need dialogic methods to support the learning of this way of working. We consider that a method from the Activity Clinic called self-confrontations is suitable for this purpose. This method follows two principles. First, the principle of indirect methodologies [14, 15, 16] suggests that "it is necessary to transform in order to understand, because activity does not allow its enigmas to be resolved until it is put into movement" [12] (p. 287). Second, the law of the double source of development states that new functions first appear on an interpersonal plane before appearing on an intrapersonal plane [17]. This methodology therefore relies on processes of objectivation and subjectivation, in which the subjects develop new ways of looking at their work activity through engagement in a dialogical process with the researchers, with their peers and with traces (here, video recordings) of their work activity. The change of addressees, that is, the participants to whom talk is directed, is a way in which to enhance dialogue and the emergence of new objects. By being dialogical and interested in increasing understanding and effecting change, the Activity Clinic can help phronesis, enhancing a socially relevant form of knowledge [32].

Although human perspective remains central in our study, its nature depends on the material and social practices in which it is involved, and the mediational tools used by the agent [33]. In activity theories, human conduct is seen as activities that are oriented towards social and material objects in the world, and mediated by signs and tools [34]. Objects are sources of motivation and sociality. Considering the activity of robotic surgery as far as it is analysed in our research, we distinguish between primary and secondary objects.

Table 1. Types of object used in the study

Objects	**Description**	**Example**
Primary objects – related to the work activity		
O1	Main social object of the activity of robotic surgery	Removing cancerous prostate of patient
O2	Material objects of the work environment	Surgical tools, body of patient
O3	Psychological object, situated leading motive of the human agent organizing one's action	Operating quickly and smoothly; saving bladder neck
Secondary objects – related to the dialogic activity in the intervention process		
O4	Object of the research, constructed and partially shared by the researchers and the professionals	Analysing robotic surgery in order to understand and support interpretive practice
O5	Object of dialogue, linguistic object whose appearance and development can be traced in transcripts	Cutting or not cutting?
O6	Object of thinking, psychological object on which the professionals reflect	Best way to proceed in this and future similar cases

The primary object types concern objects of the concrete work activity under examination in the intervention. The first type, O1, includes the main objects of the work activity. These are socially shared objects, the motive around which the whole activity system is designed, such as, in our case, removing the cancerous prostate of the patient. The second type, O2, are the material objects of the work environment. These are external, physical and symbolic objects, including

technical tools for mediating the work activity and the target, and the application point of the work activity. For example, the surgical tools, the robot and the body of the patient are of the O2 type. The O3-type object is a psychological object, a leading motive of the human agent at a given time in a specific situation, and organizes actions.

The types of secondary objects are related to the research activity, and more precisely, to the dialogic activity in the intervention process. The fourth type of object, O4, is the object of the research as constructed and partially shared by the researchers and the professionals. In this research project, this type of object is understanding the phenomenon of interpretive practice more deeply, and outlining a method for enhancing it. The fifth type, O5, is the object of dialogue. In Sitri's sense [35] these objects are linguistic objects that allow us to understand what interlocutory partners are discussing, as it becomes discernible in the self-confrontation transcripts. The final type, O6, are objects of thinking, which are the psychological objects that the participants reflect on and argue about.

In the self-confrontation encounters, the main O1 objects are generally obvious and shared by the professionals, and have been mentioned to the researchers during earlier phases of the intervention. The material O2 objects are represented through the video-recording of the work activity and might be picked up by the participants in their dialogues for further discussion. The organizing O3 objects are not directly apparent in the video-recordings, nor directly expressed in the protocols of the work activity, but may appear in the dialogues. The O4 object is also generally implicit, defining the framing of the intervention encounters which has been negotiated earlier and which may or may not be remembered in the dialogues. The O5 objects of dialogue must be reconstructed through an analysis of the transcribed dialogues. The O6 objects are implicit, and not always present. But when they are, they might be reconstructed from the development of the dialogue, or from the architecture of the whole conversation as in a case of controversies [36].

Our categorization above is inspired by the concept of "object of activity" of A.N. Leont'ev [23] in the cultural-historical activity theory. For Leont'ev, an object is something both given and imagined, projected or constructed. The given nature of objects mean that they have independent existence outside human perception and action. In the imagined or constructed capacity, an object gains a motivating force that gives shape and direction to human activities and defines the horizon of its possibilities. This view suggests, from the activity perspective, an intimate connection between concrete material and psychological, socio-cultural objects. Next, we will take a look at the methodical process of self-confrontations in robotic surgery.

4 Self-Confrontation Process

Simple Self-Confrontation. The first phase in this developmental intervention, simple self-confrontation, means that the professional – in this case a surgeon – together with the researcher-interventionist, watched a series of short sequences of video-recorded material of their activities. The video excerpts were selected by the researchers, based on the surgeons' suggestions on important and challenging operation phases. These phases were difficult for surgeons who were learning the robotic technique, and more routine for the experienced senior surgeons. The researchers had observed all the surgical operations that formed the chosen video excerpts. Prior to the self-confrontations, the researchers had also interviewed the surgeons, who were from various hospitals and had read urological material about the robotic-assisted prostatectomy.

The researchers asked the surgeons to describe as precisely as possible the gestures and actions that were observable in the video, and tried to support their questioning of what they see themselves doing in the video. Explaining one's actions to a researcher from outside the medical and surgical domain, as was the case in simple self-confrontations, prompts professionals to articulate their intentions and actions in different phases, according to what is visible on the video-recordings. This is intended to help the professionals work in an interpretive way, by forming new relationships between the objects, their actions and multiple other issues in their work [37]. The simple self-confrontation was carried out separately on two surgeons who were already experienced in robotic techniques, and two other qualified surgeons, who were learning to operate using the robot.

In addition to watching the video excerpts, the surgeons were asked in advance to bring with them the current case histories of the patients undergoing the operations in the videos. Due to practical reasons, the time interval between the initial surgical operation (in the chosen video excerpts) and the simple self-confrontation was sufficient so that in most cases, the pathologic results (regarding the removal of the cancer as the main object) and some information about post-operative complications and the functional outcomes of the operation (at least urinary continence) were already available. The case histories added a temporal dimension to the self-confrontations and thus changed their quality. Patients' case histories were present in all three phases of the intervention process.

Crossed Self-Confrontation. Later, encounters were organized between a researcher and two surgeons who had both previously participated in a simple self-confrontation. In this crossed self-confrontation, the video sequences in which each of the surgeons was the main operator at the console, were watched together. The actions of the same surgeon were again shown on the same video excerpt. The researcher asked the surgeons to comment on the actions of their colleague, on their own actions, and to share their opinions and questions. The purpose of this phase was to create a dialogue regarding different ways of acting. The professionals now needed to address their speech to both the researcher and their colleague.

The aim of this "double addressing" was to help the professionals further change their way of looking at the actions in the video. Earlier work from the Activity Clinic perspective has found that repetition and change of addressee plays a critical role in elaboration [34].

Workshop. In the third phase, all four surgeons, together with the researchers, gathered for a workshop to discuss the findings of the project so far. During the workshop, they watched selected video excerpts to discuss the variety of practices that were revealed during simple and crossed self-confrontations.

All six self-confrontations and the workshop were video-recorded, and the discussions were transcribed for analysis. Later, in this still ongoing project, a joint workshop with the surgeons and the competence developers of the hospital will be held, in order to discuss and generalize the organizational guidance practices. Below, we demonstrate the intervention process with an account of the self-confrontation process. We also raise and interpret, in a preliminary and exploratory way, the different objects revealed in the data.

5 An Extra Hole in the Urinary Bladder

Our empirical case is about a situated action detail in an operation phase during which the prostate is released from its contact with the urinary bladder (Figure 1, phase B). The case was selected because this phase is generally challenging, has an interesting variation, and exemplifies the surgeons' reflective dialogue throughout the process. The robot has significantly changed the technique of this phase from that of open surgery.[1] In this particular operation, the installing of the catheter was much more difficult than usual, due to a stricture of the urethra. The patient needed another operation, an incision of the stricture, before the catheter could be installed. Therefore, the beginning of the surgical operation using the robot was delayed by about 45 minutes.

A video excerpt of Surgeon 1 operating the bladder neck area was first watched in a simple self-confrontation between the researcher and Surgeon 1. As well as the biological tissues and structures around the bladder neck, the video excerpt shows the instruments of burning and cutting as teleoperated by the main surgeon, and the suction, traction and transporting instruments handled by the assisting surgeon. It also shows how the catheter controlled by the nurse is used for identifying the transition space between bladder neck and prostate.

Excerpt 1 (from Surgeon 1's simple self-confrontation)

[1] With the robot, the bladder neck transection is the first step in releasing the prostate gland, while in open surgery it is the last phase. In open surgery, the right place for the transection can be tactilely felt by the fingers, whereas in the robotic technique, the challenge lies in identifying the right place for the transection on the basis of mere visual cues; those either already existing, or those induced by the surgeons or nurse.

S1: [watching the video, 15 sec] You can see that it's [bladder neck] open, on the bladder side, open more than necessary, but this isn't a problem. It's easy to sew, even if it was 5 cm here, even that could be sewn, it's not a problem. But you don't have to sew it, but when you sew it now, it makes anastomosis easier. We try to keep the bladder neck as small as possible.
R1: Would there be an alternative?
S1: If you just leave it like that, and there's the small isthmus, you would just cut that isthmus and then, when you do the anastomosis, you would just patch it up, because then you have to join two things, a tube of this size and another of this size, and then you just patch up and patch up here, so in this way (inaudible).

Figure 3 shows the part of the video discussed in this situation. Only a narrow isthmus separated the extra hole from the bladder neck where the urethra was already partly cut.

Fig. 3. An extra hole (left) when separating the prostate from the urinary bladder

Some of the objects, such as those of the organizing O3 type, can be interpreted through the way in which the surgeons express the reasons or justifications for their actions and choices. First, Surgeon 1 claimed that the object and purpose for his decision to repair the extra hole in this phase was *easier anastomosis*. Another object expressed by Surgeon 1 was to "keep the bladder neck narrow" which in other instances is also called *saving the bladder neck*. These are not activity-level O1-type objects (such as the removal of the cancer here) in Leont'ev's terms. As

they are projected "downwards", and thus direct the practices of the operation, we call them O3-type objects – objects that manifest themselves in the actions of individual surgeons, and become articulated by them. The psychological activity of the surgeon is directed towards the body of the patient, and mediated by the technical instruments, including the robot.

The same video excerpt was watched again in the crossed self-confrontation between two surgeons.

Excerpt 2a (from crossed self-confrontation between Surgeons 1 and 2)

R1: S1, can you tell us about the hole?
S1: Yes, it [the hole] is here on the left, it goes to the bladder side. Here from the bladder neck. I reflect for a while about what to do here, to cut the isthmus or, to put some sutures (--) It's just a small hole and…
S2: You cut.
S1: No, I (--).
S2: Really?
S1: Yes.
S2: I see. I would have cut.
S1: You would have cut?
S2: I would have cut.

Here, Surgeon 1 observes his small reflection. It is visible in the video as a three-second pause without moving the robotic instruments. Seeing the video excerpt prompts Surgeon 1 to explain the pause to his colleague, because, as we interpret, it is an exception to the normal pace. This explanation can be due to an implicit O3 organizing object, *operating quickly and smoothly*. He accounts not only for the object of the hole and the urethra, but importantly, also turns his own actions, by explaining his "*putting some sutures*", into an O5-type object of dialogue. Surgeon 2 is spontaneously surprised by his colleague's action, and openly expresses this. The fact that Surgeon 1 turns his actions into an object of joint discussion and reflection, and that Surgeon 2 expresses a different opinion on the best way to proceed, suggests that the dialogical framework is working; encompassing trust, freedom of expression, shared interest in investigating the activity and balance of power. This excerpt shows variety in the actions of the surgeons.

Excerpt 2b (from crossed self-confrontation between Surgeons 1 and 2)

R1: Interesting, how did you end up sewing?
S1: Well, I mainly thought that there's a nice isthmus anyway and it's open from there, the bladder neck, in the right place. So I thought let's close the wrong place, so it went as was planned.

Now, Surgeon 1 expresses another O3-type of object: *a return to the initial plan*. We interpret that this object aims at restoring the patient "form" to the normal state: in contrast to the norm, the hole was a deviation from the kind of incision that is typically inflicted on the patient, and therefore sewing would restore nor-

mality. The plan here may refer to two things: the standardized process or protocol followed globally in the robotic surgery to remove the cancerous prostate [34], or the plan made for each individual patient. As regards the former, according to our interviews, following a standardized protocol is even more important in robotic than in open surgery.[2] This is curious, as (or maybe because!) the robotic device extends surgeons' visual and dexterity capabilities. Regarding the latter, the individual plan is about the concrete aims in each operation. It is indeed possible that the disturbance in installing the catheter and the subsequent delay in starting the surgical operation strengthened this object, i.e. the surgeon's motive to return to the initial plan.

Excerpt 2c (from crossed self-confrontation between Surgeons 1 and 2)

R1: Yes. And S2 how do you justify this?

S2: It's so close to the bladder neck that I would have cut it and then sewn it, as normal, as part of the anastomosis there. It wouldn't have been so big, you could've saved the bladder neck quite easily from the right side. It [the bladder neck] would not have become very big.

S1: No, I guess not.

In this excerpt, Surgeon 2 interestingly justifies his alternative action with the same object of saving the bladder neck. This shows that it is a collectively shared object. The actions are different, but the object is common. This is a very interesting outcome of crossed self-confrontation, which allows the researchers to understand which shared objects of the O3 type are present at a given time in the situation, and how they are influenced by the technology.

The same video clip (Figure 3) was discussed again in a workshop of four surgeons involved in self-confrontations.

Excerpt 3 (from the collective workshop of four surgeons)

R2: [showing again the same video excerpt as in Excerpts 1 and 2 above]. Does this raise any comments or thoughts?

S2: Double opening done, in a handy way (laughing)

S1: Yes, I can personally admit that there I contemplated, is it a good idea to leave that isthmus there.

S4: -- because you cut there

S1: Mm. To cut or to close it there, is it really a good idea to close that small hole.

R2: What are the alternatives?

S1: If you cut, the bladder neck remains bigger, you need to stich more up later. What would you have done? S2 shows (--) commented last time that (--) S4, would you cut that track?

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[2] A strong standard does not diminish the importance or possibility of variation and flexibility [19].

S4: I don't know if it makes any sense to keep it. It's burnt, there's certainly no blood circulation, it has no function, so I would rather cut it properly and join it with a few stitches [shows a uniting gesture with hands], so I don't understand … On the other hand, if you keep it at this phase, you could later see and maybe cut it and stitch it, or not cut it – but honestly, I don't know. But it may help in reconstruction [in the anastomosis] if it holds it in place.
S3: I would cut it. You can't put anything on it. On such a small isthmus.
S2: Me too, I would have cut.

Surgeon 1 questions his decision. He seems to focus his reflection on his relationship with this object of "putting some sutures", by encouraging his colleagues to give their comments. He used the eyes of his colleagues, their external perspective, as a resource to observe and evaluate his own activity differently. Surgeon 4 provides many justifications in a dilemmatic way, and notes the "help in reconstruction" (which is the same object, we interpret, as easy anastomosis). The intense participation and shared inquiry show how the object of the psychological activity of Surgeon 1 is shared by all the surgeons in the workshop.

During the workshop, the surgeons said that they planned to organize meetings for watching selected video excerpts together, also after the intervention. This idea may materialize later as a new organizational practice. This would also strengthen the local community spirit of robotic surgeons, as expressed by a surgeon later.

6. Discussion and Conclusion: How Do Objects Evolve in the Self-Confrontation Process?

The dialogue in the intervention, facilitated by the researcher and the video excerpts, makes the relevant objects of the surgical activity sharable among the participants. This is accomplished thanks to the intervention framework, in which video, questioning by the researchers and talking to peers make actions and objects emerge. Just as the robotic camera changes the surgeons' viewpoint regarding the patient's body and operation process, so does the intervention, albeit in an unusual way. In this paper, we conceptualize this change of viewpoints as evolving objects.

The camera of the robotic device producing the digital video images is perhaps the most important technical object from the perspective of this paper. Its role is crucial in the surgical operation for transmitting the ongoing visual image for the team. In the research, researchers and professionals select some video excerpts to be shown in the intervention encounters. The fact that the video clip is also an outcome of the surgeons' own collaborative activity may enhance engagement and learning when watching and reflecting on them. Although not totally neutral, the video images still offer an objective view to what happened in a particular work situation. The power of video excerpts in self-confrontation encounters is in showing numerous material objects in action. The concreteness of the ob-

jects in the video excerpts, present in all phases of the self-confrontation process, is a rich resource for reflection and interpretation in the intervention. Some objects in the video are taken into participants' discussion and others are not, which is an interesting theme for further study.[3] In our case, the extra hole in the urinary bladder was such an object. Our study contributes to discussions of the pedagogic uses of digital visual images, increasingly important in both workplaces and society.

Inspired by the notion of sociomaterial assemblages [1], we use the temporal intervention process to trace the appearance of the objects. The dialogue in the first intervention encounter identified a material object (the hole in the bladder), the concrete action taken and a possible alternative action for dealing with this situation. Our analysis uncovered how various situated and psychological O3 objects were taken up in the discussion. They function as organizing situational actions, but they may be partly implicit for the actors. They are expected to either help the fluidity of the operation or contribute to other societal and functional objects of the activities. The O3 objects are flexible and dynamic – individual surgeons may harness them into use as either a standard or occasional practice. The material and technical objects visible in the video excerpts were crucial in revealing these organizing objects and enabling their articulation in the dialogue.

The second, crossed self-confrontation with two professionals made the O3-type objects ones of dialogue and disagreement (O5). The research point in raising them for discussion is not to judge what is right or wrong, but to better understand this work activity by supporting professional development through discovering and reflecting on the variation of its objects. In the third encounter – the workshop – the same initial object seen in the video gave rise to yet another O5-type object: a professional taking his relationship with his action as an object of dialogue, using his colleagues' perspectives as resources for reflection. Through objects of the O5 type, an action may turn into a means of thinking about other possibilities. The active participation of professionals shows the shared nature of this object. The temporal sequence of evolving objects is visualized in Figure 4.

[3] The robot is both an instrumentality and a medium [38], as it modifies the modes of perception of the environment. The technical objects of the robot were not often taken as objects of dialogue by the surgeons in the self-confrontation process. The robot may be such an intimate part of the everyday organizational experience that it becomes "invisible' [1].

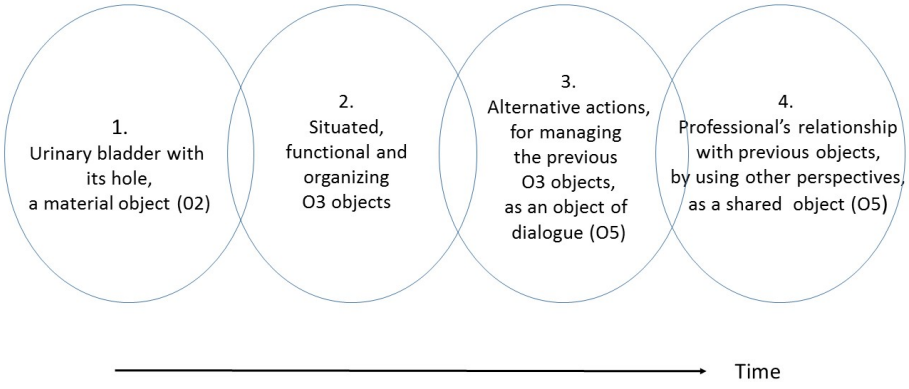

Fig. 4. Evolution of objects in the self-confrontation process

The variation and complexity of the objects is of interest for the study of making new connections in interpretive practice [18]. The development of the objects of the activity in the intervention is supported by the research framework, which offers a strong focus on a shared analysis of the activity of the surgeon, based on video clips of real operations. This shared analysis then intertwines two related activities: one activity concerning joint observation of the significant details of their actions, based on concrete visual images of their own working; and an activity of dialogue, in which the questioning and reasoning regarding situations and alternative actions – thus enhancing the interpretive practice – is first experienced at the interpersonal level, through dialogical exchange, before being experienced at the intrapersonal level, as multiple possible viewpoints of one's own activity, offering perspectives for its development. Turning back to the objects and their development, which we have traced in our exploratory analysis as analytical tools to help understand complex technological activities, we show how O5-type objects of dialogue appear in the discussion from O3-type psychological objects, which are not usually easily shared or observed in everyday practice. These O5-types objects of dialogue may then become O6-types objects of thinking, which may be a means of considering other possibilities, and therefore have some potential for transforming the material and organizational objects (01- to O3-type objects of the concrete surgery activity). Therefore, throughout the intervention, the focus may shift from production activities to ways and means for developing these activities. This is why we call this kind of research developmental.

We see the intimate connection between different types objects. The main social object of removing the cancerous prostate would not exist without the mate-

rial prostate in the human body or the technical instruments for removing it. However, differentiating between these object types facilitates analysis, for both researchers and practitioners. Thus, the dialogue around these objects may strengthen individual, collective (in the community of surgeons) and organizational development. Although we did not yet analyse the objects of thinking of the O6 type, the surgeons' interest in continuing to collectively watch the operation video excerpts, and their expression of how the intervention strengthened their local community spirit, indicate positive outcomes of self-confrontations. However, the intervention needs to be evaluated further.

Activity-theoretical interventions differ from many other developmental approaches, as they focus on concrete human activities and their objects. The objects of professionals' work, often in their material and concrete forms, are made visible for collective reflection, learning and revealing developmental possibilities. Despite the ambiguity of the concept [39, 40], objects of activity are powerful sense-makers that help anchor and contextualize subjective phenomena in the objective world. It is important that more subjective object constructions, such as those examined here, find a voice in organizational practice and research.

In this paper, we have, in an exploratory way, identified and analysed some objects in an intervention using the method of self-confrontation. The intervention related different kinds of objects; first the material objects transmitted by the video image to the psychological and social objects in the intervention encounters, which led to an idea of a new concrete practice. We see that the temporal process of self-confrontations is helpful in seeing different objects, their interrelations and their renewal. Activity theoretical developmental interventionist research could contribute to studies of technology and organization by revealing the complexity and evolution of objects.

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