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**Learning a new ecology of space and looking for new routines:
Experimenting robotics in a surgical team**

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Abstract

When organization members face change, they can struggle to adapt, and may create new routines. Drawing on insights from a case study of bariatric robotic surgery, we illustrate how a new ecology of space transforms the ostensive and performative aspect of a routine during the introduction of a new technological artefact. We discuss two types of spaces: the experimental, and the reflective. We show that the reflective space enables practitioners through debriefings to discuss about the new patterns of interdependent actions. Practitioners explore the different aspects of the performative struggle encountered with new artefacts and try to integrate new actions and to delineate the boundaries of this change during experimental performances. Our findings put light on the role of the reflective space added to the experimental space in routine change and suggest that socio-material ensembles can produce opportunities for reshaping routines.

Key words: routines, artefact, change, spaces, ostensive, performative

1. Introduction

The concept of routines is at the centre of organizational evolution leading scholars to try to unpack the organizational ‘black box’ in order to grasp the complexity of this notion (Salvato and Rerup, 2010; Rerup and Feldman, 2011). Many researchers believe that it is critical in the context of routines to disentangle the dynamics of their ecologies (Birnholtz et al., 2007; Sele and Grand, 2016). This can be reframed to include the way that technological artefacts can reshape the performance of day-to-day routines.

Organizational routines defined as ‘*repetitive recognizable patterns of interdependent actions, carried out by multiple actors*’ (Feldman and Pentland, 2003: 93) are challenged continuously during the adoption of technological artefacts which require effective team work, i.e. coordination and collaboration among experts (Edmondson et al., 2001; Edmondson and Zuzul, 2016; Jarzabkowski et al., 2012). Thus, artefacts are ‘mediators’ of human cognition and activity but ‘*do not lie outside the routine*’; on the contrary they ‘*participate in the co-creation of knowledge and transformations of actions*’ (D’Adderio, 2011: 199). As a result, they capture, encode, and select among performances while also having an impact on organizational routines (D’Adderio, *ibid*). Also, material artefacts involve new relational dimensions within the pattern and new sequence of action. Indeed, within a routine, ‘*actions are related sequentially over time (...) The sequence matters, not in the sense that it is always the same, but in the sense that the order in which actions are taken is often meaningful*’ (Feldman et al., 2016: 507). Ecologies of routines are critical not only for the adoption of technological artefacts but also for the stability and changes within the patterns of interdependent actions.

Based on these insights, one of the authors collected ethnographic data to show how much technological artefacts provide new opportunities for the creation of new

ecologies of routines. Indeed, our empirical findings are based on three years of observation of robotic surgery by a gastric bypass surgical team. This allowed us to document diverse dimensions of the ‘ecology of space’ (Bucher and Langley, 2016), and new interactions among team members in both experimental and reflective spaces. Along these lines, Bucher and Langley (2016) show that in hospitals the ecology of routines can become ‘an ecology of space’, i.e. a ‘*community of practices that experiment changes within their own routines and delineate what can be the boundaries of this change*’. They observe two options for questioning the current interactions patterns, the reflective spaces and the experimental spaces:

whereas reflective spaces are set apart by social, physical, and temporal boundaries and involve interactions that are geared toward developing novel conceptualizations of a routine, experimental spaces enable the integration of new actions into routine performances by locating them within the original routine, while establishing symbolic and temporal boundaries that signal the provisional and localized nature of experimental performances. (Bucher and Langley (ibid: 601)).

In this direction, we introduced the notion of debriefing (Godé and Lebraty, 2015) used during the reflective space allowing open discussions about the new performances. To focus on how the team explores new patterns of interdependent actions, we address the following questions: What are the implications of these technological artefacts for developing new experimental spaces that challenge current organizational routines in both their ostensive and performative dimensions? And, what is the role of debriefings for creating reflective spaces to overcome performative struggles and to delineate the boundaries of these potential changes?

Following this introduction, we summarize our theoretical framework, discuss the notion of technological artefacts, and develop the idea of space and socio-material

ensembles to frame the concept of ‘experimental space’. In the methodology section, we describe our empirical data gathering and ethnographic observation context, followed by presentation of the data analysis and a discussion. The last section provides some conclusions.

2. Experimenting with artefacts while implementing routines

Robotics surgery in hospitals

Surgical acts have been performed since prehistoric times (Ellis, 2002). The evolution from open surgery to mini-invasive surgery was an important evolution in surgery. Open surgery refers to the traditional surgical act which involves use of a scalpel to make an incision, and the surgeon in direct contact with the internal organs. Mini-invasive surgery is less aggressive and involves smaller incisions. The surgeon uses special instruments guided by the images on the screen in front of him/her.

Another important evolution in surgery was the development of robotic surgery. Robotic surgery is a form of mini-invasive surgery in which the surgeon manipulates the arms of a robotic system through a small incision. The surgeon operates via a console located outside the sterile zone in the operating room (OR). Although the surgeon is positioned away from the patient and the rest of the team, his or her visualization is enhanced by the console’s 3D screen. The robotic system tries to reproduce the surgeon’s actions. This new ecology affects the interactions in the OR, and thus, creates new coordinating mechanisms in practice.

Unlike mini-invasive surgery, in robotic surgery the surgeon’s performance is replaced (Compagni et al., 2015). Thus, the technological artefact is disruptive since it codifies and encodes some human skills to act as the surgeon. However, although robotic surgery encodes some human skills and changed the interactions between actors, it still needs non-verbal exchange of knowledge and communication (Von Scheve, 2014).

The artefact codifies and encodes in a way (Lazaric et al., 2003; D’Adderio, 2011) that challenges both the ostensive and performative level of routines, i.e. the way the surgery act will be envisioned in the future, and the team’s current performance. In this context, the introduction of a new technological artefact does not involve just the simple transfer of ‘best practice’ but resides in finding new arrangements to the organizational context, i.e. how teams explore new interactions and perform using the new tools as “*some agencements*” or *ensembles of artifacts and actors* “*are more, and some less, able to enroll people and materials and therefore are more or less successful*” in modifying the routine (D’Adderio, 2011: 218). In short, the problem lies not in how the technology can reproduce or not human expertise but rather how to delineate new performance and their diverse outcomes for the team. In line with D’Adderio (2011), we argue that artefacts are at the centre of routines, and routines are ‘*stretched across actors and artifacts*’ requiring reconfiguration of both the ostensive and performative aspects of routines, and significant learning to identify a suitable ‘ecology of space’ to fit this new arrangement (Bucher and Langley, 2016).

Finding a new ecology of space

Bucher and Langley (2016) examine how diverse aspects of what they define as « reflective space » reveal various opportunities for change and shed light on « the role of collective reflection in routine change ». Here, spaces are defined as “bounded social settings” that can influence the ostensive and performative aspects of routines (Bucher and Langley, 2016: 597). As already recognized “*the field has traditionally overlooked the ways in which organizing is bound up with the material forms and spaces through*

which human act and interact” (Orlikowski, 2007: 1435). While reflective spaces can involve a set of distant actors involved in the original routine, experimental spaces are “*nested within the surrounding structure [...]and are cover subroutines, including actors who perform these subroutines but not others*” (Bucher and Langley, 2016 :600). The two types of spaces are important mechanisms in which actors “*engage in deliberate efforts to alter both performances and abstract aspect*” (Bucher and Langley, 2016: 594). Experimental spaces enable the integration of new actions in new routine formation while reflective spaces aim to conceptualize a routine.

Inspired by the literature introduced above, we examined the role of the interaction between both these spaces, and how they influence the performative and ostensive aspects of routines when a robotic surgery is implemented. Experimental spaces are putting these new concepts to the test and challenging the coordinating mechanisms already in place. Our empirical findings show that actors are selectively involved in the interactions and in the surgical act during robotic surgery. The debriefing phase is thus essential for understanding changes occurred and for representation all outcomes of these potential changes and for giving a chance to have a new ostensive routine. The experimental space helps practitioners to integrate change step by step with the possibility to stop robotic surgery when liability of the process is endangered.

3. Methodology

To understand the new coordinating mechanisms created by this technological artefact, we conducted an ethnographic study of robotic bariatric² surgeries. Data collection and analysis were inspired by key contributors to the field such as Hindmarsh and Pilnick (2007). These authors taking the nature of the ‘embodiment’ in the workplace very

seriously, observe the importance of « *intercorporal* » knowing in real- time coordination through a video-based study. We were inspired also, by the review of ethnographic studies in Jarzabkowski et al. (2014) which provides persuasive data. Our empirical setting is an OR routine in Nice Hospital. We observed 60 hours of gastric bypass surgery performed using the robotic system, and 15 hours of laparoscopic gastric bypass surgeries. The robotic system is introduced occasionally once a week, generating lack of repetition within the team creating extreme conditions for learning, high expectation but also the possibility of having corrective actions in case of misfits. The observation of both robotic and laparoscopic surgery allowed us to compare the coordinating mechanisms related to different technological artefacts used by the same team.

The first author started by conducting 20 semi-structured interviews with surgeons from different specialties. The interviews started in December 2013 and completed in February 2014, constituted the preliminaries for understanding the medical context and preparing the ethnographic study. The aim was to collect insights from practitioners about their interactions in the OR while operating using the robotic system.

¹ *Weight loss surgery.*

Following this preliminary stage, our live observations began in February 2014 and continued to May 2016. The surgeries were video-recorded for further analysis. We obtained approval to make the video recordings from the hospital's ethics committee and hospital team members. Thus, video recordings provide a unique opportunity to observe the emergence and the creation of experimental and reflective spaces discussed by Bucher and Langley (2016). In our case, debriefings appear to be critical for shaping the reflective space. Debriefings were meetings with practitioners operating in the OR and adding to them practitioners not present in the original surgical routine. The meetings were held in a room distant from the OR, followed the surgical procedures and lasted for 90 minutes. They allowed the practitioners a deeper understanding of the new coordinating mechanisms and interactions in the OR resulting from the adoption of the new robotic system.

Debriefings were oriented by a psychologist with a video recorded sequence of the surgical interactions (symbolic boundaries). The psychologist led the reflective talk and introduced the different topics. Two topics dominated: the organization of the tasks of each practitioner in the OR, and the interactions among team members during robotic surgery compared to laparoscopy. The psychologist created conditions for a fruitful reflective talk to discover how each practitioner perceived his or her role. In this reflective space, reflection and interactions about new ways of enacting routines in the OR were discussed.

4. Data Analysis

Team work in a traditional laparoscopy surgery

In laparoscopy surgery, practitioners are used to working under time pressure and uncertainty with high levels of coordination. Surgical acts in the OR are repeated with

specific actors performing specific actions in specific spaces. The practitioners involved in the surgery are the primary surgeon, the assistant surgeon, the scrub nurses, the circulating nurse, and the anesthetist and anesthetist nurse. Each practitioner has a specific role and occupies a specific space in the OR. The primary surgeon and the assistant surgeon operate facing each other and coordinate their surgical tasks while watching the laparoscopic screen. The scrub nurses stand next to the primary and assistant surgeons to hand them surgical tools and control the laparoscopic instruments and the camera. The circulating nurse moves around the OR ensuring the overall surgical procedure goes smoothly. Figure 1 depicts the spatial arrangement of the actors during laparoscopy.



The primary surgeon is operating with his assistant surgeon while explaining the surgery to the intern.



The nurse hands the primary surgeon an instrument.



The primary surgeon is looking at the patient to verify where to put the instrument.



The primary surgeon inserts the instrument in the patient's body.

Figure.1: Laparoscopic surgery

New interactions with the robotic system

In contrast to laparoscopic surgery, the spatial arrangement in robotic surgery changes. The primary surgeon is in front of the console outside the sterile zone in the OR. The assistant surgeon stands next to the robotic arms in the sterile zone accompanied by a scrub nurse. The other practitioners present have the same spatial arrangement as in laparoscopic surgery.

The change in spatial alignment reflects the changed roles of most practitioners present.

« Being away from the rest of the team is a bit tricky. It changes the whole concept of surgery based on team work ». Dr. "N" (Interview data).

This new configuration with the distance between the primary surgeon and the rest of the team is more effortful for accomplishing the surgical task.

Dr. "I" uses a great deal of eye contact with the scrub nurse and with his assistant while operating to transmit messages. Thus, being situated away from them is disabling (*observation data*).

Robotic surgery changes the configuration in the OR and the roles of each team member quite radically. This change begins with the installation of the robotic system at the beginning of each surgery. Figure 2 shows a five-minute sequence of installation steps for the robotic system, and each team member's involvement in this process. During this short sequence, team members replace the laparoscopic tools with the robotic system. The sequence starts with the placement of the robotic arms next to the patient. All team members help the surgeon to set up the robotic system. The primary surgeon ensures that the robotic arms and the screen are in place. The primary surgeon moves towards the console while the assistant surgeon stands next to the patient.

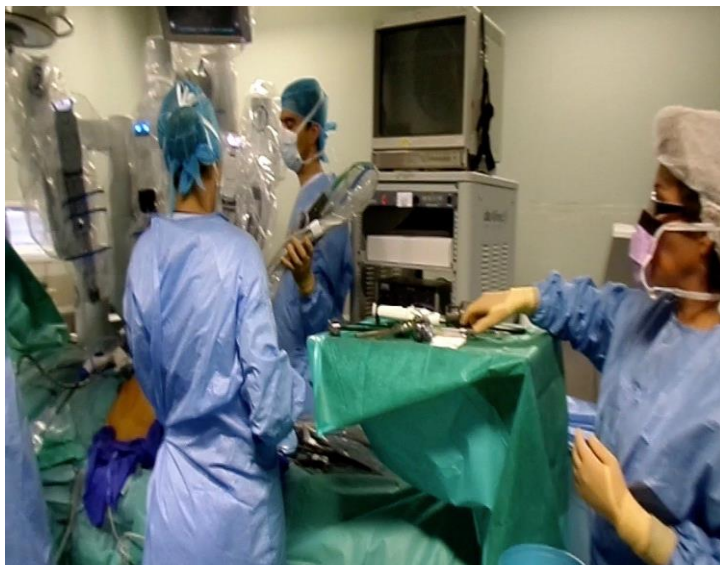


(i)



In figure (i), (ii) and (iii), team members are positioning the robotic arms.

(ii)



(iii)



The primary surgeon is helping the rest of the team with the robotic arms



The primary surgeon makes sure that the screen is in position.



The primary surgeon verifies the screen placement.



After ensuring everything is in place, the surgeon moves to the console to start operating



The assistant surgeon stands next to the patient and the robotic arms waiting for the primary surgeon to start operating.



The primary surgeon starts manipulating the robotic arms from the console.

Figure.2: Robotic system installation steps

When operating using the robotic system, the anesthetist's role is to monitor the patient's vital signs and reaction to the anesthesia. The circulating nurse ensures the continuous well-functioning of the OR equipment and the machines. However, the roles of the primary surgeon and the assistant surgeon change. During laparoscopy surgery, the primary surgeon stands next to the patient facing the screen and leads the surgery to perform the surgical tasks while coordinating with the assistant surgeon, the nurses, and the anesthetist. The assistant surgeon's role in laparoscopic surgery is mainly to support the surgeon in his surgical act. These acts are performed between the two practitioners during laparoscopy, and their proximity facilitates their coordination. When operating using with the robotic system, the primary surgeon sits at a console to manipulate the movements of the robotic arms and looks straight at the screen. This allows better visualization and a clear 3D view of the surgical act. The surgeon manipulates all the instruments including the camera, from the console. Interaction

between the surgeon and the rest of the team members is limited to communication with the assistant surgeon – sometimes to change the instruments on the robotic arms, or in the case of some sort of problem. We observed a situation when the primary surgeon had a problem, and due to technical difficulties needed the help of the assistant surgeon:

Dr. “I”, the primary surgeon, had a problem with the image presented and the haptic feedback. He noticed that the tactile feedback was not accurate with the 3D image provided by the system therefore he asked his assistant Dr. “T” to verify that everything is well positioned or if he is noticing something that is going wrong. When the latter answered negatively, Dr. “I” moved away from his console toward the patient to verify for himself (Observation data).

Interactions between Dr. “I” and Dr. “T” during robotic surgery were limited to brief remarks: *« go ahead Dr. “T” put the tube in...it is perfect ».* (Observation data).

During one surgical procedure the interactions between the two surgeons were substantial due to a problem with the robotic system. However, the interactions were mostly non-verbal and tacit and consisted of handing over technical tools.

« Non-verbal interaction plays an important role in surgery: eye contact, gestures and body movements » (Interview data).

The assistant surgeon has minimal interaction with the scrub nurse. In laparoscopic surgery, the scrub nurse passes instruments to the primary surgeon anticipating his/her needs (observation notes/video analysis).

« I know exactly what Dr. “I”. wants during surgery even without him saying. It has been a while we are working together ». A scrub nurse affirmation (debriefing data).

During robotic surgery, Dr. “I” completes the task alone, from the console, asking for help only if needed. Anticipation is neither necessary nor possible.

Performative struggle and tension during experimentation

We noticed that while the proximity to the patient was present previously, it gave also practitioners more security and confidence in their actions providing a sense of continuity, as the state of ‘ontological security’ described by Giddens (1994). In case of robotic surgery, the surgeon is distant from the patient and operates from a console. When a problem occurs, the primary surgeon needs the reassurance of the assistant surgeon who is positioned next to the patient. In most of the surgeries we observed, if the surgeon encountered a specific communication or technical problem, he/she moved towards the patient to ensure that his/her actions were in line with the “normal situation,” and to ensure that the robotic system arms were positioned correctly. One surgeon explained:

“Being placed far from the patient can make a surgeon feels that he is away from the actual act and have a negative psychological effect. Even though we have full control on our surgical actions. There is always some risk in robotic surgery” (Interview data).

In robotic surgery, the surgeon is positioned away from the patient. The new spatial arrangement moved Dr. “I” away from the patient. Dr. “I” moved from the console several times during surgical procedures when a problem was suspected (*Observation data*). While technological artefacts should in principle enable things by extending human skills, in practice learning robotic appeared more difficult than planned.

If the robot seems easy to use as summarized below:

« The use of the robotic is simple once you get used to it. It present lots of technical advantage especially concerning precisions and degree of liberty » (Interview data).

Although simple to use, problems occur frequently. Dr. “I” faced problems with it which led him to stop the manipulations. In the case of a technical problem (i.e. haptic feedback/touch feedback or offset between the 3D image and the manipulation), the learning may be disrupted for security reason. The disruption is largely due to a difficulty to have the same rituals of communication creating pressures and performative struggles within the team. In a context of such changes, we observed clearly the performative struggle that practitioners face. Indeed, significant differences in communication between laparoscopy and robotic surgery are present. In the latter, the primary surgeon frequently moved away from the console towards the assistant surgeon to direct him/her, and correct misunderstanding due to distance.

The “reflective space” created during the introduction of the debriefing session allowed some contemplation of the changes in the interdependence of actions. For instance, it has been asked to the surgeon why he moved away from the console towards the patient when a problem occurred. He answered the following:

“I am trying to ask my assistant Dr. “T” to move away the robotic arm to his right side he is not understanding my directions and moving it to the left side” (Interview data).

This example of the miscommunication during surgery creates potential misfits. Miscommunication can be caused by the misinterpretation of words or actions, according to the surgeons: *“Because they misinterpreted my words or actions”* Dr. “H” or *“I ask others to repeat what they were saying since I am not understanding what their message, or I can’t hear it”* Dr. “H” declared.

For instance, one scrub nurse, who had no experience with robotic surgery, replaced another colleague during one of the surgeries observed. Due to her lack of experience and unfamiliarity with the robotic system, she was unable to understand the surgeon's needs while communicating with him. This communication problem was reinforced by the physical distance of the surgeon from the rest of the team and by the high level of noise from the machines in the OR.

The new technological artefacts in the OR, and the distance between practitioners may hamper both verbal and non-verbal communication, which remain critical during the sequences of actions, notably the eye exchanges and the body language. The new ecology of space and the new roles of the actors affected team functioning and disrupted the sequence of action within the pattern of action, and therefore the usual decision-making. In robotic surgery, all decisions are centralized around the primary surgeon. This new ecology of space and the distance between the surgeon and his team changed the flow of information and may provide potential misfits. In the surgeries observed, when the surgeon was in an uncomfortable situation he/she might decide to abandon the robotic surgery and resort to normal laparoscopy to reduce potential risk.

Another aspect that reflected the difficulty to perform the routine smoothly is the presence of tension. Tension is a normal situation within the surgical team members in the OR. Comparing both types of surgeries reveals an increase of tension with the new technological artefact as discussed below:

One surgeon argued: « *It is totally normal to have tension in the OR. It is considered part of the procedure. If you didn't have tension, then the*

practitioners are trying to control themselves due to your presence »

(Interview data).

Although tension is frequent in laparoscopic surgery, we observed it more often and more accurately during robotic surgery.

« Why don't you do anything right ?! » Dr. "D" to Dr. "N during a robotic surgery (Observation notes).

In addition to the presence of tension, the distance of the surgeon from the patient and from the instruments caused lack of tactile feedback. This latter usually allows the surgeon to have simultaneously input and output of his surgical act and to "feel" the organs to decide how to proceed:

Dr. "C" argued that he relies mostly on visual cues since he does not have any tactile feedback in robotic surgery. *"When precision is needed like doing a suture it becomes tricky. I start manipulating slowly the robotic arms"* (Interview data).

During one robotic surgery, Dr. "I" "felt" a delay between his manipulation and asked his assistant to check if there was a problem. Dr. "I" left his console to ensure for himself that the robotic system was working properly (Observation data). Because of some performative struggles around the primary surgeon and the team, the learning process is disrupted for safety reason creating a place where practitioners prefer to come back to the usual way of doing things and to the 'old' technique. Also, in laparoscopy, a surgeon can revert to conventional open surgery although this is rare nowadays (*Dr. C argued*):

"Both robotic and laparoscopy it is totally normal to convert to the type of surgery that the surgeon feels more comfortable with and thinks it is safer for the patient" Dr. "S" argued (Interview data).

What emerges from our data is the increased frequency of conversion from robotic surgery to laparoscopy during surgery in case the surgeon is not confident enough about the technology. As soon as a technical problem occurred in robotic surgery, the surgeon came back to laparoscopy for avoiding his or her perception of risks and thus for reducing the performative struggles.

Introduction of a deliberate reflective space with debriefings

After the surgical procedures, a reflective space with the introduction of a debriefing session with all the team members operating in the OR with the new robotic system, and other members operating in non-robotic surgery (laparoscopy surgery) has been implemented. Debriefings may appear to be critical during the new adaptation stage (Godé and Lebraty, 2015). Indeed, a debriefing is a *“process involving the active participation of learners, guided by a facilitator or instructor whose primary goals is to identify and close gaps in knowledge and skills”* (Raemer et al., 2011) and a bounded social setting on *“how teammates use what they know and capitalize on it to avoid repeating errors”* (Hollenbeck et al., 1998:270).

In our observation, debriefings allowed all the practitioners to explore the change to their actions and interactions (verbal and nonverbal), to discuss the experimental space with the robotic system, and analyze the performative struggles encountered (see figure.3). This session was a reflective session which allowed the actors present in the OR to question their actions in light of the video recordings of the robotic surgeries.



Figure.3: Practitioners during the debriefing session

An example of a practitioner questioning his actions occurred when one of the surgeons witnessed himself on the video recording being verbally aggressive to the assistant surgeon:

Dr. “D” apologized to Dr. “N” for his attitude (*debriefing data*). This apology decreased the tension that was present in the OR and clarified the point of view of each practitioner.

The primary surgeon interrupted the talk during the debriefing to insist on the role of communication in these types of surgeries. He added that the surgery depends on the robotic system as well as on his assistant surgeon and nurses. He looked at the assistant surgeon and said: “*You are minimizing your role during the surgery, but you have to understand that I depend enormously on you*”. He looked then at the nurse and said: “*I also depend on you because if I don’t have the appropriate material to integrate into the robotic arms I cannot operate*”.

To understand their interactions more in depth, the actors present were shown the videotaped surgeries by the psychologist (see figure 4). These videos encouraged further reflective talk, and deliberate learning on the performative struggle, and therefore, on the experimental space of the new routine that was encountered in the OR.



Figure.4: Practitioners confronted with video recordings of their surgical acts in the OR.

Being confronted with their actions opened a new discussion on the nature and content of the interactions among the practitioners. The change of the way of communicating and the limited interaction between the practitioners when robotics was introduced were the main issues that the surgeon was interested to discuss.

5. Discussion

On the one hand, our data allowed us to investigate the difficulty experienced by surgeons in performing routines following the introduction of new technological artefacts and the potential changes to interdependent recurrent interactions patterns. Indeed, during the experimentation of robotic surgery, interaction is limited to when problems occur. The primary surgeon manipulates the robotic arms. This leads to the surgical procedure being centered around the primary surgeon, and contrasts with the ostensive aspect of the traditional surgery defined by a decentralized teamwork. Bucher and Langley (2016) describe the boundaries of spaces in the OR as social, temporal,

physical and symbolic. In laparoscopic surgery, the social boundary is represented by those present during the surgery: the surgeon, assistant surgeon, nurses and anesthetist. The physical boundaries are related to the locations of each team member present in the OR: the surgeon and assistant surgeon facing the laparoscopic screens in front of them, the nurses serving the surgeons, and the circulating nurse outside the sterile zone.

In terms of experimental spaces, we identified the social boundaries which emerged in robotic surgery. The surgeons and nurses, for example, perform a different bariatric surgery. Physical boundaries also are present. Being at a distance from the patient and the rest of the team made communication more difficult and reduced confidence. The interactions between the two surgeons are limited during robotic surgery since the actions are centered on the primary surgeon. Real interaction occurs only if a problem arises. All these changes represented the experimental space that reshape both the abstract representation and the performance of the surgical act. In this context debriefings provide a reflective space that complement the experimental space leading to a potential redefinition of current interdependent actions patterns. Indeed, social, physical, temporal, and symbolic boundaries emerged when the envisioned routine was put to the test, and while coordinating the process in both the reflective and experimental spaces (Bucher and Langley, 2016).

On the other hand, our empirical findings allowed us to gauge how much the ostensive level of the surgical procedure routines may be changed. The relationship between the ostensive and performative levels related to a routine create ongoing opportunities for changes to patterns of actions. The ostensive aspect refers to the structure or abstract pattern of a routine, and the performative aspect embodies the specific actions of actors (Pentland and Feldman, 2005). The performative level creates, maintains and modifies the ostensive aspect of a routine (Feldman and Pentland, 2003). These mutually

constitutive aspects are co-shaped by artefacts (D'Adderio 2011). The ostensive element originates in and guides performance. Surgical team members follow an abstract representation of their surgical tasks which direct their patterns of actions. A typical surgical bariatric intervention routine in the OR includes placement of the patient in the OR, nurses and anesthetists preparing the patient for surgery, primary surgeon operating assisted by the assistant surgeon. The nurses are situated in the sterile zone alongside the surgeon to hand them instruments while a circulating nurse who is located outside of the sterile zone supplies the nurses with instruments. The surgical team has an abstract understanding of the patterns of interdependent actions that should take place in the OR (the ostensive aspect) and the pattern of their everyday performance (performative aspect).

Practitioners in the OR explore new ways of enacting surgical procedures using robotic surgery. The reflective space is enacted through exploration of the new tasks observed during the “debriefing phase” when the surgeons and the rest of the team discussed new ways of interacting and coordinating with the rest of the team.

Experimental spaces also enacted. Indeed, new interaction patterns between the primary surgeon, the nurses and the assistant surgeon were tested during robotic surgery. For example, when the primary surgeon asked the assistant surgeon to move the robotic arms to allow him a clearer view. In the hospital context with a sharp division of labor, the team leader’s actions are critical for maintaining team stability and enabling the adoption of technological artefacts (Edmondson et al, 2001). In our observation, during robotic surgery the primary surgeon was the leading actor in the OR. This led to a more centralized form of coordination, and a new ecology of space reinforcing the primary surgeon’s position and responsibility for misfits.

Our empirical findings reveal also the difficulty involved in defining and shaping the performative and ostensive levels of routines. The video recordings allowed us to observe two kinds of problems. First, the struggle to find a suitable ecology of space which would enable the performance of the surgical routine. In this experimenting space, technological artefacts produced both new arrangements and new interactions among team members. The distance between the primary surgeon and his team created new forms of interactions different from previous team rituals, creating a performative struggle for defining a new surgical act avoiding any potential misfit. Indeed, communication, roles and interactions needed to be redefined. Notably, the tacit dimension of communication among the surgical team was lacking as was anticipation of the surgeon’s actions by the scrub nurse. Some redesign is required to avoid tensions, and to promote psychological safety within the team. Resolving these tensions involved coming to the old pattern of action, which is considered by practitioners as the ‘safer’

option.

Second, this struggle to perform the routine had a direct effect on the ostensive aspect of routines. Not only was the ecology of space redefined by this new organizational setting but also the abstract pattern and the representation of the surgical act were reframed thereby creating new ostensive routines. Trial and error learning emphasized by Rerup and Feldman (2011) was observed and allowed the possibility to revert to previous recurrent interaction patterns if communication problems threatened surgical performance and the surgeon's ability to conduct a smooth surgical operation.

Conclusion

The surgical act involves many challenges. Technological innovations have changed how surgical procedures are performed in the OR through the introduction of digitization, miniaturization, improved optics, novel imaging techniques, and computerized information systems (Ganapathi, 2017). Increased automation and innovation in surgical procedures require practitioners to learn and to be trained. In this context, our aim was to understand how a new ecology of space affects the ostensive and performative aspects of a routine to support the introduction of a new technological artefact. The findings from this study suggest that socio-material ensembles produce experimental and reflective spaces in which both the ostensive and performative dimensions of routines are questioned and temporarily redesigned.

The introduction of the robotic system has resulted in former more or less smooth routines performances becoming effortful and creating new interaction patterns within the team. This emphasizes the critical role of the primary surgeon to adapt to this new spatio-temporal arrangement like, and to create a new collective representation of a more centralized surgical act. This ostensive level of routine is critical to implementation of

the performative level.

Our empirical findings show how technology is at the center of routines and needs to be theorized as such (D'Adderio 2011). Moreover, being at a distance from the patient creates a new form of interaction that is unfamiliar to the team leader and the team. Thus, the team leader (here, the primary surgeon) cannot transfer his or her expertise to team members, creating a situation where exploration is observed but not performed efficiently. Experimenting with new actions and learning through trial and error are frequent in many organizations (Rerup and Feldman, 2011). However, the professional context of a hospital introduces many difficulties related to resources, time for learning, and the enabling conditions for emergent patterns of actions to be performed smoothly.

As a result, the experimental space is continuously questioned, creating permanent learning inside the team with opportunities for the implementation of new coordinating mechanisms. In line with Bucher and Langley (2016), we observed a “reflective space” during the debriefing period, allowing scrutiny of the content of the routine at the performative and ostensive levels. The reflective space will emerge if the actors are able to adopt some distance and discuss the outcomes of these changes within the team and decide how to arrange their interactions in this new setting.

The “reflective space” offered a solution to the “experimental space” and smoothed the effortful implementation of robotic surgery. Debriefings support both reflective and the experimental spaces by providing a deliberate form of learning and by suggesting the missing links in the new interdependent actions that needed to be improved and adjusted for securing and stabilizing this learning.

Finally, our empirical findings have also some implications for future research. Beyond the importance of materiality as generating an interference on the usual and recurrent interaction patterns, the tools for collecting data matter providing a possible new role for researchers. The presence of a researcher during the video recording can be central for helping practitioners to build a new representation of their action and for helping them to question and co shape potential new visions of what can be a routines at both performative and ostensive levels. Furthermore, if the presence of the researcher is not neutral and may interfere on the data collection by pushing actors to show only some part of their performance. These methodological and ethical questions have also to be mentioned and observed in empirical findings where video recordings are used and should benefit a greater attention for future research settings.

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