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Lea Kiwan

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THÈSE DE DOCTORAT

Effects of a new technology on expertise

Case of robotics in bariatric surgery

Effets d'une nouvelle technologie sur l'expertise

Le cas de la robotique dans la chirurgie
bariatricque

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grade de docteur de l'Université Côte d'Azur*

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Introduction



Chapter 1

Cognitive expertise overview and naturalistic decision making process



Chapter 2

Interpersonal expertise: organizational routines' stability in changing environments



Chapter 3

Healthcare background and technology implementation

Chapter 4

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Chapter 5

Implementation of a technological artefact in surgery: robotic system in bariatric surgery



Chapter 6

Comprehension of the technological implementation process and its effect on individual and collective level



Conclusion

General Introduction

S *eptember 7th 2001, first transatlantic surgical intervention performed on a human took place. It is known by “operation Lindbergh”. The surgery was performed in New York while the patient, with the presence of two other surgeons by his side, were in the operating room in Strasbourg.*

This surgical procedure marked the history of surgery and was the result of long years of research on the development of robotic surgery and computer-aided surgery. Controversial debates took place on the effectiveness and efficiency of this technique on the surgeon, surgical team and on the hospital as a whole. Surgeons and operating room (OR) teams had to develop new technical, cognitive and interpersonal skills to adapt to the new technological artefact adopted.

This presents an example of the challenges that organizations and practitioners face to maintain stability in a changing environment when dealing with technological innovation (Edmondson 2001). Adopting a new technology is one of them, requiring effective teaming, i.e. coordination between experts working together (Edmondson, 2001; Edmondson and Zuzul, 2016). Implementation of a new technology disrupts occupational roles (Black et al, 2004) and therefore new interactions patterns between professionals are needed. The impact is in the same time cognitive in terms of individual expertise and interpersonal in terms of new interaction

and coordination patterns. Adoption of a new technology has a direct effect on an expert's behavior. Lots of studies had already demonstrated the changing behaviors of experts while implementing a new technology. To begin with, we define an "expert" as an individual having a high amount of knowledge in a certain domain. Therefore, expertise is the degree of knowledge and abilities in a specific field, based on the intensity and quality of past experiences (Salas, 2010). It consists of having a high level of performance using deformed subjective operative images (Pastorelli, 2009). Naturalistic scholars studied the expert's decision-making process while facing a critical situation (Klein, 2001). Naturalistic research illustrated how experienced individuals working in highly dynamic and uncertain environments take decisions. The term "naturalistic decision making" appeared in 1989. Studies using this approach focus on decisions taken by experts in their real-life work settings instead of laboratory settings (Lebraty, Pastorelli-Nègre, 2004). Based on different action research, an analysis model on the intuitive decision was elaborated and called "Recognition-Primed Decision" model (RDP) (Lebraty, 2007, p.34). This approach describes how experts take decisions while taking into consideration operational parameters. RPD has three possible paths of decisions making routines, depending on each situation encountered. According to the naturalistics, there is an assessment to solve a particular problem. There is a gap in the naturalistic literature on how a technological artefact, that changes an expert's role, affect his decision recognition's pattern.

On the other hand, in addition to the new technical medical skills required and the personal cognitive skills stated above i.e decision making, medical expertise includes interpersonal skills. Interpersonal skills are the skills that allow the surgeon interact with the other surgical team members in the OR. These interaction patterns in the OR are routinized. When dealing with change, these patterns are affected. Therefore, when we discuss about technology adoption in an organization, we also take into consideration the impact on new interaction patterns among individuals which will therefore be disrupting their old routines. The concept of routines is at the center of organization evolution facing changes i.e. technological evolution. A routine is defined as “repetitive recognizable patterns of interdependent actions, carried out by multiple actors” (Feldman and Pentland, 2003:93). In this direction, scholars underlined the importance of actions (social) and artefact (material) that produces a routine where expertise and knowledge are required (Jarzabkowski et al., 2016: 118). Artefacts are mediators of human cognition and activity, and are the interface between ostensive visions of routines and their performance. Material artefacts are involved in the individual and collective pattern of action.

Having this background in mind, our main interest is to illustrate the effect of a technological artefact on the individual decision making process of an expert and on the collective team work when dealing with new ecologies of space thus creating new interaction patterns. In order to do so, our case study focuses on robotic surgery implementation in gastric bypass surgery.

Healthcare is a promising field for observing changing pattern of action with the implementation of a new technological artefact (Edmondson et al., 2001, 2004; Bucher and Langley 2016; Compagni et al., 2015; Pisano et al., 2001 and others). This sector is encountering continuous development since three decades. Surgery presents one aspect of healthcare evolution. It was marked by three main events: the shift from conventional *open surgery* to *mini-invasive surgery* (laparoscopy) and from this latter to *robotic surgery*. In the 1980's there was a big evolution in surgical procedures with the introduction of mini-invasive surgery (MIS). Starting 1990's MIS started expanding and open surgery started to disappear. MIS consists of making small incisions through which the surgeon can operate using laparoscopic instruments and cameras. This technique is called laparoscopy. The main objectives of laparoscopy were to reduce patient's pain and post operation recovery time mainly due to the trauma caused by large incisions (G. Gruthart, J. Salisburg, 2000). The limited freedom of movement of the surgeon's hand instruments manipulation and the limited 2D images provided were considered technical challenges that surgeons face. In order to overcome these difficulties, scientists started looking for a way to evolve MIS and the difficulties encountered by laparoscopy. As a consequence, robotic surgery was developed. Robotic surgery is a type of MIS that was expanding fast in the last decade since its introduction. The da Vinci robot is one of these robotic surgical systems developed to improve conventional laparoscopic procedure. The system was FDA (food and drug administration) approved in 2000. Since then, the use of the systems started growing to the rest of

the world. There was a remarkable increase in the Da Vinci robot's adoption by hospitals. Da Vinci robot consists of the robotic arms and the console. During robotic surgery, the instruments held by the robotic arms are inserted into the patient and manipulated by the surgeon who is sitting at the console located in the operating room outside the sterile field. The system is design in a way to replicate the surgeon's movements. Nowadays, da Vinci robot is the only available system for soft tissue (Abrishami et al.2014). Edmondson (2001) illustrated changing routines in OR while passing from conventional open surgery to MIS. Our study is in continuity of these studies.

Since its introduction, the robotic system faced controversial debates on the necessity of its adoption. The MIS and medical literature scholars studied the feasibility of robotic systems in different types of surgeries from the technical and medical perspective. One example is a comparison study on MIS approach and robotics in rectal resection for cancer (I. Popescu et al 2010). Furthermore, the majority of the medical studies focused on the performance of the console surgeon from the technical point of view. Others took into consideration the important role of the patient-side surgeon in this type of surgery (O. Sgarbura, C. Vasilescu 2009). However, it was not until recently that scholars from other disciplines started being interested in robotic surgery. Few studies targeted the effect of robotic surgery from the organizational perspective. A recent study in cognitive science illustrated the impact of robotic surgery on teamwork specifically on communication and decision making in the OR (R. Randell et al, 2016). Scholars in management studies were

interested in robotic surgery. Ravasi (2015) studied the social positioning and skill reproduction in the diffusion of robotic surgery in hospitals. He answered broader questions on how early implementation influence late adoptions of technology. Management and organizational literature were particularly interested in studying the effect of a technological artefact adoption on expertise and on organizational routines.

In order to do so, we collected ethnographical data after interviewing experts i.e. surgeons operating with a technological artefact illustrating how it affects expert's course of action. Furthermore, it demonstrated how the current interaction patterns help notably sharing and transferring expertise. Thus, we were able to document diverse dimensions of learning a new "ecology of space" (Bucher and Langley 2016), new individual patterns of action and new interactions among team members. To be more specific we focused on how experts take decisions with a new team alignment, how the team creates provisional pattern of action and a new ecology of space to support the technological artefact implementation. We answer the following questions: what are the implications of this artefact on expert's decision making process when facing a problem? What are the implications of these artefacts in terms of professional roles, communication and new forms of coordination? And why some emergent patterns may stay at an exploratory stage and others may be more inclined to be performed effectively within an organization?

In brief, our interest is to find the impact of this robotic surgery from both individual and collective point of view. To be more precise, we aim to discover how this robotic system affects the expert (i.e. the primary

surgeon) and his decision-making process from the non-technical perspective. In addition to that, our main interest is to understand how the Da Vinci robot will change coordination in the OR therefore its impact on surgical team routines.

In order to answer the questions stated above, we conducted a qualitative study with an interpretative approach. Before our ethnographic observation, we started our study with twenty semi-structured interviews with surgeons from different specialties. The interviews started three years ago, December 2013. The length of each interview was for two hours. The aim of this approach was to generate insights from practitioners about their interaction with the robotic system and with other team members. We followed the naturalistic approach precisely the critical decision method to construct the context of our questionnaire. The aim of this approach is to generate insights from practitioners about their expertise, their decision making process while facing a critical situation and their interaction with a new technology like robotic surgery (Hoffman, Klein 2001). The results of our questionnaires were useful later on in our observation process: we observed the themes that emerged from our questionnaires.

The heart of our research is an ethnographical study that we conducted in Nice Hospital, France. Our empirical setting is an operating room routine in Nice Hospital. We observed 60 hours of gastric bypass surgery performed with the Robotic system (including 30 hours conducted partially with the robotic system) and compared them with 15 hours of laparoscopic gastric bypass surgeries during 3 years starting May 2013. The hospital is concerned with new technology adoption to maintain a certain image.

Surgery evolution is one of the points of interest of the hospital. Robotic surgery was introduced in the hospital 5 years ago. The robotic system is used mainly in a regular basis in the hospital in urology whereas it is used occasionally on Wednesdays in the digestive pole to operate with it during gastric bypass surgery.

The surgeries observed were video-recorded for further analysis. In addition to the field observation analysis, we transcribed and conducted gestures and conversation analysis of the videos recorded. The aim of our observation study was to understand how a new technology will affect collective interactions in the OR. Moreover, we concluded our study with a debriefing with the surgical team with the presence of a psychologist to understand further the coordination process and new communication patterns in the OR. We conducted the debriefing after a surgical procedure. It lasted for an hour and half with the presence of all team members. All practitioners were exposed to the video of the surgical procedure recorded thus having an opportunity to understand with practitioners the nature and the difficulty they may encounter during the enactment of new interaction patterns.

This led us to an interpretative approach from the epistemological perspective.

Our empirical findings illustrated the importance of repetition in new technology adoption. Repetition creates pattern of action recognizable by the expert, the primary surgeon in our case, when encountering a critical situation therefore adapting to the situation becomes easier. In our study, even though the surgical act is fully manipulated by the primary surgeon,

he is still away from the actual surgical act by being on the console outside the sterile zone. The new alignment decreased the individual situation awareness of the surgeon. In order to overcome this issue, he needs flow of information that will increase his ontological security that was affected. Thus, collective situation awareness is needed to replace the lack of individual situation awareness. In our study, technology is brought at the center of routines (D'Adderio 2011) and the robotic system was adopted in non-disruptive matter once a week. In this context, novel patterns of action suffer from a lack of recurrence and new forms of communication appear to be not really well performed. In the hospital's context with a clear division of labor, the team leader's actions are critical for maintaining the team stability and psychological safety enabling the adoption of technological artefacts (Edmondson et al, 2001). In our study, during robotic surgery, the primary surgeon is the leading actor in the OR. With the introduction of the robotic system, actions are centralized around him due to new role repartition, modes of communication and human's interactions. This led to a more centralized form of coordination and a new ecology of space reinforcing his position and his responsibility in case of misfit. Moreover, being away from the patient with this new ecology of space, creates a new form of interaction that remain unfamiliar to the teams 's leader and his or her team. Thus the team's leader (here the primary surgeon) can not transfer his own expertise to the rest of the team creating a situation where exploration is observed but not performed efficiently. Learning by trial and error is in fact a normal situation encountered by many organizations (Rerup and Feldman 2011). However,

the professional context observed in hospitals faces with many difficulties impeding to give resources, time for learning and enabling conditions for new patterns of action to be performed smoothly. As a result, a new sort of provisional coordination is maintained without creating possibility for potential routinization. Thus, new forms of procedural knowledge for implementing reliable interactions enabling emergent patterns of actions to be performed smoothly are lacking and patterns remain provisional ones (Lazaric and Denis 2005). Finally, another methodological question emerges from our ethnographic study: the place of researcher who is using video- recording. For instance, we may ask to what extent our observations is interfering (or not) on reality and on patterns of action that can be different with the absence of this recording. This issue was well debated by psychologists from the ethics point of view (Leroy et al., 2012, Bobiler-Chamon and Clark 2008). Psychologist scholars tried to use debriefing (Hamed et al., 2007) with the observed team as a method to avoid any ambiguity and have assurance about the data. In our study we explored a debriefing with the surgical team in order to understand further some of the actor's human and technology interactions. This issue was not really embraced by organizational scholars and deserves greater attention in ethnography for future research in this field.

From theoretical perspective, our qualitative study enabled us to enrich the naturalistic theoretical approach on expert's decision making processes when the role of this latter as a team leader is affected. It enabled us also to understand the the difference between individual expertise and new routines adoption. Furthermore, to contribute to routine's literature on how

a technological artefact creates provisional routines when new ecologies of space are encountered. From the managerial perspective, we were able to give recommendations for organizations that are dealing with the same technological adoption situation. We illustrated the impact that has a new technological artefact adopted on individual and team work hence affecting the whole organization. The OR is a sample representation of a managerial system where a manager is leading his team. We demonstrated that a technology can have a negative influence on the coordination aspects of the team. We are going through an era of digitalization. Even though robotic surgery is not automated and assisted, it gives us a small overview of how healthcare system is going through evolution that will totally remodel the healthcare system especially treatment chain.

This thesis is composed of two parts. First part is dedicated for the theoretical concepts. It has three chapters each one specific to a literature overview. Chapter one presents a summary of the literature on the naturalistic approach , research studies on expertise and decision processes. Chapter two presents a theoretical perspective on organizational routines and changing routines while dealing with a new artefact. It introduces the notions of time and repetition to explain the formation of a new 'ecology of space'. Last chapter in this part consists of an overview of the medical context with a brief presentation of scholar's work in this area on new technologies, specifically robotic surgery.

In part two, the research methodology applied in this study and the empirical findings are discussed. It starts with the presentation of the

underlying research philosophy in terms of ontology, epistemology and methodology. This is followed by a presentation of how the model used is executed and methods of analysis afterwards. It presents the context in which we gathered our empirical data and conducted the ethnographical observation.

Chapter 5 illustrates details on the empirical findings of our research. It provided first the data collected, analyzed with the findings.

Chapter 6 is our discussion chapter. Our research findings were discussed through cross-validation with the literature, interpreting the possible reasons for the results and the implication of this later.

Our general conclusion reviews our research process and research findings. The research question is answered clearly. Moreover, the theoretical and managerial implications are presented. We end our conclusion with the strengths and limitations of our study and recommendations for future research.

Summary / Résumé (Français)

Cette thèse s'intéresse aux effets des technologies d'assistance robotique sur l'expertise individuelle et collective des médecins dans un bloc opératoire de chirurgie gastrique. Notre recherche est fondée sur l'analyse de l'émergence des routines organisationnelles et de leur mise en évidence en mobilisant l'approche naturaliste de la décision

L'adoption d'une nouvelle technologie présente un exemple d'incertitude qui exigent une coordination plus renforcée entre les membres d'une équipe « effective teaming » (Edmondson, 2001 ; Edmondson and Zuzul, 2016). La mise en œuvre d'une nouvelle technologie perturbe les rôles respectifs de chaque membre de l'équipe (Black et al, 2004). Par conséquent, la création de nouveaux modèles d'interaction est nécessaire. L'impact est à la fois cognitif (expertise individuelle) et collectif (interaction et coordination). D'autre part, l'adoption d'une nouvelle technologie a un effet direct sur le comportement d'un expert. Plusieurs études ont déjà démontré l'évolution des comportements des acteurs lors de l'adoption d'une nouvelle technologie. Les recherches naturalistes ont illustré comment les individus expérimentés qui travaillent dans des environnements très dynamiques et incertains prennent des décisions. Le terme "prise de décision naturaliste" est apparu en 1989. Les recherches utilisant cette approche se concentrent sur les décisions prises par des experts dans leur milieu de travail et non pas lors des simulations dans des laboratoires (Lebraty, Pastorelli-Nègre, 2004). En se basant sur plusieurs recherches d'action, un modèle de décision intuitive a été élaboré

et appelé "Recognized-primed decision model" (RDP) (Lebraty, 2007, p.34). Cette approche décrit comment un expert prend des décisions en tenant compte des paramètres opérationnels. La RPD comporte trois cas possibles de prise de décision en fonction de la familiarité de chaque situation. Selon les naturalistes, il existe une évaluation pour résoudre un problème particulier. Dans cette littérature, nous trouvons un manque d'information sur la façon dont un artefact technologique impact le modèle de reconnaissance d'une situation.

Par ailleurs, de plus des compétences techniques médicales requises et des compétences cognitives personnelles énoncées, l'expertise médicale inclut aussi les compétences interpersonnelles. Ces dernières permettent au chirurgien d'interagir avec les autres membres de l'équipe dans le bloc opératoire. Ces modèles d'interaction sont routinisés au sein du bloc. Face à un changement, ces interactions sont affectées. Par conséquent, lorsque nous adoptons une nouvelle technologie dans une organisation nous prenons en considération l'impact de ces nouveaux modèles d'interaction entre les membres de l'équipe qui vont donc perturber leurs anciennes routines. Le concept des routines se positionne au centre de l'évolution et du changement de l'organisation. Une routine est définie comme un modèle reconnaissable répétitif d'action interdépendantes, réalisées par de multiples acteurs (Feldman and Pentland, 2003 :93). Dans cette direction, les chercheurs ont souligné l'importance des actions (sociales) et des artefacts (matériels) qui produisent une routine où l'expertise et les connaissances sont nécessaires (Jarzabkowski et al., 2016 : 118). Les artefacts sont des médiateurs de la cognition et de

l'activité humaines et sont l'interface entre les visions ostensives des routines et leur performance. Les artefacts matériels s'impliquent dans le modèle d'action individuel et collectif. Dans ce contexte, notre intérêt principal est d'illustrer l'effet d'un artefact technologique sur le processus décisionnel individuel d'un expert et sur le travail collectif lorsqu'il s'agit de nouvelles écologies de l'espace, créant ainsi de nouveaux modèles d'interaction. Afin d'atteindre cet objectif, notre étude de cas porte sur l'adoption de la robotique dans la chirurgie gastrique. Dans notre étude nous avons recueilli des données ethnographiques après avoir interrogé des experts, des chirurgiens opérant avec cet artefact technologique. En outre, nous avons démontré comment les modèles actuels d'interaction favorisent notamment le partage et le transfert d'expertise. Ainsi, nous avons pu documenter diverses dimensions de l'apprentissage de la nouvelle « écologie de l'espace » (Bucher et Langley, 2016), nouveaux modes d'action individuels et nouvelles interactions entre les membres de l'équipe. Pour être plus précis, nous nous sommes concentrés sur la façon dont les experts prennent des décisions avec un nouvel alignement spatial de l'équipe. De plus, comment l'équipe crée des modèles d'action provisoire et une nouvelle écologie de l'espace pour soutenir la mise en œuvre de l'artefact technologique. Nous répondons aux questions suivantes : quelles sont les implications d'un artefact technologique sur le processus décisionnel ? Quelles sont les implications de cet artefact sur les membres de l'équipe : leurs rôles respectifs, la communication et les nouvelles formes de coordination ? Et pourquoi certains modèles

émergents peuvent rester à un stade exploratoire et d'autres peuvent être plus enclins à être effectivement effectuée au sein d'une organisation ?

Le cœur de notre recherche est une étude ethnographique que nous avons effectuée à l'Hôpital de Nice. Nous avons mené des observations de soixante heures de chirurgies robotique suivi par les observations de chirurgies laparoscopiques. Notre méthodologie consiste en un processus en quatre étapes : (a) entretiens avec des chirurgiens en utilisant la (b) observations non participantes au bloc opératoire(c) analyse des chirurgies vidéo enregistrées (d) débriefings et auto-confrontations avec les chirurgies vidéo enregistrées.

Nos résultats mènent à des contributions du point de vue managérial, théorique et méthodologique.

Du point de vue théorique, nous avons trois contributions. Tout d'abord, l'importance de la sensibilisation de la situation. La situation individuelle (Endsley 2016), l'évaluation du sens de la situation d'un expert dans le processus décisionnel, en particulier lors de l'adoption d'une nouvelle technologie est démontrée dans notre étude. Le manque de conscience de la situation et l'évaluation de la situation diminuent la confiance des experts, ce qui affecte leur réintégration. Lorsque le raisonnement est affecté, l'expert ne sera pas en mesure de prendre des décisions pour choisir un plan d'action efficace adapté à la situation rencontrée.

L'approche naturaliste est basée sur la recherche de ressources non limitées afin de permettre aux experts de prendre une décision appropriée. Dans notre cas, le manque de conscience de la situation a diminué la confiance des experts. Ceci est dû à la pression temporelle et à l'attention

limitée lors de l'utilisation du nouvel artefact technologique.

Deuxièmement, l'importance du rôle du chef d'équipe dans la mise en oeuvre d'une nouvelle technologie au sein de l'équipe (Edmondson 2001, 2004). Du point de vue naturaliste (Klein 2001), nous attribuons un rôle important à l'expert lors du processus décisionnel. L'aspect individuel est pris en considération et non pas l'aspect collectif.

Nous avons démontré le rôle du chef d'équipe / expert sur le processus décisionnel en équipe. Lorsque l'expertise individuelle est perturbée par le nouvel artefact technologique, l'expertise collective sera affectée, de sorte que la création de nouvelles routines performatives durables devient difficile. Lorsque le chef de l'équipe est encore en phase d'essai et d'erreur, il ne peut pas transférer ses connaissances et assurer la sécurité psychologique au reste de l'équipe. Ce dernier élément est essentiel dans la mise en oeuvre d'une nouvelle technologie (Edmondson 2004).

Troisièmement, la répétition est essentielle pendant l'implémentation des nouvelles technologies. Dans notre étude, la technologie est au centre des routines (D'Adderio 2011). Le système robotique a été adopté de manière non perturbatrice une fois par semaine. Dans ce contexte, de nouveaux modèles d'action souffrent d'un manque de récurrence. Par conséquent, de nouvelles formes de communication semblent ne pas être vraiment bien exécutées. Dans le contexte hospitalier avec une division claire du travail, les actions du chef d'équipe sont essentielles pour maintenir la stabilité de l'équipe et la sécurité psychologique permettant l'adoption des artefacts technologiques (Edmondson et al., 2001).

En outre, être éloigné du patient avec cette nouvelle écologie de l'espace

qui crée une nouvelle forme d'interaction reste inconnue par le chef d'équipe et le reste de l'équipe. Ainsi, le leader de l'équipe (ici le chirurgien principal) ne peut pas transférer son propre expertise au reste de l'équipe en créant une situation où l'exploration est observée mais pas vraiment efficace. L'apprentissage par essais et erreurs est en fait une situation normale rencontrée par de nombreuses organisations (Rerup et Feldman 2011).

Cependant, le contexte professionnel observé dans les hôpitaux fait face à de nombreuses difficultés empêchant de donner des ressources, le temps nécessaire, l'apprentissage et la mise en place harmonieuse des conditions pour que les nouveaux modes d'action se déroulent.

En conséquence, une nouvelle sorte de coordination provisoire est maintenue sans créer de possibilité de routinisation potentielle. Ainsi, il manque de nouvelles formes de connaissances procédurales pour implémenter des interactions fiables qui permettent de réaliser en douceur des modes d'action émergents. En conséquence, les modèles restent provisoires (Lazaric et Denis 2005).

Dans notre étude, lors de la chirurgie robotique, le chirurgien principal est l'acteur principal dans le bloc opératoire. Avec l'introduction du système robotique, les actions sont centralisées autour de lui en raison des nouvelles répartitions des rôles, de modes de communication et d'interactions humaines. Cela a conduit à une forme de coordination plus centralisée et à une nouvelle écologie de l'espace renforçant sa position et sa responsabilité en cas d'inadéquation.

D'un point de vue méthodologique, d'abord l'utilisation de l'analyse vidéo

combinée avec d'autres méthodes est rarement utilisée en sciences de gestion. L'analyse vidéo détaillée basée sur l'analyse de la conversation et des gestes est généralement utilisée en psychologie (Hostetter 2011, Krauss et al 1996). Notre étude est un exemple de l'efficacité de l'utilisation de cette technique dans notre domaine et ouvre la voie à une utilisation plus fréquente de la technique, en particulier dans les études ethnographiques. En outre, une question émerge de notre étude ethnographique : le rôle du chercheur qui utilise l'enregistrement vidéo. Par exemple, nos observations interfèrent (ou non) sur la réalité et sur les modèles d'action qui peuvent être différents avec l'absence de cet enregistrement. Cette question a été bien débattue par les psychologies du point de vue de l'éthique (Leroy et al., 2012, Bobiler-Chamon et Clark, 2008).

Deuxièmement, les chercheurs en psychologie ont essayé d'utiliser le debriefing (Hamed et al., 2007) avec l'équipe observée comme méthode pour éviter toute ambiguïté et avoir l'assurance des données. Dans notre étude, nous avons exploré un débriefing auprès de l'équipe chirurgicale afin de mieux comprendre les acteurs et les interactions technologiques.

Ce problème n'a pas été vraiment étudié par les chercheurs de l'organisation et méritent une plus grande attention dans l'ethnographie pour des futures recherches dans ce domaine.

Du point de vue managérial, quand une nouvelle technologie est adoptée par une organisation, cette adoption devrait être sans retour en arrière. Par exemple, les chirurgiens une fois qu'ils adoptent le système robotique, ils devraient l'utiliser de façon continue. Dans notre cas, il n'y a pas eu de

perturbation dans l'adoption. Les organisations sont en évolution technologique continue. La médecine est un domaine prometteur. Les nouvelles technologies sont adoptées dans le diagnostic ainsi que dans les traitements. Les médecins sont formés depuis leurs premières études. L'aide de la simulation et d'autres types de technologies qui les aideront à diagnostiquer ou à traiter un cas spécifique, par exemple les serious games. Tout le milieu médical évolue vers les nouvelles technologies et l'ère de la numérisation. Dans notre recherche, nous avons été intéressés par le traitement plus précisément le système semi-assisté robotique. Ce système robotique a changé les rôles et les interactions au sein du bloc opératoire. La configuration du bloque opératoire change complètement. En raison du manque de répétition, cette nouvelle configuration a affecté l'expertise du chirurgien en termes de perturbation de son processus décisionnel. En outre, les actes chirurgicaux sont centralisés et le chirurgien est isolé du reste de l'équipe. En conséquence, les interactions habituelles entre les membres de l'équipe en fonction de la communication, de l'anticipation de la coordination et de la prédiction de l'action de l'autre ont été perturbées en raison du nouvel arrangement spatial.

Deuxièmement, pour que ce système robotique soit bien adopté, la gestion des ressources de l'équipage devrait être développée. Au cours de notre étude, nous avons eu l'occasion de rencontrer des représentants de l'entreprise qui développe le système robotique que nous observions. Ils imposent une liste de recommandations, y compris des formations, maintenances techniques et autres pour les hôpitaux. De plus, ils étaient

d'accord avec nous sur les erreurs de communication qui peuvent survenir lors de la chirurgie robotique. Du point de vue technique, l'entreprise développe plus de fonctionnalités dans le système robotique. Par exemple, ils intègrent la réalité augmentée pour avoir des informations et des données complètes. Un autre exemple est le développement de sensations de retour tactile. En développant ces deux caractéristiques, la société essaie de compenser la perte de retour tactile et le manque de conscience de la situation en raison de la distance entre la console et le patient. L'objectif est de créer une sécurité psychologique pour le chirurgien. Pourtant, nous avons constaté qu'il est important de minimiser la distance entre la console et les bras du robot. Cela va créer plus de sécurité pour le chirurgien. La société a soutenu que la formation cible la manipulation technique du système robotique pour tous les membres de l'équipe. Les formations qui guident les nouveaux modèles de communication et de coordination manquaient.

Troisièmement, cette étude déclenche les idées pour d'autres études sur le terrain. L'un d'eux est le risque, les erreurs et la sécurité

INTRODUCTION GENERALE (*Français*)

Le 7 Septembre 2001, la première chirurgie transatlantique a eu lieu. Elle est connue par « l'opération Lindbergh ». Le médecin qui a opéré était présent à New York tant dis ce que le patient était à Strasbourg sous la présence de deux autres chirurgiens.

Cette intervention chirurgicale a marqué l'histoire de la chirurgie. Elle était le résultat de longues années de recherche sur la robotique et la chirurgie assistée par ordinateur.

Plusieurs débats ont eu lieu sur l'efficacité et l'efficience de cette technique sur le chirurgien, l'équipe chirurgicale et sur l'hôpital. L'équipe chirurgical au seins du bloc opératoire a dû développer des nouvelles compétences non seulement technique mais aussi cognitives et interpersonnels afin de pouvoir s'adapter au nouvel artefact technologique. Cet exemple montre les défis auxquels les organisations et les praticiens doivent faire face pour maintenir leur stabilité dans un environnement incertain (Edmondson 2001). L'adoption d'une nouvelle technologie présente un exemple d'incertitude qui exigent une coordination plus renforcée entre les membres de l'équipe « effective teaming » (Edmondson, 2001 ; Edmondson and Zuzul, 2016). La mise en œuvre d'une nouvelle technologie perturbe les rôles respectifs de chaque membre de l'équipe (Black et al, 2004). Par conséquent, la création de nouveaux modèles d'interaction est nécessaire. L'impact est à la fois cognitif (expertise individuelle) et collectif (interaction et coordination). L'adoption d'une nouvelle technologie a un effet direct sur le

comportement d'un expert. Plusieurs études ont déjà démontré l'évolution des comportements lors de l'adoption d'une nouvelle technologie. Pour commencer, nous définissons un "expert" comme un individu ayant des connaissances dans un domaine précis. Par conséquent, l'expertise est un degré de connaissances et de capacités dans un domaine spécifique basé sur l'intensité et la qualité des expériences passées (Salas, 2010). De plus, ça consiste à avoir un haut niveau de performance en utilisant des images opérationnelles déformées (Pastorelli, 2009). L'approche naturaliste a été intéressée par le processus décisionnel de l'expert face à une situation critique (Klein 2001). Les recherches naturalistes ont illustré comment les individus expérimentés qui travaillent dans des environnements très dynamiques et incertains prennent des décisions. Le terme "prise de décision naturaliste" est apparu en 1989. Les recherches utilisant cette approche se concentrent sur les décisions prises par des experts dans leur milieu de travail et non pas lors des simulations dans des laboratoires (Lebraty, Pastorelli-Nègre, 2004). En se basant sur plusieurs recherches d'action, un modèle de décision intuitive a été élaboré et appelé "Recognized-primed decision model" (RDP) (Lebraty, 2007, p.34). Cette approche décrit comment un expert prend des décisions en tenant compte des paramètres opérationnels. La RPD comporte trois cas possibles de prise de décision en fonction de la familiarité de chaque situation. Selon les naturalistes, il existe une évaluation pour résoudre un problème particulier. Dans cette littérature, nous trouvons un manque sur la façon dont un artefact technologique impacte le modèle de reconnaissance d'une situation.

Par ailleurs, en plus des compétences techniques médicales requises et des compétences cognitives personnelles énoncées, l'expertise médicale inclut aussi les compétences interpersonnelles. Ces dernières permettent au chirurgien d'interagir avec les autres membres de l'équipe dans le bloc opératoire. Ces modèles d'interaction sont routinisés au sein du bloc. Face à un changement, ces interactions sont affectées. Par conséquent, lorsque nous adoptons une nouvelle technologie dans une organisation nous prenons en considération l'impact de ces nouveaux modèles d'interaction entre les membres de l'équipe qui vont donc perturber leurs anciennes routines. Le concept des routines se positionne au centre de l'évolution et du changement de l'organisation. Une routine est définie comme un modèle reconnaissable répétitif d'action interdépendantes, réalisées par de multiples acteurs (Feldman and Pentland, 2003 :93). Dans cette direction, les chercheurs ont souligné l'importance des actions (sociales) et des artefacts (matériels) qui produisent une routine où l'expertise et les connaissances sont nécessaires (Jarzabkowski et al., 2016 : 118). Les artefacts sont des médiateurs de la cognition et de l'activité humaines et sont l'interface entre les visions ostensives des routines et leur performance. Les artefacts matériels s'impliquent dans le modèle d'action individuel et collectif. Dans ce contexte, notre intérêt principal est d'illustrer l'effet d'un artefact technologique sur le processus décisionnel individuel d'un expert et sur le travail collectif lorsqu'il s'agit de nouvelles écologies de l'espace, créant ainsi de nouveaux modèles d'interaction. Afin d'atteindre cet objectif, notre étude de cas porte sur l'adoption de la robotique dans la chirurgie gastrique. Le milieu médicale

est un domaine prometteur pour l'observation de l'évolution des schémas d'action lors de la mise en œuvre d'un nouvel artefact technologique (Edmondson et al., 2001, 2004; Bucher and Langley 2016; Compagni et al., 2015; Pisano et al., 2001 and others).

Ce secteur est en développement continu depuis trois décennies. La chirurgie présente un aspect de l'évolution de la chaîne de soins. Elle a été marquée par trois événements principaux : l'évolution de la chirurgie ouverte conventionnelle à la chirurgie mini-invasive (laparoscopie) et de ce dernier à la chirurgie robotique. Dans les années 80, un grand changement a eu lieu dans les procédures chirurgicales avec l'introduction de la chirurgie mini-invasive (MIS). À partir de 1990, MIS a commencé à se développer et par conséquent le concept de la chirurgie ouverte a commencé à disparaître. Le concept MIS consiste à faire de petites incisions à travers lesquelles le chirurgien peut opérer en utilisant des instruments laparoscopiques et des caméras. Cette technique est appelée laparoscopie. Les principaux objectifs de la laparoscopie consistent à réduire la douleur du patient et le temps de récupération post-opératoire, principalement en raison du traumatisme causé par les grandes incisions (G.Gruthart, J. Salisbury, 2000). Le degré de liberté du mouvement des instruments par la main du chirurgien est limité. Les images 2D limitées fournies ont été considérées comme des défis techniques auxquels les chirurgiens sont confrontés. Afin de surmonter ces difficultés, les chercheurs ont commencé à chercher un moyen d'évoluer MIS et les difficultés rencontrées par la laparoscopie. En conséquence, la chirurgie robotique a été développée. La chirurgie robotisée est un type de MIS qui

s'est développé rapidement dans la dernière décennie depuis son introduction. Le robot Da Vinci est l'un de ces systèmes robotiques chirurgicaux développés pour améliorer la laparoscopie conventionnelle. Le système était FDA (alimentation et administration de drogue) approuvé en l'an 2000. Depuis, l'utilisation de ce type de systèmes a commencé à se développer au reste du monde. Il y a eu une augmentation remarquable de l'adoption du robot Da Vinci par les hôpitaux. Le robot Da Vinci se compose des bras robotiques et de la console. Dans la chirurgie robotique, les instruments retenus par les bras robotiques sont insérés dans le corps du patient et manipulés par le chirurgien. Ce dernier est assis à la console située dans le bloc opératoire à l'extérieur du champ stérile. Le système est conçu de manière à reproduire les mouvements du chirurgien (Abrishami et al.2014). Edmondson (2001), a illustré le changement des routines au bloc opératoire lors du passage de la chirurgie ouverte conventionnelle à MIS. Notre étude est en continuité de ces études.

Depuis son introduction, le système robotique fait face à des débats controversés sur la nécessité de son adoption. La faisabilité des systèmes robotiques dans différents types de chirurgies du point de vue technique et médical a été étudié. Un exemple est celui de l'étude de comparative sur la chirurgie mini-invasive et la robotique pour une résection rectale du cancer (I. Popescu et al 2010). Par ailleurs, la majorité des études médicales ont porté sur la performance du chirurgien de la console du point de vue technique. D'autres ont pris en considération le rôle important

du chirurgien assistant dans ce type de chirurgie (O. Sgarbura, C. Vasilescu 2009).

Cependant, ce n'est que récemment que des spécialistes d'autres disciplines ont commencé à s'intéresser à la chirurgie robotique. Peu d'études ont ciblé l'effet de cette chirurgie du point de vue organisationnel. Une étude récente en sciences cognitives a illustré l'impact de la chirurgie robotique sur le travail d'équipe spécifiquement sur la communication et la prise de décision dans le bloc opératoire (R. Randell et al, 2016).

Par ailleurs, les chercheurs en sciences de gestion s'intéressaient à la chirurgie robotique. Ravasi (2015) a étudié le positionnement social et la reproduction des compétences dans la diffusion de la chirurgie robotique dans les hôpitaux. Il a répondu à des questions plus générales sur la façon dont la mise en œuvre rapide influence les adoptions tardives de la technologie. Les recherches en gestion et en étude organisationnelle étaient particulièrement intéressées à étudier l'effet de l'adoption d'un artefact technologique sur l'expertise et sur les routines organisationnelles.

Dans notre étude nous avons recueilli des données ethnographiques après avoir interrogé des experts, des chirurgiens opérant avec un artefact. En outre, nous avons démontré comment les modèles actuels d'interaction favorisent notamment le partage et le transfert d'expertise. Ainsi, nous avons pu documenter diverses dimensions de l'apprentissage de la nouvelle « écologie de l'espace» (Bucher et Langley, 2016), nouveaux modes d'action individuels et nouvelles interactions entre les membres de l'équipe. Pour être plus précis, nous nous sommes concentrés sur la façon dont les experts prennent des décisions avec un

nouvel alignement spatial de l'équipe. De plus, comment l'équipe crée des modèles d'action provisoire et une nouvelle écologie de l'espace pour soutenir la mise en œuvre de l'artefact technologique.

Nous répondons aux questions suivantes : quelles sont les implications d'un artefact technologique sur le processus décisionnel ? Quelles sont les implications de cet artefact sur les membres de l'équipe : leurs rôles respectifs, la communication et les nouvelles formes de coordination ? Et pourquoi certains modèles émergents peuvent rester à un stade exploratoire et d'autres peuvent être plus enclins à être effectivement effectuée au sein d'une organisation ?

En résumé, notre intérêt est de trouver l'impact de cette chirurgie robotique du point de vue individuel et collectif. Plus précisément, nous cherchons à découvrir comment ce système robotisé affecte l'expert (le chirurgien principale) et son processus décisionnel du point de vue non technique. Notre objectif est de comprendre comment le robot Da Vinci va changer les interactions dans le bloc opératoire donc son impact sur les routines de l'équipe chirurgicale. Afin de répondre aux questions énoncées ci-dessus, nous avons effectué une étude qualitative à partir de l'approche interprétative. Avant notre observation ethnographique, nous avons effectué une étude avec vingt entrevues semi-structurées avec des chirurgiens de différentes spécialités. Les entrevues ont eu lieu 3 ans auparavant, décembre 2013. La durée de chaque entrevue était de 2 heures. Le but de cette approche était de générer des points de vue des praticiens sur leur interactions avec le système robotique et avec les autres membres de l'équipe. Nous avons suivi l'approche naturaliste

précisément la méthode de décision critique pour construire le contexte de notre questionnaire. Le but de cette approche est de susciter chez les praticiens un aperçu de leur expertise, de leur processus décisionnel face à une situation critique et de leur interaction avec une nouvelle technologie comme la chirurgie robotisée (Hoffman, Klein, 2001). Les résultats de nos questionnaires ont été utiles plus tard dans notre processus d'observation : nous avons concentré notre observation sur les thèmes issus de nos questionnaires. Le cœur de notre recherche est une étude ethnographique que nous avons effectuée à l'Hôpital de Nice. Notre cadre empirique est une routine chirurgicale à l'Hôpital de Nice. Nous avons observé soixante heures de chirurgie gastrique réalisées avec le système robotique et nous les avons comparées à quinze heures de chirurgie gastrique laparoscopique pendant trois ans à partir de mai 2013. L'hôpital est intéressé par l'adoption de nouvelles technologies pour maintenir une certaine image compétitive. L'évolution de la chirurgie est l'un de ces points d'intérêt. La chirurgie robotique a été introduite à l'hôpital 5 ans auparavant. Le système robotique est utilisé principalement de façon régulière à l'hôpital en urologie alors qu'il est utilisé occasionnellement chaque mercredi dans le pôle digestif. Les chirurgies observées ont été enregistrées pour une analyse plus détaillée. En plus de l'analyse d'observation sur le terrain, nous transcrivons et menons analyses gestuelles et de conversation des vidéos enregistrées. Le but de notre observation était de comprendre comment une nouvelle technologie va affecter les interactions collectives dans le bloc opératoire. De plus, nous avons conclu notre étude avec un debriefing avec l'équipe

chirurgicale avec la présence d'un psychologue pour comprendre davantage le processus de coordination, d'interaction et de communication dans le bloc opératoire. Le débriefing a eu lieu après une intervention chirurgicale et a duré une heure et demie sous la présence de tous les membres de l'équipe. Tous les praticiens ont été confrontés à des extraits de la procédure chirurgicale enregistrée qui nous a permis de comprendre avec les praticiens la nature et les difficultés qu'ils peuvent rencontrer lors de l'adoption de nouveaux modèles d'interaction. Ceci nous a conduit à une approche interprétative du point de vue épistémologique.

Nos résultats empiriques ont illustré l'importance de la répétition durant l'adoption des nouvelles technologies. La répétition crée le modèle d'action reconnaissable par l'expert, le chirurgien principal dans notre cas, par conséquent l'adoption de la situation devient plus facile. Dans notre étude, même si l'acte chirurgical est entièrement manipulé par le chirurgien principal, il est situé loin de l'acte chirurgical sur la console en dehors de la zone stérile. Le nouvel alignement a diminué la conscience de la situation individuelle du chirurgien (individuel situation awareness). Pour surmonter ce problème, il a besoin de flux d'informations qui augmenteront sa sécurité ontologique qui a été affectée. Ainsi, la conscience de la situation collective est nécessaire pour remplacer le manque de conscience de la situation individuelle.

Dans notre étude, la technologie est placée au centre des routines (D'Adderio 2011). Le système robotique a été adopté de manière non perturbatrice une fois par semaine. Dans ce contexte, les nouvelles formes d'action souffrent d'un manque de récurrence et de nouvelles

formes de communication semblent être mal réalisées. Dans le contexte de l'hôpital avec une division claire du travail, les actions du chef d'équipe sont essentielles pour maintenir la stabilité de l'équipe et la sécurité psychologique permettant l'adoption d'artefacts technologiques (Edmondson et al, 2001). Dans notre étude, lors de la chirurgie robotique, le chirurgien est l'acteur principal dans le bloc opératoire. Avec l'introduction du système robotique, les actions sont centralisées autour de lui en raison de la répartition des nouveaux rôles, des modes de communication et des interactions humaines. Cela a conduit à une forme de coordination plus centralisée et à une nouvelle écologie de l'espace renforçant sa position et sa responsabilité en cas d'inadéquation. De plus, en étant loin du patient avec cette nouvelle écologie de l'espace a créé une nouvelle forme d'interaction qui restent inconnues par les membres de l'équipe. Ainsi, le chef de l'équipe (ici le chirurgien principale) ne peut pas transférer son propre savoir-faire au reste de l'équipe en créant une situation où l'exploration est observée mais pas vraiment réalisée. L'apprentissage par essais et erreurs est une situation normale dans de nombreuses organisations (Rerup et Feldman 2011). Cependant, le contexte professionnel observé dans les hôpitaux fait face à de nombreuses difficultés qui empêchent de donner des ressources, du temps pour l'apprentissage et des conditions propices à l'adoption de nouveaux schémas d'action. De ce fait, une nouvelle sorte de coordination provisoire est maintenue sans créer de possibilité de routinisation potentielle. De nouvelles formes de connaissance procédurale pour mettre en œuvre des interactions fiables permettant d'exécuter des schémas

d'actions émergents sont manquantes et les schémas restent provisoires (Lazaric et Denis 2005).

Par ailleurs, une autre question méthodologique ressort de notre étude ethnographique : l'effet des vidéo-enregistrements sur le comportement des individus. Par exemple, nous pouvons nous demander à quel point nos observations interfèrent (ou non) sur la réalité et sur les schémas d'action qui peuvent être différents avec l'absence de cet enregistrement. Cette question a été bien débattue par les psychologues du point de vue de l'éthique (Leroy et al., 2012, Bobiler-Chamon et Clark, 2008). Les psychologues ont essayé d'utiliser le débriefing (Hamed et al., 2007) avec l'équipe observée comme méthode pour éviter toute ambiguïté et avoir une assurance sur les données. Dans notre étude, nous avons exploré un débriefing avec l'équipe chirurgicale afin de mieux comprendre certains des acteurs humains et des interactions technologiques. Cette question n'a pas été vraiment envisagée par les spécialistes de l'organisation et méritent une plus grande attention en ethnographie pour les futures recherches dans ce domaine.

D'un point de vue théorique, notre étude qualitative nous a permis d'enrichir l'approche théorique naturaliste sur les processus décisionnels des experts lorsque le rôle de ce dernier en tant que chef d'équipe est affecté. Il nous a également permis de comprendre l'interaction entre l'expertise individuelle et l'adoption de nouvelles routines. En outre, pour contribuer à la littérature des routines sur la façon dont un artefact technologique crée des routines provisoires lorsque de nouvelles écologies de l'espace ont lieu. Du point de vue managérial, nous avons

été en mesure de formuler des recommandations à l'intention des organisations qui traitent de la même situation d'adoption technologique. Nous avons illustré l'impact de l'adoption du nouvel artefact technologique sur le travail individuel et en équipe, affectant ainsi toute l'organisation. Le bloc opératoire est un exemple de représentation organisationnel où un manager dirige son équipe. Nous avons démontré qu'une technologie peut avoir une influence négative sur les aspects de coordination de l'équipe. Nous traversons une ère de digitalisation. Même si la chirurgie robotisée n'est pas automatisée et assistée, elle nous donne un petit aperçu de la façon dont le système de santé fait face à des changements innovateurs qui va totalement remodeler le système de santé en particulier la chaîne de soins.

Cette thèse est composée de quatre parties. La première partie est consacrée aux concepts théoriques. Il comporte trois chapitres chacun spécifique à un aperçu de la littérature. Le premier chapitre présente un résumé de la littérature sur les études de recherche sur l'approche naturaliste de l'expertise et sur les processus décisionnels. Le chapitre 2 présente une perspective théorique sur les routines organisationnelles qui évoluent face à un nouvel artefact. Il introduit les notions de temps et de répétition pour expliquer la formation d'une nouvelle « écologie de l'espace ». Le dernier chapitre de cette partie consiste à présenter un aperçu du contexte médical avec une brève présentation des recherches dans ce domaine sur les nouvelles technologies, en particulier la chirurgie robotique.

Dans la deuxième partie, la méthodologie de recherche appliquée dans cette étude est discutée. Nous débutons par la présentation de la philosophie de recherche en termes d'ontologie, d'épistémologie et de méthodologie. Ceci est suivi par une présentation de la façon dont le modèle utilisé est exécuté et les méthodes d'analyse. Il présente le contexte dans lequel nous avons recueilli nos données empiriques et effectué l'observation ethnographique.

La troisième partie décrit les résultats empiriques de notre recherche. Nous avons présenté des les données recueillies avec analyses et les résultats.

Nous discutons les résultats de notre recherche dans la quatrième partie. Les résultats de recherche de notre étude ont été discutés à travers de la validation croisée avec la littérature, en interprétant ces résultats et l'implication de ces derniers.

Notre conclusion générale résume notre processus de recherche et nos résultats de recherche. De plus, les implications théoriques et managériales ont été discutées. Nous concluons avec les forces et les limites de notre étude et des recommandations pour la recherche future.

Overview

A. General problematic

Experts and organizational routines when dealing with a new technological artefact are the main interest of this study.

B. Research question

What are the effects of a new technology on expertise? case of robotics in bariatric surgery

C. Research philosophy

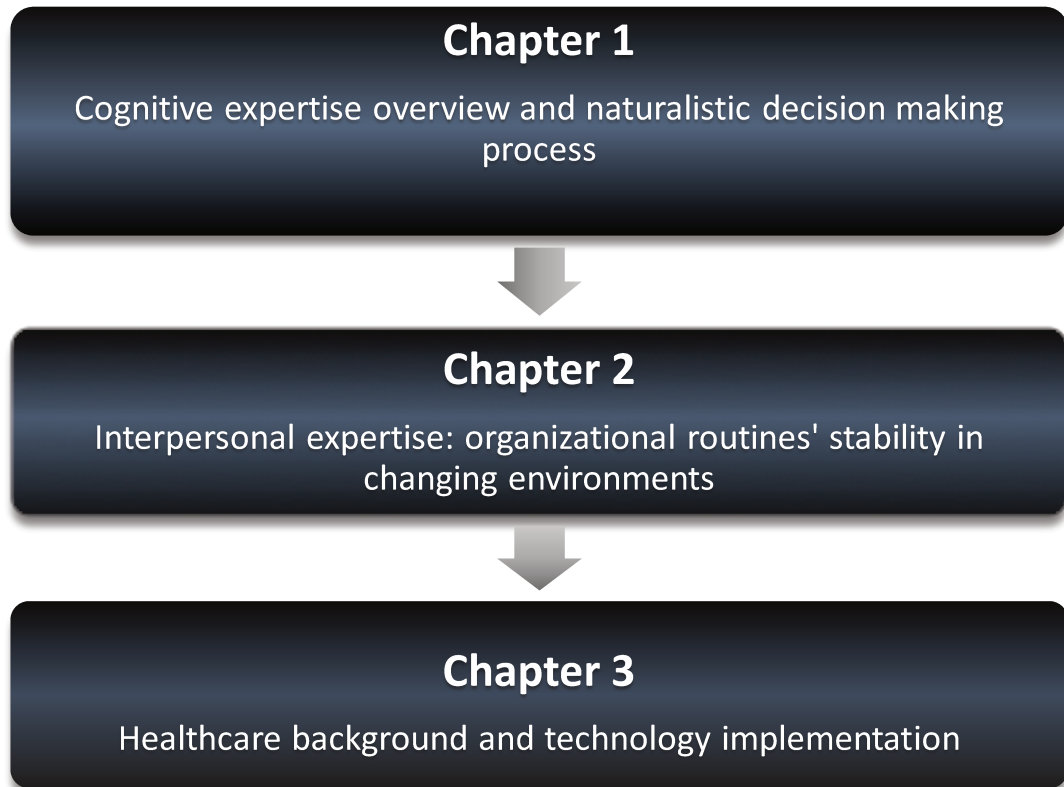
We followed the interpretativist perspective in terms of ontology and epistemology.

D. Research design

Our study is a qualitative research based mainly on a case study. We followed critical decision method analysis in brief for our questionnaire and the heart of our study is an ethnography.

Part I

**Conceptual background of expertise and the relation
between technological artefacts implementation and
organizational routines**



Part I

Overview

The aim of this literature review is to develop the research question by reviewing and analyzing the extant literature in the area of interest. It provides the theoretical foundation for the research, and the basis to operationalize the research variables for the correlational study on the influence of project success factors on success criteria.

This literature starts with a presentation of expertise and expert's definition and the difference between an expert and a novice. This is followed by a presentation of an expert's decision-making process using the naturalistic approach more specifically recognition-primed model. The second part of the literature is routine's part. This latter starts with a presentation of organizational routine followed by the different aspects of a routine that is affected when facing a new artefact. At the end of this part we present the medical context to have an understanding of the field that we are targeting. We present the evolution of surgery and the research studies that already exist related to our topic.

Chapter 1 Cognitive expertise overview and naturalistic decision making process

Chapter introduction

In this chapter we are going to present the different aspects of expertise illustrated in literature. We start general definitions of experts and expertise followed by the scholar's interpretation of expert's action compared to novices one. In the second section of this chapter; we discussed the naturalistic approach on decision making in particular the recognition-primed decision model. Moreover, we introduced the importance of situation assessment and situation awareness in the decision making model. This will help the decision maker assess and have cues of the situation in order to choose the corresponding course of action based on the three level present in the RPD model. We concluded this chapter by a link with the following chapter concerning collective aspect of expertise and organizational routines creation.

1.1 Expertise and experts

1.1.1 Definition

The general recognized meaning of an expert is a person with knowledge and skills in a specific domain. We refer to those skills as expertise.

Expert performance is different than novice's one. The routine function is one of the differences. Doctors' handwriting is one example: it is less comprehensive than other health professionals (Lyons, Payne, McCabe, 1998). In this literature we look into numerous perspectives from psychology on the concept of expertise and expert.

Since ages ago, the fact of having superior knowledge intrigued researchers and psychologist. The knowledge of experts each in his domain was acknowledged since the Greek civilization. Socrate said: *I observe that when a decision has to be taken at the state assembly about some matter of building, they send for the builders to give their advice about the buildings, and when it concerns shipbuilding they send for the shipwrights, and similarly in every case where they are dealing with a subject which they think can be learned and taught. But if anyone else tries to give advice, whom they don't regard as an expert, no matter how handsome or wealthy or wellborn he is, they still will have none of him, but jeer at him and create an uproar, until either the would-be speaker is shouted down and gives up of his own accord, or else the police drag him away or put him out on the order of the presidents (Plato, 1991, pp. 11-12).*

In the middle ages, craftsmen passed their specific knowledge to their students after having monopoly or providing specific types of services

(Epstein 1991). The students or apprentices started at age of 14 for 7 years to study with their masters. The length of the studies depends actually on different aspects as the age and experience of the apprentice. In this way an apprentice is given a letter of recommendation to actually work with other craftsmen. The concept of master- student was reinforced in the 12th and 13th century. The goal of universities back then was to explain an accumulate knowledge from the masters that were organizing them. It is not anymore necessary that a person discover the relevant knowledge by himself.

The concept of expertise nowadays differs from the concept in the middle age. For example, in the 13th century it was impossible to become an expert in mathematics by self-studying in less than 30 to 40 years (singer 1958). Today mathematics and calculus are taught in schools and universities in accessible forms. If the way experts organize their knowledge is discovered, it will be easier to improve the efficiency of their performance. Testing expert's capabilities: measuring intelligence, memory and speed of interaction, started in the 20th century. According to Galton, there is no higher knowledge in general. The superiority the experts have is limited to a particular domain. This hypothesis is also presented by Ericson and Lechman (1996).

Couple of approaches focused on the experts' knowledge (organization of the knowledge and content) (Chi, Fetovich & Glaser 1981; Chi, Glaser, & Rees 1982). Furthermore, it focused on the different methods that enable to build computer-based models based on the expert's knowledge in order to improve their performance.

According to the Michelene T.H. Chi, the nature of expertise is studied in two different ways: (1) first way is based on observation and analysis in order to understand how the experts perform in their domain. (2) The second way consists of comparing the experts' actions to the novices' ones.

(1) By observing how experts perform: "one could choose an expert that have well established discoveries or choose scientists whose breakthroughs may still be debatable" (Michelene T.H. Chi) some assumptions consider experts as having exceptional innate capabilities (Simon, 1977).

(2) The second approach is based on comparison and relativity. The person with more knowledge is considered the expert. The other one is the novice. "Experts are defined as relative to novices on a continuum" (Michelene T.H. Chi)

Based on the general definition of an expert, "a person more knowledgeable in certain domain" (Ericsson & Smith 1991), using this second approach helps more to understand the difference between an expert and a novice. The aim is to transfer the knowledge to the novice.

Different approaches to accounting outstanding performance.

Attribution	Construct	Research approach
<i>Primarily inherited</i>	Intelligence,	Correlation with
General abilities	personality	personality profile,
Specific abilities	E.g, music ability,	general intelligence
<i>Primarily acquired</i>	artistic ability, body	Correlation with
General learning and	build	measures of specific
experience	General knowledge	ability
Domain-specific	and cognitive	Investigation of
training and practice	strategies	common processing
	Domain- or task-	strategies
	specific knowledge	Analysis of task
		performane, i.e, the
		expertise approach

Table 1.1: Ericson K. and Smith J. (1991), Towards general theory of expertise: prospects and limits.

1.1.2 Experts and errors

According to Michelene (2006), Experts doesn't only excel but also fail.

They usually have the best performance, thus provide the best outcome, solution or result than non-experts. They also have more abilities than novices: they detect features, situations or problems that a novice cannot detect. In addition to that, experts with their qualitative analytical skills choose more appropriately their strategy. Moreover, experts are more

opportunistic than novices. They use all the information that they have to solve a specific problem (Gilhooey et al., 1997). However, experts do not excel in everything (Sternberg 1996). Their knowledge is mainly tacit. A novice will have the same problem to explicit the knowledge once he is on the same level than an expert. One characteristics of expertise is the way experts interact in their working environment. Naturalistic research focus on the way experts deal with dynamic and uncertain situations in their working environments. Gary Klein revealed an analysis model as a synthesis of his work called Recognition-Primed Decision model. This model describes how experts take decisions while taking into consideration operational parameters.

1.1.3 Operative vs. cognitive images

An expert identifies a situation that his knowledge allows him to treat. Expertise consists of attaining a high level of performance using deformed subjective "operative images" instead of precise neutral, "cognitive images" (Pastorelli 2009). Those operative images are perceived for a specific situation using the knowledge and the know how of the expert. While reproducing the images, the expert chooses wisely the information that he considers important and neglect the others: the images reproduced are partial, subjective and deformed. This is the reason the experts base their reasoning on mental or operative images. (Ochanine, 1971).

On the contrary, novices use neutral exact and precise “cognitive images” since their know-how is limited. They still didn’t have the opportunity to test their knowledge so they aim perfection in their image representation.

On the other hand, the margin of error is much more important in the reasoning of an expert than a novice. The error is not only by the representation of images (operative images) as mentioned before. Errors also exist during the reasoning. The experts make more errors than the novice. This is due to the fact that a novice when he detects an error, he starts again the whole reasoning in order to rectify those errors. On the contrary, an expert integrates the errors in his course of action while making sure to attain the objective (Pastorelli 2009). Different definitions exist already on expertise. Salas (2010) considers it as a degree of knowledge and abilities in a specific field. Expertise is based on the intensity and quality of past experience. The general definition didn’t differ much. Even in the late 19’s, expertise is considered having a higher amount of knowledge in a certain domain. Minsky and papert (1974):” A very intelligent person might be that way because of specific local features of his knowledge. - Organizing knowledge is the most important characteristic because of global qualities of thinking. In other words, the experts excel in their own domains.

1.1.4 Medicine and expertise:

1.1.4.1 Overview

Expertise in medicine is different than expertise in other fields. It requires mastering a diversity of skills and knowledge, which includes *motors, cognitive and interpersonal skills*. Some areas in medicine require to master specific skills more than others. Surgery is one example. Clinicians are knowledgeable in all domains and might have higher focus in a specific area depending on their specialization.

Expertise in medicine is difficult to measure. We can classify medical practice into two general parts: expertise in diagnosis and expertise in surgery. In surgeries, we can link the success of a surgery to the degree of expertise. Blood loss, death complications etc. are indicators of the surgeon's expertise. (Ericsson 2004; Norcini et al. 2002). Despite that fact, the general definition of medical expertise is still too shallow since most reasoning is not mostly based and measured in surgeries but in all types of medical practices. It is more difficult to measure the competence when no concrete indicators are noticed.

Despite the fact that being accepted at medical school is difficult, it is likely that the majority will graduate. Some researchers assign the word "experts" to graduate physician. Others assign the word only to doctors with years of experience.

We can distinguish two forms of knowledge in medical expertise: A *formal basic* one and the *experiential one*. The formal knowledge in medicine is different than the knowledge in other fields. This domain is in a continuous change. Expertise should be dynamic in order to be up to date with the

development. A practitioner should be informed of a new therapy, new drug (Choudhry and al 2005). To pass to the experiential expertise, couple years of apprenticeship is required before the specialist is able to become an independent practitioner. The process of passing from formal knowledge earned to experiential expertise intrigued lot of researchers. The purpose is to understand better medical expertise.

As mentioned before, we distinguished two main practices in medicine into: diagnosis and surgery. Diagnosis is the most represented in medical expertise's literature.

Diagnosis' expertise was considered a general skill acquired from medical knowledge, which is different than general knowledge. This hypothesis was replaced by new hypothesis that considers expertise as a well-organized knowledge. Nowadays, expertise is considered involved in the coordination of different kinds of knowledge.

1.1.4.2 Medical diagnosis as a general skill

Medical expertise was considered a general skill. Doctors have general strategies and techniques to solve diagnosis problems. These skills can be transmitted to medical students. Studies were conducted to test the diagnosis process and reasoning of both medical experts and students in order to make a comparison and to understand better the difference. Common ground was found in this diagnosis process and similar strategies were used. At the beginning couple of diagnosis hypothesis were encountered. Further researches were done afterwards in order to confirm the hypothesis.

Based on that, the difference between experts and less experienced first year students was not the process of reasoning; it was the accuracy of diagnostic hypothesis. As a result, knowledge of experts is well organized and it enables them to generate more precise hypothesis and test it (Feltovich et al. ,1984; Neufeld et al., 1981). We can say that doctors while gaining experience, they somehow learn how to organize their knowledge and classify it in a way that makes it easier for them to retrieve the information when needed in order to be more precise.

1.1.4.3. Medical expertise and amount of knowledge

In the medical sector, we examined that novices could recall as many information as experts (Muzzin et al. 1983). The best explanation for this is that novices or medical students remember every single detail. It is an adaptive strategy that they use. On the contrary, medical experts synthesize all the details to make it more problem oriented strategy ignoring all the unnecessary details and extraneous details (Norman, 2005; Eva, Norman, Neville, Wood & Book, 2002).

We can conclude that experts have large memory chunks. These memory chunks enable experts to have superior memory that is more efficient: the recognition process is easier since the knowledge is well organized. Superior memory when used by experts reinforces a rapid pattern matching related to experience (Ericson 2005; Simon and Chase 1973).

The focus shifted from the amount of knowledge present to the way knowledge is organized.

1.1.4.4. Medical expertise and organization of knowledge:

Knowledge is organized in various ways. Investigations examined three kinds of knowledge: causal knowledge, analytical knowledge and experiential knowledge (Schmidt, Norman & Boshuizen, 1990, Gruppen & Frohan 2002).

Despite the fact that experts and novices have similar process reasoning, experts show greater diagnostic accuracy than novices. Based on a first study done in this area by Patel and Groan in 1980's, experts and novices were given case studies to analyze and explain. The two parties could use their memories and also science books and references (Patel & Groen 1986). Experts were more selective in the analysis. Less use of basic science and references were used by experts than by medical students rather they focused on reasoning and use of memory. It is called forward reasoning.

Schmidt and Boshuizen (Schmidt and Boshuizen, 1992) investigated why experts don't use science in the clinician's protocols. They ended up with a conclusion that although experts don't use basic science mechanism in their case analysis, they have the information in case they might need it.

All studies that took into account the study of medical expertise agreed on the minimal role of basic science. Despite that the use of basic science is limited, studies showed that the use of it become more present when experts are faced with difficult situations (Norman et al (1994)).

Mechanic basic science is not the only kind of knowledge learned at school.

Although medical students start their learning by the basic science, this learning process is not completed until experiential knowledge through practice is completed for couple of years.

Reasoning of medical students and experts are categorized as “schema induction”, “pattern-recognition” and “hypothetico-deductive” (Coderre, Mandin, Harasym & Fick, 2003).

1.2 Naturalistic approach and Recognition-primed decision model

1.2.1 Naturalistic approach overview

Previous research on classical decision strategies has not yield useful insights for developing better systems for this environment. This section of the literature consists of presenting strategies for expert decision makers when their tasks involve selecting one course of action.

Our study focuses on the impact of a new technology on the individual and collective level in the operating room therefore we are interested by the naturalistic approach in order to understand further the decision making process the surgeon during the surgical procedure. This research take into consideration medical expertise from one hand and on the other hand the strategies used by experts while doing their daily jobs or face a specific critical situation.

This literature review is descriptive. Different descriptions in literature on expertise and experts are presented. In addition to that, the different strategies listed by the literature used for making a decision are presented. Decision making process mainly relies on choosing the best option. We find different options for strategy selection. This selection depends on the situation faced by the expert. According to Svenson (1979), strategies are limited to those that can be rationalized within the prevailing logic of mainstream decision theory and research.

Strategies are considered as procedures during which a person ends up taking a decision. Some of the strategies are based on choosing between

alternatives while trying to make a comparison between different ones that will lead to choose the best alternative. Another type of strategies relies on choosing from the beginning an option without making a comparison.

Observation of the decision making process, revealed that only one option is considered from the beginning rather than different alternatives (Mintzberg 1975).

Moreover, the decision making process is not that structured. "It is about muddling through than to do precise evaluation of alternatives". The benefit of a decision aid system remains unclear. Training exists already to help individuals choose the correct strategy. But, the effectiveness of the training is still ambiguous also. There is no concrete evidence that shows its importance.

Eisenberg (1984) considers that managers use decision aids intensively. Even though sometimes the decision prescribed by the decision aids is different than the decision maker's intuition, the intuition is considered the winner. Making the appropriate decision is not that simple. Sometimes the decision makers hire analysts to do the decision for them. According to (Beach 1990), the process and the effort put together to make a final decision helps more than the decision strategy itself.

Naturalistic decision researches may offer an interesting method or perspective. The level of expertise defines what decision or course of action to take in a critical situation.

Expertise plays an important role in the situation assessment, which is the most critical part of the decision-making process. The use of the term naturalistic refers to the way experts take decisions in their work

environments (Lebraty, Pastorelli-Nègre, 2004) highly dynamic and under uncertainty. According to the naturalistic approach, an individual evaluates the problem that he is facing in order to find the appropriate solution. If the solution proposed does not work, then other solution is selected. Testing experts while taking decisions was particularly the interest of Gary Klein. He conducted couple of field study in order to understand experts' decisions especially when having time pressure. After couple of investigations and field studies, a decision model is elaborated. This latter describes how experts take decisions while taking into consideration operational parameters (Klein, 1999). In this area Klein distinguish three decision cases procedure depending on the situation and the familiarity of the situation. His model describes how the experienced individual take decisions and is not a model that describes how the individual have to act. He distinguishes three cases of possible decisions. Each case is detected by a change of situation.

An individual usually does not admit making a comparison between different available options. (Beach & Lipslitz, Donaldson & Lorsch, 1983; Klein, 1989; Mintzberg 1975, Peters, 1979). Instead, he chooses a specific one then tries to adapt it according to the situation.

Despite the fact that this used method is not based on comparison between different options, it is actually based on a quick assessment. This assessment is based on the experience of the decision maker. The way these experienced decision makers function is structured by the naturalistic decision making models. Those models enable the expert to take the appropriate decision in ambiguous or unexpected situations. Klein

discusses one model of the Naturalistic decision-making process. (Klein, 1989, Calderwood & Clinton-Cirocco, 1986). His model is called recognition-primed decision-making. Klein describes how decision-makers benefit from their past experiences to take an appropriate decision after assessing situations that are not familiar to them. This way they can change their course of action to adapt it to a specific situation. This model is based on a cognitive package (Ross et al., 2006). According to Klein, experts consider themselves usually in familiar situations. They do a pattern matching using their chunk of memory from their past experience to recognize a situation. They find the situation matching with an old one. If the experts didn't find similarities they start looking for new strategies, new ideas in the real time that can be helpful sources for reassessment of the situation in order to take the convenient decision or course of action. An expert project himself in a specific course of action then he modifies it according to the circumstances.

Lots of researches focused on mental simulation. It really helps experts projecting themselves in the course of course. Getty (1983) already took into consideration this assumption. He focused in his research on the important role of mental simulation in order to have like he describes it “a walk-through” the course of action until he figures out the best one to proceed.

1.2.2 Recognition-primed decision (RPD) model of rapid decision-making:

We take into account this specific model in our analysis. The model was formulated around 10 years ago. It is based on mental simulation done to evaluate a course of action. This model is an example of naturalistic approach model and fits the criteria of this latter which are: *“Experienced agents working in complex uncertain conditions who face personal consequences for their actions. In addition to that, the model addresses situation awareness and problem-solving as a part of decision-making process”* (Klein, 1997). This process is associated with four variables: recognition of goal, cues, expectancies and course of action.

Traditional models for the decision-making process are mainly analytical. The majority focuses on comparing different alternatives in order to decide at the end what is the best optimal choice. On the contrary, recognition-primed decision process focus on situation assessment and mental simulation. Experts, as this model describes, does not compare options in order to choose the best one between the alternatives. The goal is to have an acceptable solution through a certain course of action that is evaluated. This model is the result of observation and studies done with some experts. Example: Fire ground commanders insist that they did not have to compare alternatives to choose the optimal option. The commanders do not have time to even think of comparing between options. Instead, they act and react based on their prior experience. *“They were more interested in finding actions that were workable, timely, and cost effective.”* The

commanders were able to discuss about the different alternatives possible when they were asked about it. But, they insist about the fact that they did not use the alternative comparison during the incidence.

The RPD model is represented through three different situations. The first and the simplest one is when the person is facing a familiar situation. In this case he will rely on his prior experience to act. In a more complex situation the expert will use a mental simulation that enables him to be sure of the appropriateness of his course of action. If the assessment shows the opposite, then a different course of action is implemented. RPD model focuses on situation assessment based mainly on prior experience to choose a course of action instead of comparison between options through mental simulation. Experts mainly use this model since it is based primarily on prior experience. Analytical strategies or classical decision-making models are used arguments to justify the decision needed when the decision maker has no time limit. This approach distinguishes three possible cases of decision-making. The first case is the case of simple correspondence where an individual simply is in a familiar situation. Couple of indices are perceived in the environment, in case these indices are related to prior experience then the expert will refer to a course of action taken previously.

Second case of decision-making process is where situation is partially familiar. In this case, not all information perceived in the real world is already stored in memory. The expert in this case pursues a diagnosis of the situation. The objective is to reconsider certain critical indices then to generate a meaning to the particular situation. If the new situation seems

familiar, then a new course of action associated to this new evaluation is available in memory.

Evaluation of the course of action is the third case that can be faced by an expert. This is the case where the situation is not familiar. The objective is to anticipate possible future problems. Mental simulation takes place in order to check if the solution proposed can be applied.

RDP model role is to understand the situation in order to take an appropriate course of action. We can relate this model to the sensemaking and situation awareness theories. In the below section we are going to present the cases of the RPD model.

1.2.2.1 Level 1: Simple match

This first case for a decision to be taken is the case of a familiar situation. In this case the individual recognizes the situation and knows the course of action associated to this situation. Below is a figure that presents the first case of RPD model.

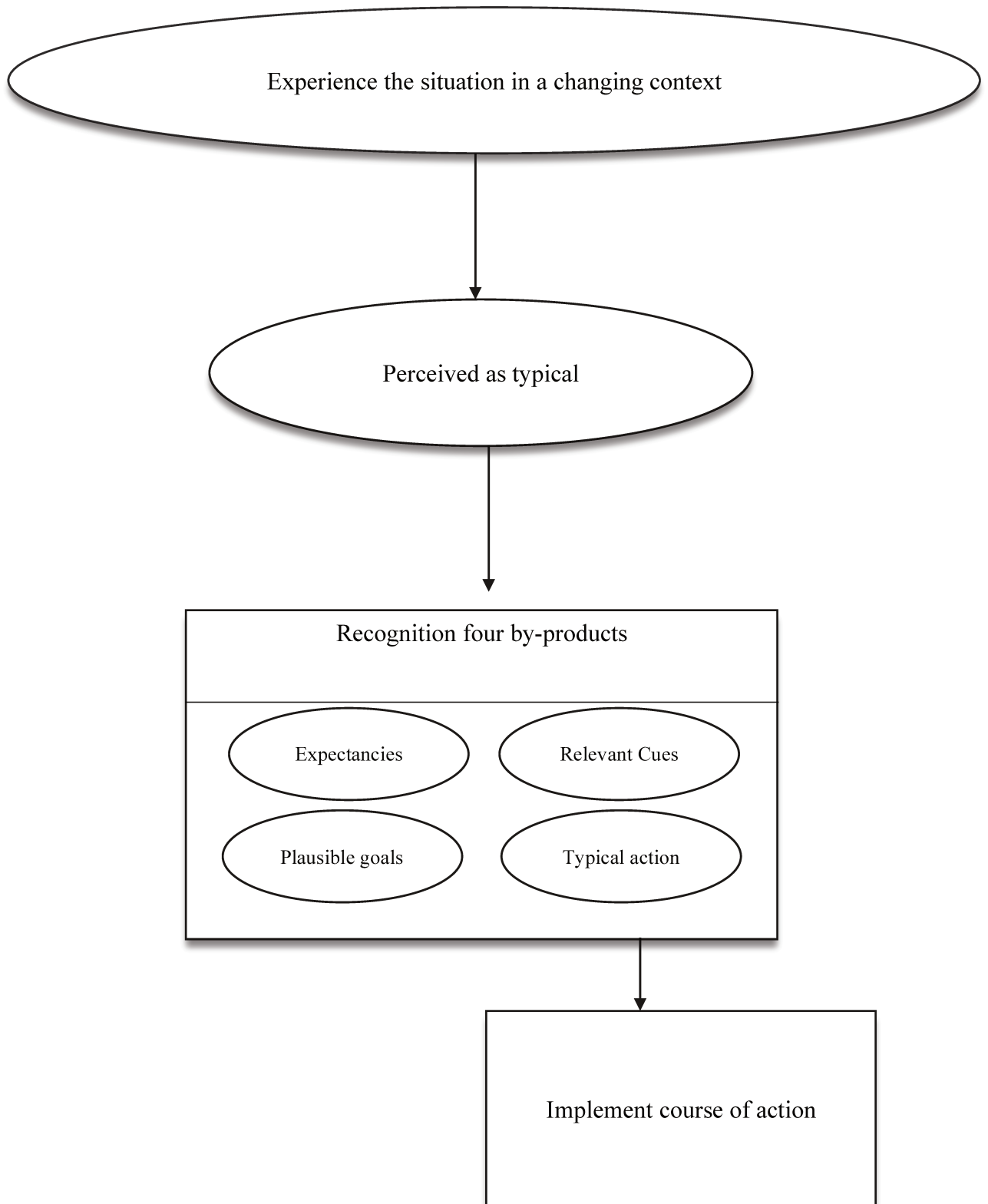


Figure 1.1: Level 1 Recognition-primed model- Simple match (Klein, 1999)

Level 2 Diagnose the situation

Second level is the case when the expert face with a situation a bit familiar. In this case the information does not match what the expert have already in memory. In this case the expert diagnoses the situation. The aim of this diagnosis is to understand what is perceived compared to what is stocked in memory. The expert search for cues in order to organize the information and have a general new overview of the situation. Based on this new organization, the expert will be able to identify is familiar and accordingly choose the course of action. The figure below presents this second level of the RPD model.

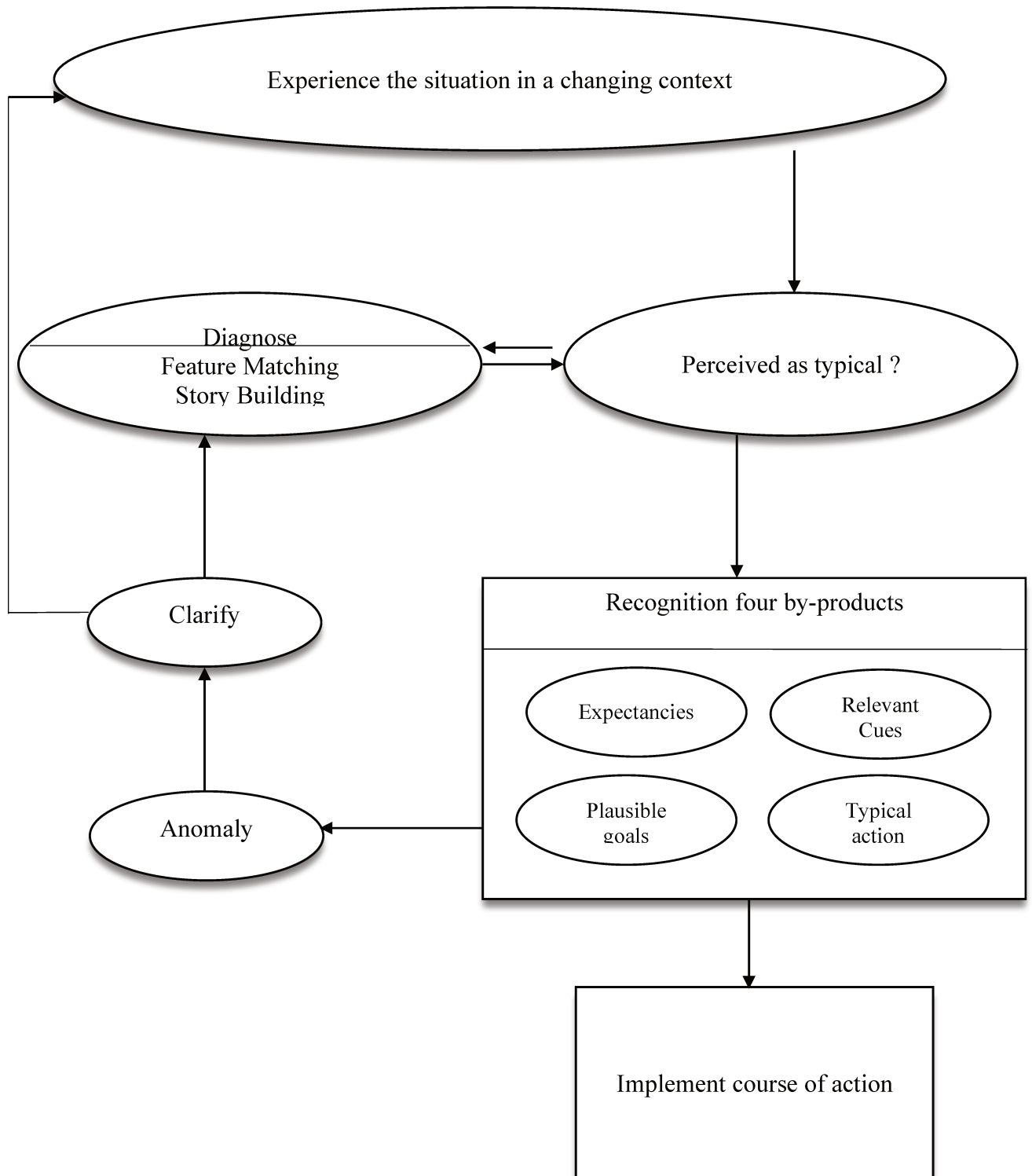


Figure 1.2: Level 2 Recognition-primed model- Diagnose the situation

(Klein, 1999).

Level 3- Evaluate course of action

This level is activated when an expert faces a non-familiar situation. He uses a mental simulation in order to project the course of action. Mental simulation consists of verifying that the course of action or the solution perceived is suitable of the present case. If the individual finds that the solution is adequate, then it will be executed. In the opposite case, if the course of action is not appropriate, the expert will do another mental simulation in order to find to right option. The following figure presents the third case of recognition-primed model.

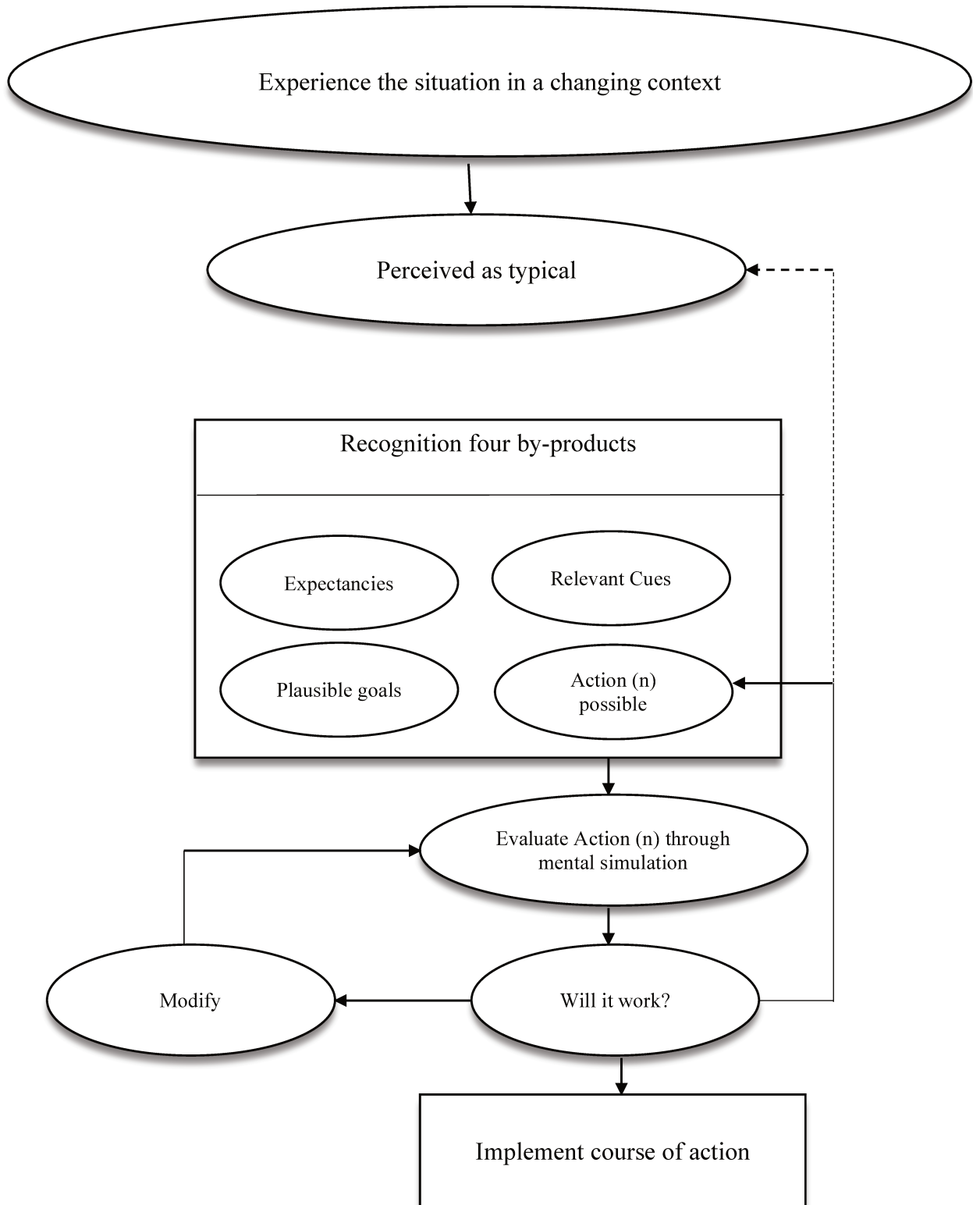


Figure 1.3: Level 3 Recognition-primed model- Evaluate Course of Action (Klein, 1999)

In summary RPD model considers that an experienced decision maker is able to change his course of action while taking into consideration the evolution of the situation. This is done through the comparison of past and present experienced situations. Characteristics of actions are stocked in memory. The decision maker, through mental simulation, is capable of making sure that the solution is efficient otherwise it will be rejected and replaced by another one

When we talk about an expert taking decisions or acting in a given situation, we are taking into account actions happening in real time. Real time situations are characterized by uncertainty. Therefore, it is important for experts to comprehend the situation that they are in. Two concepts in literature enables full understanding of the situation and analyzed this aspect: situation awareness and sensemaking. In the following sections we are going to present these two concepts.

1.2.3 Role of situation awareness in NDM:

As mentioned before, NDM provides a description on how people take decisions in their actual settings. Experts make rapid decisions while recognizing a situation and pattern matching to memory structures (Klein, 1989, 1993). Therefore, situation awareness (SA), an internal conceptualization of the situation is the primary factor in the decision making process (Zsombok & Klein, 1997). Understanding fully a given situation will lead to better decision making. Naturalistic scholars have attributed human error and accident to SA (Endley, 1995 a). Decision makers take decision they perceive correct to a given situation that might be perceived wrong (Zsombok & Klein, 1997). In order to take correct decisions, it is necessary to understand correctly the situation. Thus it is important to understand the construct of situation awareness and the factors that can affect it.

By definition SA is the *“perception of the elements of the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future”* (Endsley, 1988, p.97).

In summary, SA involves going through three levels. *First level* is the perception of the elements in the environment. For example, during a surgical procedure, the surgeon perceives other team members' actions, an alarming sign in the machines or a warning organ malfunction. *Level two* is understanding the significance of the elements perceived in level one, not just being aware of them, and to perceive if they are coherent with one's goal. For instance, in OR, the surgeon should understand the meaning of the signals perceived. The warning signals on the machines

or the malfunctioning of an organ indicate that the patient is not responsive to the surgical procedure or this latter is going wrong. Final and highest level is *the third level* where the decision maker projects future actions. This level is achieved by going through level one and two. The surgeon by perceiving the elements and understanding them will have enough knowledge that will enables him to take the corresponding course of action that meets the objectives of the surgery.

Endsley describes SA under uncertainty and the factors that underlines and conceptualize it (Endsley, 1988, 1990, 1995b). Some of the key features that influence SA are: (1) limited attention and working memory, (2) mental models and schema, (3) pattern matching and critical cues, (4) ties between and automatic action selection, (5) categorization, (6) data-driven and goal driven processing, (7) expectations (8) dynamic goal selection and (9) automaticity (Endsley, 1997).

(1) *Limited attention and working memory.* Lack of SA can be caused by the limited attention given to some elements while ignoring others. This is the case of dynamic systems where new situations are encountered. These systems are characterized by a load of information that exceeds the individual's limited attention. Working memory plays an important role in SA and decision making. Normally in dynamic environment, an individual combines the old information with new ones; understands the situation as a whole and therefore make decision.

(2) *Mental models and schema.* Experts usually use long-term memory to make decisions. Long term memory uses schema and mental

model. A well-developed mental model provides three levels of SA discussed above. The situation does not need to be exactly the same then a situation encountered before since an individual has a high ability of pattern matching. Mental models provide also informations that can be useful under uncertainty and in dynamic situation. For example, experts have higher ability to predict system preferences under uncertainty. On the contrary a novice will be lost by the missing information. Having mental models from past experience will help a decision maker add the missing information he is searching for when dealing with uncertain situation thus taking the appropriate decision.

A novice, due to his lack of experience, hence mental models, will have difficulties in SA and decision making.

(3) Pattern matching and critical cues. SA and decision making are dependent on the pattern matching between cues in the environment and mental models. An individual experienced in a particular situation normally have the ability to recognize critical cues in the environment that will lead to features in the mental models. Thus, the model will provide higher level of SA.

(4) Automatic action selection. Working memory's role diminishes when for a particular situation the appropriate course of action is already developed. This is coherent with Klein's single step RPD where the individual chooses directly the course of action associated to a situation.

- (5) *Categorization of information.* A highly detailed classification of information provides the individual access to information from his long-term memory that will map the mental model. When expertise increase, it becomes easier to do these classifications.
- (6) *Data driven and goal driven processing.* Features are processed while signals are detected to elaborate cues for the first level of SA. Moreover, and more importantly, SA is directly affected by a decision maker's goals; his attention is directed to what seems to be coherent with the goal that he wants to achieve. The information detected will be interpreted to in order to form level 2 of SA and choosing the course of action afterward (level 3).
- (7) *Expectations.* Experts tend to make faster decision when dealing with a situation that has information that is in agreement with their expectations. Expectation of certain information can have a direct effect on the expert's perception of a situation. Long-term and short term memory has an impact on one's expectations. Long-term memory enables the person to limit his attention to certain kind of information after pattern matching. Working memory's role afterward is to modify one's attention to be more relevant to his current goals.
- (8) *Dynamic goal selection.* A specific plan will be selected to match individual current goal. When scripts are available for the wanted plan then they will be directly executed.
- (9) *Automaticity.* Automaticity can help to overcome attention limits of an individual. Otherwise, automaticity can affect negatively SA

when dealing with changing or uncertain environments by making the individual less responsive to new cues.

In summary, the key for an effective decision making is a good understanding of a situation thus a well-established SA. In a changing environment, a decision maker will have less reliable and accurate decisions since he doesn't have enough resources. On the contrary, when the decision maker already encountered a given situation and he is familiar and experienced in it, he will be able to do a pattern matching with the mental models of past experience using his working memory if needed.

1.2.4 Role of sensemaking in NDM

We presented above the concept of situation awareness, its role in the situation assessment and demonstrated its importance in the decision making process. In this following section we are going to present the concept of sensemaking and its importance in the naturalistic decision making approach. Sensemaking's role is to answer the two main questions: what is going on and what an individual should do next? It is a matter of synchronization between the senses and the actions. This theory focuses on how an individual is capable of staying aware of what is happening around him. It takes into consideration the difficulties faced to detect the signs of security lacks, other anomalies and how to adapt the course of action when faced to an unpredictable situation. Four main factors influence sensemaking:

- (1) Individual factors
- (2) Characteristics of work situation
- (3) Factors related to team work
- (4) The impact of the organization process

- (1) Individual factors

The sensemaking process begins by the selection of signs that the individual detect in a given situation. This selection is subjective.

Developments of false hypothesis, lack of framing for the interpretation, regression in a recognizable action, difficulty of reorienting an action, are the major individual factors that influence sensemaking.

Based on Weick it is important and also problematic to stay in contact with the world around us. Sensemaking and actions are the same process when an action is taken an individual makes sense of the efficiency of the sense he created.

Sensemaking leads to a general overview of the situation. If a situation A is produced, then B is the action related to it.

The classical interpretation is that action is the result of interpretation.

Weick describes that sensemaking is a result of action.

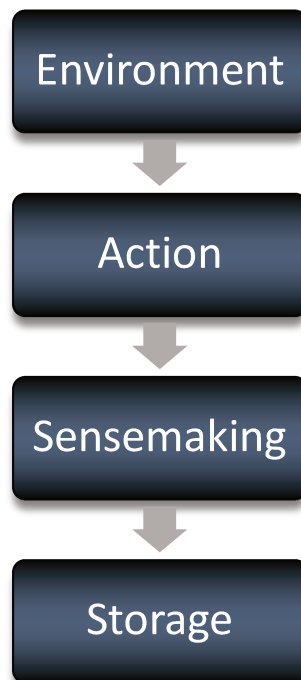


Figure 1.4: Sensemaking and action (Weick at al. 2005).

According to Weick, we live in a world in which we create our own reality.

Sensemaking is created in a continuous unconscious way. An individual becomes conscious about it when confronted to ignorance or confusion.

Generally, it is presented when strong emotions are present. Most of the time the crises that an individual face interrupts his course of action. Based on that, we can say that the crises faced are a moment of revelation. An individual will discover if the course of action is adapted to the situation and if the different hypothesis are correct. This revelation is based on the storage of senses inherited from a past experience. According to that the crises is considered a moment of re-creation where an individual is reconnected with the real world.

The biggest challenge is not to surrender and go back to normal situation. Instead, the crises are considered an opportunity to make contact again with reality through the usage of sense storage (Roux- Duffort 2007).

Different factors can affect an individual touch with the reality. An individual may not be selecting the correct clues and don't interpret them correctly. Action in this case becomes a trap that slow sense's creation. The sense creation starts, as mentioned before, by the selection of indices from the environment. This selection depends on the person's own interpretation of everything around him. Sometimes an individual doesn't find a right decisive index so he gives much importance to another one. One case that is a good example is the case of one of the biggest aeronautic crash in history in 1977 between two aircrafts:

27 March 1977, KLM flight 4805, a boing 747 was on its way from Amsterdam to the Canaries. In the same time a flight PANAM 1736, another boing 747, was on its way from Los Angeles and New York to the Canaries. The two flights change routes to land in Tenerife instead of Las Palmas due to a Bomb alert in this airport. After hours of waiting, Las

Palmas opens again. The two planes start the take off while following the indication of the tower controller. Couple of minutes later while KLM Boeing starts its take off, a crash took place with the Boeing of Panam on the runway. 583 passengers passed away. It was the biggest crash in history (Weick 1990).

Through the analysis of the conversations between the pilots and the controllers Weick focus on the fact that the actors seem to perceive or formulate wrong hypothesis about the situation. The pilot of KLM expects that the controllers give him the green light for the takeoff. Due to technical errors, sounds transmissions were not that clear. While waiting the authorization for the takeoff, the message was incomprehensible. Unconsciously the pilot distorted the message from “okay, standby for takeoff I will call you” to ok, take off”.

This example puts the importance on the role of interpretation and also on the information systems. The information received is influenced by the expectations of the individuals of the situation that they will face.

Being optimistic can affect negatively the interpretation process. It pushes an individual to neglect certain indices and just focus on other points. In this case pluralistic ignorance also appeared where an individual doesn't really understand what is happening. He acts as if he does and takes the action according to the hypothesis that others took. The co-pilot of the aircraft didn't make an effort to understand what was happening. He acted as if he does and took the pilots decision into action.

A wrong hypothesis usually is produced when an individual is concentrated on other tasks or after a very intensive concentration period

that mobilized many cognitive resources. That can cause a misperception in interpretation. This misperception is not only when choosing the wrong indices but also sometimes when an individual misinterpret the right indices due to lack of experience.

According to Weick, it is important that an individual have faith in himself and in his capabilities. When a person knows, while facing a particular situation, that he is capable of resolving the problem, the person becomes more attentive. Most of the time, we tend to act before even having a reflexion. This action usually generates more indices. In a crisis situation an individual base his interpretation on what he knows best; even if this interpretation is far from the reality. Furthermore, when an individual finds himself so involved in a course of action, he is engaged to continue the path up to a point that it is difficult to reformulate meaning to the situation or create a sense from the scratch.

(2) Factors relevant to work situation

Stress is the first influence on the process of sensemaking. A stressful individual is less available cognitively to collect or to notice available indices. In the case of the two aircrafts crash, the controllers of Tenerife airport and pilots were stressed due to overload and out of ordinary situation. A disturbed work situation weakens the sensemaking process due to excessive cognitive load that put on the individuals.

(3) Factors related to collective labor work

We are interested in knowing the nature of the interaction between individuals working together. It is not necessary that everyone agrees and thinks in a similar way in an entity. It is more important to articulate well

our own interpretation in order to be able to coordinate the actions. This coordination will be efficient to the sensemaking process. In case an individual couldn't really adapt his own adequate interpretation objectively or couldn't assure an interaction, this might lead to missing indices and as a consequence wrong interpretation.

Couple of elements can degrade the quality of interpersonal communication.

Material conditions are one of these elements. Technology and technical conditions should be adapted.

Hierarchy and roles in an organization play a role in the process of sensemaking. Weick describes how crisis confirm the strong presence of Hierarchy (Weick 1990). A very hierarchical structure can have negative consequence on communication. In general, it is complicated to question a false assumption formulated by a superior. Having a very centralized and hierarchical structure can deplete the communication or disempower the communication of certain participants and reduce the skills of reasoning. The actors become less engaged as a result they are involved less in new indices search. Weick suggest that instead of mentioning authority to use the terminology expertise. The power of a decision should be transmitted to the person that is better qualified to take a decision and not based on hierarchy and authority. For example, giving the authority to an operator that has control over a machine. In both cases, giving lots of importance to a hierarchical responsible will block the communication. It is important to distinguish general expertise and situational knowledge.

When working in a team, when communication is present, the exchange of hypothesis and indices will take place. This will enrich the creation of senses. According to Weick it is important to have a team who is competent but also full variety in this team in order to have enriching communication.

For the purpose of describing what an individual sensory perceives, he usually uses sketches or any other known categories of representations. Experimenting our senses is dominating and the transmission of what is perceived is secondary. We give importance to what our senses perceive and little to transmit what we perceive to others. We tend to normalize certain indices and not really taking them into consideration since it is considered familiar (Weick 2010). In most cases, when indices are not taken into account, it is mainly for one of two reasons. It is either there are no sketches or images to interpret them or the individuals that are interacting couldn't integrate them in a coherent sketch. To face this difficulty, certain organizations develop practices that allow the process of individual sense fabrication. Weick mentioned the effect of commitment that an individual has once he took certain action specially if this one is irreversible. Once an action is taken, it becomes a constraint in the process of sense creation. In order to overcome the wrong hypothesis, to fight the bad effect of hierarchy and authority and to avoid being in the action or falling into the trap of commitment. Weick (Weick 2009) puts the emphasis of having doubts while interpreting a situation. An individual, even a leader, should recognize publicly that the situation is unfamiliar to him and favorite open dialogue. Creating doubts permits an individual to

debate, organize his thoughts and have continuous arguments for his visions.

Sensemaking helps creating plausible images of what people are doing. it can be considered as a way station on the road to coordinate actions. The central role of sensemaking is the determination of human behavior. Sensemaking primary occurs when a current state of the world around us is different than the expected state of the world. In this case, people try to look for explanations that made the difference. Sensemaking role is either change the course of action or to look for additional explanations. The process can be defined as a process that make sense of a situation with all contextual features rather than taking into consideration the decision maker as a primary target. The primary focus is interpretation of the circumstances that led to taking the wrong decision not the choice in itself.

Sensemaking and organizing information:

Sensemaking and organizing information are two concepts that complete each other.

“A central theme in organizing and sensemaking is that people organize to make sense of equivocal inputs and enacts this sense back into the world to make that world more orderly” (Organizing and the process of sensemaking, organizational science, Karl E. Weick, Kathleen M. Sutcliffe)
Organization starts with organizing the flux of information received. While faced to a particular situation, an individual encounters a flow of activities. These activities can have a direct effect on the perception of the individual.

In parallel, sensemaking is a process of noticing and labeling a particular situation based on prior experience using mental models.

As mentioned before, the process of sensemaking is divided to two parts. The first part is about understanding what is actually going on. The second part is taking the appropriate actions. Ignorance and knowledge both exists in this process. Adaptive sensemaking exists to adopt prior course of action or reject it by replacing it with new interpretation.

In the medical field as in any other field, changes occur with time. Based on that, some actions that were perceived correct in the past can become incorrect.

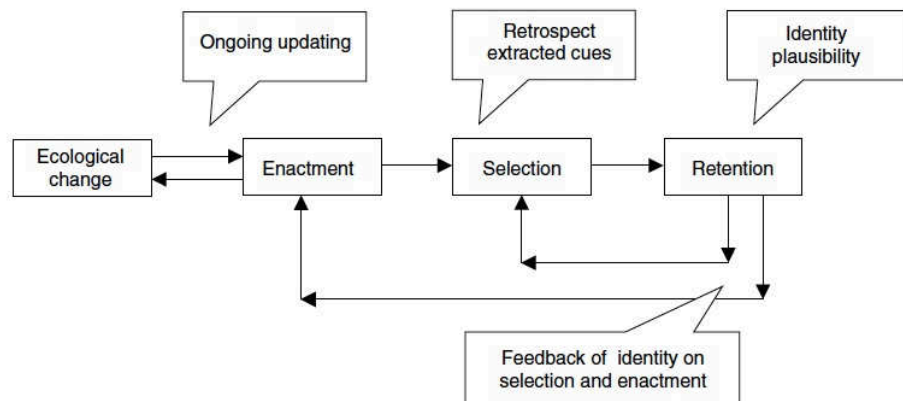


Figure 1.5 Relation between enactment, organizing and sensemaking. Jennings and Greenwood (2003; adapted from Weick 1979, p. 132).

The figure above represents the relationship between enactment, organizing and sensemaking. This ongoing process starts with a reciprocal exchange between the actors and their environment. With the selection step these exchanges are made meaningful then preserved.

Chapter summary

In this chapter we presented what is individual expertise and who is considered an expert. We are looking on taking into account expertise in terms of decision making process and the choice of a course of action. Our theoretical framing if the naturalistic approach for decision making. Thus, we presented this latter and detailed a specific model: recognition-primed model that we will base our analysis on. In the following chapter we are going to present collective expertise from routine's perspective. We consider collective expertise is the degree individuals in teams can coordinate and work together efficacy and effectively by creating a routine.

Chapter 2 Interpersonal expertise: organizational routines' stability in changing environments

Chapter introduction

In the previous chapter we discussed expertise from the individual perspective. The aim of our research is to understand the effect of technology on expertise from both individual and collective perspective. Having well-coordinated interactions and communication, teams can overcome difficulties encountered when dealing with change or uncertainty like a new technology introduction. This chapter is dedicated to understand what is a routine, how a routine is affected in case of uncertainty; how an artefact is at the center of a routine.

2.1 Organizational routines overview

The concept of routines was first introduced by Nelson and Winter (1982) as stable “memory of organizations” (as cited in A. Kozica, S.kaiser, M.Friessl (2014)). A routine is defined as “repetitive, recognizable patterns of interdependent actions, carried out by multiple actors (Feldman and Pentland, 2003, p.93). In other words, routines are considered automatic behaviors opposite to strategic well defined plans (Cohen, 2006, 2007; Lazaric, 2008).

Routines are elaborated through the interaction of performative and ostensive parts (Feldman & Pentland, 2003; Pentland & Feldman, 2005; Zbaracki & Bergen, 2010). Through these two parts that constitutes them, routines promote stability and change.

2.1 Characteristics of a routine

Since its introduction, the notion of *patterns* was at the center of a routine's definition. It is a “pattern of behavior that is followed repeatedly but is the subject to repetition if conditions change” (Winter, 1964:263). This notion is mentioned again with the definition of Nelson and winter (1982; 14, 15 and 113). *Recurrence* is another major characteristic of a routine (Winter, 1990; Cohen et al., 1996, Betch et al., 2001). It is not possible to attribute the term routine to something that is happening only once and not in a repetitive manner. Furthermore, a routine is *collective* involving multiple actors (Nelson and Winter, 1982; Lazaric 2000). These latter can be especially separated but linked by their interactions.

Lots of empirical studies described routines as collective phenomena (Weick,1990,1993; Cohen and Bonedayan,1990; Edmondson et al., 2001). Routines will be disrupted when actors “start acting in a manner that is more individual then collective” (Weick, 1990: 579). A balance between both individual and collective aspect of an organization will maintain this latter stability. A routine is a sort of stability for the organization when this latter encounters change: it enables researches to map organizational change” (Becker, 2002). It is a process in which it is important to understand the procedural characteristics. Examples of these procedural characteristics is the speed of executing the routine, reaction speed, frequency of repetition, time of pressure and lot of other characteristics. We are particularly interested in the frequency of repetition and time pressure that plays a role in our case selection afterward.

Frequency of repetition is one of the most important characteristics of a routine (Weick, 1990; Narduzzo et al., 2000; cf betsch et al., 1998). Regularity is important for routine maintenance. Cohen (1994) argued that routines choices are affected by time pressure. Furthermore, routines are embedded in an organization. Context and routines are complementary. Sometimes when removed from its context, a routine becomes meaningless (Becker, 2002). It can change based on the past in a path dependent manner (Nelson and winter, 1982; David, 1997). It is important having feedback about action's outcomes in order to understand the path of a routine and hence understanding the initial reason why this latter was created. Feldman (2000,2003) argued that routines changes in

incremental manner over time. It is a one of routine's characteristics. When conducted repeatedly, actors influence changing actions.

Recent studies show that routines are not stable and highlighted the concept of dynamic routines. Organizational routines can be characterized by endogenous change (D'adderio (2008); Feldman (2000); Feldman and Pentland (2003); Howard-Grenville (2005); Parmigiani and Howard-Grenville (2011); Rerup and Feldman (2011)) (as cited in A.Kozica, S.kaiser, M.Friesl (2014)).

Recent advances on routines and performativity theory study the influence of artefacts and agencies on the change and stability of routines. In the earlier years, routine's dynamics started to have researchers' attention. Learning, change and adaptation are the key aspects that are in the forefront of these studies. Authors in recent studied were interested in understanding the dynamism of routines (Pentland and Rueter, 1994; Cohen et al., 1996; Feldman, 2000; Lazaric and Denis, 2001; Zollo and Winter, 2002; Feldman and Pentland 2003; D'adderio, 2001, 2003; Becker et al.; 2005; Pentland and Feldman, 2005a). Scholars have already stressed on the key role of artefacts in organizational routines. Attention on artefactual representations and external objects in routines theory started since the first emergence of routine (Nelson and Winter, 1982; Cohen *et al.*, 1996). In the following section we are going to present how artefacts are brought at the center of routines

2.3 Routines in changing environment

2.3.1 Artefact at the center of organizational routines

Routines are not caused only by humans but by a whole of “Sociomaterial ensembles” including artefacts (Labour, 2005 Leonardi, 2011, Leonardi and Barley, 2008; Orlikowski, 2007, Suchman 2007). Artefacts includes tools, technologies, procedures etc. according to Leonardi (2011), actors and material agencies are not separable. Therefore, organizational routines and technological artefact are equivalent. Some scholars minimized the role of artefact while others emphasized the role of this latter in practices and routines.

Earlier scholars considered artefacts as part of a context (Physical or motivational or relational contexts) to create routines. They are considered external memory of routines (Nelson and Winter 1982). The role of artefacts was proven to be more than just objects outside the routine theory. It brought artefacts at the center of routines theory (D'adderio 2008). Cognitive science started to emphasis on representing knowledge as functional relationship between human minds and external objects (Hutchins, 1991, 1995; Hutchins and Hazlehurst, 1991). Therefore, the role of artefacts was questioned. D'adderio acknowledged that artefacts are at the center of routines. The below schema taken from D'adderio 2008 explains this evolution of the role of artefacts over time.

Technology in particular has been recognized as a special kind of artefact that impact organizational routines (A.Kozica, S.kaiser, M.Friesl (2014)). Artefacts play an important role in supporting or preventing coordination

among organizational communities and functions (D'Adderio, 2001; Carlile, 2002; Bechky, 2003).

2.3.2 Role of coordination

Coordination is defined as people working collectively where the work is interdependent to achieve a goal, task or piece of work (Okhuyen and Bechky 2009 p.469). To cope with change and uncertainty, scholars emphasized on the fact that coordination must be flexible to deal with change like novelty (Adler 1995). Routines' main role is to coordinate (Nelson and Winter, 1982) thus provide every actor the knowledge of what another actor is doing in order to make decisions. Recent empirical research started to emphasize the role of having a routine on coordination. Routines enhance interactions between individuals and therefore positively impacting their performances. While facing a major change like the use of a new technology, team members encounter both technical and interpersonal challenges. Speaking up has a central role in overcoming these challenges and thus facilitating the implementation of new practices (Edmondson 2011). Roles and hierarchy have an important impact on the team member's ability to speak up and therefore communication between team members. Speaking up and communication will help the learning process of adopting this new technology as a result implementing new routines. A team leader promotes coordination specifically in medicine where a leader's behavior influences directly team performance. Thus, a team leader's role is to encourage communication between team members while giving them psychological safety.

Team members are able to anticipate each other's move based on the shared cognition and mental models acquired with their routine. Despite this solid coordination, they still have lots of challenges when facing a major change like the adoption of a new technology. Introduction of a new technology requires both new skills and new routine creation. To adapt to this new routine, coordination must be intensified. This transition period is facilitated by a good communication process and therefore creating a smooth coordination environment. Implementation is considered a learning process that involves collective discussion and experimentation with new behaviors (Edmondson 2001). This learning process is directly affected by psychological safety of each team member. Hierarchy and power mainly cause needing psychological safety. Surgeons have enormous organizational power compared to other team members in operating room. Hierarchical barriers can be surpassed by the team leader's behavior. When teams are learning new routines, members will feel anxious about the new challenge (Schein 1985). The aim is to overcome this anxiety in order to be able to implement and adapt to this new routine.

In addition to promoting psychological safety and the ability to speak up, team leader should encourage the learning process to adapt to the change.

2.3.3 Time and repetition for building new patterns of action *

Recently, Kremser and Schreyögg (2016: 705) introduced the concept of “clusters “of routines and show first, that “*organizational outcomes are brought about in a concerted effort that depends on multiple, interrelated routines* », and second, the significant issue of focusing on dynamics and path dependency around no single routines but on intermingled or interrelated routines. The basic idea developed in their empirical findings is that technological complementarities reduces the scope of possible change by creating path-dependent obstacles to new technologies. Bucher and Langley (2016) put the discussion a step forward by showing that in hospitals the ecologies of routines may become ‘an ecology of space’, i.e. some ‘community of practices that experiment changes within their own routines and delineate what can be the boundaries of this change. The ‘ecology of space’ appears to be critical for observing the nature and the context for integrating new patterns of action and the reconfiguration of the current routines in hospitals Bucher and Langley (2016). Indeed « *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 a similar

* This part is taken from the paper accepted to EGOS Colloquium : “Learning a new ecology of space and looking for new performative routines : Implications of new technological artefacts inside a surgical team” (L. Kiwan, N. Lazaric 2016).

vein, Dittrich et al., (2016) scrutinized how diverse aspects of what they defined as the « reflective talk » reveal diverse opportunities of changes and shed some light on « the role of collective reflection in routine change », on variation and selective, retention in routine change, and « on how organizational members balance the need for consistency and change in the enactment of routines ». As underlined by Deleuze (2004), repetition is critical for emergent patterns to achieve some degree of stability and change (Aroles and McLean 2016). During the implementation of technological artefact, team psychological safety is critical for building new patterns of action. Repetition may thus provide some opportunity to stabilize learning and to create some ontological security needed by individuals confronted to change (Giddens 1994). Our empirical data will illustrate this tension provided by technological artefacts. While these tools offer new opportunities for changing current patterns of action, lack of repetition and insufficient learning phase provide provisional patterns that are performed in an exploratory stage. In some hospital's units, robotic surgery is routinized and fully adopted such as Urology department (Compagni et al., 2015) whereas in other places such as gastric's unit, it remains at an exploratory phase suffering from a lack of learning. In short, technological innovation in the same organization can be at the same time fully routinized or temporary performed since accumulation of experience varies significantly across organizations (Pisano et al., 2001). We explore these challenges in robotic surgery showing the temporary coordination between team members when roles are changing in operating room (OR).

2.3.4 Learning

Learning is an important aspect while adopting a new technology. Process of learning can affect directly the ability to adapt to change in an organization. Collective learning is an important aspect in implementation success (Edmondson 2001).

When knowledge is tacit proximity and interpersonal interaction are necessary for its transmission (Davenport & Prusak, 1998; Hansen, 1999; Sole & Edmondson, 2002; Szulanski, 1996). This proximity and interpersonal interaction are reinforced by a good coordination. Knowledge in healthcare, more specifically in operating room, is a collective knowledge where coordination is required. Literature specifies the difference between tacit knowledge and codified knowledge. In medical field difference between both types of knowledge is just temporal. With a new routine put in place, tacit knowledge will become a codified knowledge in the future (e.g.; Vosburg & Newbower, 2000). Adopting a new technology rely mainly on tacit knowledge before it is transformed later on with time and experience to codified knowledge. Tacit knowledge for using new technology may include developing trust and awareness of how to respond to subtle cues from glances, body language and other forms of nonverbal communication (Edmondson 2001). Body language and nonverbal communication require physical proximity between members in order to promote good coordination. Codified knowledge is easier to transfer among users. When the use of new techniques is based on codified knowledge it is easier to transfer between team members. On the other hand, tacit knowledge is harder to transfer. Despite codified

knowledge used for good implementation, new technology implementation is based on tacit knowledge. Intense forms of communication are needed to transfer it. Thus, good coordination is important to aid implementation process (Edmondson 2003). A technology with proven advantages can fail when tacit knowledge is needed even though it presented obvious advantages. In this case intensive communication is required to overcome this issue (Edmondson 2003).

2.3.4.1 Creating psychological safety

Extensive literature exists on examining how organizations reduce people's anxiety facing change (Schein 1985). This level of anxiety is higher in these types of situation where the individual does not know if his actions will work out as expected. Individuals are afraid facing uncertainty to take risk therefore they limit their interpersonal behaviors. This limited interpersonal exchanges will limit the learning process.

In a given organization, the majority of the people are evaluated in a continuous manner. When faced with uncertainty like the introduction of a new technology, individuals are afraid of being judged or classified & as ignorant, incompetent or disruptive if they ask questions or do mistakes (Edmondson, 2002). Asking questions or admitting of mistakes might be seen wrong by others. Even though this might seem a sign of failure perceived by others, admitting of having mistaken help avoiding bigger problems especially in environments where it is risky or where lives are in danger such as in hospitals (Leap et al., 1991). Being afraid of affecting one's own image will impact negatively individual and collective learning.

In addition to that, it is hard for an individual to hear feedback on his own work. The fact that people accept all the risks mentioned before is considered psychological safety (Edmondson 1992; 2002). When people perceive an environment as safe enough for them, hence that they will not be judged for asking questions or making mistakes, this environment promotes learning. Having psychological safety is essential for the learning process of the team. The team's leader's role is to promote this psychological safety. By definition, psychological safety is the individual's perception about the results of interpersonal risks taken at work. It consists on how others will respond to one's actions, questions, mistake etc. (Edmondson, 2002). The need to create psychological safety is important when dealing with change or when people are having learning anxiety/ having psychological safety does not imply that no problems or pressure, it just means that the environment is based on productive discussions where disagreements can take place. Psychological safety allows learning behaviors and taking risks by seeking help and discussion between team members. For example Edmondson, Bohmer and Pisano (2000) illustrated the importance of speaking up while implementing mini-invasive surgery in the OR. Speaking up is one indicator of having psychological safety. New routines were created and roles were re-negotiated allowing new technology implementation (Edmondson, bohmer and Pisano, 2001). In this study, all team members i.e. nurses, assistant surgeon, anesthesiologist had to speak up in order to share information with their other team members. Even though speaking up might be difficult especially when hierarchy exists, it is important under uncertainty example

in the OR during a surgical procedure. Based on their study, Edmondson, Bohmer and Pisano found how speaking up made technology implementation easier even if it means correcting superiors. In some teams this might be difficult depending on team members and on the degree of psychological safety presented. Creating psychologically safe environment will remove the fear of speaking up and therefore promote innovation (Edmondson et al., 2001). It was the case in cardiac surgery where the nurse was not afraid of proposing the use of equipment when adapting the new technique. The learning process facing change is motivated by psychological safety. In presence of this latter, the effects of goals on behavior are enhanced. It helps groups setting high goals and attaining them through good team work and learning. In other words, psychological safety “translates inputs into outputs” (Edmondson, 1999).

2.3.4.2 Team leader's role in creating psychological safety

A team leader encourages interpersonal risks to be taken. He facilitates freedom between team members and promotes psychological safety in order to learn and attain the shared goal. A team leader has a direct influence on psychological safety, structuring team learning and communicating team's goal (Edmondson, 2002). Team members are directly affected by the team leader's behavior. This latter can create environments of trust and learning by acting in a way that encourages psychological safety. Usually team leaders are chosen based on their expertise in a certain domain for example the primary surgeon is the leader of the team. According to Edmondson (2002), accessibility and

acknowledging fallibility are very important characteristics that the leader should have. Being accessible and involved promote learning during the implementation of a new technology in OR, the surgeon's ability to take time to explain lead to a successful adoption. Furthermore, tolerating errors creates psychological safety for team members.

Team leader's action are the indicator if a technological implementation will be successful or not. A team leader will maintain team stability and the psychological safety of team members that will lead to an efficient collective learning thus creating new organizational routines.

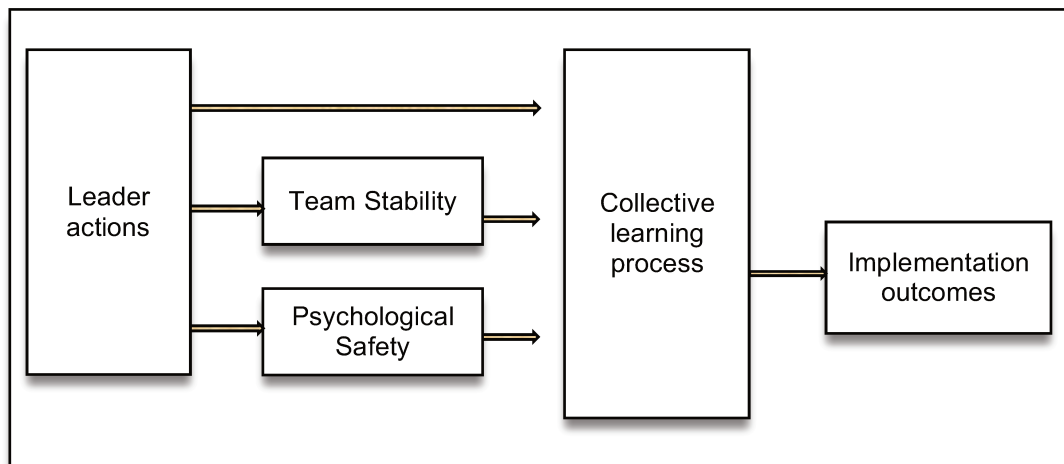


Figure 2.1: Team leader and technology implementation

Edmondson studied the implementation process of Mini-invasive surgeries by operating room surgical teams. This process will fail if the team leader does not complete his role and if team members' actions are not interdependent.

The figure below presents the process for establishing new technological routines.

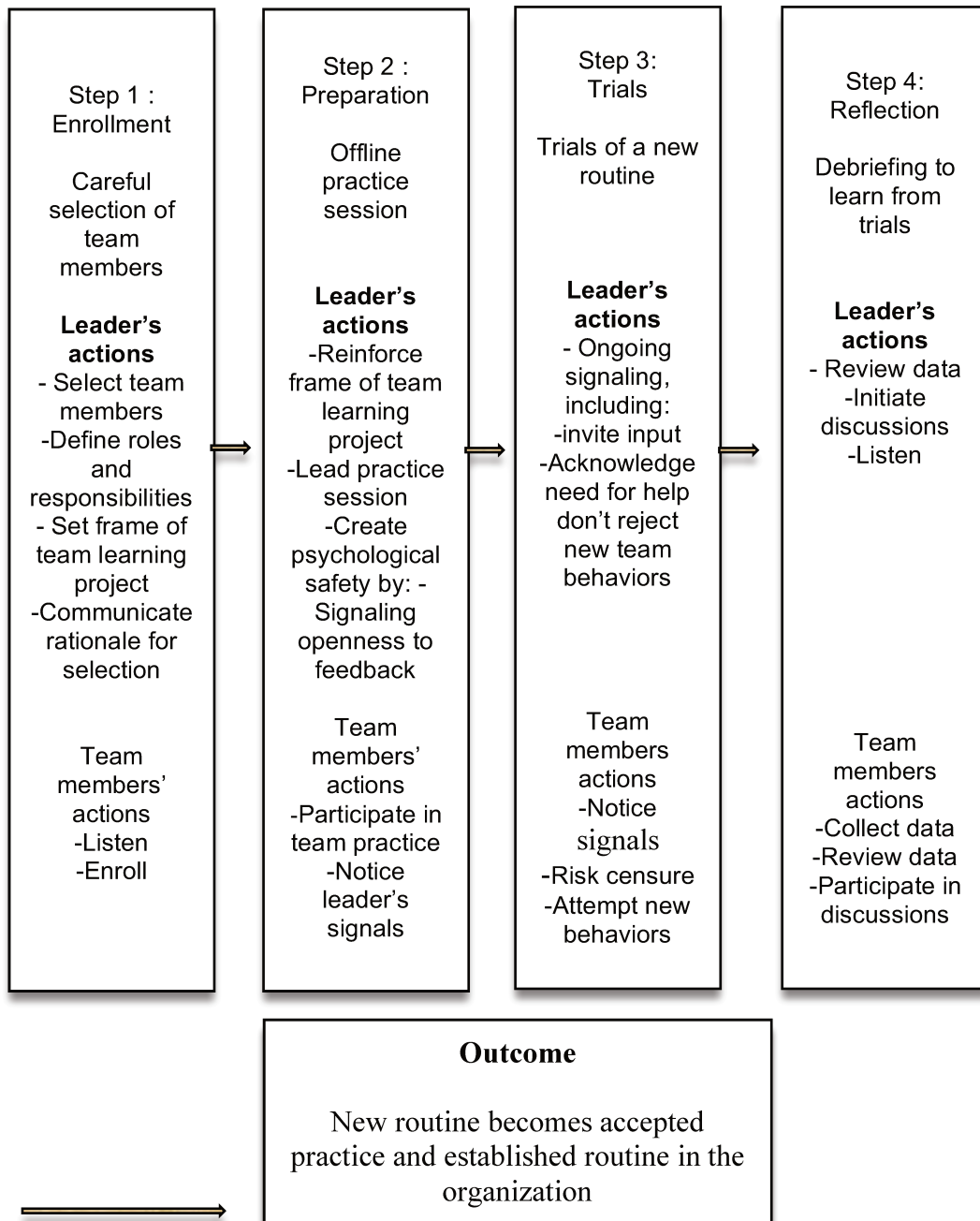


Figure 2.2: A process model for establishing new technological routines

Chapter summary

In this chapter we presented the concept of organizational routines and the change of this latter facing uncertainty. When dealing with a new artefact, organizational routines start changing automatically. To adapt to this change and uncertainty, psychological safety is important among team members in order to overcome difficulties. This will create an efficient learning process, thus creating new routines. Furthermore, scholars illustrated the necessity of repetition to adopt these organizational routines.

Chapter 3 Healthcare background and technology implementation

Chapter introduction

In this chapter we are going to present a brief presentation of the medical context. This consists of presenting the evolution of surgery till the introduction of robotics in surgery with the different classifications of these latter. Furthermore, we will present the different roles of each team member in the operating as presented in literature and the aspects of an efficient OR. In addition to that we present at the studies conducted in medicine on robotics vs. mini-invasive surgery.

3.1 Medical context

Medicine is a field submerged by new technologies. Development is emerging in a too rapid pace to keep up with. These technologies' aim is to help the doctor fulfilling his tasks towards the patient. Technologies involved can be classified into two main categories: diagnosis and treatment

The figure below presents a brief presentation of the medical chain and the presence of different sort of technologies in this chain.

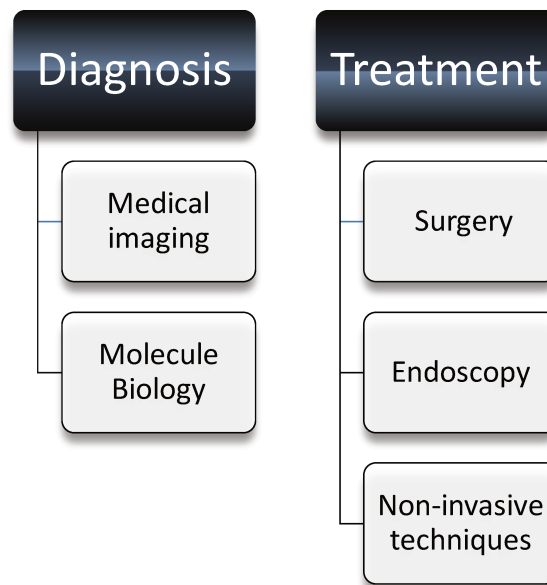


Figure 3.1: Medical chain & technologies

Even though our interest is robotic surgical procedures, we are going to present briefly the technological developments in the diagnosis and treatment procedures.

3.2 Treatments: from conventional open surgery to Robotic Surgery

Developments in treatment include technical evolution in surgical procedures and in non-surgical procedures. Technological development in surgery evolved over the years starting with the big shift in surgery from conventional open surgery to mini-invasive surgery (section 1.2). Till now mini-invasive techniques are in continuous development. Robotic surgery was developed first to surpass the difficulties that mini-invasive surgery encountered. Robotic surgery is also mini-invasive since the operation is done through small incisions. Some treatments consist of treating the patient only through endoscopic techniques without the need to go through surgery.

Technological development in treatments reached also non-invasive treatments techniques (no need to reach inside the body). Example of non-invasive technological treatment is radiosurgery that is a procedure based of radiation.

3.2.1 Mini-Invasive Surgery Evolution

Minimal invasive surgery (MIS) was introduced in the early 1980's. The aim of MIS was to reduce the negative aspects of conventional open surgery. The main objectives were to reduce patient's pain and reduce post operation recovery time mainly due to the trauma caused by the large incisions (G. Guthart , J. Salisbury, 2000).

MIS consists of operating through small incisions. The surgery consists of using specific tools like endoscope* and other instruments while operating. The surgeon operates using instruments that were produced by

manufacturers specifically adapted to mini-invasive surgery while looking to a screen that will allow him to have a full view of the organs. The endoscopic camera enables these images. At the beginning the images used were 2D images. The figure below presents an evolution timeline of mini-invasive surgery. This timeline presents the main dates that marked the evolution of mini-invasive technique.

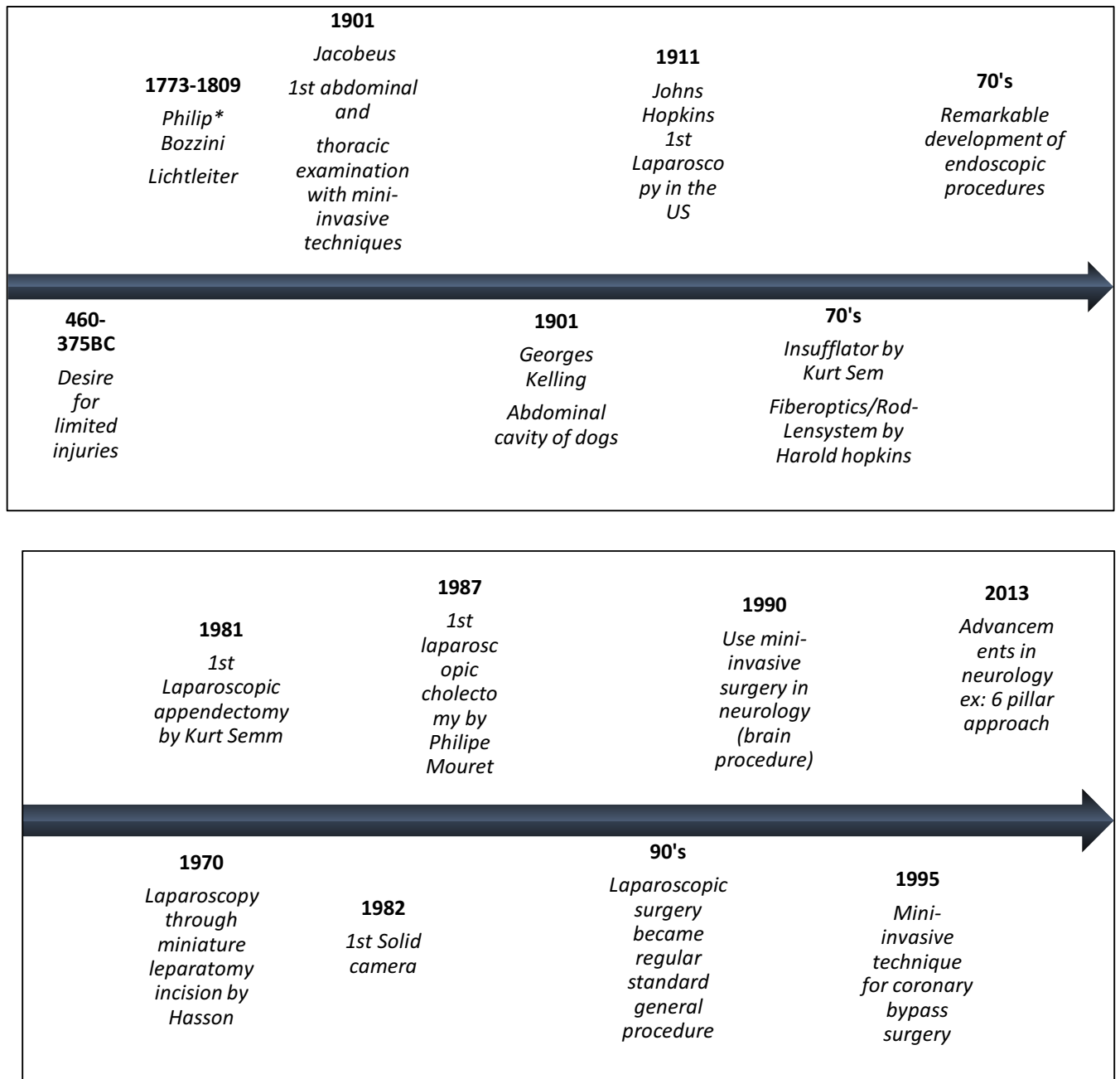


Figure 3.2: Mini-invasive surgery evolution timeline

3.2.2 Robotics

Autonomous and semi-autonomous systems in surgery are in continuous evolution. They are expected to become the new standard way of the surgical procedure and revolutionize the face of the surgery.

Surgical systems can be classified following different classifications.

Taylor and Stoianovici (figure below) classification consists on dividing surgical systems into two main categories. The first category is *computer aided-system/ manufacturing* (CAD/CAM). This first category regroups the technological systems that assist in planning the operation. This is done through the reconstruction of 3D images and preoperative images. One of the main objectives of these systems is to use overlay displays to assist the surgeon during the operation to execute the intervention as planned. The second category is *surgical assistants* that assistant surgeons while operating with a different role that CAD/ CAM. Surgical assistant are also branched further into two classes: *surgical extenders* and *auxiliary surgical support*. The purpose of surgical extenders is to extend human capabilities in different surgical tasks. The surgeon leads these tasks. On the other hand, auxiliary surgical supports work side by side with the surgeon.

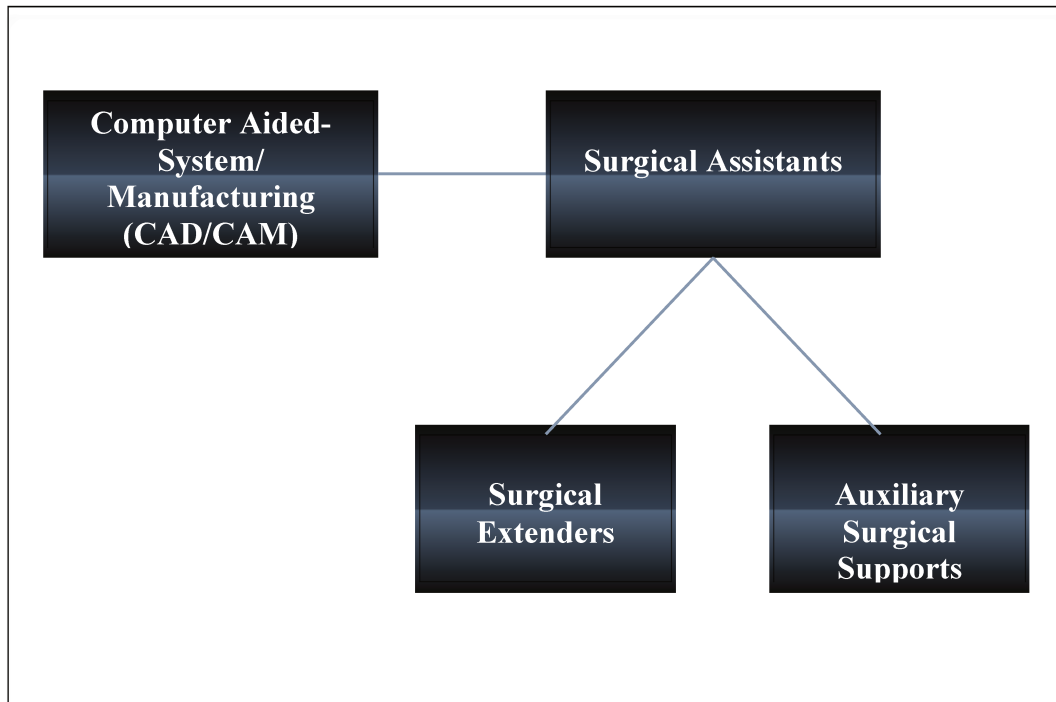


Figure 3.3: Taylor and Stoianovici surgical classification

The second classification method is Wolf and Shoham classification method. This classification consists on dividing medical robots into four categories based on autonomous functions: *passive robots*, *semi-active robots*, *active robots* and *remote manipulators* (Figure below). Passive, semi-active and active robots are considered CAD/CAM and Auxiliary surgical support if we consider classifying them using the previous technique. Likewise, remote manipulators fall into surgical extenders category. Remote manipulators or surgical extenders are the most used surgical robots in surgery. One the most known surgical robot is Da Vinci robot, which is the main interest of our study. Da Vinci Robot and MiroSurge System are examples of remote manipulators and fall into a broader category that is called telesurgery.

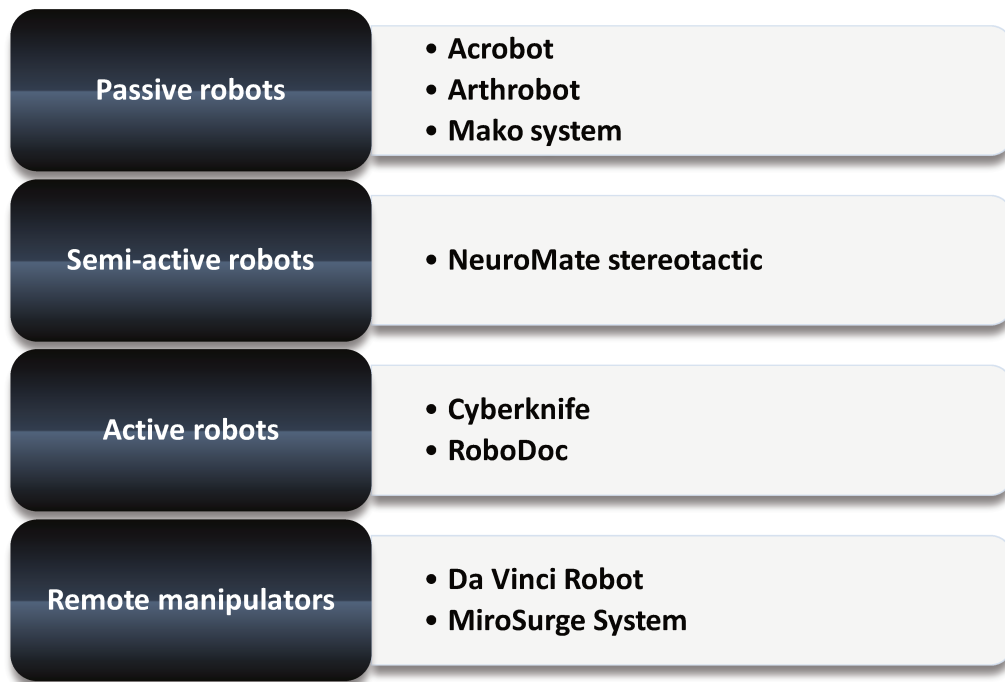


Figure 3.4: Wolf and Shoham classification with systems examples

The third type of classification is Niemeyer et al classification. This classification is more engineering oriented and is based on degree of user interaction. Three groups emerge from this classification: *direct or manual control, shared control and supervisory control*. In manual control the surgeon is in full control of the robotic system. The robot mirrors the surgeon's actions therefore no autonomy from the robot's side. In Shared control, the autonomy is shared between the robotic system and the surgeon: "*Virtual fixtures are invisible rulers that constrains the surgeon's movements*" (G.P. Moustiris 2011) . The controller's role is to guide the surgeon in case he deviates from the correct path. The third and final group is supervisory control. In this category, the operation is fully done by the robot based on input planned prior to the surgery planned by the

surgeon. The surgeon's role is limited to the planning process and to supervise if the surgery is going as planned.

3.2.2.1 Robotics challenges: Operation time

Scholars have argued that despite the advantages of robotic surgery, the robotic system present also lots of challenges. The robotic system can affect the patient's safety therefore conversion to open surgery is necessary to avoid any complications from the patient's side. The robotic system is therefore moved away (Baik 2008; Fung and Aly, 2013). Moreover, operation duration increase with robotic surgery due to the time for set up (Antoniou et al., 2012). Studies has taken into consideration the lack of tactile information transmitted in robotic surgery. Surgeons had to rely on their visual information more (Lim et al., 2013). As a results the surgeon moves more slowly since he is mainly relying on his visual information only. Lots of debates in literature on robotic surgery on the time issue. While the main objective of this type of surgery is to reduce the operative time, some argued that on the contrary the operating tile increased and others illustrated that the same time is needed. This is the case of a study on Colonic cancer where they found that there is no difference between robotics and laparoscopy (Helvind et al., 2013).

3.2.1.2 Robotics challenges: Communication in the OR

Communication in the OR is defined by the "quality and quantity of information exchange between team members (Healey et al., 2004). It does not only include verbal communication but also non-verbal one. This

latter consists of body gestures, orientations and eye contact (Benzemer et al., 2011; Welddon et al. 2013). In other words it is the combination of physical artefact, gesture and speech that complement each other (Hutchins and Palen, 1997). Scholars reported the difficulties encountered by surgeons when they are physically separated from the rest of the team. In laparoscopy, prospective sensemaking is essential between team members. Prospective sensemaking (Rosess et al., 2015) refers to Weick's theory presented before in chapter 1. It concerns the ability to anticipate events that may occur in the future (Rosness et al., 2015 p. 55). For example, in laparoscopy a scrub nurse anticipates the surgeon's actions by giving him the right instrument (Zheng et al., 2009).

3.3 Operating room (OR) interactions

3.3.1 OR efficiency

In the section above we presented the evolution of surgery and the different classifications of robotic systems that exists nowadays. In this section we are going to present the different aspects that makes an operating room efficient followed by the roles of each member of the surgical team present in the OR. This will enable us to have understanding on how work is done in the or that will lead us to have a better analysis of the different actions.

In the OR the link between surgical efficiency and the composition of surgical teams has been investigated in literature. The right combination and a balance between training, experience and teamwork is needed. Like in any other area in the hospital, in the OR, managing time is essential. It

is the place where people, equipment, coordination and time are the four important elements. In order to implement a new technology that is assigned normally with change in the OR, we should first understand what is OR efficiency and efficacy in order to know how to maintain these stabilities when dealing with change. The correct use of time is a key element in OR efficiency. Furthermore, defining well each one's role and standardization of team work is part of managing OR. Research in health care examined the scientific management discussed by Taylor (1911). The table below summarize these principles and how they apply in OR.

Principles of Scientific Management theory	Principles of Scientific Management Theory applied in OR
Professional mix in job placement: The right person in the right place (Taylor, 1911, pp. 56-57).	One scrub nurse whose role is to manage the sterile field during the surgery. One circulating nurse for every patient. The primary surgeon who is normally assisted for the surgical act by another surgeon (not necessarily) etc. Roles are well defined.
Division of labor (Taylor, 1911, p. 123).	Each member in the OR has specialized tasks correlated though.
Standardization in work organization: creating functional teams (Taylor, 1911, p.129).	A stable team in the OR enhances workflow. Doing the same way every time thus creating OR routines.

Table 3.1: Principles of scientific management theory applied to OR (M. McLaughlin 2012).

OR is an example where the principles of scientific management are clearly respected.

One aspect of inefficiency in health care is the inappropriate teaming i.e. mix of staff (Chisholm & Evans, 2010; World Health Organization, 2010). Literature demonstrated the importance of specializing surgical team and its link to OR efficiency. For example, teams specialized in laparoscopy may reduce the surgical time and patients' complications (Kenyon, Lenker, Bax & Swanstrom, 1997). Schneider studied this aspect. He analyzed the role of the hospital's environment, the surgeon and surgical team, on the surgical and on perioperative time. The higher the experience of the surgeon the less time is needed to operate and vice versa (Schneider et al., 2011). Surgeon experience and expertise thus their learning curve were also discussed in literature (Kiran, Kirat, Ozturk, Geisler & Remzi, 2010)*. The importance of having a routine thus having team stability in OR is considered essential in literature to create efficiency.

3.3.2 Communication in the OR

Communication is another aspect that maintains OR efficiency. Having misleading transmission of information between team members or having troubles in communications between lead to communication failures. As a consequence, surgical errors occur. Communication failures can harm the patient in some surgical cases (Greenberg et al, 2007). Miscommunication is the result of bad coordination. This can be caused by the introduction of a new team members or a new artefact that need a new coordination

pattern. Miscommunication and bad coordination affect negatively the surgical team by creating tension and cognitive load (Lingard et al; 2004). Communication failures are totally normal in the OR. It occurs in 30% of exchange between team members and is responsible of most of the surgical errors. In order to maintain the patient's safety, the efficacy and efficiency of the surgical team, it is important to understand the source and cause of these errors. A recent study classified four types of communication failure: *occasion (suboptimal timing)*, *content (insufficiencies or inaccuracies)*, *purpose (lack of resolution)*, *an audience (gaps in group composition)*. These communication failures have several effects. First, it leads to inefficiency. While encountering communication problems, members redo steps and can waste resources more than usual. This leads to delay in the surgical procedure. These failures can create tension between members leading to procedural errors as a result of decision making or failures of techniques.

3.3.3 Staff arrangement and roles in the OR

This section presents an overview of surgical team members in the OR. Surgical procedure consists of one or more procedures usually invasive. Surgical procedures are normally routinized with the presence of at least one surgeon, one anesthesiologist, one circulating nurse RN (the circulator) and one scrub nurse. In some cases, additional nurses may be required. In teaching hospitals, a surgical resident and one anesthesiologist resident (or a certified registered nurse anesthetist) can be present. The

surgery is led by a specialized surgeon in the type of surgery and assisted by other team members not necessary specialized in the type of surgery.

3.3.3.1 Surgical team

Our main focus in this research is OR and surgical procedures therefore, it is important to identify clearly the different roles of each practitioner present in the operating room. We are going to present below the different team members present with their respective roles.

The OR team is subdivided into two teams: the sterile and the unsterile team. The sterile team is the team that is actually the team that is located in the sterile field directly surrounding the patient where all the instruments are sterilized. The sterilized team only works in this area and handle only sterilized instruments. The unsterilized team works outside this area and handle instruments that are not considered sterilized. Their primary role is to keep the sterilized team supplied with the instruments needed, ensure the patient's care and provide any other requirements if needed. The sterilize team consists of the surgeon, the assistant surgeon and the scrub nurse. In parallel, the unsterilized team consists anesthetist, anesthetist assistant, circulator nurse and any other person present like a student or any other technician or specialist needed in a specific kind of surgeries. In the section below we are going to present the respective roles of the practitioners present in the operating room starting with the sterilized team followed by the unsterilized one. These roles start from the pre-operating, during the actual surgical procedure and post-operation.

The surgeon

The surgeon is the main actor or the captain of the ship. His responsibilities include preoperative diagnosis and care, selection and performance of the surgical procedure and postoperative care.

He is the one directing all the personnel present and taking the critical decisions in directing the course of the surgical procedure. He is coordinating with the nurses and assistants during the surgery to make sure that the operation is going smoothly as planned. The surgeon also works with the anesthesiologist to manage the patient's condition. In addition to that, he is coordinating with his assistant, the resident surgeon. The resident surgeon normally is a senior surgeon and the resident surgeon is working with him during the process of the residency training. Gastric bypass surgery is not considered a complicated surgery therefore two surgeons are enough. In other types of surgeries, more complicated ones, three or even four surgeons can be involved and work together.

Assistant surgeon

The assistant surgeon is one the professionals normally present in the OR. In some types of surgeries, the presence of the assistant surgeon is deemed unnecessary (American School of Surgeon). The primary surgeon normally decides whether the presence of an assistant surgeon is necessary or not.

One of the primary roles of the assistant surgeon is to check the patient's records to be sure that all the medical requirements and precautions are fulfilled. These medical records are shared with the primary surgeon and the anesthesiologist. Roles of the assistant surgeon during the surgical act

depend mainly of the preferences of the primary surgeon. These tasks usually include employing sutures to hold the tissues with the surgeon. His duties as an assistant surgeon are from one side working with the primary surgeon and to make the surgery easier for the later one. This is done for example by ensuring the primary surgeon's view. From the technical perspective, his role is to be complimentary to the primary surgeon. He employs sutures to hold body tissues with the surgeon, securing retractors to hold back tissues and to stop hemostasis*. Even though in general all surgeries are very similar from the point of view of team's structures, the assistant's surgeon roles may differ from one team to another. These differences are mainly due to the primary surgeon preferences and to the routines created between them. In summary his role is to control bleeding, maintain the visibility of the surgical site and close wounds during the surgery

Post-surgery role of the assistant surgeon is to close the surgical cut, examine and assess the patient's condition and aiding his transport from the OR.

Scrub nurse

The scrubbed nurse is the person located in the operating field directly next to the primary surgeon with a continuous attention to the operation field. The nurse is directed by the surgeon's actions. In the pre-operation phase, the scrub nurse assists in the preparation of the OR. Her/his main role during the surgical procedure is to passes the instruments to the surgeon while maintaining the instrument's table neat and anticipating the surgeon's actions. In addition to that, a scrubbed nurse main duty is to

assist during the draping procedure. All these actions are done while maintaining the operating field sterility.

Circulating nurse

Registered nurses' roles during the surgery are variant. Their role starts before the arrival of the patient to the OR. They first make sure that all the machines are working well, the instruments are put in place, the computer is working well and that the room by itself has all the sanitary and requirements to welcome the patient. Verification of the sterilization in terms of instruments and materials that the practitioners will wear to sterilize themselves is a very important step in the pre-operation preparations. A circulating nurse is one of the registered nurses. The role of a circulating nurse starts before the surgery while reviewing the patient records, monitoring patient's condition, preparing and admitting him to the OR. In addition to that, a circulating nurse helps before the surgery the sterilized practitioners prepare themselves. The role of the circulating nurse continues during the surgery. Her/his role is to keep the scrub nurse supplied, to open the sterile supplies and to handle all the unsterilized equipment while monitoring the devices present. During the post-surgical phase, a circulating nurse's role is to accompany the patient to the recovery room while making sure of the stability of his condition. Furthermore, his/ her role is to report and document all the details of the surgery.

Anesthesiologists and nurse anesthetists

Practitioners in charge of administering and monitoring anesthesia to the patients prior, during and after the surgery. Nurse anesthetist's role is to

administer the prescribed anesthetic, to monitor the patient. Monitoring the patient involve monitoring his oxygen level and inserting artificial airways during the surgery. Their role is not only limited during the surgery but also pre and post operation preparation and patient's care.

The table below indicates the different roles of each team member present in the OR.

	Pre-operation	Operation	Post-operation
Primary surgeon	<ul style="list-style-type: none"> -Pre-operative diagnosis and care -Surgical procedure decision 	<ul style="list-style-type: none"> - Leading the surgery - Performing the surgical performance - Coordinates with his assistant, nurses and anesthetist 	<ul style="list-style-type: none"> - Post-operative care
Assistant surgeon	<ul style="list-style-type: none"> - Diagnostic care - Re-checking patient's records + medical chart - Positioning of the patient 	<ul style="list-style-type: none"> - Maintaining the visibility of the primary surgeon - Control hemostasis(bleeding) 	<ul style="list-style-type: none"> - Closure the surgical cut - Examine and assess the surgeon - Aiding in patient removal
Scrub nurse	<ul style="list-style-type: none"> -Assist in the prep of the room 	<ul style="list-style-type: none"> - Passes instruments to the surgeon -Assist in the draping procedure -Maintaining the sterility of the OR -Keeping the OR table neat while anticipating the surgeon's actions 	<ul style="list-style-type: none"> -Instruments count
Circulating nurse	<ul style="list-style-type: none"> - Machines are working well and instruments in place 	<ul style="list-style-type: none"> - Ergonomic work - Well functioning of the material - Sufficiency of the material -Assuring the comfort of the surgical team 	<ul style="list-style-type: none"> - Reinstallation and transportation of the patient - Cleaning the OR - Traceability of the patient's record (written and computerized)
Anesthetist/ Anesthetic nurse	<ul style="list-style-type: none"> - Interpreting pre-surgical tests - Assuring that adequate blood supply is available 	<ul style="list-style-type: none"> - Monitoring functions and parameters - Monitoring reactions to anesthesia during the surgery, vital signs, oxygen level communicate them to the primary surgeon 	

Table 3.2: Surgical team individual roles

3.3.3.2 Roles Dynamics in the OR

World health organization (WHO) insisted since 1978 on the importance of teamwork in healthcare. This concept has taken firm hold in healthcare. Some medical tasks may be too complex or require different specialization therefore teamwork is needed. In literature a team is consistent of two or more individuals having a common goal each one with a specific role working together interdependently (Salas et al. 1992)

Lots of studies already focused on the importance of teamwork on the positive outcome of a surgery. All the studies done in assess the performance in the operating room insist on the importance of coordination. Interactions between team members are essential for an effective team performance. Communication, coordination and technical proficiency are at the center of good teamwork (Leach et al. 2011).

Surgical team members have specialized expertise. They are used to work under time-pressure and uncertainty with high level of coordination.

Non-technical skills are very important in surgery. Although it is difficult to identify these skills, couple of studies started being interested in these sort of expertise. Currently, non-technical assessment of surgeons is still at its infancy. However, the proposed draft of non-technical skills is presented in the table below (Yule et al. 2006).

Interpersonal skills	Cognitive Skills
Communication	Situation awareness
Leadership	Mental readiness
Teamwork	Assessing risks
Briefing/ planning/ preparation	Anticipating problems
Resource management	Decision making
Seeking advice and feedback	Adaptive strategies/flexibility
Coping with pressure/stress/ fatigue	Workload distribution

Table 3.3: Non-Technical surgical skills (Yule et al. 2006)

The figure below represents a sociotechnical view influences on surgical team performance and thus surgical team outcome (Leach et al. 2011).

The environment nature inside the OR is very dynamic. It is a changing environment characterized by team adaptability and coordination. The roles and behaviors of surgical teams emerge in the OR during a surgical procedure. Team members have expectations about their respective roles. These expectations shape their individual and collective behaviors (Leach et al.2011).

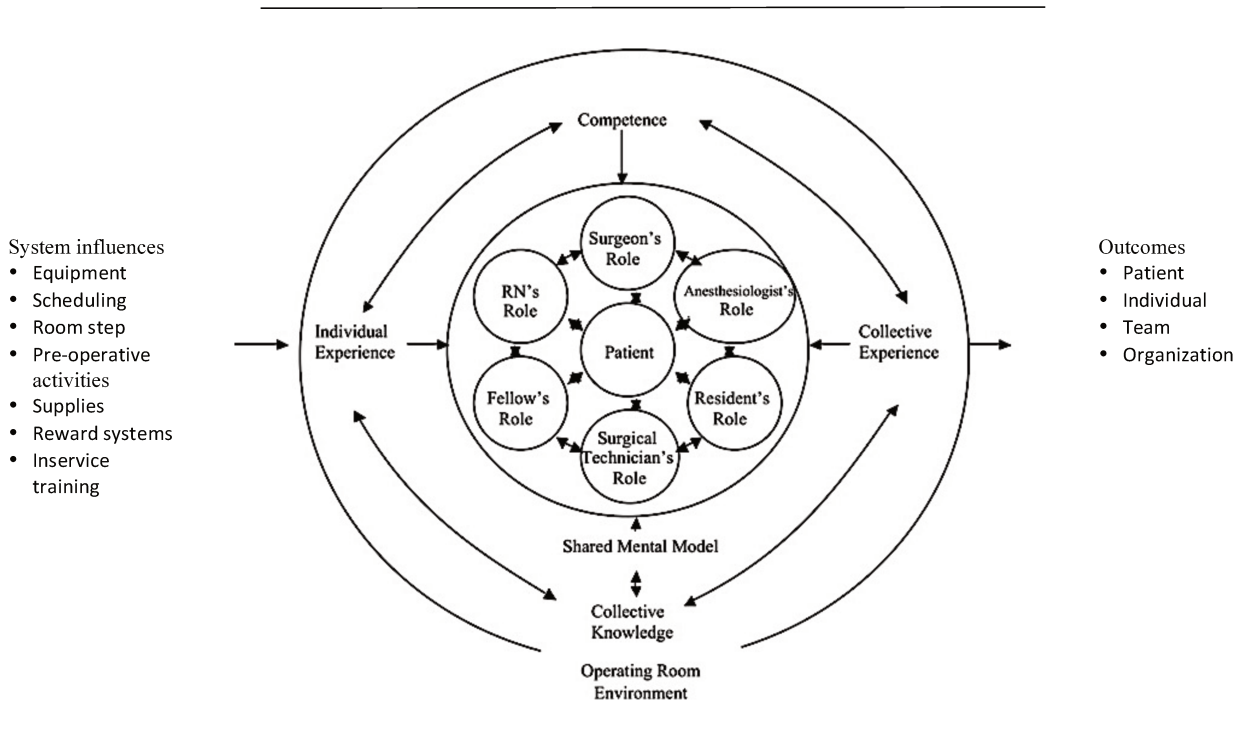


Figure 3.6: Sociotechnical view influences on surgical team performance and surgical outcome (Leach et al. 2011)

Chapter summary

In this chapter we presented the medical context. We illustrated the evolution of surgery with its two main evolutions: from conventional open surgery to mini-invasive surgery, laparoscopy, and from this latter to robotic surgery. In addition to that we presented the specific roles of each team member in the OR that makes an efficient. At the end of the chapter we presented the comparison done in medical literature on laparoscopy and robotics: couple of studies exist on the technical benefits for both types of surgeries. In addition, it is not until recently that medical scholars started being interested in the change that robotics pursue on the non-technical, personal and interpersonal level.

Literature Gap / Summary of Part I

We illustrated in part I an overview of three different literatures that we base our analysis on.

In chapter one we presented the different concepts that define an expert and expertise. Using the naturalistic approach, we developed the literature on an expert's decision making process more specifically the recognition-primed decision model. This model enables the expert decision maker to take adequate decisions based on prior familiar experience facing the same situation. Otherwise, under uncertainty, changing environments when the situation is not familiar, the expert adapts his course of action accordingly. Using sensemaking and situation awareness the expert will be able to collect cues to understand well the situation he is in and therefore take the appropriate decision thus course of action.

In chapter two, we presented an overview of routine's literature. We focused our presentation on how routines maintain stability and how they evolve in changing environments in particular when an organization adopts a new technological artefact.

The last chapter in part I presented the medical context. We started our presentation with a general overview of healthcare. We divided healthcare into two main parts: diagnosis and treatments. Our interest is the treatment part, more specifically surgical procedures. In addition to that, we illustrated the different roles of team members in the operating room during a surgery. After the presentation of the surgical evolution and existing technologies in this field, we described in details the robotic

surgical procedure especially the robotic system that we base our study on. Furthermore, we reviewed couple of research on robotic surgery.

Despite the growing interest in healthcare, specifically in new technologies implementation, there is still a lack in literature on the impact of robotic surgery on different aspects. There is a lack of studies that demonstrate the effect of a new technology on decision making process of an expert in healthcare where not only the individual is affected but also the rest of the team. Recent studies have already started to be interested in the impact of a robotic system on communication between team members. Thus studies did not develop further the impact on coordination and on operating room practices therefore affecting team members' routines.

With our study, we contributed to both literatures and created the link between the individual and collective perspective.

Part II

**Towards a comprehension of technology implementation process
and its effects**

Chapter 4

Methodology: methodological choices and methods of analysis



Chapter 5

Implementation of a technological artefact in surgery: robotic system in bariatric surgery



Chapter 6

Comprehension of the technological implementation process and its impact on the individual and collective level

Part II - Overview

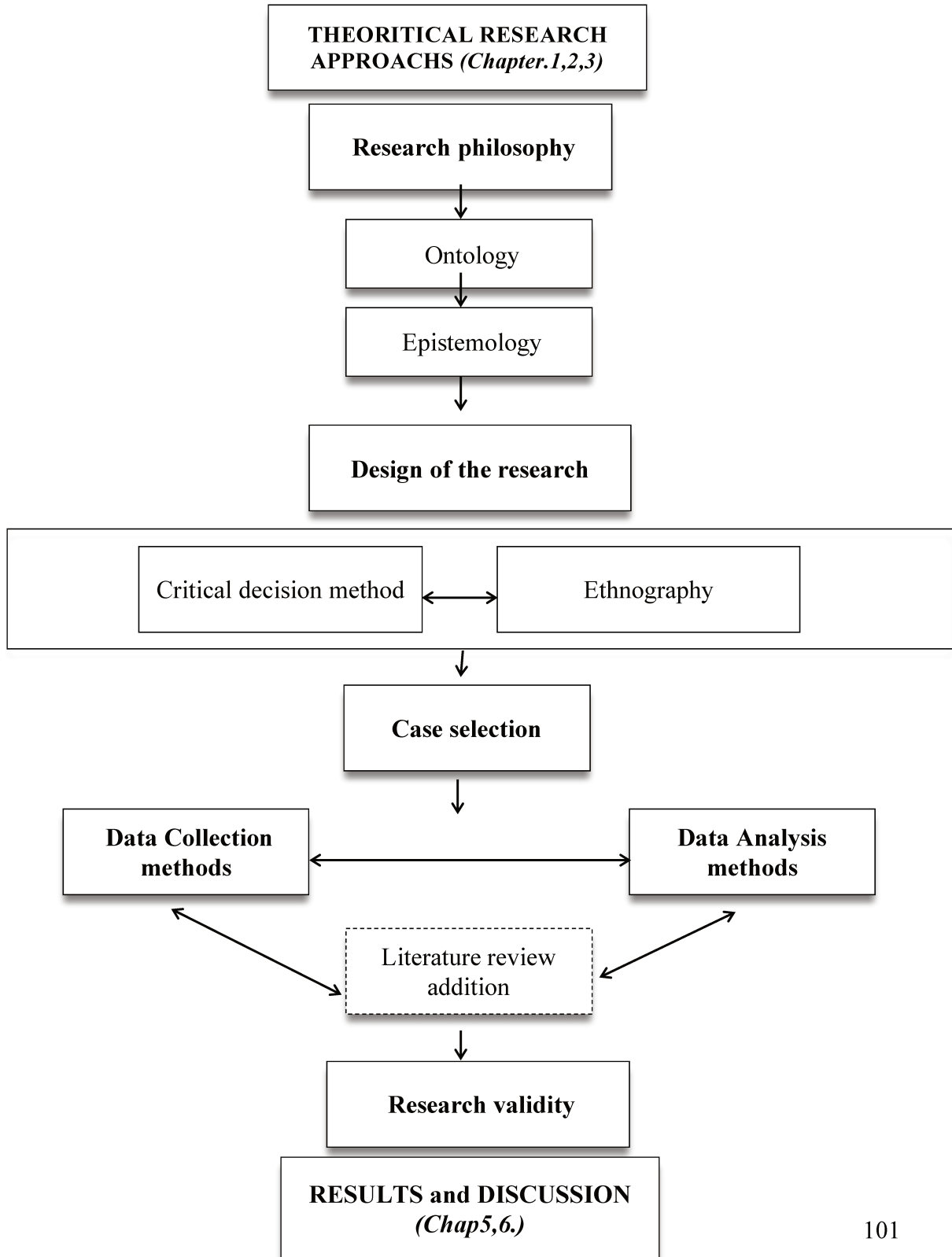
The aim of this part to generate result from our field study and data. We start this part with chapter 4 that presents the methodology adopted in our study including the research philosophy, methodological choices, the methods adopted for analyzing the data and presentation of the observation field. We present our data findings in chapter 5. These findings include data from both interviews, our observation and video analysis. We end this part with the discussion chapter where we discuss the results of our study by creating a link with the theoretical aspect presented in part I.

Chapter 4 : Methodological choices and methods of analysis

Chapter introduction

The purpose of this chapter is to present the research methodology. To facilitate our methodology presentation, we present a figure that clarifies our methodological choices. This chapter is divided into two main sections. The first section presents the research philosophical aspects in terms of ontology, epistemology, methodology and research design. This section is followed by the research execution and the methodology used for the data analysis. A summary of the chapter is provided at the end. The figure below presents the general planning of the research with a presentation of the different section of this chapter.

Figure 4.1: Research planning



4.1 Research type

Frascati (2015) characterized research and development R&D into three main categories based on the type of activity of the research: basic research, applied research and experimental development one. We classify our research between applied research and experimental development. It is the same time an investigation to acquire new knowledge directed to a certain objective (applied research). But, in the same time this work draws knowledge from practical experience directed into improving existing product or process: new technology implementation specifically robotic surgery (Frascati 2015).

4.2 Research philosophy

As Johnson and Clark (2006) noted, it is important to be aware of the philosophical commitments we make through our research strategic choices since it will affect directly what we are studying. Research philosophy contains assumptions on how a researcher sees the world and reflects the researcher's methodological choices.

The methodology applied in a study reflects the philosophical perspective of the researcher. Our research started without a predefined philosophical positioning. It was constructed all along the research in an incremental manner and faced couple of adjustments (Baumard, 1997). Denzin and Lincoln (1994) explained that the epistemological and methodological

approaches of a research are not well established in advance but they are largely influenced by the research context.

Alvesson and Sköldberg (2009) argued that ontology and epistemology are determinants of a good social science rather than just a simple method.

Therefore, a researcher who has a profound understanding of the philosophy reflect the philosophical choices and can defend better the adopted strategies to conduct the research (Saunders, Lewis, & Thornhill, 2009).

The figure below is a graphical presentattion adapted by Saunders et al. (2009) of the different philosophical choices. It is know as the research “Onion”.

Saunders showed in this model the choices involved in developping the research design. These choices englobe philosophies, aproaches, strategies, choices, time horizons techniques and procedures.

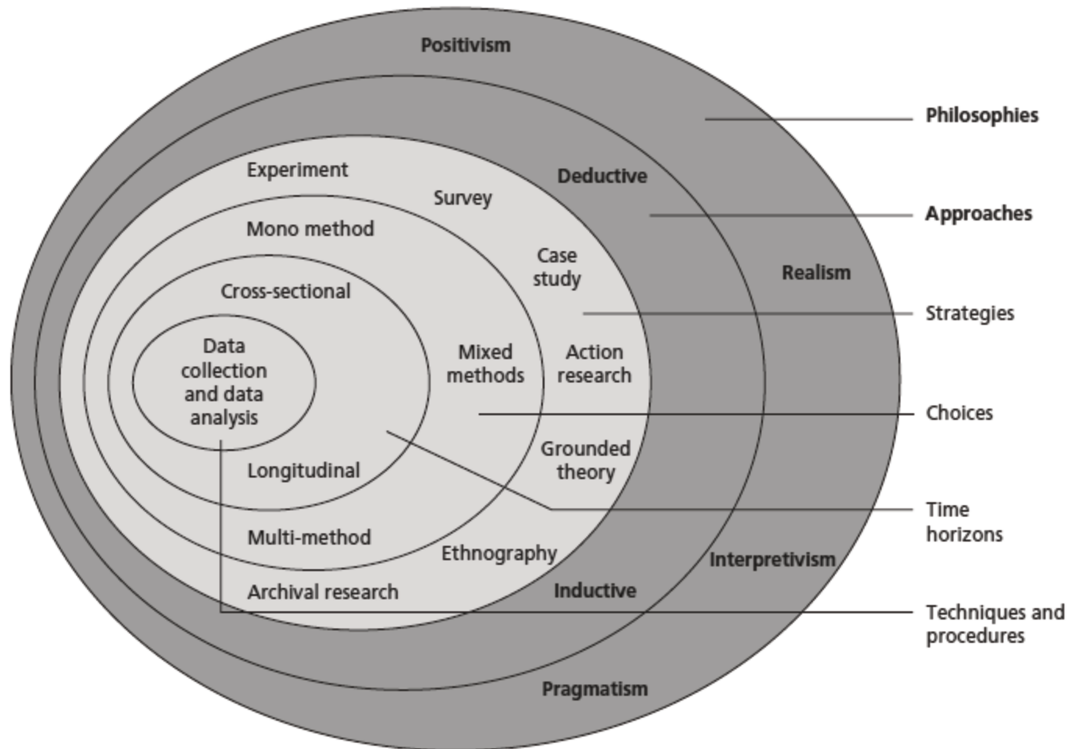


Figure 4.2 : The Research 'Onion' (Saunders et al., 2009, p. 108)

We are going to present in this section the research paradigm in terms of ontology, epistemology and methodology. A paradigm is: *“a set of basic beliefs (or metaphysics) that deals with ultimate or first principles. It represents a worldview that defines for its holder, the nature of the world, the individual place in”* (Guba and Lincoln, 1994 p.107). In the following sections we present the founding assumptions or the “what exists” represent the ontological assumptions followed, the epistemic assumptions represent the origin/nature of knowledge and finally the methodological assumptions or how knowledge is elaborated.

From the different existing scientific interpretative and critical paradigm, interpretative paradigm is the one coherent with our research study.

Interpretativism is the most used approach in Organization, management and information system research. As Yanow (2006) refer to it, interpretativism include phenomenology, hermeneutics, interactionism, ethnomethodology and others.

4.1.1 Ontology

Ontology is concerned about the *what is*, the study of being (Crotty, 1998, P10). It represents the research's view of the nature of reality. The reality of things in other words how things work. Ontological position of interpretative paradigm is relativism. This latter presents our ontological perspective. According to Guba and Lincoln (1994) realism consists of the fact that reality differs from person to person.

4.1.2 Epistemology

The choice of the epistemological positioning affects directly the reasoning of the research. Epistemology is concerned about the nature and forms of knowledge (Cohen at al., 2007, P.7). It represents the research's view regarding what constitutes acceptable knowledge.

Interpretative epistemology is based on subjectivism, which is based on real world phenomena. Knowledge and the world are interdependent.

The aim of this research is to understand the effect of a new technology on expertise from one side and on the collective team interaction on the other side. Our study is based on the analysis of organizational reality.

In order to answer our research question, we adopted an interpretative perspective. An interpretative methodology perspective is to understand a phenomenon from an individual perspective. It consists of investigating interaction among individuals (Creswell, 2009, P.8). Interpretative perspective considers that the reality is socially constructed (Berger, Luckmann, 2011). The objective of interpretivism is to understand how humans create sense to the world individually or collectively (Klein and Myers, 1999, Sandberg 2005). Knowledge is collected through plausible interpretations that fit lived experience. It takes narratives form supported by thick descriptions (M.J Avenie & C. Thomas, 2005).

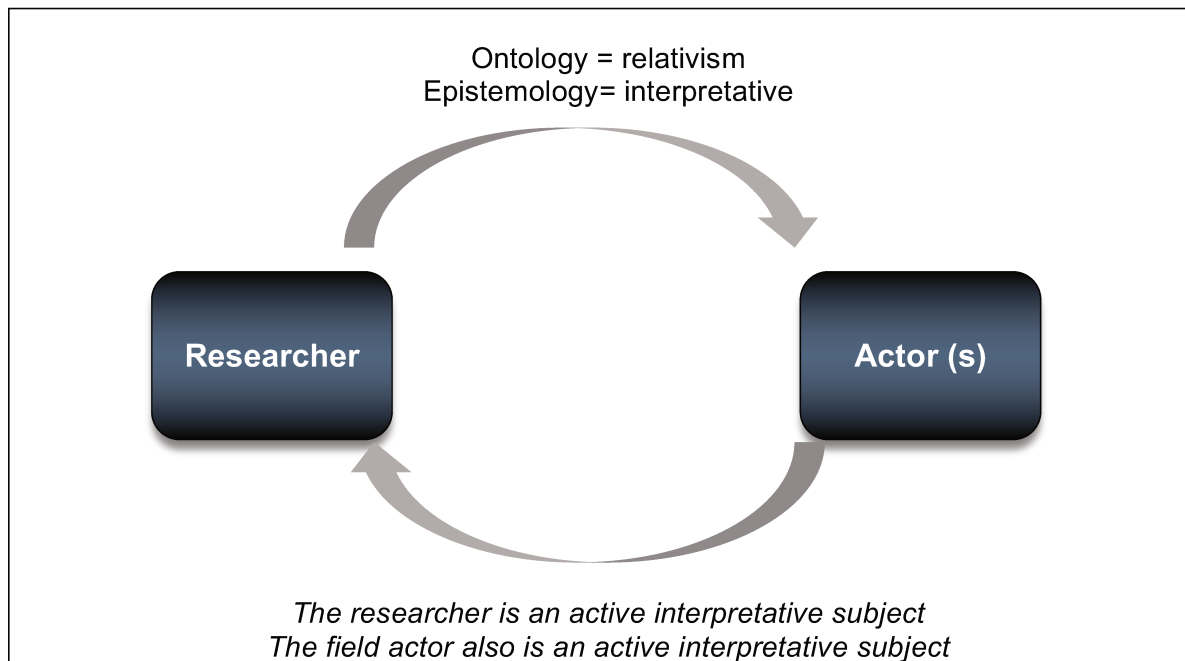


Figure 4.3:
Interpretative approach (Gavard-perret, Gotteland, Haon & Jolibert 2012)

The table below presents the different aspects that characterize interpretativism and therefore our study.

Ontology	Reality is socially constructed, subjective and may change. Human activity is structured. Not governed by any natural laws.
Epistemology	There is a reality behind the details of a situation. Subjective meanings that motivates actions. There is interdependence between the actor and what he is studying. The intention of an actor influences his experience.
Axiology (Role of values)	The researcher is subjective. He is part of the study and cannot be separated.
Knowledge objective	Understanding the interpretation processes and situation engagement.
Justification techniques	Ethnographic and hermeneutic methods.
Data collection techniques most used	Qualitative methods, in-depth investigations using small samples.

Table 4.1: Criteria of interpretative researches (M. Sauders, P. Lewis, A. Thornhill, 2009 p.108) & (Avenier, Gavard-Perret, 2012).

4.3 Research design

Our research is a qualitative study that was developed in an incremental manner over time. Knowledge creation is a recursive process of abductive, deductive and inductive nature. The choice of an iterative inductive approach led us to construct a research question based on the data field findings. Induction approach begins with open mind on theory and letting theory emerge from the data. It allows the data speak up for themselves. It is usually the adopted method in ethnographical study. Induction is a hybrid approach. It consists in the same time to infer from the observed actions and to deduct from the existing theories. Induction consists of going back and forth between observations and theoretical knowledge all along the research process. He will support his empirical observations with theory while going back and forth frequently between empirical material collected and the theory. Our objective is to construct a mental image of the reality (David, 1999) from a procedure that starts with facts observation.

Our methodology is a combination of two methods: critical decision method (CDM) and the heart of our research is an ethnographical study. The CDM is an approach to cognitive task analysis. It has been used to elicit expert's knowledge. Following this method let us understand expert's performance. On the other hand, ethnography is a "methodology used to study the methods in which members concedesly produce and assemble the features of everyday life in any actual, concrete and not hypothetical or theoretically

depicted setting” (D.W. Maynard and T. Kardash). In order to examine the impact of an artefact of group members, ethnomethodology explores how people interact and establish a sense of social structure. The schema below presents a summary of the combined two methodologies and the methods used for each one.

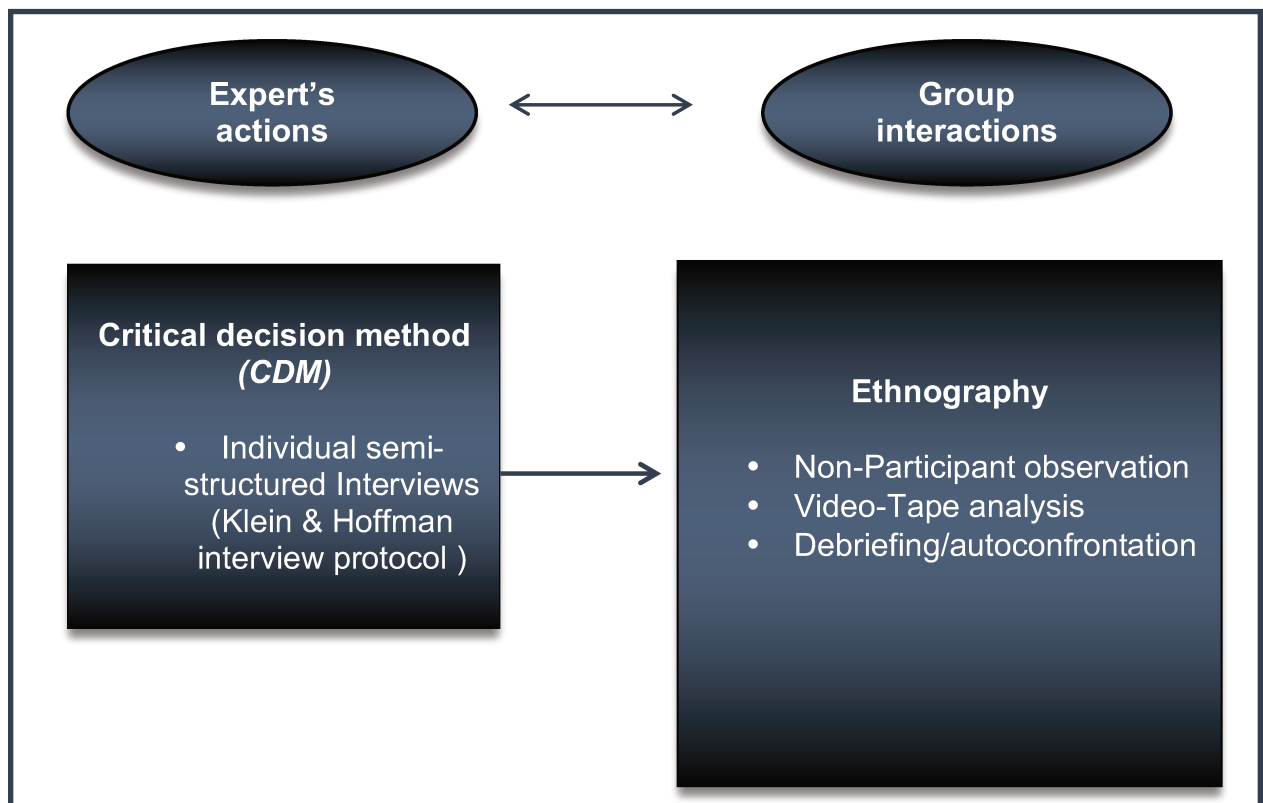


Figure 4.4: Methodologies methods

Our study is mainly based on non-participant observations that are videotaped and analyzed later on. Our methodology consists of a four-step process: (a) interviews with surgeons (b) non-participant observations in the operating room (c) analysis of the video-taped surgeries (d) debriefings and auto-confrontations with the video taped surgeries.

Video analysis is a technique introduced by the Goodwins in the 70's for social science and in medicine in 1986 by Christian Heath to observe medical consultations.

Our case study is a robotic gastric bypass surgery. Observation is conducted in the operating room while surgeons are pursuing their professional activities as experts and team members are achieving their usual behaviors.

A preliminary step before the elaboration of our research was the search for initial information that we consider a starting point to understand and lead our observation process. We were in contact with surgeons that are familiar with the field of new technologies in medicine more specifically robot surgery. Not coming from a medical background, these semi-directive interviews allowed us to choose wisely our case study.

The second step after the data collection from the semi-directive interviews was the actual starting point of our study. These interviews are based on the naturalistic approach interview protocol. It consisted of a direct field observation of actual real life situations: robotic surgeries. This led to the emergence of our research question. These observations were recorded for further analysis. Data collection from the observations respect the naturalistic approach that requires that participant's activities be observed in their ordinary social context (Mondada 2006).

The third step was the analysis and the development of our observations. This step was achieved with the transcription of the videotaped surgeries in hand. In addition to that for additional insurance and investigation, couple of

sessions of auto-confrontation was conducted with the observed team in order to validate further our analysis.

4.4 Methodology

4.4.1 A qualitative research method: Critical decision method

In order to study the impact of an artefact on an expert, we wanted to form an interview that will enable us to lead the experts to recognize a situation when they were dealing with a new technology. We used critical decision method (CDM) (Hoffman & al. 1998) in order to analyze in depth expert's actions. This method is coherent with our research theoretical approach on naturalistic decision-making, in particular recognition-primed decision model (Klein, 2008).

From another hand, this method is also inspired from ethnography that we base our study on. The CDM was developed out of a desire to capture the kinds of knowledge and experience involved in real-world decision-making and problem solving (Hoffman 1998). This method was initially called "Critical incident technique". Klein, Calderwood and Clinton-Cirocco (1986) developed this method while working with firefighters by letting them recall a specific situation and assess all the decisions and actions taken. These studies combine with others led to refinement of the critical incident method especially issues questioned concerning reliability, validity and efficiency of the method. These refinements let consist led to the formulation of Critical Decision Method (Klein, Calderwood & MacGregor, 1989).

Different methods exist to study expertise and expert's performance. We choose CDM since it is the method used by the naturalistic approach to study the decision process and actions of an expert in his operational context. CDM is an approach in cognitive task analysis. This study is mainly used to study how experts take decisions and choose their course of actions. The decisions taken are then compared to novices' ones, in our case the surgeon's assistant, in order to compare the differences in the decision-making process.

This interview method consists of guiding the expert with semi-structure questions to a certain situation when his expertise was tested. In our case, we were interested in testing the expert's actions while dealing with the robotic system and compare it to a novice's one.

Based on Hoffman (1998) interview protocol, the questionnaire was divided into different themes: description of the problem, planning, signals, options, interactions, experiences, objective, action, knowledge, hypothesis and result of the actions taken. The CDM procedure is summarized by the 6 steps procedures:

Step 1: preparation

Step 2: incident selection

Step 3: incident recall

Step 4: incident retelling

Step 5: Time line verification and decision point identification

Step 6: progressive deepening

(Hoffman 1998). We developed our questionnaires according to these previous steps (questionnaire found in Apendices).

4.4.2 Ethnography:

As mentioned before, we started our field work with semi-structured interviews based on CDM. Our research is an ethnography study. In contrary of CDM, ethnography “is not interested in individuals as such but in the competences involved in being a member id a collectivity” (P. Ten Have, 2004). The objective is understanding social life as the outcome of interaction of structure and agency through the practice of everyday life (K. O’neil) it is the best way to learn in details on complex social phenomena (Adler 2007). It is about learning about people within the context of their own life. The term ethnography became more common recently. It raises the question on managing relationships. Our aim is to study the effect of an artefact not only individuals but also on collective work or organizational routines.

Till nowadays, there is still a misunderstanding about ethnographic work. Storytelling lies at the heart of ethnography (Jarzabkowski et al 2014). We used mainly this technique (storytelling) to present our data. We described the scene setting with to transform our fieldnotes (annex 3) and observations into meaningful and vivid narratives.

The main characteristic of this method is to study the methods and common knowledge used by individuals to deal with their daily life or activities (M. Andon 2006, p.21). Two main focuses for ethnography. First one is studying

how individuals acquire their cultural perspective and use them in their daily life. Second focus of this this method is conversational analysis.

Ethnography permits to understand how people “construct mutually intelligible world”. This is done through the study and analysis of the situated actions: what exact actions are taken in a particular situation. In order to answer a part of our research question: what is the impact of an artefact on routines? we conducted an ethnographical study of people working together. We observed operating room teams that are operating with robotic surgery. In our case we are facing a situation where unexpected events can occur. They are dealing with a new technology therefore people are not familiar with the situations that can occur.

Ethnography is coherent with our research objective since is not only concerned with how people act and interact in familiar situations but also when actions deviate from ordinary settings. Participants make sense and take actions based on their prior actions.

4.5 Case selection

4.5.1 Field presentation

The objective of our research is to understand the impact of a new technology on on an expert and on organizational routines. This research question is large enough not know from the beginning the final articulations. In the same time, it is accurate enough to enable us to focus on how the experts (surgeon) and individuals are elaborating in the operating room.

Our research began with an interest on the impact of a new technology on an expert then it was expanded to organizational routines. Healthcare is a field that interested us specifically due to the big effect of technology adoption on physicians, teamwork and on the organization as a whole.

It is necessary then to explain our approach by specifying the exact process observed.

In order to understand this impact, we used a triangulation between semi-directive interviews, non-participant observation and videotape analysis.

To investigate the proposition that a new technology has a direct effect on roles and hierarchy in an organization, we collected live data from a hospital adopting the Da Vinci robot technology.

We started our research with 20 interview based on Hoffman and Klein's interview protocol (appendice). This interview protocol took into consideration the interaction between human cognition and technology. The objective of these interviews is to describe the relation between surgeons and a new technology; The impacts of this new robot on the surgeon's behaviors, decisions and course of actions. In order to study the impact of an artefact on routines, we chose the medical field and robotic surgery as a case for our study.

Centre hospitalier de Nice- Archet (CHU) is one of Nice (France) hospitals with 602 beds. The hospital is specialized in different areas in medicine. It has several departments: cardio vascular department, anesthesia and intensive care department, digestive-gynecology and obstetric department,

imagery department, laboratory department, neuroscience clinic department, odontology department, medical specialty department and finally urology-nephrology department. The hospital provides a range of standard and specialty services.

Technical platforms in the Hospital

The hospital is involved with the technological development. It has different types of technologies that be divided into three groups.

First group is the medical imagery and functional exploration. These technologies globe the technologies that present the techniques to create visual representation of the interior of the body. In addition to that, techniques that presents visual presentation of the functioning of some organs and tissues. The second group presents the surgery and therapy equipment. These are equipment used in the therapy process or during the surgical procedure as a semi-assisted technology for the surgical act.

The third group represents technologies that are related to medical biology or technologies that help during laboratory diagnosis.

The tables below present the different technologies present in the hospital grouped according to their utilities. This show the commitment of the hospital to having new techniques and technologies.

	2014	2015
Gamma Camera	1	1
MRI	3	4
Scanner	4	5
Biplane interventional neuroradiology room	1	1
Optical coherence tomography	1	1
Numerical electrophysiology room	1	4
Exploration system of the autonomous nervous system	1	1
Coronarography room	1	1
Navigation system (cardiology and pneumology)	2	2
Multi-laser microscope for advanced melanomas diagnostic	1	1
Position emission tomograph	1	1
Numerical Angiopgraphy	2	2

Table 4.2: Technical platform of medical imagery and functional exploration

	2014	2015
Extra- corporel Lithotritor	1	1
Neuro-navigation system	1	2
Navigation systems (ORL and Pneumologic)	2	2
Da Vinci Robot	1	1
Hyperbaric chamber	1	1
Robotized device for stereotaxic and tumor neurosurgery assistance	1	1
Ophthalmologic laser	1	1

Table 4.3: Technical platform of surgical techniques

	2014	2015
Automated multi-parametric of biochemistry	11	26
Automated multi-parametric of immune enzymology	14	27
Automated multi-parametric of hemostasis	6	6
Robotized chain of hematology	1	1
Chromatography chain in liquid phase	8	7
Chromatography chain in gas phase	4	16
Spectrometer of atomic absorption	2	2
Mass spectrometer	8	10
Images analyzers (caryotype)	5	9
Images analyzers (Fish technic)	5	3
Images transmission posts	4	3
Thermo cyclers (molecular biology)	15	19
Automated hematology (numeration formula)	6	6
Molecular biology sequencers	15	19
Nucleic acid extractor	12	13
Quantitative PCR automated	8	11

Table 4.4: Technical platform of medical biology

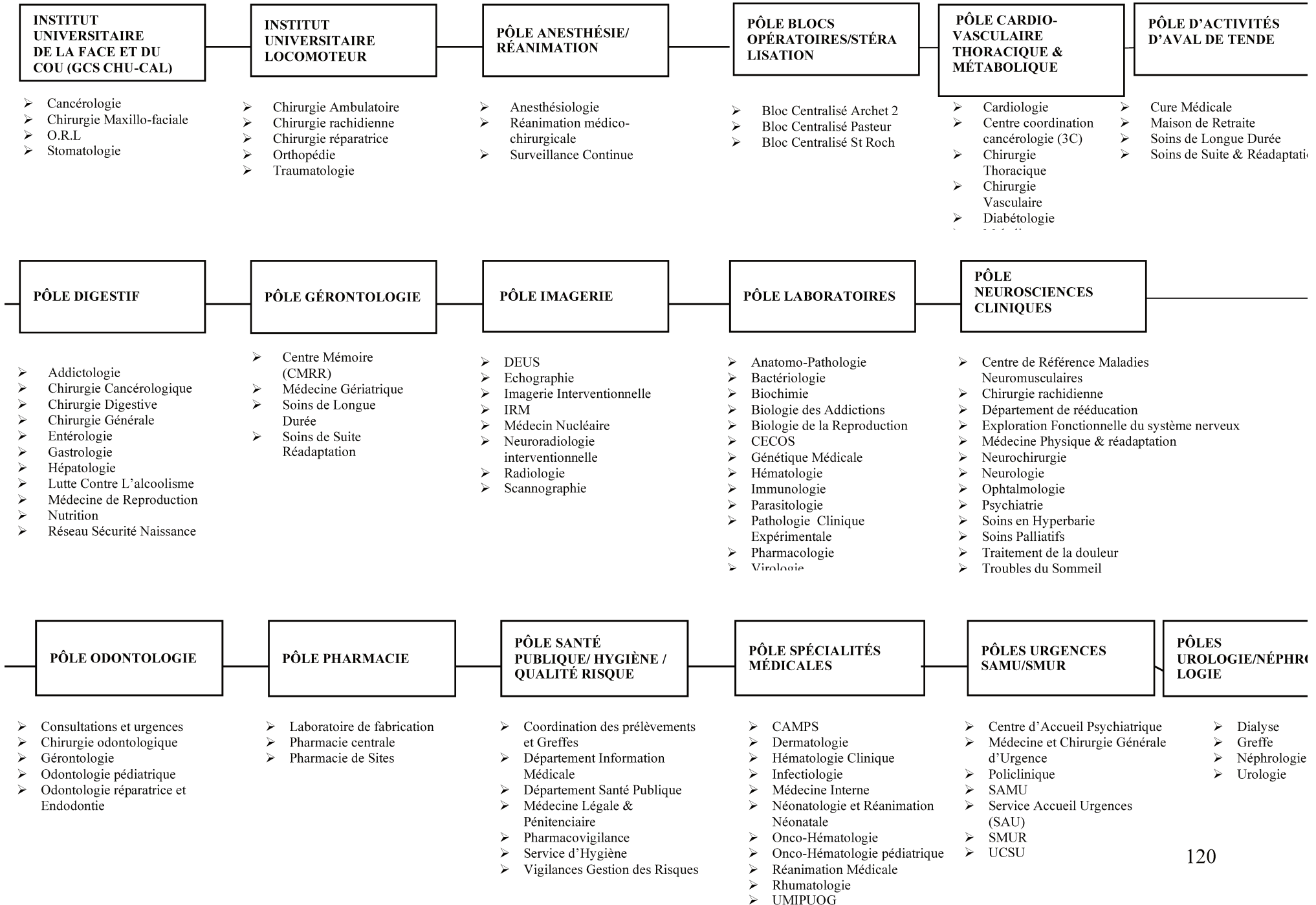
General digestive surgery and hepatic transplantation

In this section we are going to present the digestive surgery unit since it represents the unit that we observed the surgeries in. This unit is in charge of all pathologies of digestive surgery: general surgery (hernias, eventrations, abdominoplasties); bariatric surgery; hepatic surgery; cancerologic digestive surgery. This unit has 18 beds for general digestive surgery and hepatic transplantation. Beside the doctors, a team is available for the patient when hospitalized. This team consist the unit chief, the social assistant, a dietitian, a stoma nurse, a psychologist, a transplant coordinator.

The hospital's aim is to be always updated with the recent technological development in the medical field. Technological developments globe surgical, diagnosis and treatment. Robotic surgery is one of the developments that the hospital is specialized in the area. The Da Vinci robot is a semi-assisted robot adopted recently by the hospital. This semi-assisted robot is used in different types of surgeries. The use of the Da Vinci robot is limited to a certain type of surgeries. Since the benefits of this new technology is still under examination. The most common use of Da Vinci robot is in neurology. It demands lots of precision. The precision that a surgeon obtains by the use if the robot is high: the degree of liberty of the robot is 360 vs. 180 of the human hand rotation.

The figure below presents all the units of the hospital including the digestive unit where we were observing.

Figure 4.5: Units of the hospital



4.5.2 Case description

4.5.2.1 Laparoscopic bypass gastric surgery (*Chap.3 presents detailed medical context description*)

Laparoscopic bypass gastric surgery is a mini-invasive surgery that has the same benefits as an open gastric bypass surgery. The main difference between mini-invasive surgeries and conventional surgeries is the accessibility to the organs and tissues: the access is done through small incisions. In laparoscopic surgery, the surgeon is operating through small cuts instead of having a large surgical cut to open the patient's belly. This surgery uses special instruments and a camera inserted through the cuts. The camera is connected to a video monitor that will enable the surgeon to have a general view inside patient's belly. This procedure consists of creating a small stomach pouch and attaching it to the lower section of small intestine. The stomach is stapled and transected. The food will bypass the stomach directly to the lower section of the intestine. The capacity of the stomach is reduced from 1,5 liters to around 30 ml. The surgery is a two steps surgery; the first step consists of dividing the stomach into two parts will using the staples. The small upper section of the stomach called pouch and the larger lower section. The second step consists of connecting the pouch of the upper section to the lower small intestine. This connection is done with a small hole in the pouch.

Gastric surgery is one type of surgical procedures in which robotic can be used with less technical benefits accorded to it. Our focus was in the digestive department more precisely robotics in gastric bypass surgery. Gastric bypass surgery is not considered a risky surgery. We are looking

to understand the impact of robotic surgery while eliminating all other variables. This is the reason why we choose this type of surgeries.

4.5.2.2 Da Vinci robot

Mini-invasive surgeries appeared couple of years ago to surpass the limitation of conventional surgery. However, even though mini-invasive surgeries have positive impacts by avoiding some complications from the patient's side, the surgeons were having some technical problems mainly the accessibility to the organs and degree of liberty were so limited.

In order to surpass all the technical problems of mini-invasive techniques, robotic systems started to expand their attention on mini-invasive or laparoscopic surgeries.

Da Vinci robot is a system with two components: the console and robotic arms. The surgeon is sitting on a console facing a 3D display while manipulating the instruments. Robotic arms are mounted on a four-armed patient cart. The manipulations of the surgeon are transferred to the robotic arms and are translated into precise movements.

The figures below present the two types of surgeries.



Figure 4.6: Robotic surgery



Figure 4.7: Laparoscopic surgery

4.6 Data Collection

As suggested by Miles and Huberman (2003), we adopted different forms of data collection.

4.6.1 Semi-directive interviews

The interview concept is based on the questioning practice of the subject with a non directive attitude of the investigator facing the subject (Baumard et al. (2003). The semi-directive interview follows a certain protocol with different themes. The interviewer a particular question linked to a certain theme before or after another based on the interviewee answers and sequence of ideas.

We questioned around 20 different surgeons between France and Lebanon having different surgical specialties. Surgeons interviewed were surgeons that used already the robotic system. All these interviews contributed in shaping a general overview on the subject and to have a closer understanding of the medical field.

This is coherent with the naturalistic approach, which we base our study on, that take into consideration decisions taken by experts in their “natural” environment.

To elaborate appropriate and more precise results we used the data found in the interviews to establish a common ground to our next in depth analysis. What emerged from our interviews were changing routines therefore coordination, role, hierarchy and the learning process.

4.6.2 Non-participants' observations

Qualitative approach is carried out by the use of detailed observations (Van Maanen et al., 1982). The data focus on events that take place in naturel context in order to really know what is happening daily, in real life (Miles & Huberman, 2003, P.27). The most common way to ethnographic research is to observe naturally occurring events. This is done by non-participant observations. We used fields notes that we transformed later one into meaningful storytelling. These fields notes were sufficient evidence of the concepts that we were trying to convey. These observations are often accompanied by the use of audio or video recording. In our case we videotaped the whole procedures observed. This will enable us to observe as closely as possible the actions pursued.

We observed 20 robotic gastric bypass surgeries and 5 traditional mini-invasive gastric surgeries. The average time for a surgery is around 3 hours. Starting May 2013. The majority of the surgeries were recorded, transcribed analyzed and coded. Mainly the same surgical team was observed in order to analyse the evolution of the implementation in time. We observed another team to compare the interaction between them. We recorded and analyzed the conduct of the surgeons while operating with and without the da Vinci robot. From one hand, we observed the "talk" while using conversation analytic. Talk is always situated between artefacts and tools. This is coherent with the notion of socio-materiality presented by Orlikowski (2007) that focus on the important of both materiality and social aspects in an organization. From another hand, we

observed also the material aspects in our live non-participants' observations and video-recordings.

4.6.3 Debriefing

(a) Presentation

We are following an ethnographical approach. Our aim is to observe the interaction between participants and interpreting these interactions with the new technology in our case robotic surgery. In order to understand better and to give more sense to our analysis, we chose to do a debriefing with the OR team members. Group interview and debriefing benefit from the interactions between members and permits to analyze the processes of interrelations of actions. This group interview was semi-structures. We had some themes that we wanted to abord with the team members we interviewed the surgeon leading the surgery and we did an auto-confrontation of the whole team that was present in the OR with the videotaped surgery.

The mix of the observation analysis and interviews are complementary strategies of ethnography

A debriefing is an exchange between two or more individuals to think about a sequence (a simulation) in which participants are encouraged to explore and analyze their actions, their decision process, their emotional states and other elements in the objective of analyzing their performances in real situations.

This debriefing helped us explaining more the different phenomena observed earlier. Our aim was to understand the non-technical interactions during an operation while using a video analysis.

The objectives is to decrease the problems faced in OR and ameliorate the work quality in order to decrease psychosocial risks. The purpose is to film an operation and to debrief some sequences or the totality of the surgery. The debriefing was done in the presence of a psychologist specialized in debriefing methods. Patient's identity is preserved due to the operating field and materials. The acceptance of health professionals and practitioners is necessary. The confidentiality is guaranteed. The debriefing was done on the non-technical elements: communication, coordination, mutual activity control, and different members' interactions. This was based on the elements and data found in literature on routines, expertise and CRM (Crew resource management) To evaluate the effectiveness of this process, we proposed satisfaction questionnaires and a measure the recurrence of undesirable events before and after the debriefing.

We know that for more than 10 years, according to IOM report "to err is Human-Building a safer health system", that the undesirable events associated to healthcare are frequent (8th cause of mortality in the USA). French research ENEIS of 2005 and 2009 has put a frequency of around 1 undesirable event every 5 days for a sector of 30 beds and 4,5% of total hospital stay. Database showed an important percentage on communication bias: the defiance of communication in a team is the most important common cause of medical errors. Around 70% of the analyzed

events by the Joint Commission proved that a communication problem is the initial cause of these undesirable events. Veterans database (Veterans administration National Center for Patient Safety Database) shows same results with a percentage of 75% for communication problems. We also know that the quality of teamwork impact directly the patient's security. Ameliorating teamwork is efficient to ameliorate the healthcare process and its results. A recent work demonstrated a decrease of 18% of mortality after putting a special program to ameliorate teamwork.

For instance, technical elements debriefing while using surgery videos already proven its efficacy (Zuckerman et al., 2012) (hand et al., 2007).

(b) Debriefing phases

Debriefing should allow participants to:

- Express their reactions
- Analyze what happened and consider an application to their practice
- Resume their learning process

Phase 1: Invite the participants to express their reactions

Formulate open questions directed to each actor. Accept and encourage the reactions.

Phase 2: Analysis

The aim of the analysis phase is to give sense for the situations and actions taken. The objective is to make the participants question themselves on the cognitive process and the emotions that guided the actions.

It consists of introducing new practices and tools for ameliorating teamwork.

Phase 3: Synthesis

The target of this phase is to synthesis the end of the debriefing, to mention the most important points and to summarize the session as principles to remember in way that participants can assimilate them and use them for future practice.

The majority of the debriefings aim to ameliorate weak performances but they also to explore good ones: what actions or processes let a person or a team be efficient.

The American governmental TeamSTEPPS and the program PACTE of the HAS that have as objective to communicate patient's security insist on 4 main domains in the team life. (1) communication (2) letting each member playing his role (3) controlling the situation (4) help each other.

Here are some tools that help ameliorate these domains:

(1) Communication tools

- Built a checklist
- Think aloud
- Directed communications
- Communication feedback
- Resume

(2) Leadership tools (a leader encourages team work)

- Collect other team member's opinion
- Inform
- Encourage the autonomy

- Not punish for errors
- (3) Tools for a mutual control of the situation
 - Describe the situation
 - Express concern
 - Suggest alternatives
 - Analyze reactions
- (4) Tools to help each other
 - Interprofessional collegiality
 - Express contradictions

4.7 Data analysis

Before proceeding to the data analysis phase, the data collected were transcribed. Transcription is understood as the graphic representation of the behavior of individuals engaged in a conversation (S. Kowal & D. O'Connell, 2004). The purpose of the transcription is reproducing in a written form the behaviors of the actors. The transcription is not a description. It is the exact words and behaviors of the actors. The purpose is not to describe but to have the biggest amount of similarities between the conversational behavior and the paper notation. We started the transcription of semi-directive interviews, observations notes and the videotaped surgeries. The transcription enabled us to take a step back on our own observations. It allowed us to understand better what was happening on the field while going back to what was experienced. The aim of the data analysis process is to create a meaning from the observation data in order to nourish the reflexion of the studied phenomena. Data

analysis consists on reducing the information to categorize them and link them before reaching to a detailed description, explication or configuration (Wacheux, 1996 p. 227).

As mentioned before, the first phase was the semi-directive interviews. The interviews were based on Hoffman interview protocol. We coded the answers by different themes that we found mainly emerging from the data. We used Nvivo software for our coding phase.

Second phase was analyzing the videotaped non-participant observations. Video analysis is a technique introduced by the Goodwins in the 70's for social science and in medicine in 1986 by Christian Heath to observe medical consultations. By using records of naturally occurring events, we can concentrate our analytic attention on the methods that individuals used in bringing off these events. Observing video-records and transcripts "fixes the details of the stream of life and makes them available for a non-participating onlooker" (P. Have, 2004).

We used the themes that emerged from the data collected from the interview as a base in our analysis. The videos were transcribed then coded by themes. For our coding method we used live coding (Feldman 2015). Codes emerges from our observation that enabled us creating and making sense of we were observing. We used GIOA method to analyse and make sense of our data (first order and second order analysis).

Conversation analysis is a method used to analyze the structure and process of social interactions. The characteristic of CA is the way it demonstrate how action, structure and intersubjectivity are managed in talk and interaction (Anssi Peräkylä). The analysis process starts with the

selection of the research site. The site choice is done according to what kind of interactions is important to us. Second step in CA is tape recording. Even if the research study or some of the research question does not involve any vocal interactions. The interpretation of body movement and the gestures of the participants can have lots of meanings. We filmed the whole surgical procedures even when there was not talk involved between the practitioners present in the OR. Additional information most of the time is used to contextualize the CA. We used couple of interviews and group interviews to have additional information that helped us contextualize the CA. Transcribing the video recording is the following step. The transcriptions were done also through gestures analysis from the videos. Exemple of photos taken from the video are presented in annex 3. This technique is used usually by psychologist to analyse in detail individuals behaviors and interactions in order to make a good story telling.

4.8 Reliability and validity of the research

Reliability of the research is an assessment of the data collection and analysis methods. If the data present consistent results. Therefore, if other researchers analyze the same data same results will emerge. Qualitative researches face lots of interrogations according to reliability compared to quantitative research.

On the other hand validity of the research assess if the research is supported by theories. The general validity of the research consists of testing different types of validity: internal validity and external one (Yin 1994). We present below a table that summarizes the different tests for the validity and reliability of the research inspired by Yin (1994)

	Principals	Techniques
General construct validity	Ensure that the right variables are used for the research by defining the concepts studied in order assimilate the right method to be used	<ul style="list-style-type: none"> • Clarify the studied processes • Use different source of information • Validate the results with the actors
Internal validity	Ensure the relevance and consistency of the research results	<ul style="list-style-type: none"> • Compare the empirical results to the literature • Exchange with the actors
External validity	Generalizing question	<ul style="list-style-type: none"> • Case selection studied • Accurate case description on different theoretical level
Reliability of the research	Ensure that the analysis and the results are the same with other researchers and in different time	<ul style="list-style-type: none"> • Control certain variables • Present in details the research method

Table 4.5: Reliability and validity test according to Yin (1994)

In addition to Yin four tests proposition to ensure the validity and reliability of the research, we followed Klein and Myers (1999) criteria to evaluate an interpretative research. These criteria are summarized in the below table (Klein and Myers 1999, P72).

	Principals	Techniques
The principle of Contextualization	There is a difference between the interpreter and the audience of a text therefore, the subject matter should be set in a social and historical context	Detailed description of research settings that will enable the reader to have detailed descriptions and understanding about how the situation studied emerged
The principle of interaction between the researchers and the subjects	How the research data were collected through the social interaction between the researchers and participants	The use of different source of data
The principle of abstraction and generalization	Relate particulars as described in contextualization to very abstract categories	Presenting a rich and accurate description that will allow the reader to adapt the results to other contexts
The principle of dialogical reasoning (or internal validity)	Confronting the theoretical prejudices guiding the research design with the actual findings	Considering different contradictory explications to the results
The principle of multiple interpretations	Taking into consideration the possible difference in interpretation and confronting the potential contradictions	Understanding and presenting details of the context and the participant's background

Table 4.6: Criteria of evaluating interpretative research Klein and Myers (1999)

In our research study we respected from one side Yin (1994) four principles test and the principles presented by Klein and Myers (1999) on interpretative research validity.

Chapter summary

In this chapter, we presented the methodological choices. We conducted a qualitative study based on the critical decision method and ethnography with a mixed data collection from interviews, live observations, video observation, debriefing.

Our research problematic is interested by the impact that an artefact has on an expert and on organizational routines. In order to answer our research question, we studied the case of robotic surgery. Our research is an interpretative qualitative study based on ethnography.

The methodology described in this chapter provides basis for the next chapter that presents the data analysis chapter.

Chapter 5 Implementation of a new technological artefact in surgery: robotic system in bariatric surgery

Chapter introduction

This thesis involved interviewing experts in order to have a general review about their interaction with a new technology. On the other hand, it involved observing experts while they are actually using these technologies in their daily routines.

The observations were done in an incremental matter over three years' period.

In this chapter we are going to present the findings of both the interviews followed by the findings of the observations.

5.1 Interviews briefing

As mentioned before in our methodology, we started our field work with interviews with surgeons from different specialties that have already undertaken surgeries using robotic surgery. This part of our field study, aims to gain insight on what is mostly perceived important aspect while taking a decision by a surgeon in the OR. These aspects will be useful later on in our analysis for a detailed on field observation.

To begin with, we asked surgeons about what they perceive as an important element while taking a decision. What was recurrent as important to the majority of practitioners interviewed was “atmosphere between team members”, “being confronted to a similar situation in the past”, “lack of information” and “past experience”. These aspects reveal the important role of experience of the surgeon in a given situation and while using the technology. Lack of information is an aspect identified with higher scores which indicates the importance of situation awareness of the surgeon in order to take efficient decisions. The atmosphere between team members is another aspect identified as very important that will affect a surgeon’s individual decision.

All these factors and their associate scores is represented in the below figure. 20 representing the number of surgeons interviewed.

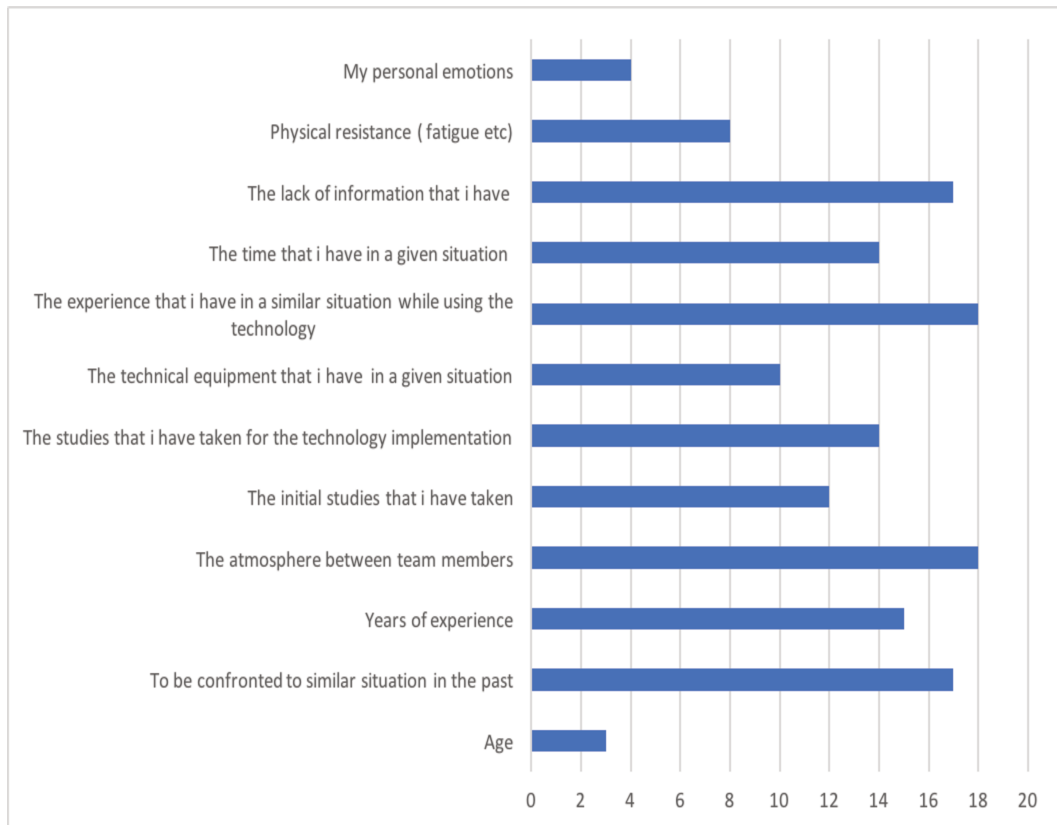


Figure 5.1: Factors affecting individual decisions in the OR according to surgeons

Undesirable events during a surgical procedure is normal. Alerting signals are the patient's health issue or a technological failure. In a surgical procedure, it is necessary to decide in advance the course of action. As we conclude from our questionnaire, most of the time the plan changes according to the circumstances and to the complications encountered.

The 20 surgeons had almost opinion about the facility of the robotic system but also almost same opinion about the difficulty classifying incides of malfunction. Despite the facility of the use almost half of the participants did not find any significant contribution tu surgery. They agreed on the fact that robotic surgery add precision and all the technical positive aspects that it was originally developed for. What emerged from our questionnaire

are the following themes: importance of the development of new coordination patterns in the OR, important role of expertise on the decision making process while implementating a new technology.

5.2 Case of Robotic surgery

We presented a chapter one a general presentation of the medical context in which we presented a description of new technologies in the medical field. New technologies are present in different aspects in medicine from diagnosis to treatments. Examples of diagnosis are the developments done in imagery like IRM, endoscopic techniques and molecular biology. On the other hand, treatments involve surgical or non-surgical techniques. Our main focus is surgical procedures. As mentioned in chap.1, surgical procedures techniques evolved over time: From conventional surgery to mini-invasive classic surgery to robotic surgery that appeared initially to surpass the negative aspects of classical mini-invasive surgery. The main positive aspects of robotics include the degree of liberty of the surgeon's hand and the eye-screen movements.

Our case is about robotic surgery in particularly the Da Vinci robot. This robot is considered a *remote manipulator* (see chap.1) according to Wolf and Shoham classification of robotic surgery. The robot is not autonomous. It is controlled fully by the surgeon. It mirrors the surgeon's actions taken from the console present in the operating room. In CHU-Nice, Da Vinci robot is mainly used in the digestive and urology pole in the hospital. Urology need lots of precision this explains the use of robotics that allows the surgeons operates with more precise movements due to

the degree of liberty enabled by the robot. Figure 4.1 presents a general presentation of the different poles in the hospital. Our focus is the digestive pole, more precisely the digestive surgery.

5.2.1 Surgery general description

Gastric bypass is the surgical treatment of morbid obesity. It is the most frequent procedure performed that will allow the patient to loose weight. The purpose of this surgery is to reduce the stomach size up to 90% of its actual size. The aim of this surgery is to shorten the paths of the food therefore less food is absorbed.

The surgery is a two steps surgery. The first step consists of dividing the stomach into a small upper section called the pouch and the larger bottom section. This division is done using a staple. This step is called stomach stapling. The second step is to connect the pouch to the small intestine. During this step a greater degree of precision is needed. The larger section of the stomach and first part of the small intestine (the duodenum) is totally separated from the rest of the small intestine. The surgeon connects the jejunum (a small part of the small intestine farther then the duodenum) to the hole created in the pouch. This surgical technique is called Roux-en-Y (Figure 4.2). Gastric bypass can be done either with open surgery or laparoscopically (mini-invasive surgery).

In the digestive pole in CHU Nice, the two most common used surgical techniques are mainly gastric bypass and gastric sleeve. Both surgeries are mini-invasive surgeries. Robotic surgery, as discussed earlier, appeared initially to eliminate the side effects of regular mini-invasive

surgery and other negative issues when dealing with instruments in mini-invasive surgery.

The hospital uses robotic surgery since five years ago in the digestive pole. The use of Da Vinci robot is limited to one day per week. Every Wednesday, early morning is dedicated to gastric bypass while using the Da Vinci robot. This is the most advanced platform available for mini-invasive surgery. The integration of high-resolution 3D vision wristed instruments and intuitive motion control enable the surgeon to transcend the limitation of conventional surgical technologies. This will enable making new mini-invasive options possible for new complex procedures. Three network components comprise the Da Vinci surgical system. (a) the ergonomic surgical console, (b) a patient's side with four interactive robotic arms and (c) a high definition 3D system.

Seated at the console, the Da Vinci surgeon has a clear 3D image of the surgical field. The system scales filters and translate the movements of the surgeon's hands on the master console to four interactive arms on the patients' card. The Da Vinci HD system provides a magnified view that is 3D and high definition. The precisely controlled micro movements of the Da Vinci are enabled by the computer processor of the system. These processors perform millions of safety checks over the course of the procedure for enhanced surgical precision and control. Da Vinci wrist instruments provide seven degrees of freedom for range of motion greater than the human wrist.

This design enables surgical maneuvers impossible in conventional laparoscopic tools. While the surgeon operates from the console, the Da Vinci robot filters out hand tremor and translates his controlling motions to the articulating tip. The system also provides motion scaling that enables the surgeon to tailor the ratio of his hand movements to a corresponding micro movement. The system requires that every surgical maneuver is under the direct control of the surgeon. Safety checks prevent autonomous movement of the instrument or the robotic arms. The system provides rapid instruments exchange. The internal view of the operative field is visible on the monitor for the other team members present. The endoscopic camera enables a better 3D vision of the tissues. Unlike the conventional laparoscopic surgery, the robotic arms move around a fixed pivot point reducing port site trauma and increase overall precision.

Conventional mini-invasive v.s robotic

In this section we are going to describe the flow of both robotic and conventional mini-invasive surgery in order to have a general overview of the main differences of both types of surgeries.

5.2.2 Robotic surgery case description

We had the chance of observing the progress of robotic surgery in Nice CHU Hospital throughout three years' period. Our first non-participant observation took place in 2013. As mentioned before, robotic surgery specifically the Da Vinci robot is used in several units and types of

surgery. Our case is gastric bypass digestive surgery conducted with a specific team. This team's primary surgeon is Dr "I".

We are going to describe the whole process while insisting on specific events that occurred during the sixty hours of surgery that we observed. We will describe the process using storytelling.

Findings

In this narrative, Doctor "I" is the leading surgeon in the operating room. We can divide the surgery into three main sequences. First the *pre-operation preparation* followed by the actual *operation* and at last the *post-operation*. These sequences differ in robotic surgery versus conventional mini-invasive surgery.

In general, we noticed specific routines that took place in every procedure. People present in the operating room are the main surgeon, the assistant surgeon, the anesthesiologist, a nurse and at least one circulator that are present in order to handle any instrument if needed.

During the pre-operation, Dr "I" has a very little interference. It is the nurse, the anesthesiologist and the assistant surgeon normally who interfered the most during this phase. The nurse and the anesthesiologist prepare the room and the patient for the operation. The robotic system is already put in place in the operating room.

In our case in the CHU, the same team members work together with Dr "I". The same nurse and anesthesiologist and same assistant Dr "T". Dr T's role is to assist Dr "I" during the operation. During the pre-operation the anesthesiologist with the aid of the nurse prepare to patient. The

anestheologist places a mask over the patient mouth. From here he places an endotracheal tube into the patient's mouth. This tube is connected to a respirator. At this stage Dr "I". is not involved with the events. Sometimes he is even not present yet in the operating room. Another step that we consider is the last part of the pre-operation is placing the instruments and the robotic system. Dr "I". or Dr "T". his assistant made incisions with the scalpel. They place into each incision a trocar* in each incision. These devices help to put the instruments such as the stapler. Dr "I". usually asks the nurse to fill the abdomen with carbon dioxide to have plenty of room to work.

Pre-operating stage is over. Second stage is the *actual operating procedure*. During this stage Dr "I". is the main character present in the room. He is leading the surgery. He asks his assistant Dr "T". to place the robot and the instruments into the patient's body. The two doctors with the interference of the nurse are working together to put in place the robotic system. Once done, Dr "I". position himself at the console from where he will be controlling the robotic system while Dr "T". stays next to the patient. Dr "T". is next to the patient and the robotic arms. He has a 3D visualization on the screen directly placed in front of him. This will allow him to control the surgery and manipulate the robotic arms if needed.

Dr "I". starts operating using the robotic arms. The interface between the surgeon and the robot are the finger controller. They allow the movements to be transmitted from the surgeon to the robot. During the whole surgery, the surgeon looks at the 3D view finder and manipulates

the robotic instruments. Foot controls allows the surgeon to perform things like cutury or move the robotic camera in and out. Dr "I". have the capability to take away images from any radiology sweet, transmitting them to the router and then to the surgeon's consol. That will allow him to see radiology images in real time. During the whole procedure Dr "T"'s interaction with the surgeon is limited. He is located next to the patient with a direct view on the screen to control the arms in case it is needed. His role is to monitor the instruments place into the robotic arms and the camera to make sure that actions are done as planned. The interactions between the two surgeons is limited to when there is a gap between Dr "I". manipulations using the finger controller and the actual actions visualized on the screen. The lack of tactile makes it more complicated to detect the presence of a gap. This is the reason why Dr "I". is in need to Dr "T". to assure him about his actions due to his proximity with the patient.

As mentioned before, Dr "T". role is limited to the supervision and control of the robotic arms that are initially controlled by the leading surgeon. In addition to that his role is to change instruments placed on the robotic arms when needed.

A nurse is present next to the patient and Dr "T". He role is very minimal and most of the time conducted by Dr "T".

5.2.3 A comparative case of conventional mini-invasive surgery

We observed one team using robotic surgery and compared it to the same team operating without robotics. The photos in the previous

chapter and in the appendices show the team members present during a laparoscopic gastric bypass surgery from one side and robotic surgery from the other side.

As mentioned before, usually members present in the operating room are usually the same in a given team.

5.2.4 Comparison with another surgical team

In order to understand further if all team members have the same routines in different teams, we had to possibility to observe another team while operating conventional mini-invasive gastric bypass. This team is in the same pole; same procedure with different actors. The team primary surgeon is Dr "D" his interne assistant is Dr "N". The purpose of this observation is to understand the team effectiveness, coordination and communication processes. This observation was done with the presence of a psychologist. As mentioned earlier this gastric surgery is the same gastric-intestinal surgical service under the supervision of the service's chief professor "G". This surgery was operated by Doctor "D", one assistant surgeon, an intern, two nurses, one anesthetist, and one scrub nurse and one observant surgeon. The Duration of the surgery was 1H30.

As any other gastric bypass surgery, each team member has his own role. The leading surgeon is the one operating with the help mainly of the assistant surgeon. What differentiate this surgery of other surgeons that we observed is that the assistant surgeon is new on the team. The surgery was followed by a debriefing that lasted 30 mins.

The team was auto-confronted to two sequences chosen from the video film of the operation. These two sequences were chosen to understand better the interactions between team members and their reactions while dealing with an artefact.

This auto-confrontation and the assessment of the reactions of team members were solicited based on the reflexive debriefing used in simulation.

The two main sequences were:

- Telephone call during the surgery and the surgeon's choice to answer the call; in particular, the way he communicated his decision to the rest of the team.
- The surgeon's reactions facing the inexperienced assistant.

As indicated in the methodology chapter, questionnaires were distributed to the members present in the auto-confrontation session to have their feedback on the communication process in between actors in the OR. During the auto-confrontation, the participants filled two questionnaires individually (appendix). Our aim was to measure the quality of the communication between people present in the OR and their satisfaction according to the quality of these communications processes.

Results of the questionnaires were as follows:

Average grade given for group work: 8/10

Average grade on the whole communication: 7,8/10

New team member integration: non pertinent

Sharing thoughts: 8,2/10

Directed communication: 8/10

Communication feedback: 8,2/10

In addition to these questions, practitioners were asked about their point of view after

the debriefing. Their responses are presented in the table in the appendices.

To resume, the debriefing had a positive feedback. This shows the importance of having more of these kinds of sessions that encourage exchange between members. These exchanges help identifying the interactions problems faced in the operating room. The general feedback of the debriefing was positive. Actors encouraged debriefing exchanges since it embraces actors to speak up about the problems, misunderstanding or even positive courses of actions taken during the operation.

In the section below, we are going to present the different teams that emerged from our field. We divided them into two main sections. The first one represents the themes related to organizational routines whereas the second one represents the cognitive representation of the surgeon's more specifically themes that tests his expertise and decision making process.

We will start by describing the different stages that the surgeon and his team pass through without the use of robotic surgery.

To begin with, as mentioned before in the description section of the surgical procedure, the OR is prepared for the patient. Instruments are put in place and the room is ready for the patient's entrance. During

this phase normally the people involved are the nurses. Interactions are limited between members especially that each know exactly his role. Second the patient is installed in the room and prepared for the surgery. During this phase, usually the people present in the OR are the nurses and anestheologists. After, the surgeon or the surgeons (the surgery could be conducted by several surgeons, most of the time the surgeon is accompanied by his assistant) enter the OR to start the procedure.

The settlement process after years of working together becomes routinized. Each practitioner knows exactly where to position himself and how to start the operation.

Despite the fact that this whole procedure is routinized lots of interactions take place between OR actors. We can say that even these interactions are routinized. For instance, one of the nurse's roles is to make sure that all the instruments and machines are well placed. Interactions between the surgeon and this nurse is inevitable since he is leading her in the *placement of the instruments and the machines* while operating.

We take as an example a sequence was the surgeon (Dr "I") is leading the nurse (M) to well position the screen while operating in order to have a better visibility straight to the screen:

Dr "D": M put the screen a bit better between the two heads

Scrub nurse M: It is better like this?

Dr "D": Yes, thank you."

We noticed that these interactions can be a bit with a strong tonality or a bit aggressive (according to us) but all the time ends directly after couple of seconds. The aggressivity disappears and tonality go back to normal without any discomfort between the actors:

“Dr: M lower the limunausity please

What are you doing... Don't touch, don't touch...

M: What if i put it automatic?

Dr: That's perfect, thank you!”.

The usual interactions that also are routinized are the interactions between the surgeon and the nurse that is directly situated next to him to exchange with him the appropriate instruments when needed. Due to repetition, the nurse's actions are routinized for this type of surgeries. For instance, she knows exactly to give the right tool at the right timing. During these exchanges interactions can sound a bit aggressive but in fact actors are used to work with each other therefore some words that we might interpret as aggressive can be friendly to them. Example: *“You always say silly stuff”.*

5.3 Themes/ codes emerged from our study

Primary surgeon and the assistant surgeon interactions

Interactions between the two surgeons are limited. Even though they are operating in the same time, half an hour can pass without any communication between the two practionars. Each one of them is directed towards the screen facing him while operating. Tasks are well known but each one knows exactly what to do and when.

Communication is limited to couple of words just when necessary:

“Dr “I”: Go ahead Doctor “T” put the tube in... It is perfect”

Couple of side discussions can take place during the surgery specially when everything is going as planned and no stress is faced.

To be noted that all team members' eyes are directed towards the screen to be able to have all clear visibility on. Dr “I” is the one leading the surgery hence, he is the one asking the nurse to give him and his assistant all the adequate tools. The leading surgeon usually leaves the room before the end of the surgery letting his assistant finalizing it. Finalizing the surgery usually means doing the final stiches. These final steps are considered the simplest and routinized steps in every surgery.

Operating with the Da Vinci robot is limited to once per week. Every Wednesday, is dealing with a robotic system that in theory is supposed to assist them operating.

We will start in this section by presenting how each member is situated in the OR and compare it to their simultaneous positions while operating without the robotics system.

In the figure below we see how each member is located during a conventional mini-invasive laparoscopic surgeon. Both surgeon's each looking at the screen directly in front of him with a wide visibility on the targeted organs. To the left, a nurse is located next to the leading surgeon. Her role is to regularize the camera's positioning. On the other hand, the other nurse is located next to the assistant surgeon. Her role is to hand all the instruments located on the table during the

surgery. She has a knowledge on all the instruments and on what exact time the appropriate instrument is needed.



Figure 5.2: Laparoscopic bariatric surgery OR configuration

In theory, the role of robotic surgery is to minimize the operation time. In practice it was different. Even though the time during the actual surgical act decreased during robotic surgery, if we add the time needed for placing the robotic system and moving it away it will be almost the same in total. The installation of the robotic system is not too complicated. The robotic arms are placed usually next to the patient for an easy access. The assistant surgeon and the nurse's role is usually to place the robotic arms into the patient's incisions. But when the actors switch from laparoscopy to robotics then from robotics to laparoscopy during the same surgery, time is lost. Gaining time is essential during surgery. It is essential to maintain the patient's stability. In the figure below we can see the interaction between the

crub nurse and the assistant surgeon while installing the robotic arms into the patient's body.



Figure 5.3: Da Vinci robot installation (1)



Figure 5.4: Da Vinci robot installation (2)

After dealing with the robotic arms, the assistant surgeon and the nurse are well placed next to the patient to start the surgery. The assistant's

role is place the right instrument into the robotic arms and to move the arms when needed according to the leading surgeon's assistant. From another hand, the nurse's role is to move the camera when needed (even though the leading surgeon is the one manipulating it but in some cases some problems might occur).

The leading surgeon is manipulating the robotic arms from the console placed in the corner in the operating room (figure below). The surgeon is looking the screen directly facing him. He is looking at the same images (3D) images in real time of the organs with the same representations as the screen located next the patient facing the assistant surgeon and the nurse. The fact that the surgeon is looking at the console screen without being able to have any other interaction with the other team members is not coherent with OR principals. In Laparoscopy or open surgery, the primary surgeon has eye contact with the rest of the team that is not possible in robotics due to the distance that separates them. Eye contact is considered a sort of interaction or non-verbal communication between team members. This gives the team safety feeling.



Figure 5.5: Surgeon's location on the console



Figure 5.6: Team spatial alignment robotic surgery

Distraction in the OR

During robotic surgery, the primary surgeon is less distracted usually by what is actually happening around him. He is on his console manipulating what is happening around him thus less distracted by his surrounding. During laparoscopy, the surgeon can be distracted by any artefact.

During one of the laparoscopic surgeries observed, one surgeon one distracted by a phone call that he received outside the operating room. He was informed of the phone call by a nurse. At the beginning he refused to take the call but end up leaving the OR to take the call. During robotic surgery, the surgeon does not have this kind of distraction. He can not permit himself to be distracted by any sort of artefact since he is the only one manipulating the robotic arms from the console. Therefore, he can not let anyone else replacing him.

Tension between team members

While working together team members can face tension. Having tension between each other is normal in the OR. We noticed how the atmosphere can change from being calm to having tension between practitioners. When asked about the atmosphere in the OR during a surgical procedure, a surgeon reply was: *“It is totally normal to have tension in the OR. It is considered part of the procedure. If you didn’t notice any tension, then the practitioners are trying to control themselves due to your presence.”*

The most common tension that exists in the OR are tension that take place between the primary surgeon and his assistant or between the primary surgeon and the scrub nurse. These four actors are the main actors that are interacting with each other. The primary surgeon is leading the surgery with the assistance of his assistant surgeon that is helping him with the surgical act. It is quite recurrent that tension will take place between the two surgeons especially if the assistant surgeon is a novice.

Even the tension in the OR became routinized. Team members do not notice or remember after the surgery what actually happened in the OR after the surgery. During a debriefing that we did with the presence of all team members we confronted the surgeon and his assistant with a video recorded sequence of a situation where tension was obvious between the two actors. The primary surgeon was surprised by the way he was communicating and by his attitude toward his assistant to the extent that he excused from this latter. His assistant was not expecting these excuses since he is used to these kind of remarks and he mentioned: *"It is normal to have these sort of reflections at the end I am here to learn and Dr. "D" want to prevent any error from affecting the patient's safety."* These tensions last for couple of second then the actors continue their tasks as if nothing happened. For team members having tension is part of OR routine. While observing robotic surgery, we did not notice that.

Tension did not disappear between members during robotic surgery. The frequency of recurrence of tension decreased in robotic surgery

since members are not interacting with each other and the surgical tasks are centralized to the primary surgeon. When tension sets in this latter it becomes more intense.

Anticipating team members' actions

One of the main advantage of working in teams is that team members get used to each others and to each others' actions. Actions are routinized and therefore every member can anticipate other members' actions which facilitate the interactions and can diminish the surgical time required. During laparoscopy, the scrub nurse knows exactly every step of the the procedure so she is able to anticipate what the surgeon need as an instrument and prepare it to give it to him while finalizing his previous tasks.

Being physically next to each other, facilitates this anticipation process. The scrub nurse has a direct full view of the surgeon's actions thus can predict his futures actions. We can say that the same is also happening between the primary surgeon and his assistant surgeon where this later can anticipate the surgeon's actions while looking at his hands movements. The spatial configuration in the OR during robotic surgery does not allow the anticipation process. Being far from each other, the scrub nurse and assistant surgeon can not be aware at the surgeon's actions. They can see directly his actions through the screen facing them but this can not allow them to anticipate his actions by giving him the instruments for example (the scrub nurse). They will wait for the surgeon himself to ask them to do a certain task.

Tactile, haptic feedback, force feedback

In laparoscopy, there is a lack of force feedback. It represents the interactions forces at the instruments tips. Usually in surgery, the surgeon is accustomed to manipulating tissues in the presence of force feedback. It was proven that it was proven in literature that is a source for error. While using the instruments, forces are transmitted but not in the same way as in open surgery. Touch is the feedback that allows the surgeon simultaneously to have the input and output. Sense of touch is missing in robotic surgery. Dr. "I" argued that he relies mostly on visual cues since he does not have any tactile feedback. *"When precision is needed like doing a suture it becomes tricky. I start manipulating slowly the robotic arms"*. The benefit of having force feedback is to feel the tissues' characteristics, more appropriately tension the suture and better identify pathologic conditions. The instruments in laparoscopy limit the tactile feedback that the surgeons had in open surgery but do not totally eliminate it. In robotics, tactile feedback is totally removed. Surgeons try to rely on visual cues presented in robotic surgery through the screen of the console.

Conversion frequency

During our observation process we were observing surgical procedures with and without the assistance of the robotic system. In some of the surgeries, the surgeon was using both techniques simultaneously.

When we talk about conversion we are talking about conversion between two types of surgery. In Robotic surgery, we noticed that the surgeon converts frequently from robotic surgery to laparoscopy when facing a problem. The surgeon asks his assistant surgeon and the scrub nurse to take away the robotic arms and start using laparoscopic instruments instead. The recurrence of this scene was frequent. As soon as a technical problem occurs or the surgeon is doubting the technology and have offset between the images that he is receiving and the actual actions from the patient's side. On the other hand, in laparoscopy conversion to open surgery can occur. Doctor "S". argued that in 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. On the contrary from robotic surgery, we didn't witness during our observation any conversion from laparoscopy to open surgery.

Other artefact distraction

Surgical procedure can last from 2 to 3 hours. During this time lots of perturbation can emerge that can distract the surgeon. These distractions can be any sort of irrelevant interaction with other artefacts then the robotic surgery or laparoscopic instruments. The primary surgeon is working from the console; he is manipulating the robotic arms while looking at the screen facing him. This will decrease the interactions with any artefact around him. He is the only individual responsible and capable of manipulating the surgical gestures

therefore no disruption is allowed. On the opposite side while operating in laparoscopy, the surgeon is interacting with all practitioners around him and distraction is more tolerated. Artefacts can be instruments, documents, machines or even the phone placed outside the OR. We noticed this distraction aspect in laparoscopy. For example, in one the laparoscopic surgeries, the surgeon received a phone call from the division chief. A circulating nurse announced the urgency of the phone call. At the beginning the surgeon did not wanted to respond to the call since he was in the middle of the surgical act. After the insistence of the scrub nurse he finally got out of the OR and took the call. Meanwhile his assistant was completing the tasks. This can not happen in robotic surgery where all the tasks are centralized to the primary surgeon. He could not allow any artefact disrupt his surgical task since no one can therefore complete it accurately using the robotic system.

Actors changing roles laparoscopy vs. Robotic surgery

Surgical team members have each one specialized expertise. While conducting laparoscopy, they are used to work under time-pressure and uncertainty with high level of coordination. Team members are rarely changed therefore surgical act in the OR is conducted most of the time in a routinized way.

During conventional gastric laparoscopic surgery, the practitioners involved are: the primary surgeon, assistant surgeon, scrub nurse,

circulating nurse and anaesthetist or the anaesthetist nurse. Figure one presents the social alignment and interactions between actors during laparoscopy.

When operating with the robotic system, the anaesthesiologist whose role is to control the patient's vital signs and reaction to anaesthesia did not change. Likewise, the circulating nurse tasks of making sure of the well functioning of OR equipment and machines did not change.

During laparoscopy, the primary surgeon is situated next to the patient facing the screen. His role is to lead the surgery by performing the surgical performance while coordinating with his assistant, nurses and anaesthetist. While performing a gastric bypass using the robotic system, the primary surgeon is sitting on the console manipulating his (or her) movements while looking straight to the screen that gives him a 3D clear view of his surgical act. He (or she) is manipulating all the instruments from the console including the camera. The interactions between the surgeon and the rest team members is limited to the communication with his (or her) assistant from time to time to direct him to change instruments on the robotic arms or in case of a problem to make sure the system is working well. We highlight a specific situation where the primary surgeon had a problem and due to technical difficulties was in need of his assistant:

"I" the primary surgeon had a problem with the image presented and the haptic feedback. He noticed that the feedback was not accurate with the 3D image provided by the system therefore he asked his

assistant T to verify everything is well positioned or if he is noticing something that is going wrong. When the latter answered negatively, doctor I moved away from his console toward the patient to verify by himself (Observation data).

The assistant surgeon's role in laparoscopic surgery is mainly to maintain stability of the surgeon and assist him during the surgical acts. These acts are routinized between the two practitioners during laparoscopy where the proximity of both surgeons facilitates their coordination.

The scrub nurse whose role normally is to pass the instruments to the primary surgeon, is located next the assistant surgeon with a minimal role of maintaining the camera and passing instruments to the assistant surgeon when needed. In Laparoscopy, usually two scrub nurses are next to the primary surgeon one maintain the camera while the other passing the instruments.

Actors' spatial alignment in the OR

The ecology of space is totally different in laparoscopic surgery vs. robotic surgery. In laparoscopy, the surgeon is situated next to the patient facing the screen while operating. Usually two scrub nurses are located one next to the primary surgeon to hold him the instruments and one on the opposite side responsible of the camera.

A circulating nurse is moving back and forth in the OR to make sure that the overall procedure is going smoothly, the equipments are well functioning and that the scrub nurse does not need any additional equipment.

Contrary to laparoscopy, the primary surgeon in robotic surgery is located on the console outside the sterilized zone in the operating room (it is the zone where patient is present and where all the people and equipment are sterilized). The assistant surgeon is present next to the robotic arms in the sterile zone accompanied with a scrub nurse standing directly next to him.

Other practitioners present have the same spatial alignment as in laparoscopic surgery.

Communication

Team members in robotic surgery are separated by space and lack face to face communication. Our observation illustrated the complexity of communication when dealing with robotic surgery. We noticed lot of difference in communication during laparoscopy and robotic surgery. In the latter, the most recurrent action is the primary surgeon that moves from his console toward his (or her) assistant to lead him (her) with his (or her) act due to misunderstanding in the message the primary surgeon wants to transmit. During the "reflective talk" introduced with the debriefing for thinking about changes within the patterns of action,

it has been asked about the reason of moving away from the console when a problem occurred. The surgeon explained and argued:

“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 is one sample of the misfit that was occurring during the surgery.

Major factors were affecting the communication process in the OR. These factors include noise level in the OR, console to bedside communication, lack of nurse availability, lack of instruments availability and lack of familiarity of the participants with the procedure. While asking the primary surgeon about couple of the miscommunication we noticed, the responses were mainly *“because they misinterpreted my words or actions”* or *“I ask others to repeat what they were saying since I am not understanding what their message or I can’t hear it”*.

Noise level in the OR due to machines, instruments and team members’ communication require that team members are next to each other.

According to a recent study (Schiffer, 2016) major factors can affect communication are: change of staff, noise level, instruments availability, participants lack of familiarity with the procedure, microphone, nurse availability, physician fatigue. These factors were present clearly in our observation. We noticed that the main factors that were affecting communication were *noise level, participant’s familiarity*

with the procedure and microphone. Noise level was more important in robotic surgery due to the console noises and the ones of practitioners talking to each other. This is mainly due to the distance between them that will oblige them to talk loudly. Furthermore, being separated, both sides (the primary surgeon and the assistant surgeon with the nurse) need more information from each other to be aware of what the other side is encountering therefore more communication is needed. Participants familiarity with the procedure turned to be an important aspect of a good communication process. When nurses and trainees it affects negatively team functioning. At last good communication is assured by good transmission by the microphone at the console.

Factor	Representative data
<i>Noise level</i>	Observation illustrated that noise level increased with robotic surgery. OR is more calm during laparoscopy. Noises are generated by the vision console or from practitioners talking to each other.
<i>Participants familiarity with the procedure</i>	During two surgical procedures, a nurse took place another one usually present. The nurse does not work in a setting where the robotic system is used. The communication output was negative. There was less tension recorded during our observation between the surgeon and the nurse but communication between the scrub nurse and the surgeon was less recurrent.
<i>Microphone</i>	A microphone is placed at the console in order to facilitate the communication between practitioners. When microphone was not functioning well, communication became more complicated.

Table 5.1: Factors affecting communication

The new technological artefacts in the OR and the distance between the two practitioners presented a barrier for verbal and non-verbal communication. One of surgical team routine is to have verbal and non-verbal communication such as eye contact and body language. This prior pattern of action is thus disrupted with the physical distance between them.

The new ecology of space and the new roles of actors affected team functions and disrupt the sequence of action within the pattern of action and therefore their decision-making. Indeed, with the robotic surgery, all the decisions are now centralized to the primary surgeon creating a new ecology of space. We noticed that because of this new form of centralization, the spatial localization of the surgeon from the patient and his assistant changes the flow of information might create misfits. In large part of the surgeries observed, the surgeon, confronted to this uncomfortable situation, decides to go back from robotic surgery to normal laparoscopy in the middle of the surgery when a problem occurs.

Human interactions

Human interactions during robotic surgery are very limited. The primary surgeon is coordinating the pattern of action with a minimal assistance from his (or her) assistant. To be more specific, interactions here are non-verbal ones, most of the time tacit ones for passing technical tools between team members. From his (or her) side, the assistant surgeon

has also minimal interactions with the scrub nurse. This leads to the centralization of the whole surgical procedures around the primary surgeon. This is controversial with the concept of surgery that is based on teamwork and centralization that is maintained in laparoscopy.

Proximity with the patient

During laparoscopy, the surgeon is away from the patient. As mentioned before he is operating from his console. We noticed that having proximity with patient gives the practitioners more security and confidence in their acts. When a problem occurs the primary surgeon is in need of a reassurance of his assistant surgeon located next to the patient. In most surgeries that we observed, when a surgeon is confronted to a specific communication or technical problem, he moved towards the patient to make sure that his (or her) actions fit to the “normal situation” and to be sure that the robotic system arms are well placed. As explained one surgeon:

“Being placed far from the patient can make a surgeon feel 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).

Being far away from the actual surgical act decrease the situation awareness from the surgeon’s side. In order to overcome this lack of situation awareness, a team situation awareness is needed.

Technology/Human interactions

The purpose of technological artefacts is to extend human capabilities in different surgical tasks. The main aim of these technological tools is to replicate the surgeon's actions. In addition to that, in case of technical problem (i.e haptic feedback/touch feedback or offset between the 3D image and the manipulation) the responsibility is on the surgeon's hand. In the specific case of the laparoscopic surgery, the robotic system is introduced once a week, generating a lack of repetition inside the team. The surgeon is thus placed in a critical place and may remain unfamiliar with the robotic system and the corrective actions that should be taken in case of misfits.

The lack of repetition creates also a critical lack of 'ontological security' (Giddens, 1991) and a lack of confidence inside the team obstructing stability within the pattern of action and potential routinization in laparoscopic tasks.

The two figures below present the actors alignments and the ecology of space in the OR in both types of surgery

P: Patient

A: Anaesthesiologist

AS: Assistant surgeon

S: Primary surgeon

CN: Circulating nurse

SN: Scrub nurse

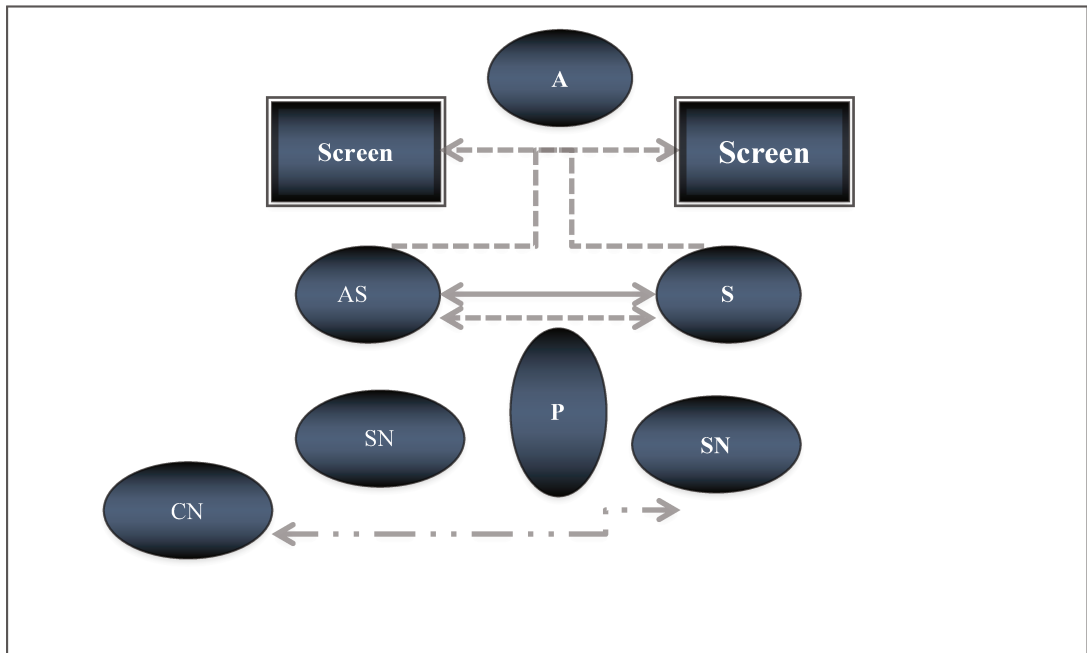


Figure 5.7: Actors alignment and interactions in the OR in Laparoscopic surgery

The figure below is a representation of every team member alignment with the different interactions taking place between team members.

First we have within comparison: the same team with and without the robotic system.

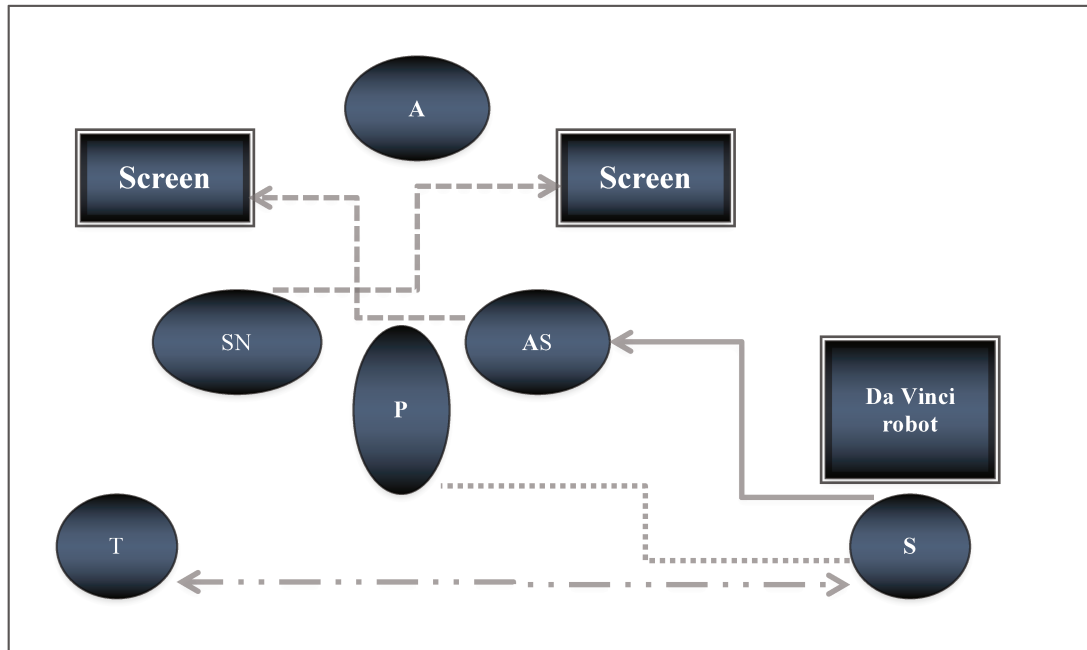


Figure 5.8: Actor's alignment and ecology of space in the OR in robotic surgery

Figure 5.3 presents a summary of our analysis and pinpoints the different aspects discussed above.

In the figure above, the different interactions between actors are presented. We can divide interactions in terms of gestures, communication or verbal interactions and last at not least technology/human interactions.

Gestures interactions between actors represent the interactions passing an instrument, shared actions etc.

Table First-Order Analysis: Balancing between old and new tasks

Themes	Representative data
<p>1. Distraction in the OR: less distraction during robotic surgery compared to laparoscopy.</p>	<p>A. Dr. “I” was operating with robotic surgery, manipulating from his console the robotic arms. He was looking straight to the monitor screen in front of him. He is not involved with any conversation (<i>Observation notes</i>).</p> <p>B. Doctor “D” was operating with laparoscopic technique. The phone rang outside the OR. The nurse transferred the message: Nurse: “Dr. “S”. is on the phone; he wants to talk to you”; Dr.“D”.: “Tell him will speak to him later”. Nurse: “but he is insisting”. Dr. “D”. left the room to answer the call (<i>Video observation description</i>).</p>
<p>2. Tension between team members: tension is a normal aspect in teams working in the OR. It is more frequent during laparoscopic surgery compared to robotic surgery. But it is more aggressive when occurred in this latter. Doctors do not realize their attitude.</p>	<p>A. « 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 » (<i>Interviews data</i>).</p> <p>B. « Why don’t you do anything right ?! » Dr. “D”. to Dr. “N”. during laparoscopy (<i>Observation notes</i>).</p> <p>C. Dr. “D”. was apologizing to Dr “N”. for his attitude while auto-confronted with the video-taped surgery (<i>debriefing data</i>)</p>

Table 5.3: First order analysis (1)

Table First-Order Analysis: Balancing between old and new tasks

Themes	Representative data
<p>3. Primary surgeon and the assistant surgeon interactions: the interaction between the two surgeons is limited during robotic surgery since the actions are centralized towards the primary surgeon. The only real interaction that takes place is when a problem occurs. On the opposite of laparoscopy when the surgeon</p>	<p>A. Interactions during robotic surgery between Dr. "I". and Dr. T. are limited to small talks : « go ahead Dr. T. put The tube in...it is perfect ». (<i>Observation data</i>).</p> <p>B. During one surgical procedure the interactions between the two surgeons increased since there was a problem with the robotic system (<i>Observation notes</i>).</p>
<p>4. Anticipating team members' actions: since actions are routinized in the OR, every member know exactly actions of other team members that let them anticipate actions and gain time.</p>	<p>A. During laparoscopic surgery, the scrub nurse handle the tools to the doctor while anticipating his steps. She was handling tools for the next step without him even asking for it (<i>observation notes/video analysis</i>).</p> <p>B. « I know exactly was Dr. "I" wants during surgery even without him saying. It is been a while we are working together ». A scrub nurse affirmation (<i>debriefing data</i>).</p> <p>C. During robotic surgery Dr. "I" is completing his tasks alone from the console and asking for help when needed. No anticipation can take place (<i>Observation data</i>).</p>

Table 5.4: First order analysis (2)

Table First-Order Analysis: Balancing between old and new tasks

Themes	Representative data
<p>5. Tactile/ forces feedback: Touch is the feedback that allows the Surgeon simultaneously to have the input and output. The benefit of having force feedback is to feel the tissues' characteristics.</p>	<p>A. 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" (<i>interviews data</i>).</p> <p>B. During one robotic surgery, Dr. "I" felt a delay between his manipulation and force feedback. He asked his assistant to check if there is a problem. Dr. I left his console direction the robotic arms to be sure by himself that the robotics system is working well (<i>Observation data</i>).</p>
<p>6. Conversion frequency: switching types of surgery for example while operating laparoscopy, going back to open surgery. Same in robotics: convert during the surgery to laparoscopy or to open surgery.</p>	<p>A. As soon as a technical problem occurs in robotic surgery or the surgeon is doubting the technology and have offset between the images that he is receiving and the actual actions from the patient's side (<i>observation data</i>).</p> <p>B. "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 (<i>interviews data</i>).</p> <p>C. Dr. "C" argued that conversion rate in laparoscopy is nowadays very rare (<i>interviews data</i>).</p>

Table 5.5: first order analysis (3)

Table First-Order Analysis: Balancing between old and new tasks

Themes	Representative data
<p>7. Other artefact distraction: surgeons can be distracted by anything present in the OR.</p>	<p>A. The instruments, looking back and forth to the screen, can distract the Surgeon (<i>Observation notes</i>).</p> <p>B. During laparoscopy on the contrary of robotic surgery, Dr. "D" permits himself to answer a phone call outside the OR leaving the patient to his and the nurses for few mins (<i>Observation data</i>).</p>
<p>8. Spatial alignment: spatial configuration in the OR change completely while operating with the robotic system.</p>	<p>A. « 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" argued (<i>Interviews data</i>).</p> <p>B. Dr. "I" while operating use lots of eye contact with the scrub nurse and with his assistant to transmit a message. Being away from them is disabling it (<i>observation data</i>).</p>
<p>9. Proximity with patient: in robotic surgery the surgeon is being moved away from the patient's side.</p>	<p>A. The new spatial alignment moved away Dr. "I" from the patient. Dr. "I" during surgical procedures was moving several times from his console when he faces any problem toward the patient (<i>Observation data</i>).</p> <p>B. "Being placed far from the patient can make a surgeon feel 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" (<i>Interview data</i>).</p>

Table 5.6: first order analysis (4)

Table First-Order Analysis: Balancing between old and new tasks

Themes	Representative data
<p>10. Communication: communication changed between team members in robotic surgery vs. laparoscopy.</p>	<p>A. "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" (<i>Interview data</i>).</p> <p>B. Miscommunication according to Dr. "H" "Because they misinterpreted my words or actions" or "I ask others to repeat what they were saying since I am not understanding what their message or I can't hear it" (<i>Interviews data</i>).</p> <p>C. We noticed that when a practitioner is familiar with the procedure, communication becomes easier: a scrub nurse who had no experience with robotic surgery, who happen to replace the old one, faced some communications failures with the surgeon (<i>observation data</i>).</p> <p>D. When the noise level was high in the OR, the surgeon encountered communication problems with the rest of the team mainly because of his distance (<i>observation data</i>).</p>

Table 5.7: first order analysis (5)

First-Order Analysis: Balancing between old and new tasks

Themes	Representative data
<p>11. Human interactions: human interaction is limited in robotic surgery.</p>	<ul style="list-style-type: none"> A. In the majority of he surgeries observed, human interactions were limited to when problems occur (<i>Observation data</i>). B. Dr. "I" in during the whole robotic urgery is operating by himself. Hence, actions are centralized and interactions limited (<i>Observation data</i>). C. « Non-verbal interaction plays an important role in surgery : eye contact, gestures and body movements » (<i>Interview data</i>).
<p>12. Technology/Human interactions: the role of the robotic to extend human capabilities in different surgical tasks and to replicate the surgeon's actions.</p>	<ul style="list-style-type: none"> A. « The use of the robotic is simple once you get use to it. It present lots of technical advantage especially concerning precisions and degree of liberty » (<i>Interview outcome</i>). B. Eventhough the use is simple but problems can be encountered. Dr. "I" faced problems with the robotic system that let him stop the manipulations (<i>Observation data</i>).

Table 5.8: First order analysis (6)

Second-Order Analysis: Balancing between old and new tasks

Theoretical aspects	Themes
1. Psychological safety	<ul style="list-style-type: none"> A. Proximity with patient creates individual and collective psychological safety. B. The new spatial alignment decreased the psychological safety of the team. C. The problems that the surgeon can encounter with the robotic system decrease his one psychological safety.
2. Learning new ecologies of space	<ul style="list-style-type: none"> A. With the new spatial arrangement, teams are learning new ecologies of space. B. New roles and interaction patterns are put in place.
3. Centralization	<ul style="list-style-type: none"> A. The new centralization of Taks created miscommunication. B. Human interaction are limited Therefore when its needed it is not efficient. C. Changing roles misled team members

Table 5.9: Second order analysis (1)

Second-Order Analysis: Balancing between old and new tasks

Theoretical aspects	Themes
4. Learning	<ul style="list-style-type: none"> A. The primary surgeon or team leader is still in the phase of trial error therefore he can not transfer his knowledge B. Being in the learning step, the team leader will not help create psychological safety in the team for a complete technology implementation.
5. Situation awareness & sensemaking	<ul style="list-style-type: none"> A. The new spatial alignment isolated the primary surgeon being away from the patient and from the other team members decreased the individual situatuon awareness no indicies or cuesto understand fully the situation. Thus creating sense out of it.

Table 5.10: Second order analysis (2)

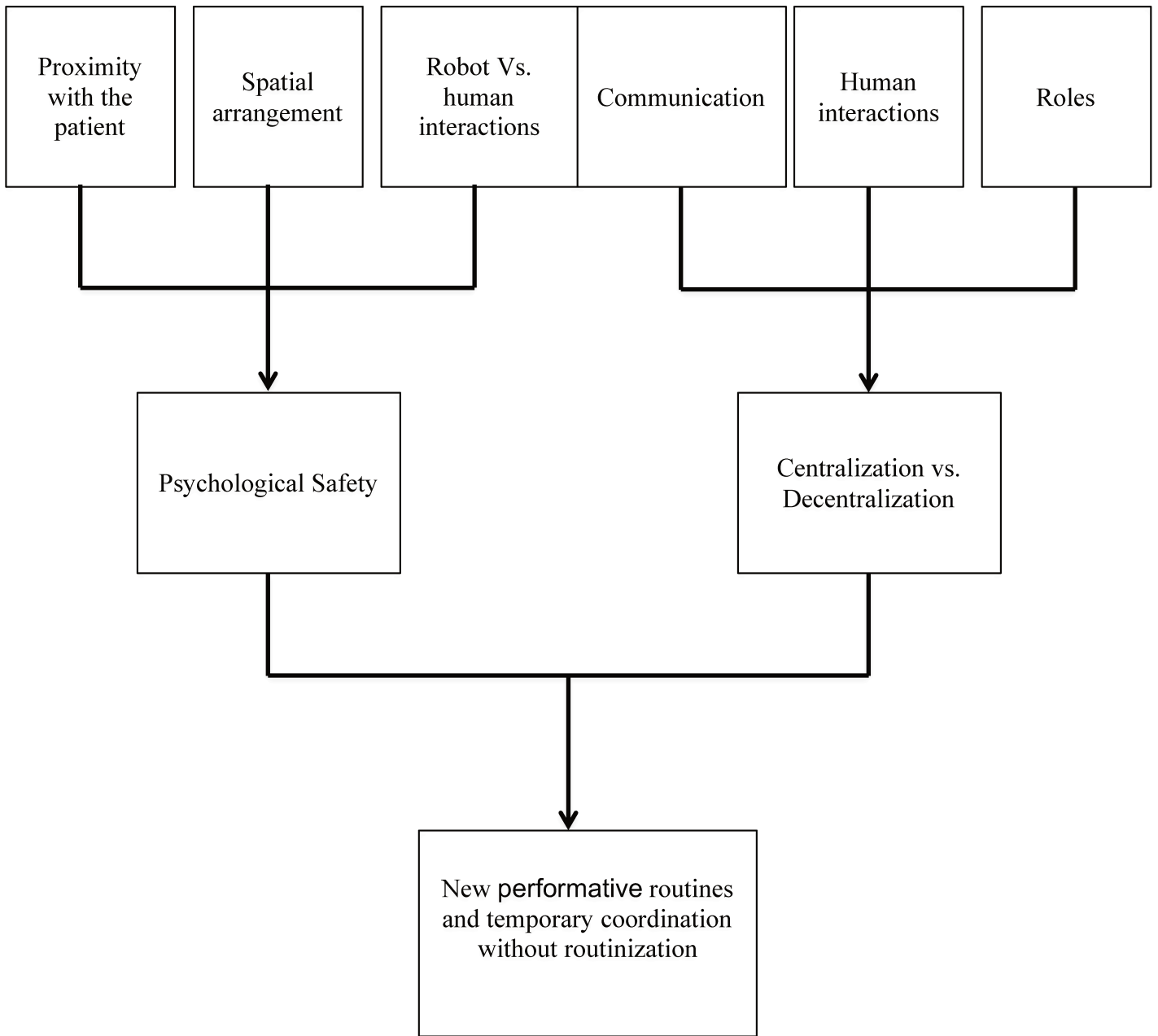


Figure 5.9: Temporary routinization factors in bariatric robotic surgery

	Laparoscopic surgery	Robotic surgery
Roles	<ul style="list-style-type: none"> - Well established - Who knows what is well defined 	<ul style="list-style-type: none"> - Central role for the surgeon - Reduced team member's number - Role negligible of team members
Coordination	<ul style="list-style-type: none"> - Deep rooted coordination - Who does what is well defined 	<ul style="list-style-type: none"> - Minimal coordination since the surgeon is manipulating the whole procedure he is trying to coordinated between his own manipulation and robotic arms - Coordination is occasional related to unexpected events
Communication	<ul style="list-style-type: none"> - Intensive communication - Communication promotes learning 	<ul style="list-style-type: none"> - Communication is limited to when adjustments are needed
Centralization/Decentralization	<ul style="list-style-type: none"> - Decentralization persists of tasks divided between the surgeon and the team 	<ul style="list-style-type: none"> - Centralization of tasks, surgical act limited to the surgeon
Learning	<ul style="list-style-type: none"> - Learning of procedural act is transmitted to other team members - Codified knowledge is transmitted 	<ul style="list-style-type: none"> - Team leader in the phase of learning by doing - Tacit knowledge hard to transfer due to lack of coordination

Table 5.11: General Comparaison

Chapter summary

In this chapter we presented our findings. We organized the data that we have from the interviews, observations, videos, debriefing, documents etc. We mainly used a story telling to present our data and create meaningful data. We added tables that summarizes our field work findings.

Chapter 6 : Comprehension of the implementation process

Chapter introduction

This chapter presents an interpretation of our empirical data discussed in chapter 5.

In the previous chapter we illustrated the results from our study based on the data collected from our observations (live and video-taped) and interviews. In this chapter we are going to present the link between the analysis and the concepts found in the literature that we presented in part I. We discuss our contribution to the literature and our methodological contributions. We conclude this chapter with a model that we developed that emerged from our discussion. This model presents a summary of the phenomena perceived.

Discussion[†]

6.1 Robotic surgery and individual expertise

Robotic surgery was mainly developed to overcome some challenges faced by the surgeon with laparoscopy. Beside these technical difficulties, one of the advantages of operating with robotic surgery is reducing the surgeon's distraction since he is totally focused on doing his operating tasks. Presumably, the decreased amount of distraction will improve the decision making of the surgeon (Deutsch et al., 2015). It was proven in literature that more distractions affect negatively decision making since there will be a flow of information and this less cues that will lead to appropriate decision making (Speier et al., 1999). This less distraction aspect is mainly due to the location of the surgeon away from the patient and other team members where discussion unrelated to the surgery may occur. In addition to that the 3D images provided by the console screen, give the surgeon a sense of immersion which is not the case in laparoscopy. The fewer information and less distraction provided to the surgeon lead to less cognitive effort. This is outweighed by the cognitive effort of the surgeon who needs to control up to three instruments and the camera all by himself on the contrary of laparoscopy where he is controlling two instruments and helped by his assistant surgeon and the scrub nurse (Embedded, 2016). Scholars in literature argued that surgeons convert from laparoscopy to open surgery when dealing with difficulties i.e. when the stress level is high (Luca et al., 2009).

[†] Part of this discussion is taken from the paper accepted to EGOS Colloquium : Learning a new ecology of space and looking for new performative routines : "Implications of new technological artefacts inside a surgical team" (L. Kiwan, N. Lazaric 2016).

Furthermore, they argued that due to the comfort presented by the robotic console, the surgeon's is dealing with less stress thus, the conversion rate decrease (Luca et al., 2009). This is the case when the surgeon is used to the use of the new technology. Our data do not support this claim. In the surgical cases we observed, the surgeon was converting from robotic surgery to laparoscopy as soon as he encounters a problem. We did not witness any conversion from laparoscopy to open surgery or from robotic surgery to open surgery. The surgeons are used to operating using laparoscopic technique therefore the stress of using the technology itself is not present anymore due to the routinization of the laparoscopic procedure. In robotic surgery, as soon as the surgeon feel insecure about his actions or about the feedback of the robotic system, he directly converts to laparoscopy since he feels more secure. This is due to the lack of confidence of the surgeon with the robotic system due to the lack of repetition. The surgeon is more secure and less stressed when he become enough experienced with the new technology (Stahl et al., 2005). Even though the surgeon is using the robotic system since couple of years ago but the use is occasional, not repetitive enough and disrupted by laparoscopy (the majority of the surgeries observed where operated with laparoscopy and then conversion to robotic surgery takes place when precision is needed). While making a decision, the surgeon is searching for cues. One of the cues is the feedback from the tactile perception. The lack of tactile feedback that is the source of anatomic information is a major limitation of robotic surgery (Simorov et al., 2012). In order to overcome these difficulties, the surgeon can rely more on his visual

perception. Anatomic information is important for the surgeon that is searching for cues to match with the pattern of actions already taken in past experiences. Role of experience is well defined in the RDP model that enable pattern matching and thus creating mental models (Klein 2008). As mentioned in chapter 1, RDP model illustrates that major role of experience that will trigger the mental models and as a consequence choose the relevant course of action based on a past experience or adapt a course of action already taken in the past to the current situation or problem. This is done while taking into consideration the familiarity of the situation.

Gillespie et al., 2010 argued that communication and coordination are improved when team members are familiar with each other and with the procedure. There are lots of debates in literature on the effectiveness and efficiency of a new technology adoption in surgery. In robotic surgery, the surgeon is affected in terms of his decision making process. In our study, we noticed how the surgeon is isolated from the actual action on his console. The surgeon burry himself on the console. Being away from the patient and the rest of the team decreased his individual situation awareness. Situation assessment and sensemaking lead to situation awareness. It is an essential element for the expert i.e. the surgeon to make a decision while operating. We followed the reasoning of the naturalistic decision making research (Klein 2001) that focuses on the importance of a situation assessment therefore situation awareness that enables an individual to take a decision based on the context of the situation. The surgeon in our study faced challenges due to the new

physical alignment in the OR. This new alignment put him away from the sterile zone where the patient and the other team members (his assistant surgeon and the scrub nurse) are present. This decreased his situation awareness. In order to take decisions, the surgeon needed a higher flow of information from other team members. As a consequence, individual situation awareness is replaced by the collective one. Recognition-primed model (RPD) presented by Klein identified situation assessment as a critical element by which an expert, the decision maker, chooses accordingly the right course of action. RPD model emphasizes the importance of the actual situation and its context to trigger mental models therefore pattern matching to guide the decision process (Klein, 2008). Better situation awareness of the surgeon is associated with better decisions and therefore less surgical errors (Catchpole et al., 2008; Mishra et al., 2008). As observed in our study, the surgeon was most of the time depending on the team communication in order to maintain his situation awareness. This is coherent with literature on robotic surgery that emphasizes on the importance of team situation while operating with the robotic system. Since we are dealing with teams in the OR coordination is essential to have positive operating output. In order to do so, each team member should be aware about his part of responsibility and his exact role during a surgical procedure. This is classified under the term situation awareness (Endsley and Robertson 2000). Distributed situation awareness (Stanton et al., 2006) recognizes that different agents have different views of the same scene. We observed how the surgeon was not very sure about his actions and about what is actually going on from the

patient's side while manipulating the robotic system from the console. Thus, even though he was asking his assistant to have more informations about the output of his manipulations and about the patient's situation. He was not totally confident of what his assistant is transmitting as information. Each individual has his own interpretation of the situation. What seem to be ok for an individual might not be acceptable for another individual. In order to attain a collective shared situation awareness, the flow of information should be shared between all team members in a clear way giving the fact that not each one have the same information access as in robotic surgery where the spatial alignment play an important role in the information disruption. Information exchange is done orally which present a challenge in robotic surgery due therefore affecting negatively decision making.

When we talk about an expert taking decisions or acting in a given situation, we are taking into account actions happening is real time. Real time situations are characterized by uncertainty. Therefore, it is important for experts to comprehend the situation that they are in. Two concepts in literature enables full understanding of the situation and analyzed this aspect: situation awareness and sensemaking.

In our case we take into consideration the third level discussed by Klein: case of non-familiar situations. The expert use mental simulation in order to take the appropriate decision. In order to be able to do these mentak simulation. He is in need of relevant cues of the situation that will enable him to have all the indices to understand the situation. These cues normally are also some key features that influence situation awareness.

This latter is a primary factor in the decision making process (Zsombok & Klein, 1997). Once disturbed, it will directly affect the decision making process. In addition to that, once the relevant cues are not well detected (Figure 6.1) it will therefore affect the expectancies of the decision maker, change his goals and as a consequence the possible actions. Once the recognition four by-products are affected, the whole process of evaluating through mental simulation is also affected since it is based on false information.

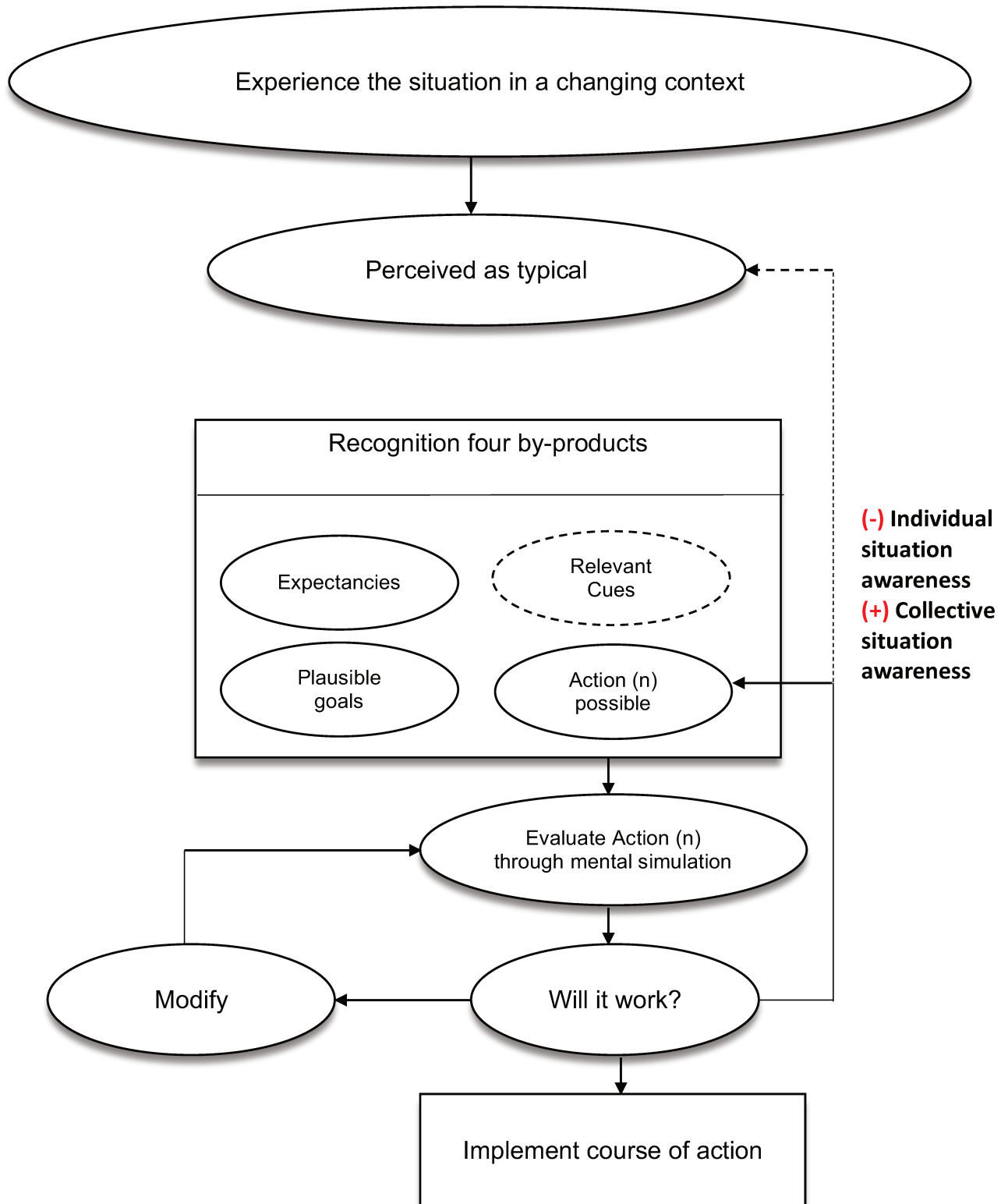


Figure 6.1: RPD and robotic implementation

6.2 Robotic surgery and collective expertise[‡]

Repetition is an essential element in new technology adoption. In our study, technology is brought at the center of routines (D'Adderio 2011) and the robotic system was adopted in non-disruptive way once per week. In this context novel patterns of action suffer from a lack of recurrence and new forms of communication appear to be not really well performed. In the hospital's context with a clear division of labour, the team leader's actions are critical for maintaining the team stability and psychological safety enabling the adoption of technological artefacts (Edmondson et al, 2001). In our study, during robotic surgery, the primary surgeon is the leading actor in the OR. With the introduction of the robotic system, actions are centralized around him due to new role repartition, modes of communication and human's interactions. This led to a more centralized form of coordination and a new ecology of space reinforcing his position and his responsibility in case of misfit.

Moreover, being away from the patient with this new ecology of space that creates a new form of interaction that remain unfamiliar to the teams 's leader and his or her team. Thus the team's leader (here the primary surgeon) cannot transfer his own expertise to the rest of the team creating a situation where exploration is observed but not really performed efficiently. Learning by trial and error is in fact a normal situation encountered by many organizations (Rerup and Feldman 2011). However, the professional context observed in hospitals faces with many difficulties

[‡] Part taken from the paper accepted to EGOS Colloquium : Learning a new ecology of space and looking for new performative routines : "Implications of new technological artefacts inside a surgical team" (L. Kiwan, N. Lazard 2016).

impeding to give resources, time for learning and enabling conditions for new patterns of action to be performed smoothly.

As a result, a new sort of provisional coordination is maintained without creating possibility for potential routinization. Thus new forms of procedural knowledge for implementing reliable interactions enabling emergent patterns of actions to be performed smoothly are lacking and patterns remain provisional ones (Lazaric and Denis 2005).

Finally, another methodological question emerges from our ethnographic study: the place of researcher who is using video-recording. For instance, we may ask also to our self to what extent our observations is interfering (or not) on reality and on patterns of action that can be different with the absence of this recording. This issue was well debated by psychologists from the ethics point of view (Leroy et al., 2012, Bobiler-Chamon and Clark 2008). Psychologist scholars tried to use debriefing (Hamed et al., 2007) with the observed team as a method to avoid any ambiguity and have assurance about the data. In our study we explored a debriefing with the surgical team in order to understand further some of the actors human and technology interactions. This issue was not really embraced by organizational scholars and deserve greater attention in ethnography for future research in this field.

Our study showed that robotic surgery faces lots of challenges. These challenges need to be understood and hospitals need to overcome these challenges in order to have a successful implementation. Our study illustrated that having enough repetition is an important element to adapt to a new sociotechnical system. On the individual level, repetition will

enable the surgeon to be experienced enough and overcome the learning by doing. Being experienced enough leads to create mental images. These mental images will be triggered once the expert is making a decision. Moreover, what can help in overcoming the lack of situation awareness is the positioning of the console in the operating room. Positioning the console facing the patient can be beneficial in terms of situation awareness. The surgeon will not feel totally isolated.

On the other on the collective level, repetition will help the team members to adapt to their new roles and new ecologies of space thus creating new routines. Not having enough repetition and the use of the technological artefact occasionally created temporary coordination therefore provisional routines. An artefact in brought at the center of a routine (D'addario 2001) therefore it should disrupt the old routines. By operating during the same surgical procedure using old routines i.e. laparoscopy then converting to robotic surgery is misleading and not disruptive. The expert is still in the phase of learning by doing due to lack of enough experience with the robotic system as a consequence psychological safety of the team if not assured. The expert or surgeon in our case is the leader of the team. The leader is the on responsible of maintaining the team psychological safety team which is a necessity during a new technological artefact adoption (Edmonson 2001).

Figure 4 presents a summary of our research outcome discussed above.

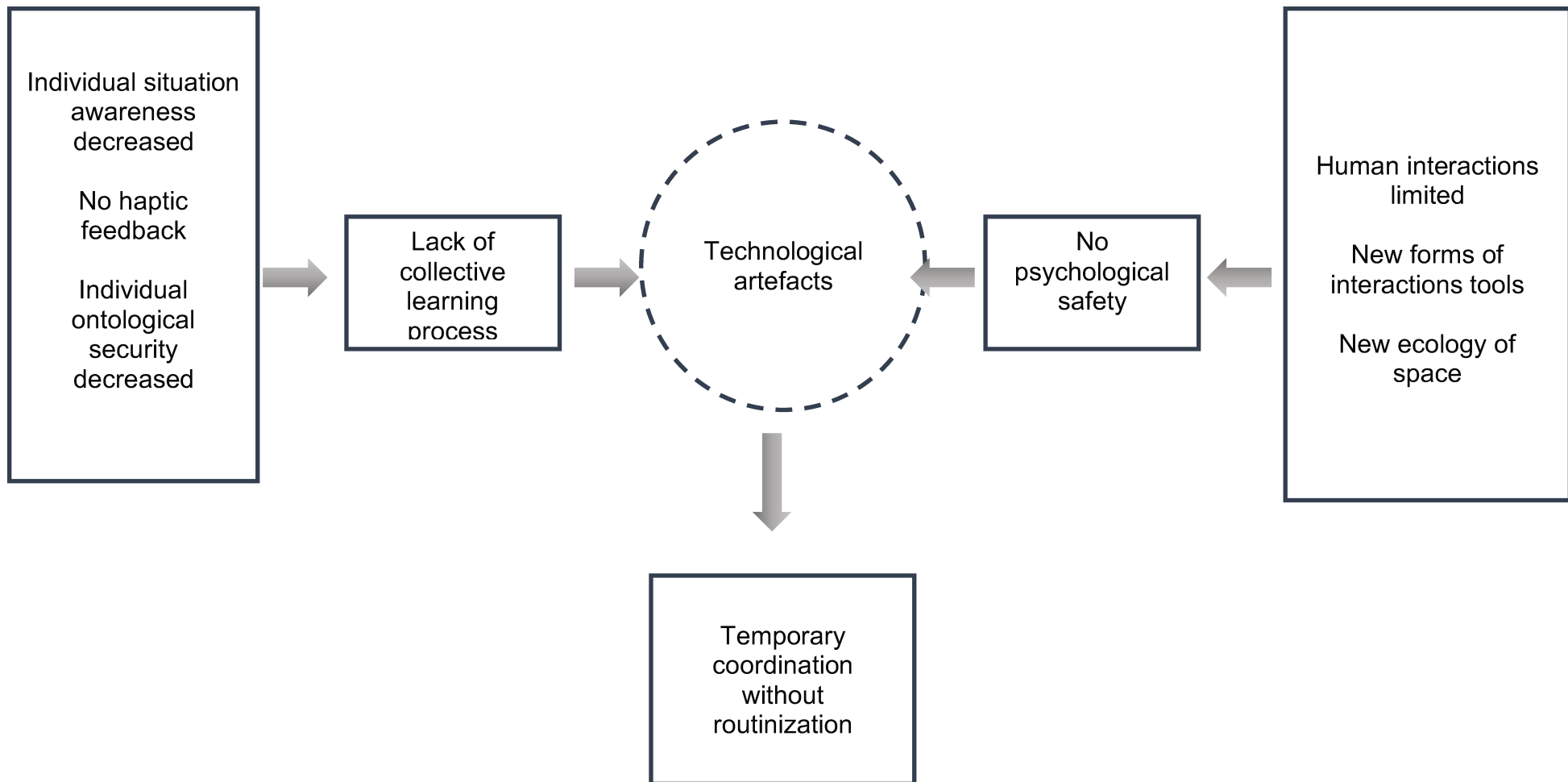


Figure 6.2: Summary of provisional pattern of action in bariatric robotic surgery

Chapter summary

In this chapter we discussed our results and linked them with the literature that we presented in part I. Robotic surgery have a negative effect on individual expertise in terms of decision making and taking the right course of action. This is caused by the lack of relevant cues that the expert can have or the misleading indices that he can be facing. As a consequence, the expert will have a decreased situation awareness and sensemaking of the situation. Form the other hand, implementing robotic surgery created new coordination patterns between team members. Due to lack of repetition, the practitioners could not be familiar with the new ecologies of space and new interactions. As a result, temporary routines are created.

General conclusion

This general conclusion enables us to have a debriefing on our research. We will present our contributions in terms of theoretical, managerial and methodological perspectives. Moreover, we will present recommendations for organizations to adopt this new technological artefact. At the end of this conclusion, we will present limitations of this study and questions for potential future research projects.

The main interest of this study is to understand the impact of a new technological artefact on an expert in terms of his decision making process. Moreover, to understand how collective team work and organizational routines are affected by this new adoption. We estimated that healthcare is a field that triggered lots of scholars in the past couple of years. Scholars from other disciplines than medicine were interested in understanding the role of innovation change and uncertainty on medical practices. New technologies have changed lots of practices in medicines specifically in surgery. Naturalistic researchers targeted also this field for a better understanding of expert's behavior in extreme situations. On the other hand, team practices in the OR was an interesting subject for scholars to study team behaviors facing change.

In order to understand the aspects mentioned above, we conducted a qualitative study aiming to analyze a particular case. It is the case of robotic implementation in the OR in bariatric surgery.

Our results show contributions from the managerial, theoretical and methodological perspective.

From **the theoretical perspective**, we have three contributions.

First, the importance of the individual situation awareness (Endsley 2016), sensemaking and situation assessment of an expert in the decision making process especially when adopting a new technology is demonstrated in our study. Lack of situation awareness and situation assesment decrease the confidence of the experts therefore affecting their reasoning. When reasoning is affected, the expert will not be able to make decisions to chose an efficient and effective course of action adapted to the situation encountered. The naturalistic approach is based on the search of non-limited resources in order to let experts make the appropriate decision. In our case, lack of situation awareness decreased the confidence of the experts. This is due to the time pressure and limited attention while using the new technological artefact.

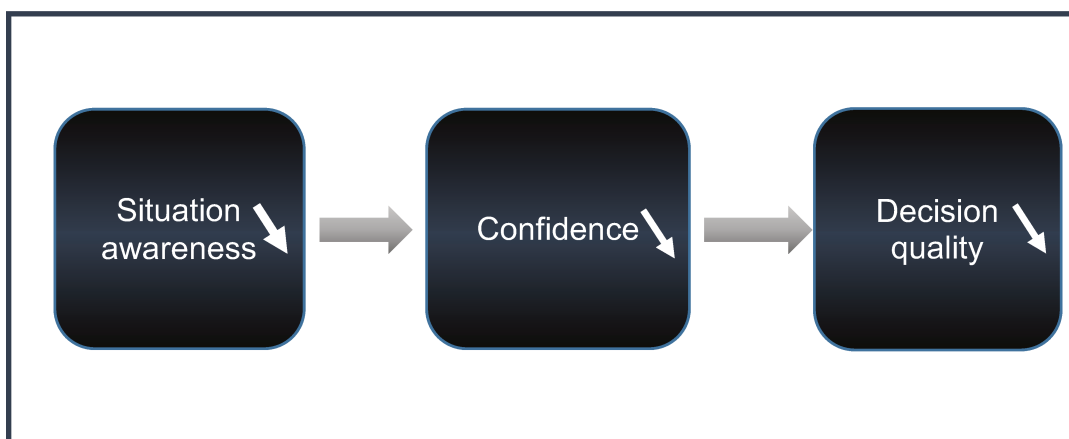


Figure -I-: First theoretical contribution

Second, the importance of the **team leader's role** for implementing a new technology within the team (Edmonson 2001,2004). From the **naturalistic perspective** (Klein 2001) we attribute an important role for the **expert**

during the decision making process. The individual aspect is taken into consideration without discussing the **collective aspect**. We demonstrated the role of the team leader / expert on the decision making process in a team. We contributed in adding the collective image of the situation. When individual expertise is disturbed with the new technological artefact, collective expertise will be affected thus creating new lasting performative routines becomes difficult. When the team leader is still in the phase of trial of error, he can not transfer his knowledge and provide psychological safety to the rest of team. This latter is an essential element in a new technology implementation (Edmondson 2004).

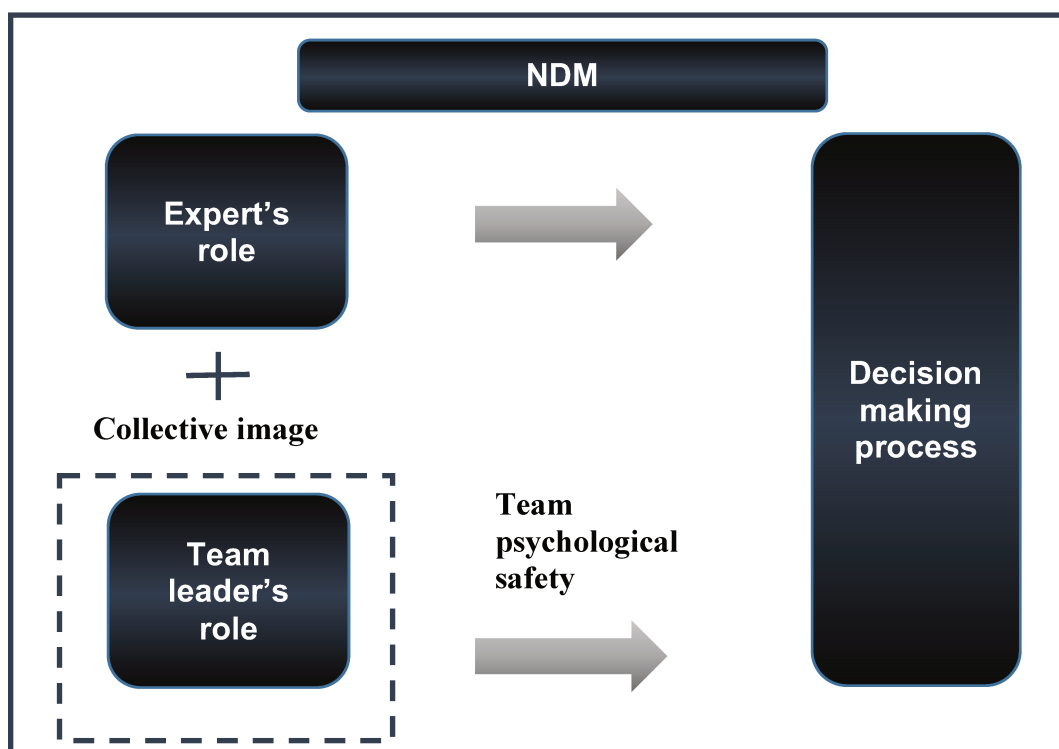


Figure -II-: Second theoretical contribution

Third, repetition is an essential element in new technology implementation. In our study, technology is brought at the center of routines (D'Adderio 2011) and the robotic system was adopted in non-

disruptive way once per week. In this context novel patterns of action suffer from a lack of recurrence. Therefore, new forms of communication appear to be not really well performed. In the hospital's context with a clear division of labour, the team leader's actions are critical for maintaining the team stability and psychological safety enabling the adoption of technological artefacts (Edmondson et al, 2001).

Moreover, being away from the patient with this new ecology of space, creates a new form of interaction remains unfamiliar to the teams 's leader and his or her team. Thus the team's leader (here the primary surgeon) can not transfer his own expertise to the rest of the team creating a situation where exploration is observed but not really performed efficiently. Learning by trial and error is in fact a normal situation encountered by many organizations (Rerup and Feldman 2011). However, the professional context observed in hospitals faces with many difficulties impeding to give resources, time for learning and enabling conditions for new patterns of action to be performed smoothly.

As a result, a new sort of provisional coordination is maintained without creating possibility for potential routinization. Thus new forms of procedural knowledge for implementing reliable interactions that enable emergent pattern of actions to be performed smoothly are lacking. As a result, patterns remain provisional ones (Lazaric and Denis 2005).

In our study, during robotic surgery, the primary surgeon is the leading actor in the OR. With the introduction of the robotic system, actions are centralized around him due to new roles repartition, modes of

communication and human's interactions. This led to a more centralized form of coordination and a new ecology of space reinforcing his position and his responsibility in case of misfit.

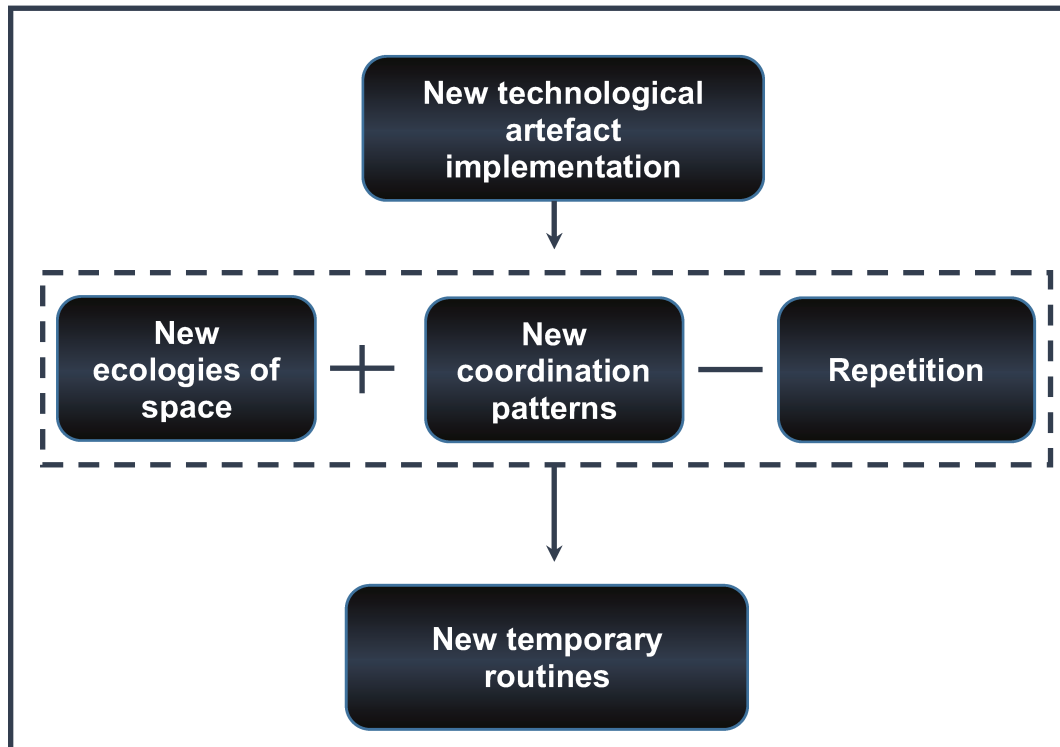


Figure -III-: Third theoretical contribution

From **the methodological perspective**, the use of video analysis combined with other methods is used rarely in management studies. The detailed video analysis based on conversation and gesture analysis is usually used in psychology (Hostetter 2011, Krauss et al 1996). Our study is an example of the effectiveness of using this technique in our field and that opens the door for the technique to be used more frequently especially in ethnographic studies. Furthermore, a question emerges from our ethnographic study: the place of researcher who is using video-recording. For instance, we may ask also to our self to what extent our observations are interfering (or not) on reality and on patterns of action that can be different with the absence of this recording. This issue was well debated by psychologists from the ethics point of view (Leroy et al., 2012, Bobiler-Chamon and Clark 2008).

Second, psychologist scholars tried to use debriefing (Hamed et al., 2007) with the observed team as a method to avoid any ambiguity and have assurance about the data. In our study we explored a debriefing with the surgical team in order to understand further the actors and technology interactions. This issue was not really embraced by organizational scholars and deserve greater attention in ethnography for future research in this field.

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- (1) Use of video observation with more detailed conversation and gesture analysis.
 - (2) Use of debriefing with auto-confrontation.

Figure -IV-: Methodological contributions

From the **managerial perspective**, once a new technology is adopted by an organization it should be done with disruption no return. For example, surgeons once they adopt the robotic system, they should operate in a continuous manner with it. In our case there was no disruption in the adoption. Organizations are in continuous technological evolution. Healthcare is one promising field where technologies are adopted in diagnosis as well as in treatments. Doctors are trained since their early studies using simulation and other types of technologies that will help them diagnose or treat a specific case i.e : serious games. All healthcare systems are shifting into new technologies and digitalization era. In our research, we were interested specifically by the treatment precisely robotic semi-assisted system. This robotic system changed the roles and interactions in the OR. The configuration of the OR changed completely. Due to lack of repetition this new configuration affected surgeon's expertise in terms of disturbing his decision making process. Furthermore, surgical acts are centralized and the surgeon is isolated from the rest of the team. As a consequence, the usual interactions between team members based on communication, coordination anticipation and prediction of each other's action were disturbed due to the new spatial arrangement.

The implementation of a new technology should be done smoothly in a continuous manner with disruption. Going back to old routine may disturb the transition.

Figure -V-: First managerial contribution

Second, in order for this robotic system to be well adopted, a system similar to **Crew resource management**⁴ should be developed. During our study we had the opportunity to meet representatives of the robotic system we were observing. They impose a list of recommendations including trainings, technical maintenance for the hospitals. Furthermore, they agreed with us on the communication failures that can occur during robotic surgery. From the technical point of view, the company is developing more features in the robotic system. For example, they are integrating augmented reality⁵ to have full information and data. Another example is the development of heptic⁶ feedback senses. By developing these two characteristics, the company is trying to compensate the loss of tactile feedback and lack of situation awareness due to the distance between the console and the patient. The aim is to create psychological safety for the surgeon operating. Still, we found it important to minimize the distance between the console and the robotics arms. This will create more safety for the surgeon. The company argued that the training is done for the technical manipulation of the robotic system for all team members. ***What we found missing is the trainings to guide the new communication and coordination patterns that were changing.***

Importance of the developement of CRM while implementing a new technology.

Figure -VI- Second managerial contribution

⁴ Trainings that focuses on interpersonal communication, leadership and decision making.

⁵ Augmented Reality (AR) is a technology enriching the real world with digital information and media, such as 3D models and videos, overlaying in real-time.

⁶ Recreating sense of touch or force feedback

Third, this study triggers the ideas for further studies in the field. One of them is **risks, errors and security**. Working on robotics in surgery made us gain insights on how team members work in the operating room. What intrigued us at the end of this study is the high level of risk to manage in healthcare specifically in the operating room during surgical procedures. Team members became more attentive about their actions, therefore the security increased. Thus, questions emerged at the end of our study: What are the effects of robotics on the risk management strategy of surgical team and therefore on the hospital as a whole? on a broader aspect what is the effect of a new technology on the risk management of an organisation? In order to answer the above questions, we developed a research plan. This plan starts with the classification of the different potential risks in the organization. These risks are classified in terms of two classifications. First, we classify risks according to their parameters and horizon. After classifying the risks observed. The next step is to put the relevant strategy to each risk measured.

When expertise decrease with a new technology implementation, the security level increase.

Figure -VII-: Third managerial contribution

Finally, we end our conclusion with the **limitations** of our study. One of these limitations is that we observed just one type of surgeries “bariatric surgery” specifically gastric bypass surgery while using the robotic system. Given the specialized context of this research, similar to every qualitative researches we are faced with the question of generalization. Hence, this study can be followed by other studies on others types of surgery in order to reinforce our results.

Furthermore, the majority of the surgeries observed were operated with the same surgical team. The results may be affected if the teams were often changed. It was mainly one of the recommendations of the company that developed the robotic system. In addition to that, the configurations and team turnover is different in public versus private hospitals. Our study was conducted in a public hospital.

Another aspect that might be considered is the influence of the video-recording on the participants’ actions. This might be considered a question for a future research. We argue that participants might be affected at the beginning of the observation process by the observant and by the camera presence. This presence will be totally ignored when the practitioners are actually in action. They can not be mistaken or continue pretending since there is a life of another human being in their hand and they are responsible in the law.

The four years of PhD were challenging years. It gave us insight on how expertise can be affected by a new technology. Like every research there will be always lots of questions to be answered.

CONCLUSION GENERALE (*Français*)

Cette conclusion générale nous permet d'avoir un debriefing sur notre recherche. Nous présenterons nos contributions théoriques, managériales et méthodologiques. De plus, nous présenterons des recommandations pour les organisations afin adopter ce nouvel artefact technologique. A la fin de cette conclusion, nous présenterons les limites de notre étude et des questions pour des futurs projets de recherche.

L'objectif principal de cette étude est de comprendre l'impact d'un nouvel artefact technologique sur un expert en termes de processus décisionnel. En outre, pour comprendre comment le travail collectif de l'équipe et les routines organisationnelles sont affectées pendant cette nouvelle adoption.

Les soins de santé est un domaine qui a suscité l'intérêt de nombreux chercheurs au cours des dernières années. Les chercheurs d'autres disciplines que la médecine étaient intéressés aussi de comprendre le rôle du changement qu'apporte l'innovation et l'incertitude sur les pratiques médicales. Les nouvelles technologies ont changé beaucoup de pratiques médicales spécialement en chirurgie. Les chercheurs naturalistes ont également ciblé ce domaine pour mieux comprendre le comportement des experts notamment dans des situations extrêmes. D'autre part, les pratiques d'équipe dans le bloc opératoire étaient un sujet intéressant pour les chercheurs dans le but d'étudier les comportements d'équipe face au changement.

Afin de comprendre les aspects mentionnés ci-dessus, nous avons mené

une étude qualitative visant à analyser un cas particulier. C'est le cas de la mise en oeuvre d'un système robotique dans le bloc opératoire en chirurgie bariatrique.

Nos résultats mènent à des contributions du point de vue managérial, théorique et méthodologique.

Du point de vue théorique, nous avons trois contributions. Tout d'abord, l'importance de la sensibilisation. La situation individuelle (Endsley 2016), l'évaluation du sens de la situation d'un expert dans le processus décisionnel, en particulier lors de l'adoption d'une nouvelle technologie est démontrée dans notre étude. Le manque de conscience de la situation et l'assessment de la situation diminuent la confiance des experts, ce qui affecte leur réintégration. Lorsque le raisonnement est affecté, l'expert ne sera pas en mesure de prendre des décisions pour choisir un plan d'action efficace adapté à la situation rencontrée.

L'approche naturaliste est basée sur la recherche de ressources non limitées afin de permettre aux experts de prendre une décision appropriée. Dans notre cas, le manque de conscience de la situation a diminué la confiance des experts. Ceci est dû à la pression temporelle et à l'attention limitée lors de l'utilisation du nouvel artefact technologique.

Deuxièmement, l'importance du rôle du chef d'équipe dans la mise en oeuvre d'une nouvelle technologie au sein de l'équipe (Edmondson 2001, 2004). Du point de vue naturaliste (Klein 2001), nous attribuons un rôle important à l'expert lors du processus décisionnel. L'aspect individuel est pris en considération et non pas l'aspect collectif.

Nous avons démontré le rôle du chef d'équipe / expert sur le processus

décisionnel en équipe. Lorsque l'expertise individuelle est perturbée par le nouvel artefact technologique, l'expertise collective sera affectée, de sorte que la création de nouvelles routines performatives durables devient difficile. Lorsque le chef de l'équipe est encore en phase d'essai et d'erreur, il ne peut pas transférer ses connaissances et assurer la sécurité psychologique au reste de l'équipe. Ce dernier élément est essentiel dans la mise en oeuvre d'une nouvelle technologie (Edmondson 2004).

Troisièmement, la répétition est essentiel dans mise en oeuvre de nouvelles technologies. Dans notre étude, la technologie est au centre des routines (D'Adderio 2011). Le système robotique a été adopté de manière non perturbatrice une fois par semaine. Dans ce contexte, de nouveaux modèles d'action souffrent d'un manque de récidence. Par conséquent, de nouvelles formes de communication semblent ne pas être vraiment bien exécutées. Dans le contexte hospitalier avec une division claire du travail, les actions du chef d'équipe sont essentielles pour maintenir la stabilité de l'équipe et la sécurité psychologique permettant l'adoption des artefacts technologiques (Edmondson et al., 2001).

En outre, être éloigné du patient avec cette nouvelle écologie de l'espace qui crée une nouvelle forme d'interaction reste inconnue pour le chef d'équipe et son équipe. Ainsi, le leader de l'équipe (ici le chirurgien principal) ne peut pas transférer son propre expertise au reste de l'équipe en créant une situation où l'exploration est observée mais pas vraiment efficace. L'apprentissage par essais et erreurs est en fait une situation normale rencontrée par de nombreuses organisations (Rerup et Feldman 2011).

Cependant, le contexte professionnel observé dans les hôpitaux fait face à de nombreuses difficultés empêchant de donner des ressources, le temps nécessaire, l'apprentissage et la mise en place harmonieuse des conditions pour que les nouveaux modes d'action se déroulent.

En conséquence, une nouvelle sorte de coordination provisoire est maintenue sans créer de possibilité de routinisation potentielle. Ainsi, il manque de nouvelles formes de connaissances procédurales pour implémenter des interactions fiables qui permettent de réaliser en douceur des modes d'action émergents. En conséquence, les modèles restent provisoires (Lazaric et Denis 2005).

Dans notre étude, lors de la chirurgie robotique, le chirurgien principal est l'acteur principal dans le bloc opératoire. Avec l'introduction du système robotique, les actions sont centralisées autour de lui en raison des nouvelles répartitions des rôles, de modes de communication et d'interactions humaines. Cela a conduit à une forme de coordination plus centralisée et à une nouvelle écologie de l'espace renforçant sa position et sa responsabilité en cas d'inadéquation.

D'un point de vue méthodologique, d'abord l'utilisation de l'analyse vidéo combinée avec d'autres méthodes est rarement utilisée en sciences de gestion. L'analyse vidéo détaillée basée sur l'analyse de la conversation et des gestes est généralement utilisée en psychologie (Hostetter 2011, Krauss et al 1996). Notre étude est un exemple de l'efficacité de l'utilisation de cette technique dans notre domaine et ouvre la voie à une utilisation plus fréquente de la technique, en particulier dans les études ethnographiques. En outre, une question émerge de notre étude

ethnographique: le rôle du chercheur qui utilise l'enregistrement vidéo. Par exemple, nos observations interfèrent (ou non) sur la réalité et sur les modèles d'action qui peuvent être différents avec l'absence de cet enregistrement. Cette question a été bien débattue par les psychologues du point de vue de l'éthique (Leroy et al., 2012, Bobiler-Chamon et Clark, 2008).

Deuxièmement, les chercheurs en psychologie ont essayé d'utiliser le debriefing (Hamed et al., 2007) avec l'équipe observée comme méthode pour éviter toute ambiguïté et avoir l'assurance des données. Dans notre étude, nous avons exploré un débriefing auprès de l'équipe chirurgicale afin de mieux comprendre les acteurs et les interactions technologiques.

Ce problème n'a pas été vraiment étudié par les chercheurs de l'organisation et méritent une plus grande attention dans l'ethnographie pour des futures recherches dans ce domaine.

Du point de vue managérial, quand une nouvelle technologie est adoptée par une organisation, cette adoption devrait être sans retour en arrière. Par exemple, les chirurgiens une fois qu'ils adoptent le système robotique, ils devraient l'utiliser de façon continue. Dans notre cas, il n'y a pas eu de perturbation dans l'adoption. Les organisations sont en évolution technologique continue. La médecine est un domaine prometteur. Les nouvelles technologies sont adoptées dans le diagnostic ainsi que dans les traitements. Les médecins sont formés depuis leurs premières études. L'aide de la simulation et d'autres types de technologies qui les aideront à diagnostiquer ou à traiter un cas spécifique, par exemple les serious games. Tout le milieu médical s'évolue vers les nouvelles technologies et

l'ère de la numérisation. Dans notre recherche, nous avons été intéressés par le traitement plus précisément le système semi-assisté robotique. Ce système robotique a changé les rôles et les interactions au sein du bloc opératoire. La configuration du bloque opératoire change complètement.

En raison du manque de répétition, cette nouvelle configuration a affecté l'expertise du chirurgien en termes de perturbation de son processus décisionnel. En outre, les actes chirurgicaux sont centralisés et le chirurgien est isolé du reste de l'équipe. En conséquence, les interactions habituelles entre les membres de l'équipe en fonction de la communication, de l'anticipation de la coordination et de la prédiction de l'action de l'autre ont été perturbées en raison du nouvel arrangement spatial.

Deuxièmement, pour que ce système robotique soit bien adopté, la gestion des ressources de l'équipage devrait être développée. Au cours de notre étude, nous avons eu l'occasion de rencontrer des représentants de l'entreprise qui développe le système robotique que nous observions. Ils imposent une liste de recommandations, y compris des formations, maintenances techniques et autres pour les hôpitaux. De plus, ils étaient d'accord avec nous sur les erreurs de communication qui peuvent survenir lors de la chirurgie robotique. Du point de vue technique, l'entreprise développe plus de fonctionnalités dans le système robotique. Par exemple, ils intègrent la réalité augmentée pour avoir des informations et des données complètes. Un autre exemple est le développement de sensations de retour tactile. En développant ces deux caractéristiques, la société essaie de compenser la perte de retour tactile et le manque de

conscience de la situation en raison de la distance entre la console et le patient. L'objectif est de créer une sécurité psychologique pour le chirurgien. Pourtant, nous avons constaté qu'il est important de minimiser la distance entre la console et les bras du robot. Cela va créer plus de sécurité pour le chirurgien. La société a soutenu que la formation cible la manipulation technique du système robotique pour tous les membres de l'équipe. Les formations qui guident les nouveaux modèles de communication et de coordination manquaient.

Troisièmement, cette étude déclenche les idées pour d'autres études sur le terrain. L'un d'eux est le risque, les erreurs et la sécurité. Travailler sur la chirurgie robotique nous a permis de comprendre comment les membres de l'équipe travaillent dans le bloc opératoire. Ce qui nous a intrigué à la fin de cette étude est le risque élevé à gérer dans la chaîne de soins spécifiquement pendant les interventions chirurgicales. Les membres de l'équipe sont devenus plus attentifs de leurs actions, donc la sécurité a augmenté. Ainsi, des questions ont émergé à la fin de notre étude: quels sont les effets de la robotique sur la stratégie de gestion des risques de l'équipe chirurgicale et donc sur l'ensemble de l'hôpital? quel est l'effet d'une nouvelle technologie sur la gestion des risques d'une organisation? Afin de répondre aux questions ci-dessus, nous avons pensé à un plan de recherche potentiel. Ce plan commence par la classification des différents risques potentiels dans l'organisation. Ces risques sont classés en deux catégories. D'abord, nous les classons en fonction de leurs paramètres et de leur horizon. Après avoir classé les risques observés. L'étape suivante est de mettre la stratégie pertinente à

chaque risque mesuré.

Pour conclure, l'une des limites de notre étude est l'observation un seul type de chirurgie la "chirurgie bariatrique".

Compte tenu du contexte spécialisé de cette recherche, semblable à toutes les recherches qualitatives, nous sommes confrontés à la question de la généralisation. Par conséquent, cette étude peut être suivie d'une autre étude sur d'autres types de chirurgie afin de renforcer nos résultats.

En outre, la majorité des chirurgies observées ont été opérées avec la même équipe chirurgicale. Les résultats peuvent être affectés si les équipes ont souvent été modifiées. C'était principalement l'une des recommandations de l'entreprise qui a développé le système robotique.

En outre, les configurations et le budget de l'équipe sont différents dans les hôpitaux publics et privés. Notre étude a été menée dans un hôpital public.

Un autre aspect qui pourrait être considéré comme comme une question pour une future recherche est l'influence de l'enregistrement vidéo sur les actions des participants. Nous soutenons que les participants pourraient être affectés au début du processus d'observation par l'observateur et par la présence de la caméra.

Cette présence sera totalement ignoré lorsque les praticiens seront réellement en action. Ils ne peuvent pas se tromper ou continuer à faire semblant.

Comme toute recherche, il y aura toujours beaucoup des questions à se poser.

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Appendix 1.a



Assistant surgeon next to the robotic arms



Primary surgeon sitting on the console

Appendix 1.b



Robotic system console



Robotic system screen

Appendix 1.c



Team members in laparoscopic surgery

Appendix 2.a**Questionnaire debriefing OR****Questionnaire individuel et anonyme**

Consigne de remplissage: Entourez la réponse qui vous semble la plus appropriée (1 seul choix)

Votre niveau de satisfaction

A l'issue de ce temps de cette matinée j'ai le sentiment que (positionnez-vous en cochant une seule case):

❶ La sécurité de la prise en charge du patient en équipe a progressé

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

❷ Le fonctionnement de l'équipe est amélioré

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

❸ Le partenariat avec le patient et/ou de son entourage a progressé

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

❹ Ma contribution au sein de l'équipe est renforcée

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

❺ Ma pratique professionnelle, mon travail sont facilités

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

❻ Mon travail est reconnu

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

❼ Ma fonction est valorisée

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

Ce projet répond à mes attentes

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

Vous recommanderiez ce projet à d'autres équipes

Tout à fait d'accord <input type="checkbox"/>	Plutôt d'accord <input type="checkbox"/>	Plutôt pas d'accord <input type="checkbox"/>	Pas du tout d'accord <input type="checkbox"/>	Ne se prononce pas <input type="checkbox"/>
---	--	--	---	---

Appendix 2.b**Debriefing questionnaire responses**

	Tout à fait d'accord	Plutôt d'accord	Plutôt pas d'accord
La sécurité de la prise en charge du patient en équipe a progressé	2	4	
Le fonctionnement de l'équipe est amélioré	3	3	
Le partenariat avec le patient et/ou de son entourage a progressé		4	1
Ma contribution au sein de l'équipe est renforcée	3	3	
Ma pratique professionnelle, mon travail sont facilités	2	4	
Mon travail est reconnu	4	2	
Ma fonction est valorisée	4	2	
Ce projet répond à mes attentes	4	2	
Vous recommanderiez ce projet à d'autres équipes	4	2	

Appendix 2.c**Echelle clinique de travail en équipe**

Date: 30/10/15

		Pas pertinent	Inacceptable	Faible			Moyen			Bon			Parfait
Ensemble													
1.	Quelle note donnez-vous au travail d'équipe ?	<input type="checkbox"/>	0	1	2	3	4	5	6	7	8	9	10
Communication													
2.	Note sur l'ensemble de la communication	<input type="checkbox"/>	0	1	2	3	4	5	6	7	8	9	10
3.	Intégration des nouveaux membres	<input checked="" type="checkbox"/>	0	1	2	3	4	5	6	7	8	9	10
4.	Pensée à voix haute	<input type="checkbox"/>	0	1	2	3	4	5	6	7	8	9	10
5.	Communication dirigée	<input type="checkbox"/>	0	1	2	3	4	5	6	7	8	9	10
6.	Rendre compte de la communication	<input type="checkbox"/>	0	1	2	3	4	5	6	7	8	9	10

Appendix 3

QUESTIONNAIRE

« Robotic surgery: determinants factors of expertise »

Léa Kiwan

C.N.R.S -G.R.E.D.E. G -

Université de Nice Sophia Antipolis

Directeur de thèse: Dr. Ivan Pastorelli

PRESENTATION

I am a PhD candidate in Nice University.

The aim of this study is to determine the effect of robotic surgery on expertise.

In order to have efficient answers, please answer spontaneously.

There is no right or wrong answer. Only your opinion counts.

Your answers will remain anonymous. Do not hesitate to ask questions if needed

Léa Kiwan

The different factors that already affected your decision making process.

Please what in your opinion what can influence your decision making process while operating:

Human factor part

Objective: the aim of this part is indicate factors that affect your decision making process and therefore your expertise.

1- Problem description: describe a situation where you encountered a problem during a surgical procedure. What did you do? And what was the result?

2- Planning: did you do exactly what you planned or you changed your course of actions?

3- Signals: what were the alerting signals?

4- Options: did you choose between alternatives to take a decision?

5- Interactions: where you in total control of the situation or other team members were involved?

6- Experiences: did you consider an old experience that you encountered?

7- Objective: did you have a specific objective before taking the decision?

8- Action: how did you decide to react? What do you think is the role of your expertise in this procedure?

9- Knowledge: what information did you use to take the decision?

10- Hypothesis: do you think training would have helped you in the decision? And what do you think a novice would have taken as a decision?

11- Result: did the course of action that you took lead to the result that you wanted?

Technology usage part (the robotic system)

1- Do you think a technology as robotics would ameliorate your performances?

2- Do you think this technology is easy to use?

3- Who do you think will benefit more from this technology? A novice or an expert?

4- Is the manipulation of the robotic system simple?

5- Were the informations presented by the robotic system simple to understand?

6- How do you think it is possible to ameliorate the robot?

Thank you for your participation

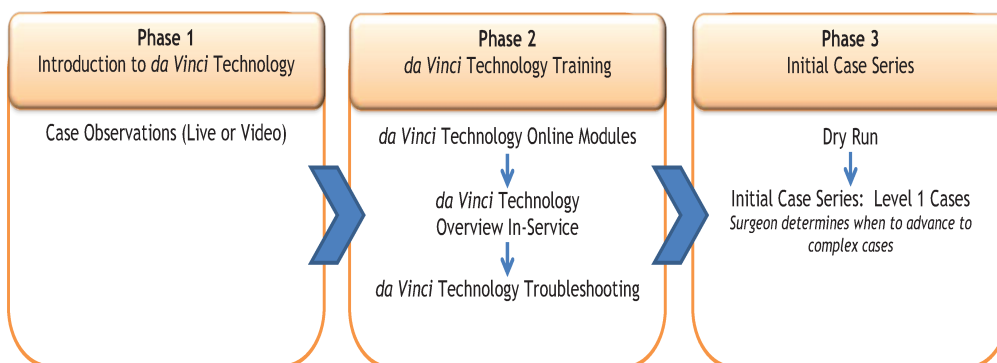
Appendix 4.a

Da Vinci technology training pathway for OR staff

da Vinci® Technology Training Pathway

OR Staff

Learning any new medical technology requires both guided and self-directed learning on the part of the surgeon and his/her surgical team. The following document outlines recommended activities for the OR Staff who seek to develop the knowledge and skills necessary to support a *da Vinci* surgeon. Please keep in mind that the recommendations provided here are only the beginning of the learning process. Self-directed study and practice are still required to master the technology. There are thousands of clinical papers on the subject of *da Vinci* Surgery. A representative sampling of high level publications is provided on the *da Vinci* Online Community. As with the use of any tool in the surgical theater, the *da Vinci* Surgical System should only be used after appropriate hospital requirements are met and when the surgeon's and the operating room team's mastery of the technology is sufficient to use the *da Vinci* System safely.



da Vinci® Technology Training programs are not replacements for hospital policy regarding surgical credentialing. Intuitive Surgical only trains on the use of its product, the *da Vinci* Surgical System and its associated instruments and accessories. Intuitive Surgical does not provide clinical training nor does it provide or evaluate surgical credentialing or train in surgical procedures or techniques. As a result, Intuitive Surgical is not responsible for procedure descriptions. Any demonstration(s) during the training on how to use the system to perform a particular technique or procedure is not the recommendation or "certification" of *Intuitive Surgical* as to such technique or procedure, but rather is merely a sharing of information on how other surgeons may have used the system to perform a given technique or procedure. Depiction of third-party products does not imply any endorsement regarding safety, efficacy, or indicated use. Before performing any *da Vinci* procedure, physicians are responsible for receiving sufficient training and proctoring to ensure that they have the skill and experience necessary to protect the health and safety of the patient. For technical information, including full cautions and warnings on using the *da Vinci* System and third-party products, please refer to the product manual. Read all instructions carefully. Failure to properly follow manufacturer's instructions, notes, cautions, warnings and danger messages associated with equipment used may lead to serious injury or complications for the patient. Inadvertent electrosurgical energy may cause serious injury or surgical complications to the patient. It is important to ensure a full understanding of the *da Vinci* Surgical System energy user interface and to use caution when working near critical anatomy. While clinical studies support the use of the *da Vinci*® Surgical System as an effective tool for minimally invasive surgery for specific indications, individual results may vary.

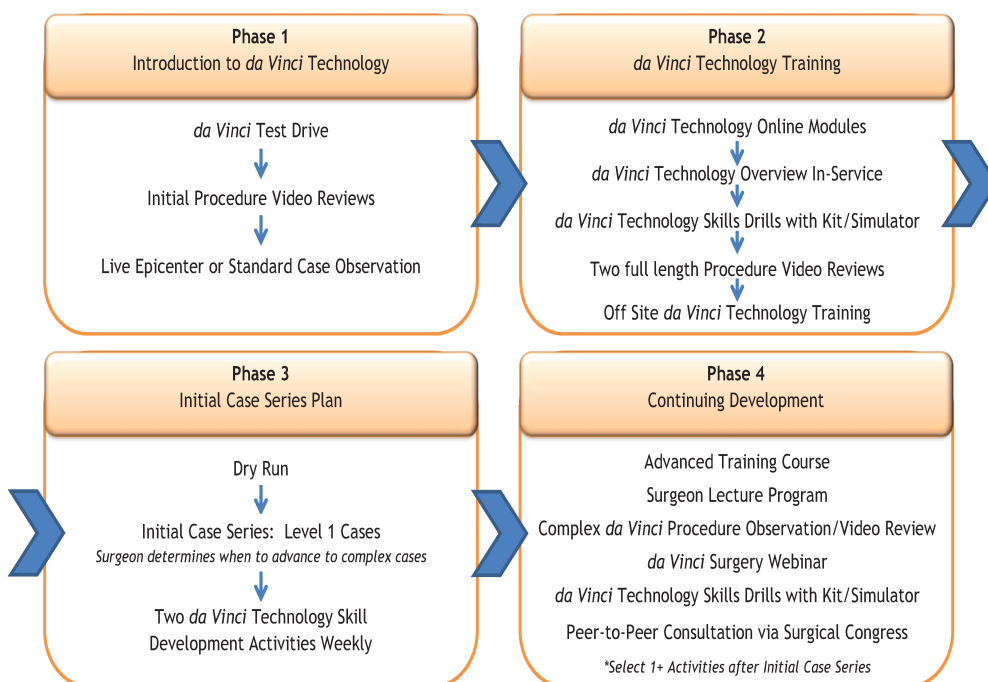
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Appendix 4.b

Da Vinci technology training pathway for the surgeon

da Vinci® Technology Training Pathway Surgeon

Learning any new medical technology requires both guided and self-directed learning on the part of the surgeon and his/her surgical team. The following document outlines recommended activities for the surgeon who seeks to develop the knowledge and skills necessary to use da Vinci Technology. Please keep in mind that the recommendations provided here are only the beginning of the learning process. Self-directed study and practice are still required to master the technology. There are thousands of clinical papers on the subject of da Vinci Surgery. A representative sampling of high level publications is provided on the da Vinci Online Community. As with the use of any tool in the surgical theater, the da Vinci Surgical System should only be used after appropriate hospital requirements are met and when the surgeon's and the operating room team's mastery of the technology is sufficient to use the da Vinci System safely.



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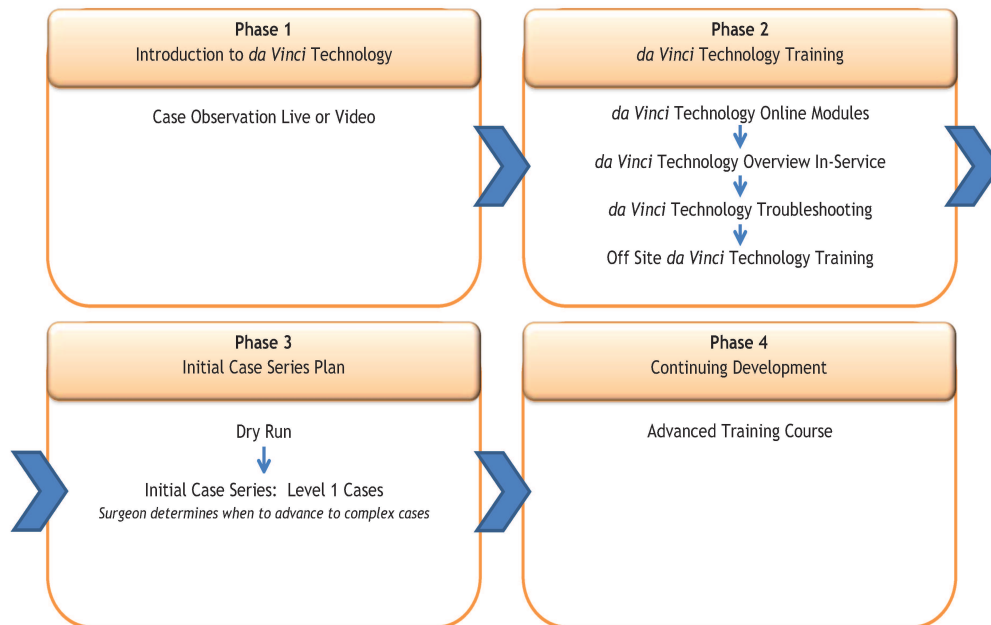


Appendice 4.c

Da Vinci technology training pathway for the first assist

da Vinci® Technology Training Pathway First Assist

Learning any new medical technology requires both guided and self-directed learning on the part of the surgeon and his/her surgical team. The following document outlines recommended activities for the surgical first assistant who seeks to develop the knowledge and skills necessary to support a *da Vinci* surgeon. Please keep in mind that the recommendations provided here are only the beginning of the learning process. Self-directed study and practice are still required to master the technology. There are thousands of clinical papers on the subject of *da Vinci* Surgery. A representative sampling of high level publications is provided on the *da Vinci* Online Community. As with the use of any tool in the surgical theater, the *da Vinci* Surgical System should only be used after appropriate hospital requirements are met and when the surgeon's and the operating room team's mastery of the technology is sufficient to use the *da Vinci* System safely.



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Abstract

The aim of this research is to understand the effect of a new technology, a robotic system, on the individual and collective expertise of practitioners in bariatric surgery. Our analysis is based on the emergence of organizational routines while taking into consideration naturalistic decision making approach. From the managerial perspective, our results demonstrate that the implementation of this technology decreases individual expertise. This is done through the degradation of individual situation awareness and coordination between team members. We established recommendations for an efficient technology implementation by restricted teams. Our methodology consists of mixing heterogeneous sources: interviews, observations, videos, debriefing with auto-confrontation... this opens the door for new analysis strategies till now used mainly in psychology. Finally, our theoretical contributions reinforced the naturalistic approach while insisting on the important role of a team leader and the role of individual expertise in the development of new functional organizational routines.

Key words: expertise, naturalistic approach, routines, technology, robotic surgery

Résumé

Cette thèse s'intéresse aux effets des technologies d'assistance robotique sur l'expertise individuelle et collective des médecins dans un bloc opératoire de chirurgie gastrique. Notre recherche est fondée sur l'analyse de l'émergence des routines organisationnelles et de leur mise en évidence en mobilisant l'approche naturaliste de la décision.

D'un point de vue managérial, nos résultats démontrent que la technologie introduite atténue l'expertise individuelle en dégradant respectivement la détection des signes cliniques et la coordination au sein de l'équipe. Nous établissons des recommandations concernant la mise en œuvre d'une technologie dans le cadre des équipes restreintes. Notre méthodologie consiste à fusionner des sources hétérogènes: entretiens, observation in situ, vidéos, debriefing, auto-confrontation... elle ouvre ainsi la voie à de nouvelles stratégies d'analyse de données jusqu'à lors essentiellement utilisées en psychologie. Enfin, nos contributions théoriques ont permis un enrichissement de l'approche naturaliste en lui adjoignant les rôles tenus par le leader et la mise en évidence du rôle de l'expertise individuelle dans la formation de nouvelles routines fonctionnelles.

Mots clés: expertise, approche naturaliste, routines, technologie, chirurgie robotique