“What’s going on there?”

Negotiating Common Ground in Robotic vs. Open Surgery

A Comparison of Surgeon-Initiated Requests for Action in Open and Robotic Surgery

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Master Thesis
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To my grandmothers

who taught me to be curious and brave.

ABSTRACT

This thesis investigates how surgical teams negotiate common ground on joint projects in the form of surgeon-initiated requests for action in robotic versus open surgery. Scrutinizing 68 hours of audiovisual data from a multimodal conversation analysis perspective, I reveal how surgical teams build common ground on a turn by turn basis. In open surgery, requests follow a two-turn structure, with the surgeon uttering the request and the addressee accepting and performing the requested action in a nonverbal embodied way. Participants incrementally build common ground on the uptake of the request, and difficulties in understanding can be dealt with smoothly, without interrupting the flow of the interaction. In robotic surgery, requests usually follow a three-turn structure, with an affirmative response token preceding fulfillment of the requested action. These affirmative verbal responses serve to explicitly display acceptance of the request, and failure to produce them causes gaps in common ground. Further, the surgeon cannot monitor fulfillment of requests, and unaccounted delays in fulfillment also result in gaps in common ground. This disrupts the flow of the surgery, causing trouble that can only be fixed by explicit verbalization. This thesis contributes a detailed understanding of requests for action in open and robotic surgery to the literature on requests in institutional settings. Further, it exemplifies how a combination of conversation analysis and Herbert Clark's theories on common ground can serve to build a detailed understanding of team practices, uncovering details that can only insufficiently be described with other methods. Finally, similarities between the team's struggle with common ground in robotic surgery and difficulties in distance collaboration imply that initial ambitions to build teleoperation systems for surgery over large distances are still reflected in the robot's design and shape team practices in today's collocated robotic surgery settings.

Keywords: Robotic surgery; requests for action; common ground; teleoperation; conversation analysis.

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LIST OF ABBREVIATIONS

CA – Conversation Analysis

CG – Common Ground

FDA – US Food and Drug Administration

FPP – First Pair Part

FTA – Face-Threatening Act

SPP – Second Pair Part

TCU – Turn Constructional Unit

TRP – Transition Relevance Place

TRANSCRIPTION SYMBOLS

Transcription symbols for verbal interaction, adapted from Jefferson (2004).

(.)	Micropause. Brief pause of less than 0.2 sec
(0.2)	Timed pause in tenths of seconds
=	Latching of utterances, no interval or overlap
-	Cut off
°a°	Utterance noticeably softer than surrounding talk
A	Utterance noticeably louder than surrounding talk
a:	Lengthening of sound (one colon for 0.2-0.5 seconds, :: for 0.6-0.8 sec, ::: for 0.8-1.0 sec)
a	Stress through pitch and/or amplitude
>a<	Utterance noticeably speeded up in comparison to surrounding talk
<a>	Utterance noticeably slowed down in comparison to surrounding talk
↑	Rise in intonation of next syllable
↓	Drop in intonation of next syllable
?	Rising intonation
,	Continuing intonation
[a]	Overlapping talk
ha/he	Laughter
( )	Transcription in doubt, transcriber is unsure about what was said
((comment))	Transcriber's descriptions
SURGEON	Participant who is performing the turn at talk

Transcription symbols for embodied conduct, adapted from Mondada (2007).

* *	Delimit description of surgeon's gestures and actions
+ +	Delimit description of scrub tech's gestures and actions
% %	Delimit description of circulator's/second scrub tech's gestures and actions
§ §	Delimit description of intern's/resident's gestures and actions
$ $	Delimit description of student's gestures and actions
*-->	Gesture continues across subsequent lines
-->*	Gesture continues until symbol is reached
-->>	Gesture or action continues until after end of the transcript
...	Preparation of gesture
,,,	Retraction of gesture
surgeon	Participant who is performing the gesture or action
im	Indicates exact point where screen shot (image) has been taken
#	Indicates position of screen shot within turn at talk

1 INTRODUCTION

"What happens if an astronaut on a space station of tomorrow needs an emergency appendectomy[1] – and there is no surgeon on board? Telesurgery is one possibility – surgery performed by a robot whose movements are precisely guided by a surgeon on Earth. He conducts the operation by a combination of computers, television and advanced sensors. The stereoscopic view entirely surrounds the doctor so that he feels he is actually part of the space station scene, and he is able, through instrumented glove technology, to direct the robot's hand movements to correspond exactly to his own hand movements" (A New Continent of Ideas, 1990).

This is the beginning of a technical report by the US space agency NASA. Due to advances in computer graphics, telecommunication and robotics, telesurgery was considered feasible within a few decades in the 1990s. Surgeons were already operating through small incisions with the help of endoscopes ("minimally-invasive" or "laparoscopic" surgery). Developing this technology further, researchers were hoping to enable surgeons to operate on patients in space, in warzones and in remote areas where medical staff lacks specific surgical expertise, without the surgeon being physically present in those locations. First prototypes were built, and surgeons successfully completed surgery on pigs in remote locations (Bowersox, Shah, Jensen, Hill, Cordts & Green, 1996; Nguan, Miller, Patel, Luke & Schlachta, 2008; Sterbis et al.,2008) and on a remote patient in Strasbourg, France with the surgeon operating the robot from New York, USA (Marescaux et al., 2001; Marescaux et al., 2002).

Today, the Da Vinci Surgical System (Intuitive Surgical Inc., California, USA) is the most popular surgical teleoperation system, with about 877 000 surgeries performed with the system worldwide in 2017 (Intuitive Surgical, 2018a). The system consists of a large robot, which is positioned next to the sedated patient, with several "arms" to which the surgical instruments and an endoscopic camera are attached (see Figure 1). These arms are inserted into the patient's body through small incisions. The surgeon controls movement of the robot arms through joysticks in a console, which also provides the surgeon with a 3D endoscopic camera stream (stereoscopic vision). Reducing tremor and allowing motion scaling, the system allows the surgeon to operate with a precision that would not be possible with a human hand. Since its approval for minimally invasive surgery by the US Food and Drug Administration (FDA) in 2000 (Hagen & Curet, 2014), the system has changed dramatically in terms of ergonomics and the number of robot arms has been increased from three to four. Still, the general idea of a robotic cart that is positioned next to the patient and a console from which the surgeon is controlling the robot has not changed (nowadays it can be controlled from two consoles, with two surgeons taking turns in operating, instead of using only one console). However, rather than being thousands of kilometers apart as initially intended, today surgeon and console are located in the same room as patient, robot and surgical team. So far, the system has not been approved for telesurgery by the FDA, and surgeon and patient have to stay in one operating room.

[1] Removal of the appendix.

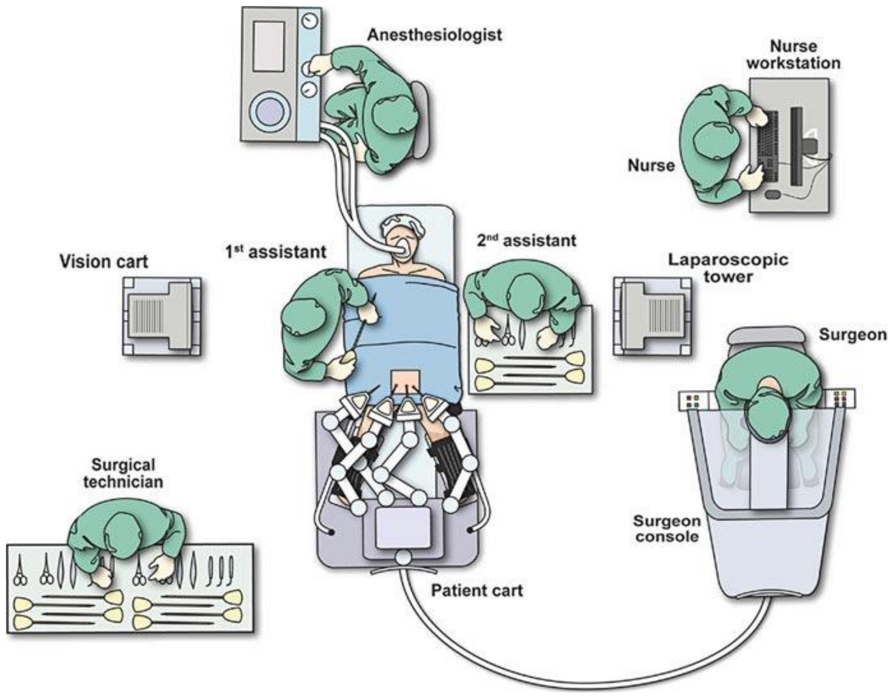

Figure 1. Operating room setup during robotic surgery. The surgeon is controlling the robotic patient cart through a console at a distance from the patient. Two assistants support the surgery in the sterile field around the patient. Reprinted by permission from Springer Nature: Springer Nature, Robotic instrumentation and operating room setup by T. T. Higuchi & M. T. Gettman (2011), License No. 4451910111175.

The Da Vinci Surgical System has repeatedly been reported to affect teamwork in the surgical team, especially communication. It has been associated with changes in communication patterns, increasing the need for explicit verbal communication (Cunningham, Chellali, Jaffre, Classe & Cao, 2013; Lai & Entin, 2005; Nyssen & Blavier, 2009; Randell et al., 2017). This is relevant because poor communication has been associated with worse surgical outcomes in gynecologic robotic surgery (Schiff, Tsafrir, Aoun, Taylor, Theoharis & Eisenstein, 2016). My own prior work (Pelikan, Cheatle, Jung & Jackson; in press), demonstrates how the Da Vinci robot reconfigures surgical work practice by changing the physical arrangement and distance between team members. Amongst others, these changes lead to struggles with situation awareness and common ground. Difficulties with common ground in robotic surgery have also been reported by others (Cao & Taylor, 2004; Webster & Cao, 2006) but it has not been systematically investigated how exactly the robot affects practices for building common ground.

In this thesis I want to scrutinize how surgical teams build and maintain common ground in robotic as compared to traditional open surgery. A large part of the teamwork during a surgical procedure is achieved through requests by the surgeon to the team (Hull, Arora, Kassab, Kneebone & Sevdalis, 2011; Mondada, 2014b; Randell et al., 2017). Different types of request can be distinguished (Clark, 1996) and I will focus on requests for action, as the surgeon majorly asks the team to do things for him or her in order to accomplish the surgery. For example, the surgeon may ask the scrub tech, who is responsible for the instruments, to pass a scissor or an assistant to hold a piece of tissue. This work addresses the following research questions:

- How do surgical teams negotiate common ground when performing surgeon-initiated requests for action in open surgery?
- How do surgical teams negotiate common ground when performing surgeon-initiated requests for action in robotic surgery?

- In what way do surgical practices for building common ground on these requests differ between robotic and open procedures?

To shed light onto these questions, I annotated 68 hours of video and audio recordings of open and robotic surgery, which I recorded in a teaching hospital in the USA. Following conversation analytic methodology (Heath, Hindmarsh & Luff, 2010; Schegloff, 2007; Sidnell & Stivers, 2013), I produced detailed transcripts of selected scenes and analyzed them by comparing similarities and differences between them. As I was particularly interested in the concept of common ground (Clark, 1996), I scrutinized how participants actions can be understood and explained in terms of incrementing common ground. Drawing on both conversation analytic concepts and on Clark's definition of common ground, I combined two different theoretical approaches in the analysis, which yield interesting results.

I found that in open surgery, requests for action usually follow a two-turn structure: request and subsequent fulfillment. In robotic surgery, requests are usually built up by three turns: request and subsequent explicit acceptance and fulfillment. The surgeon expects verbal acceptance statements in response to requests, initiating repair when they are not produced. In robotic surgery, explicit verbal acceptance is thus "conditionally relevant" (see 2.1.2). While teams build common ground incrementally in open surgery, allowing even inexperienced team members to gradually arrive at fulfillment of the surgeon's request, this is not possible in robotic surgery. In robotic surgery, trouble with fulfilling a request remains unnoticed by the surgeon, and only becomes accessible when verbalizing it. Thus, in robotic surgery, gaps in common ground may lead to interactional trouble.

The contribution of this thesis is threefold. First, it adds a detailed comparison of requests in open and robotic surgery to the literature on requests in institutional settings, which has only covered surgery in a small number of publications (Bezemer, Murtagh, Cope, Kress, & Kneebone, 2011; Mondada, 2014a, 2014b; Randell et al., 2017). Second, this thesis shows how combination of conversation analysis and Clark (1996)'s theory of common ground can serve to uncover practices and struggles that have previously been inaccessible to analysis, yielding deep insights into how technology shapes practice. Third, I provide a detailed understanding of how teams build common ground in robotic versus open surgery, which has important implications for designers of interaction and collaboration technology.

In the following chapters, I will first detail the theoretical background of this work, drawing from two different schools of thought (chapter 2). In chapter 3, I present related work on requests, how they are formulated and responded to as well as prior research on requests in surgery. Chapter 4 introduces to the surgical setting and provides details on data collection, data processing and data analysis. In chapter 5, I provide a detailed analysis of surgeon-initiated requests and their acceptance and fulfillment in open and robotic surgery. Finally, I discuss the findings in the light of existing literature and point out implications, limitations and future work in chapter 6, before ending with the conclusion in chapter 7.

2 THEORETICAL BACKGROUND

In the following sections, I will introduce the basic concepts of multimodal conversation analysis, the method that is used to analyze the data. Second, I will present Herbert Clark's (1996) concept of common ground and joint projects, as this will become crucial to draw conclusions from the analysis.

2.1 WHAT IS CONVERSATION ANALYSIS?

Conversation Analysis (CA) is a data-driven empirical method that uses video recordings to study interaction in fine detail. Originating from sociology in the 1960s, CA investigates the organization of social action in naturally occurring occasions of everyday interaction. Focus thus lies on the ordinary and mundane, rather than extraordinary events (Schegloff, 2007). Scrutinizing participants' turns at talk on a millisecond level, conversation analysts find "order at all points" (Sacks, 1984, p. 22), suggesting that social interaction is orderly, not only on a general level, but on a turn by turn basis (Schegloff, 1987). One of the founding fathers, Harvey Sacks, coined the term "machinery" (Sacks, 1984, p. 26) to stress that humans stick to tacit rules when interacting. Conversation is thus a product of this machinery, and by its study we may gain a deeper understanding of the underlying interactional rules that humans attend to.

Ordinary conversation is the most variable form of interaction, as what may be said by whom and at what time is not determined in advance (Schegloff, 1987; Sacks, Schegloff & Jefferson, 1974). Conversation analysis also studies more restricted forms of interaction, such as "institutional interaction" (Drew and Heritage, 1992). Examples for institutional settings are classroom interaction (McHoul, 1978), news interviews (Clayman & Heritage, 2002), court hearings (Atkinson & Drew, 1979) and doctor-patient interaction (Heritage & Maynard, 2006). While the variety of social goals is unlimited in ordinary conversation, participants' goals are often more limited and institution-specific in institutional settings. Further, the nature of interactional contributions may be restricted in institutional interaction and the inferences that participants draw may be institution- and activity specific (Drew & Heritage, 1992; Heritage, 1998). For instance, in an interview, the interviewer asks questions and the interviewee gives answers. If for some reason, the interviewee wants to ask a question, this first has to be negotiated (Heritage, 1998). In surgery, interaction is oriented towards the cooperative goal of accomplishing a particular surgical procedure on a patient. Team members' conduct is constrained by the surgical setting, inhibiting actions that would not be restricted in everyday interaction, such as touching sterile objects while being nonsterile (Katz, 1981). At the same time, the surgical setting promotes actions which may be inhibited in ordinary conversation, such as intimately touching ones' colleagues due to spatial constraints (Bezemer et al., 2011; Pelikan et al., in press). Further, participants will reason differently about these actions in the surgical work context than during everyday conversation, e.g. the surgeon touching an assistant's hand to adjust its position is perfectly normal in surgery (Hirschauer, 1991) but the same touch would be interpreted as inappropriate outside the operating room. In this sense, surgery is also an institutional setting. To stress that CA studies more than ordinary conversation, the subject of conversation analytic study is often referred to as "talk-in-interaction" (Schegloff, 1987, 2007).

In the following, I introduce basic conversation analytic concepts. First, I illustrate how talk-in-interaction is sequentially organized. Second, adjacency pairs and the concept of conditional relevance are presented. Third, I describe how distribution of talk among different speakers is organized by a turn-taking system. Finally, I review conversation analytic work on visual actions, in particular gaze, gesture, bodily conduct and use of the material environment.

2.1.1 Sequential Organization

Human interaction is organized in sequences. Participants' turns-at-talk do not simply follow on each other like beads on a string, but rather, some seem to belong together more than others (Schegloff, 2007). Speaking in the metaphor of beads, some beads would be clumped together since participants' turns in the interaction project back on what has been said and done before and shape the following interaction by determining the set of possible next actions. The grouping into sequences can best be understood in terms of actions (Schegloff, 2007). Rather than focusing on the topic that is being talked about, CA looks at what participants are doing with an utterance (or their nonverbal conduct). Examples of such actions are asking, answering, offering, requesting, promising, and so forth. Schegloff and Sacks (1973, p. 76) have coined the question "why that now?" in this context: Participants (and analysts) constantly need to evaluate what a certain utterance is doing in the specific context at the specific time. This leads us to a central aspect of conversation analysis: a specific phrase may accomplish different actions, depending on the context (Schegloff, 2007). Other than in speech act theory (Austin, 1962, 1979; Searle, 1969), conversation analysists do not look at what makes something a greeting, but rather ask what a participant could be doing by for instance saying "hello". If it is at the beginning of an interaction, it is most certainly understood as a greeting, but later in the interaction, the same phrase may be used in a different way. This also holds for nonverbal conduct: a nod does not always signal confirmation; a laugh is not always displaying that something is perceived as funny. The list of possible actions is not exhaustive, and CA allows us to describe actions that we do not yet have concepts for (Schegloff, 2007).

2.1.2 Adjacency Pairs and Conditional Relevance

The most basic sequence construction is an "adjacency pair" (Schegloff, 2007, p. 13). As the name suggests, it consists of two parts, a "first pair part" (FPP) and a "second pair part" (SPP) (Schegloff, 2007) that are produced by two different speakers. The FPP makes the SPP "conditionally relevant", so the producer of the FPP calls for a next action of a certain kind to be produced by the conversational partner. For instance, if someone greets by saying "hello", this greeting makes a return greeting conditionally relevant. Similarly, if someone poses a request (e.g. Could you pass me the butter?) this request requires compliance (e.g. passing the butter) or a decline (e.g. by refusing to pass the butter because the other did not say please). As the butter example nicely illustrates, the parts of an adjacency pair do not always have to be performed verbally but may also be embodied (Schegloff, 2007). If the second pair part is not produced (neither in a verbal nor in an embodied way), the response is perceived as "officially absent" (Schegloff, 1968, p. 1083). Participants will draw conclusions from this absence, such as that the other did not hear them or is deliberately ignoring them.

2.1.3 Organization of Turn Taking

Another principle that organizes interaction is the turn-taking system, which determines who is to speak next and when (Sacks et al., 1974). Participants do not speak at random time points, but finely tune timing of their utterances. As Sacks et al. (1974) point out, for the majority of time, only one speaker is talking at a time. When allocating the next turn, participants take efforts to avoid overlapping talk ("overlap") and silence between turns ("gaps") (Sacks et al., 1974). Participants' turns in an interaction are built up by "turn-constructional units" (TCUs) (Sacks et al., 1974). TCUs may consist of a sentence, a phrase or just a single word. TCUs are separated by "transition-relevance places" (TRPs) (Sacks et al., 1974). At a TRP, transition to another speaker is possible. Interaction is thus built up by TCUs that are divided by TRPs, as illustrated below. At each TRP, participants to an interaction negotiate who will produce the next TCU.

-------TCU-------|TRP|-------TCU-------| TRP |-------TCU-------| TRP |-------TCU-------| TRP |-------TCU-------| TRP |…

Allocation of the next turn follows a set of rules (Sacks et al., 1974): When arriving at a TRP, the current speaker may select a next speaker (rule 1a). This is usually done by addressing the person who should speak next, such as saying their name (e.g. "What do you think, Robin?") or by looking at the person. If the current speaker has not selected someone to speak next, the next speaker may "self-select" (rule 1b). Finally, if no other participant starts talking, the current speaker may continue (rule 1c) by adding another TCU to his or her talk. If the current speaker continued, the rule is recursively re-applied until speaker change is accomplished.

The surgical setting mostly features multiparty interaction, in which more than two people are participants to the interaction. Turn-taking thus becomes more complicated, as several people may compete for the next turn, thereby producing more overlap of turns. Schegloff (1995) stresses that the turn-taking system described by Sacks and colleagues (1974) organizes talk distribution among "parties" rather than single persons. While a party may consist of only one person, it is often formed by several people. Organization into parties is embodied in the participants' conduct, as they see themselves as part of a party (e.g. informed vs. uninformed about a piece of news) and membership in a party is not fixed but may change throughout the interaction (Schegloff, 1995). In the surgical setting, surgeons and residents may be regarded as one party, the party that is operating, and nurses as another, a party that fulfils the surgeons' requests. Similarly, when the surgeon is seated at the robot console and talking to resident and assistant who are located by the patient, the distinction may be made into console party and patient-side party.

In institutional settings, turn-taking may be more restricted and specialized (Drew & Heritage, 1992). The turn-taking system may be adjusted to deal with multiple parties, reflecting the particular institutional context. For instance, in a participatory democracy setting, speakers may not simply self-select or talk for as long as they like, but a moderator ensures that everyone is heard (Mondada, 2013). This is embodied in the turn-taking system, in which turn-allocation and holding or yielding of the floor is largely done through embodied means, as participants pre-select as next speaker by raising their hands and the moderator selects and queues several next speakers through gaze, pointing, and body posture (Mondada, 2013). In a news interview in contrast, turn-taking follows a different pattern. Turns are clearly distributed and speaker change occurs when the interviewer has formulated a question and the interviewee responds. Such specialized turn-taking system thus structure the activity, defining opportunities and interpretation of actions that occur within the turn-taking system (Heritage, 1998). As we will see, some aspects of the turn-taking system in the operating room share similarities with a news interview: the surgeon issues requests for action, which are subsequently fulfilled by the team members. Since everyone speaking at the same time would lead to a lot of overlap, many actions are performed nonverbally.

2.1.4 Visual Actions

Apart from verbal utterances, participants use their hands, eyes, and entire body to produce embodied actions. Such embodied actions and the material environment that they occur in play a crucial role in interaction. In contrast to the sequential organization of participants' verbal conduct, visual actions can be carried out simultaneously to speech and are produced in close coordination with participants' talk (Mondada, 2006; Broth & Mondada, 2013). Participants use their body to perform a variety of bodily gestures, which can be categorized along different dimensions. One such type is "iconic gestures", which "present images of concrete entities and/or actions" (McNeill, 2005, p. 39). Participants may produce them to visually depict something that they are describing in their talk, often expressing an additional aspect of what has been verbally uttered (McNeill, 2005). For instance, an architect who is talking about a parking area may draw a series of squares into the air, thereby visually describing the parking slots (Mondada, 2006). Another gestural dimension is "deictic gestures" (McNeill, 2005), which are pointing gestures. Deictic gestures are often produced to establish reference and may occur in concert with demonstrative pronouns such as "this" and "that" (Hindmarsh & Heath, 2000) or deictic terms like "there" (Goodwin, 2007). Deictic gestures are important for directing attention (Goodwin, 2007) and the entire body may be involved in producing them (Hindmarsh & Heath, 2000; Goodwin, 2007, McNeill, 2005). Apart from pointing with hands and fingers, eye gaze is an important means for directing attention of the other and has been described as crucial for establishing joint attention (Tomasello, 1999; Goodwin, 2007). Speakers have also been shown to use gaze for addressing, usually by making eye contact with the addressee (Goodwin, 1979) and for selecting the next speaker (Lerner, 2003). Joint attention is even established by means of body posture and torque (Goodwin, 2007) and participants to an interaction usually arrange themselves around a shared interactional space, with their bodies oriented to the center of that space (Kendon, 2010). For instance, participants employ body posture to negotiate closure of a sequence by turning their body away from the interactional partner(s) and eventually walking away (Broth & Mondada, 2013). Embodied action occurs within the particular material environment and is structured by it. For instance, architects negotiate the end of a sequence by moving an architecture plan out of the interactional space (Mondada, 2006) and camera operators in TV production move their cameras in particular ways to signal agreement, disagreement and to highlight a particular aspect of the scene as important (Broth, 2014).

In surgery, embodied actions play an important role. For instance, surgeons use their body to build a collaborative understanding of bodily landmarks, mapping structures in the patient's body to their own arms and hands and embodying the bodily landmark that they are trying to describe (Koschmann, LeBaron, Goodwin, Zemel & Dunnington, 2007). The surgical team finely coordinates their embodied actions, as becomes evident in the passing of instruments. Surgeons have been found to prepare production of a request by first seeking eye contact with the scrub nurse and turning towards him or her. While waiting for the requested instrument, they display continued orientation to the scrub nurse through body posture, for instance remaining slightly turned towards the scrub nurse and holding a hand out for the instrument to be placed into (Bezemer et al., 2011). Scrub nurses in turn finely coordinate with the surgeon's body in passing instruments. They adjust orientation of the instrument they are passing to fit the particular orientation of the surgeon's hand, thereby allowing him or her to immediately grasp the instrument (Heath, Luff, Sanchez Svensson & Nicholls, 2018). The material environment also plays a crucial role and structures action in the operating room. In laparoscopic surgery, surgeons cannot use their hands to point inside the body. Instead they make use of surgical instruments to point to bodily landmarks (Koschmann, LeBaron, Goodwin, & Feltovich, 2011; Mondada 2014b). Further, scrub techs structure the material environment with respect to the course of actions, putting instruments that will be needed next in salient positions on the scrub table (Sanchez Svensson, Heath, & Luff, 2007).

2.2 WHAT IS COMMON GROUND?

While conversation analysis originates from sociology, the concept of common ground that I introduce in the following is rooted in psychology and thus comes from a different school of thought. Herbert Clark, a psycholinguist, and his colleagues started to investigate collaborative processes in language use in the 1980s and 1990s, studying how speakers and addressees in a conversation jointly work on establishing definite reference (Brennan & Clark, 1996; Clark & Wilkes-Gibbs, 1986; Isaacs & Clark, 1987; Wilkes-Gibbs & Clark, 1992). Clark's theories are informed by conversation analysis and both approaches have overlaps, but they are distinct in their treatment of mental states. Coming from a psychologic tradition, Clark explicitly considers people's beliefs (e.g. Clark, 1996; Wilkes-Gibbs & Clark, 1992), while conversation analysis refrains from explaining patterns in participants' conduct with their mental states and rather focuses on what participants publicly display in the interaction (Potter & Edwards, 2013).

Central to Clark's theory are "joint activities" (Clark, 1996). Surgery can be regarded as such a joint activity, as several team members (surgeon, anesthetist and several nurses) with different public roles and skills (e.g. dissecting and stitching tissue, narcotizing the patient, fetching or passing instruments) coordinate to achieve a common goal (that of a specific surgery on a particular patient). Further, surgery fulfills another feature of joint activities, as it has clear boundaries, an entry and an exit, which are jointly coordinated by the participants. Joint activities are comprised by participants' "joint actions" (Clark, 1996) that incrementally build towards the common goal. Essential to achieving such joint actions is common ground (CG), which forms the basis for coordinated action. "Two people's common ground is, in effect, the sum of their mutual, common, or joint knowledge, beliefs, and suppositions" (Clark, 1996, p. 93). Common ground thus denotes a shared understanding, which allows people to mutually coordinate actions based on the knowledge that the other and they themselves have. Common ground implies reflexive awareness of what oneself and the other knows. With every joint action two people do together, they add to their common ground (Clark, 1996) and common ground thus constantly increments.

Two types of common ground can be distinguished: communal and personal common ground (Clark, 1996). "Communal common ground" (Clark, 1996 p. 100) is built on the shared basis of cultural communities that people belong to. People are members of many different communities, based on gender, occupation, nationality and so forth. Being part of the surgical community, members share knowledge about what a surgery is, the different steps involved and a certain degree of medical knowledge. A big part of communal common ground are communal lexicons, which specify the conventional meaning of words (Clark, 1996). For example, the term "time out" carries a particular meaning in the surgical setting, referring to the announcement of relevant information on patient, medication and type of surgery at the beginning of the surgery (Guglielmi et al., 2014). This meaning differs considerably from what children playing catch would understand "time out" to mean. Further, communal common ground contains knowledge of facts, norms and procedures that is shared within the community (Clark, 1996). In the surgical setting, team members share common ground for instance on the importance of maintaining sterility (Katz, 1981). "Personal common ground" (Clark, 1996, p. 112) is built on the shared basis of personal experiences, such as joint actions and joint perceptual experience. A shared perceptual basis requires co-presence and joint attention to a particular thing, which is usually achieved through salience. Clark (1996) distinguishes three main ways in which an event can be established as jointly salient: (1) through gesture, e.g. by pointing to an object, (2) the partner's activities, such as gazing somewhere or (3) salient perceptual events, such as a loud sound or a strong smell. In the surgical setting, team members build common ground on the joint actions that they coordinate on as part of the current surgery (e.g. two nurses counting instruments and sponges together) and prior joint actions, if they have worked together previously. Shared perceptual experiences that may serve as basis for common ground could be the surgeon pointing at an instrument he or she wants to use next, the loud humming sound of the cauterizing machine or a sudden wave of the smell of burnt flesh. Like communal CG, personal common ground also contains particular lexicons. “Personal lexicons” (Clark, 1996, p. 116) are built by special words that well acquainted people use but that are not part of a communal common ground. In the surgical setting, I have overheard some people using the term “washy washy” to refer to irrigation, but this word and its meaning is not shared by the general community of people working in surgery.

2.2.1 Building and Maintaining Common Ground

The process of building and updating common ground is referred to as “grounding” (Clark & Brennan, 1991). In grounding, participants try to reach the mutual belief that the listener has understood what the speaker meant well enough for their current purposes (Clark & Brennan, 1991). Thus, participants do not always need to understand each other in every single detail, but a level of understanding that is sufficient for accomplishing their joint action and for reaching their common goal is enough. In conversation, a speaker presents a contribution in the “presentation phase” (Clark & Brennan, 1991), which the listener subsequently accepts by displaying sufficient understanding of this contribution in the “acceptation phase” (Clark & Brennan, 1991). After the end of a speaker’s presentation of some utterance U, the hearer may believe that he or she is in one of the following states the entire utterance U or parts of it: The hearer is in state 0, if he or she did not notice that the speaker produced an utterance. If the hearer noticed that the speaker was uttering some utterance but did not hear what exactly, the hearer is in state 1. If the hearer heard the utterance but did not understand the meaning of it (e.g because he or she does not speak the language or because the utterance is not part of the communal or personal lexicon), the hearer is in state 2. If the hearer attended to the speaker’s utterance, heard it correctly and understood what the speaker meant, the hearer is in state 3 (see Table 1 for illustration).

Table 1. States that the hearer of an utterance may be in after the speaker finished the production phase. Adapted from Clark & Brennan (1991).

STATE	HEARER …
0	… did not notice that SPEAKER uttered any utterance *U*
1	… noticed that SPEAKER uttered some utterance *U* (but is not in state 2)
2	… correctly heard utterance *U* (but is not in state 3)
3	… understood what SPEAKER meant by utterance *U*

Depending on the state that the hearer believes he or she is in, the hearer may ask the speaker to clarify or repeat the utterance during the acceptance phase. After the acceptance phase is completed, the contribution becomes part of the speaker’s and listener’s common ground. There is a variety of practices to display understanding (and thereby signal acceptance) of an action. For instance, there are acknowledgements in the form of backchannels such as “uh huh” and “yeah” (Clark & Brennan, 1991). Further, the listener may show his or her presupposed understanding by initiating the relevant next action, such as answering a question that the initial speaker had asked. In producing the answer to a question, one also displays the understanding of that question. If this answer in turn is not what the speaker was asking for (what the speaker meant), additional efforts are necessary to achieve closure of the grounding process (Clark & Brennan, 1991; Clark, 1996). Understanding may also be indicated through nonverbal actions, such as showing continued attention by gazing at the contributor. Turning away from the speaker or a puzzled look may be signals of trouble in understanding that needs repairing actions (Clark & Brennan, 1991). Grounding follows several principles, and the one that is particularly relevant for distinction between presentation and acceptance phase is the principle of "joint closure" (Clark, 1996, p. 226). It implies that "participants in a joint action try to establish the mutual belief that they have succeeded well enough for current purposes" (ibid.). The participants to a joint action thus need evidence that they have succeeded in performing the joint action before they can continue with the next action. If this evidence is missing, they will try to repair, repeat or stop their current action, all of which disrupt the ongoing activity (Clark, 1966). This is why signaling acceptance is important.

As we have seen in section 2.1.4, embodied actions are a crucial part of interaction. In settings in which face-to-face interaction is limited, such embodied actions might not be (fully) available. This is one of the reasons why grounding is more difficult in distributed collaboration, when team members are not collocated in the same physical space but have to collaborate over distance (Bjørn, Esbensen, Jensen and Matthiesen, 2014; Cramton, 2001; Hinds & Bailey, 2003; Kraut, Fussel, Brennan & Siegel, 2002; Olson & Olson, 2000). As Pelikan and colleagues (in press) have shown, robotic surgery shares similarities with distance collaboration and robotic surgical teams struggle with maintaining common ground.

2.3 Summary

In this chapter, I first introduced *conversation analysis*, a data-driven method for analysis of audio-visual data that originates from sociology and is suitable for the study of interaction in both everyday encounters and *institutional settings*, like surgery. I introduced the central conversation analytic concept of *sequential organization*, which implies that actions project back on previous actions and make particular next actions relevant. It is reflected in the question *why that now?* that analysts (like participants to an interaction) constantly need to ask themselves to evaluate what participants are doing with a certain utterance in the specific context at the specific time point. I explained the term *adjacency pair* for action pairs in which a first action projects a particular next action in such a strong way that it is normatively expected, thereby making it *conditionally relevant*. Moreover, I described the organization of *turn-taking*, with usually only one person speaking at a time. As participants try to minimize overlapping talk, they heavily rely on nonverbal actions in *multiparty settings*, producing them in simultaneity with the other's speech without disrupting the interaction. Finally, I presented literature that indicates that team members heavily rely on *embodied actions* when preparing and fulfilling requests in surgery, making use of and structuring the *material environment* with respect to projected next actions.

Second, I presented Clark's perspective on collaborative language use, developed out of a psychologic research tradition and informed by conversation analytic findings. I introduced the concept of *common ground*, which denotes a reflexive, shared understanding of what oneself and the other knows and illustrated the distinction into *communal common ground*, which is based on the community one belongs to and *personal common ground*, which is built on shared personal experiences. Further, I described the process of *grounding* during which people build and update common ground: The speaker utters a contribution in the *presentation phase*, which the addressee subsequently accepts in the *acceptation phase* by displaying his or her understanding of the contribution. Participants work hard to align what the speaker means and what the hearer displays to understand well enough for their current purposes, repairing their action until they have reached *joint closure*, the mutual belief that they have succeeded sufficiently well. Finally, I reviewed literature that suggests that grounding is more difficult in *distributed teams* and that robotic surgery, sharing aspects with distance collaboration, also leads to struggles with maintaining common ground.

3 RELATED WORK

In the following, I first introduce prior work on grounding in surgery, highlighting the potential of this thesis to extend this work. Second, I provide a summary of related work on requests, looking at requests as joint projects and presenting conversation analytic work on requests in surgery. I further establish the role of politeness in formulating requests and describe previous work on how participants reach fulfillment and closure of requests

3.1 COMMON GROUND IN SURGERY

Prior work has investigated grounding in anesthetic teams as well as in surgical teams during laparoscopic and robotic surgery. Johannesen (2008) and Johannesen, Cook and Woods (1994) describe how anesthesiologists build and maintain common ground with respect to fault management in neurosurgery. Their work focuses on anesthetic teams and describes in detailed transcripts how they maintain common ground by informing each other about relevant actions, explaining the flow of events and drawing attention to anomalies, thereby easing fault management.

Feng and Mentis (2016) investigated development of common ground between surgeon and resident over the course of a laparoscopic gall bladder removal. Surgeon and resident build common ground on the anatomic structure of the surgical site and need to understand each other's statements and discussions. Further, the surgeon gives instructions, which the resident needs to understand and follow. While surgeons and residents build *content common ground* (what they are doing) at the beginning of the surgery, a shift towards *process common ground* (how they do it) occurs during the phases of the surgery in which the gall bladder is isolated and removed. Feng and Mentis (2016) stress that information that is necessary for coordination between surgeon and resident is communicated verbally but information needs change throughout the surgery. While residents need a lot of information at the beginning of the surgery, adding more information may interfere with their decision process during critical phases of the surgery. Feng and Mentis (2017) also investigated the role of nonverbal actions such as gestures in the grounding process between surgeon and resident in training for laparoscopic gall bladder removal. Surgeons and residents use verbal utterances to explicitly add information, while using nonverbal actions to display understanding. Verbal utterances were found to support development of content common ground and nonverbal actions are mainly used to build process common ground. Feng and Mentis (2017) stress the interdependence between verbal utterances and nonverbal actions, highlighting that surgeon and resident both need to see each other's nonverbal actions (process common ground) and to understand the meaning of the actions in the shared view (content common ground).

Further, Koschmann, Goodwin, LeBaron and Feltovich (2001) and Koschmann and LeBaron (2003) also investigate laparoscopic gall bladder removals and describe how a surgeon, resident and student use demonstrative references to build common ground on bodily landmarks. Using references such as "right there", surgeon, resident and student negotiate the location of the cystic artery. Koschmann and colleagues (2001) stress the importance of copresence for successful demonstrative references, an aspect which is limited in robotic surgery, as surgeon and resident put their heads into large consoles (Pelikan et al., in press). Koschmann and colleagues (Koschmann et al., 2001; Koschmann & LeBaron, 2003) apply Clark's work on reference repair (Clark & Marshall, 1981) and on common ground (Clark, 1996) to detailed conversation analytic study of surgical interaction. Koschmann and LeBaron (2003) find that in multiparty interaction, overlapping talk and actions which are performed simultaneously rather than sequentially (embodied conduct in the material and social environment) make a distinction into presentation and acceptance phase difficult.

Cao & Taylor (2004) compared laparoscopic and robotic gall bladder removals and found differences in the amount and type of information that the surgeon needs to perform the surgery. When performing surgery with a surgical robot, surgeons need to ask for and convey more information as compared to laparoscopic surgery. Cao & Taylor (2004) suggest that difficulties in establishing common ground arise because team members are uncertain about whether they need to convey or ask for information. Further, they find a lack of common ground regarding terminology in relation to surgical robot. Cao and Taylor (2004) stress the role of training and specific communication patterns for improving common ground. In another study, Webster and Cao (2006) compare tool changes in a laparoscopic versus a robotic gall bladder removal. They find an increase in information flow in robotic surgery as compared to laparoscopic surgery, as common ground on the state of the robot needs to be built. In a subsequent simulated tool changing task, Webster and Cao (2006) compare three conditions: (1) no instructions about when to communicate, (2) following a script that determines what to communicate after completion of certain actions and (3) automatic feedback as to whether the other has completed an action via a TV screen. Participants were significantly faster in performing tool changes in the scripted and automated conditions than in the one without communication rules. The scripted condition resulted in less errors than automated condition, suggesting that scripted speech, which indicates what and when to communicate, may ease the grounding process and reduce errors. Randell and colleagues (2016) also propose the use of standardized speech to address the increased need to communicate between surgeon and team.

The work by Cao and Taylor (2004) and Webster and Cao (2006) has been done in the early days of robotic surgery. In Webster and Cao's (2006) study, surgeon and nurse were using the robot on a human patient for the first time during the robotic case, thus difficulties with building common ground may be explained by the fact that the surgical team had little experience with using the robot. However, surgical teams still struggle to develop common ground in robotic surgery after years of experience with using the robot (Pelikan et al., in press). In my prior work, I have shown that the difficulties in building common ground arise from the spatial arrangement in robotic surgery with the surgeon at a distance from patient and team. A major problem in robotic surgery is a lack of surgeon situation awareness (Pelikan et al., in press; Randell et al., 2015, 2016) but the team also sometimes lacks awareness of information that the surgeon holds (Pelikan et al., in press).

As I have illustrated, prior work has investigated common ground in laparoscopic and robotic surgery and finds that in robotic surgery, teams face difficulties in maintaining common ground due to limited situation awareness. However, previous work does not address common ground in open surgery and has not investigated practices to cope with grounding difficulties in robotic surgery in sufficient detail. In this thesis, I therefore look at grounding practices in both open and robotic surgery on a turn-by-turn basis. Further, while previous research has focused on interaction between surgeons, residents and students (Koschmann et al., 2001; Koschmann & LeBaron, 2003; Feng & Mentis, 2016, 2017) as well as anesthesiology teams (Johannesen et al., 1994; Johannesen, 2008) it has not investigated how common ground is built within the entire surgical team, including the nurses. This work focuses on negotiation of common ground within the entire team, which is split during robotic surgery into patient-side party (first assistant, scrub tech, circulator, students and sometimes resident) and the party controlling the robot from the consoles (surgeon and resident).

3.2 REQUESTS

Requests are directives, and their point is to get the addressee(s) to do something for the requester (Clark, 1996). So at least two people are needed for a request and its fulfillment, and these people have to coordinate to achieve the common goal of reaching closure of the request. A request and its uptake is a "joint project" (Clark, 1996, p. 150), which is achieved by several joint actions (Clark, 1996). The joint actions by which a joint project such as a request and its uptake are achieved can be described in the form of "action ladders" (Clark, 1996) (see Table 2 for an example). Each level of the ladder represents a joint action that speaker and addressee complete. Reconsider the different states that a hearer may be in, which I illustrated in Table 1. Each of these states describes the hearer's part to a joint action and the right column of the action ladder corresponds to these states. When the requester utters a request, the addressee needs to attend to the requester's utterance in order to hear what the requester said, in order to understand what the requester means. The joint project can only be completed if the addressee takes up the requested action that he or she understood the speaker proposed, and if the addressee understood what the speaker meant sufficiently well for their current purposes

Table 2. Action ladder for a surgeon-initiated request for a surgical sponge. Surgeon and team achieve the joint project of the request through several joint actions, each of which is depicted on a separate level (Clark, 1996).

LEVEL	SURGEON	TEAM
4	requests TEAM to give a surgical sponge to him/her	takes up requested action by picking up a surgical sponge and giving it to SURGEON
3	means "TEAM, give me a (surgical) sponge"	understands "give a surgical sponge to SURGEON"
2	presents signal "can you give me a sponge?" to TEAM	identifies that SURGEON asks TEAM whether they can give SURGEON a sponge
1	utters "can you u:h give me (.) a sponge?", addressing TEAM	attends to SURGEON's talk

The action ladder is completed upwards, from bottom (level 1) to top (level 4). The joint project is thus completed by performing the actions from level 1 through 4, which is called "upward completion" (Clark, 1996, p. 147). In turn, evidence that the action at a particular level is complete automatically implies that the actions on the levels below have been completed, which is referred to as "downward evidence" (Clark, 1996, p. 148). For example, if the team gives evidence that they correctly heard the surgeon, it also implies that they paid attention to the surgeon's talk.

There is a vast body of research on requests (see e.g. Drew & Couper-Kuhlen, 2014 for a comprehensive overview). Requests have been studied in a variety of settings, most of them in ordinary conversation such as in interaction with family and friends (e.g. Aronsson & Thorell 1999; Goodwin & Cekaite, 2014; Kent, 2012; Mandelbaum, 2014; Curl & Drew, 2008; Enfield, 2014). In institutional settings, prior work has studied requests in telephone calls, such as calls to the doctor (Curl & Drew, 2008), to the US emergency service 911 (Raymond, 2014), to a bookshop (Bowles, 2006) and to an airline service (Lee, 2011). Further, requests in the form of food orders in a Japanese restaurant in Los Angeles (Kuroshima, 2010) and requests produced by residential home staff to adults with intellectual impairments (Antaki & Kent, 2012) have been investigated.

3.2.1 Formulating a Request

Requests may take a variety of linguistic shapes, ranging from “give me the scissors” to “could you maybe pass me the scissors” to “let’s take some scissors”. Entitlement of a speaker to request something from the addressee plays a crucial role for the linguistic shape of the request. Depending on the context and setting, the requester may be more or less entitled to request the other to do something. In the institutional context of surgery, the surgeon is entitled to request actions from others, since the surgeon is head of the team and responsible for the surgery (Mondada, 2014b). Curl and Drew (2008) have shown that requesters display entitlement through modal verbs, using formulations such as “would you do X?” or “could you do X?” as opposed to formulations of the form “I was wondering if you could do X”, which are employed in contexts where the speaker is less entitled to request the addressee to do things.

Since requests are imposing on the other, they are intrinsically face-threatening, that is, the speaker threatens the addressee’s “face” (Brown & Levinson, 1987). Face is an abstract concept and can be divided into “positive face” (Brown & Levinson, 1987, p. 13), which is associated with the desire to be approved of by others and “negative face” (ibid.), which represents the desire to remain free and unhindered in one’s actions. Participants generally try to preserve each other’s face and try to minimize the impact of a “face-threating act” (FTA) (Brown & Levinson, 1987, p. 60), employing various politeness strategies.

One option is to produce the request baldly, uttering the request directly and unambiguously, for example saying “give me a sponge”. Alternatively, the surgeon may choose to utter the request with “redressive action” (Brown & Levinson, 1987, p. 69), employing politeness strategies in order to reduce the face threat. Since the surgeon is entitled to utter requests in the operating room, one may expect that surgeons utter all of their requests baldly. However, as we will see in the analysis and as has been touched upon in the literature (Goffman, 1961), surgeons do employ various politeness strategies[2]. Brown and Levinson distinguish between two politeness strategies: “positive politeness” (p. 101) and “negative politeness” (p. 129), which are related to the two aspects of face.

Negative politeness is what is typically associated with politeness in the Western world (Brown & Levinson, 1987). It is focusing on respect, trying to leave the addressee unimpeded in his or her actions. Negative politeness is characterized by avoidance and a common strategy is to be indirect (Brown & Levinson, 1987). We will see that the surgeon often syntactically formulates requests as questions e.g. “do you have a scissor?” or “could you give me a sponge?”. Questions of this kind conventionally carry an unambiguous meaning, they are understood as requests and thereby go on record. At the same time, they have a different literal meaning (they are syntactically questions), so the request is only formulated indirectly. This allows the requester to signal to the addressee that he or she would have liked to go off record. Formulating a request as a question thus stresses that one is not coercing the addressee, giving him or her the option not to do the requested action (Brown & Levinson, 1987, p. 132ff). Another negative politeness strategy is to stress that one does not want to impinge on the addressee, for instance by distancing oneself from the possible face threat by avoiding the pronouns “I” and “you” (Brown & Levinson, 1987, p. 190ff) or by stating the request as a general rule (Brown &

[2] Goffman (1961) argues that surgeons try to distance themselves from their role as commander, in the same way as subordinates express distance from only fulfilling commands. After all, they are individuals who are only acting in a particular role when entering the operating room.

Levinson, 1987, p. 206ff), such as “Staff is required to disinfect their hands” instead of “(I ask you to) disinfect your hands”.

Positive politeness in contrast is emphasizing solidarity and familiarity between the requester and the addressee. A common strategy is to stress that requester and addressee are cooperators sharing the same goal and that they are both included in the activity. One way to do so is by using inclusive we forms, such as “we” and “us”, while really meaning “you” or “me” (Brown &Levinson, 1987, p. 127ff). In English, the phrase “let’s” is such an inclusive “we” and “Let’s have a break” may really mean “I want a break”. Another way to include both the requester and the addressee in the activity is to give reasons why one wants the request to be executed (Brown & Levinson, 1987, p. 128). Explaining the underlying reasons, the requester tries to present the FTA as reasonable, and accounts for what the addressee’s help is needed for. For instance, when the requester adds “it’s starting to rain” after a request to close the window, the addressee may be more willing to fulfill this request.

Another aspect, which determines linguistic form of a request is whether the requested action is “unilateral” (Rossi, 2012, p. 453), in the self-interest of the speaker as individual, or “bilateral” (ibid.), part of an already established joint project. Rossi (2012) finds that in Italian, unilateral requests take an interrogative form (e.g. “will you give me X?”), with the speaker stressing that he or she is owning the project. The requester is thus stressing that he or she is the “beneficiary” (Couper-Kuhlen, 2014; Clayman & Heritage, 2014) of the requested action. When formulating bilateral requests, which are occurring as part of an already established joint project, the requester may choose imperatives, expecting that the addressee, who already accepted the joint project, will comply (Rossi, 2012). In bilateral requests, the speaker may orient stronger to the collective outcome, stressing that both requester and requestee own the project (Rossi, 2012). Bilateral requests are characterized by ellipsis and increased use of pronouns, as the requester may assume common ground (Rossi, 2012).

3.2.2 Responding to a Request

A request can be fulfilled in different ways. First of all, requested actions can be performed at different time points. In ordinary conversation, requests are majorly fulfilled “immediately” (Schegloff, 2007, p. 94), in the here and now directly after the request. Requested actions may also be “deferred” (Schegloff, 2007, p. 94), taking place at a later point in time, rather than in the immediate context of the request sequence. In contexts where participants are not co-present but distributed in space, such as in phone conversations, fulfillment of requests is often deferred to a time point after the conversation (Lindström, 1999; Schegloff, 2007).

Requests for the transfer of objects or services are usually fulfilled in an embodied way in ordinary conversation (Rauniomaa & Keisanen, 2012). In some cases, participants first explicitly accept the request before carrying out the requested action in an embodied way. Acceptance is displayed through affirmative response tokens, such as “yeah” and “okay” (Rauniomaa & Keisanen, 2012). Schegloff (2007) also describes such minimal agreement tokens for ordinary conversation, stressing that they are only sufficient to display acceptance of immediate requests. For deferred requests in contrast, an affirmative response token is not sufficient, and an additional unit of talk is required, in which the respondent confirms that he or she will produce the requested action in the future (Lindström, 1999; Schegloff, 2007).

Existing research provides different explanations as to why participants signal acceptance before producing the requested action in immediate requests. Rossi (2012) finds that in Italian, affirmative responses are produced in unilateral request sequences, as a response to the interrogative format of the request. Rauniomaa and Keisanen (2012) find that in everyday interaction, participants produce acceptance statements when they are busy doing something else and first have to stop the current activity before carrying out the requested action (Rauniomaa & Keisanen, 2012).

3.2.3 Requests in Surgery

Mondada (2014a, 2014b) studied requests in open and laparoscopic surgery in a university hospital in France and describes in detail how the surgeon requests the assistant to pass instruments, to activate the electrocautery, to hold instruments or tissue and to move the endoscopic camera in laparoscopic surgery in both French and English[3]. Surgeons minimize verbal resources and often use free-standing nouns, such as "scalpel" or "scissors" to request an instrument to be passed to them (Mondada, 2014b). Similarly, they use short imperatives such as "hold", "zoom" or "coagulate" to direct their assistant (Mondada, 2014a, 2014b). Bezemer and colleagues (2011) studied surgical work in a teaching hospital in London, UK and find that requests are usually uttered as imperatives of the form "X, please", such as when the surgeon says "scissors, please". Surgeons use minimal reference, often using the general term for an instrument ("scissors") rather than indicating which specific type of scissors[4]. Scrub techs resolve reference from context, as different tools are typically used at different stages of the surgery (Bezemer et al., 2011). Randell and colleagues (2017) looked at surgeon-initiated requests in robotic surgery as part of a large study on the impact of robotic surgery on communication, collaboration and decision making. They find that in robotic surgery, surgeons engage in more explicit preparation of requests, often uttering the name of the addressee and/or producing phrases like "alright" or "okay and then" prior to the actual request (Randell et al., 2017). The requests they present in examples often take the form "can you X?" (Randell et al., 2017). Further, Randell and colleagues (2017) note that surgeons produce longer requests than in laparoscopy, splitting them into several parts and thereby giving addressees time to fulfill each of these parts.

Requests in the operating room are often uttered in a multimodal way (Mondada, 2014a, 2014b; Bezemer, 2011) and verbal requests are often accompanied by gestures. The surgeon may point using his/her hand or an instrument to indicate where a certain action should be performed (Mondada, 2014a, 2014b). Some requests are even accomplished completely nonverbally (Mondada, 2014a, 2014b; Sanchez Svensson et al., 2007), e.g. the surgeon's waving of a piece of tissue may be understood by the assistant as a request to grasp it (Mondada, 2014a, 2014b). Scrutinizing the preparatory work that precedes surgeon-requests, Mondada (2014b) finds that by orienting to the ongoing trajectory of actions, the surgical team is able to predict many actions before the actual request is uttered. The importance of anticipation for successful collaboration in surgical teams, especially instrument handovers, has also been stressed by others (Bezemer et al., 2011; Heath et al., 2018; Sanchez Svensson et al., 2007) but is not the focus of this thesis.

Mondada (2014b) stresses that requests are adjacency pairs, consisting of the request as a first pair part and the requested action as a second pair part. As described above, the FPP of an adjacency pair makes the SPP conditionally relevant, that is, the requested action is normatively expected. If a requested action is not produced, it is noted as "officially absent" and the surgeon will engage in a form of repair, such as repeating the FPP in an intensified way (Mondada, 2014b). The surgeon may for instance repeat the request by stressing it (e.g. through increased loudness), producing it in a faster tempo or providing more details (Mondada, 2014b). Bezemer and colleagues (2011) find that if the

[3] In the studied laparoscopic surgeries, the endoscopic camera images are sometimes transmitted to a remote expert or a student audience, which the surgeon addresses in English.
[4] There is a variety of different scissors for surgery. Similarly, there is a variety of different forceps, dilators etc.

scrub tech does not display compliance with a request, surgeons initiate repair and produce a more specific reference to the tool they are requesting. Fulfillment of requests in surgery is done immediately and nonverbally in an embodied way (Bezemer et al., 2011; Heath et al., 2018; Mondada, 2014a, 2014b; Sanchez Svensson et al., 2007). Randell and colleagues (2017) report that in robotic surgery, requests require some form of explicit oral acknowledgement when the team needs to perform actions which are not visible through the endoscope as part of the request, thereby maintaining awareness of the surgeon to what is happening.

In the same way that participants prepare request sequences, they may expand them by adding a third turn after the requested action has been performed, e.g. the surgeon may say “okay” or “yes” when the assistant is performing the requested action (Mondada 2014b). This third turn also applies if the request has not been sufficiently been addressed and repair is needed (Mondada 2014b).

3.3 Summary

In this chapter, I first summarized previous work on grounding in surgery, highlighting that there is a small body of research on common ground in laparoscopic surgery, but grounding has not explicitly been studied in open surgery and only insufficiently in robotic surgery. Further, while prior research has investigated how surgeon, resident and student as well as anesthetic teams build common ground, it has not studied grounding processes in the entire team, thereby ignoring the role of the nurses.

Second, we have seen that requests are *directives*, in which the speaker is trying to get the addressee to do something for him or her. A request and its uptake can be described as *joint project*, consisting of several *joint actions*. Requests can be formulated in a variety of ways, depending on the speaker’s *entitlement* to request the addressee to do something. While requests can be uttered *baldly*, requesters often employ *politeness strategies* to minimize the *face threat* that the request poses on the addressee. Compliance with a request can be *deferred* to a later point in time, but requests in surgery are usually fulfilled *immediately*. Requests for the transfer of objects or services, as we are dealing with in surgery, are often complied with in an embodied way, and embodied fulfillment is sometimes preceded by an *affirmative response token*. A small body of research suggests that in open and laparoscopic surgery, requests are brief and take the form of free-standing nouns and imperatives that are often combined with embodied action, while surgeons take more time to prepare requests in robotic surgery. Fulfillment of the requests is *conditionally relevant* and if addressees do not display compliance with the request, surgeons initiate *repair*. Prior work suggests that fulfillment is largely embodied in open and laparoscopic surgery, but participants verbally acknowledge requests in robotic surgery when the requested actions are not captured by the endoscopic camera.

4 METHOD

This work is part of a larger project at Cornell University, during which a team of researchers carried out ethnographic fieldwork in two US hospitals over a period of two years. As part of an internship in the Robots in Groups Lab at Cornell University, I collected video data in one of the hospitals, a medium-size community teaching hospital with about 1000 medical employees. In total, I shadowed 21 gynecologic surgeries (12 robotic, 9 open), 12 of which I videotaped (7 robotic, 5 open surgeries). Gynecologic surgery was one of the first specialties for which the Da Vinci system was approved by the FDA, the US Food and Drug Administration. Since its approval in 2005, robotic procedures have dramatically increased (Bouquet de Joliniere et al., 2016).

4.1 SETTING AND DATA

The surgical setting is quite distinctive from other settings and a basic understanding of how teams are built up and what the surgical robot looks like will help to understand the following sections. I therefore introduce the individual members of a surgical team and give an overview of the different parts and functionalities of the Da Vinci robot.

4.1.1 MEMBERS OF A SURGICAL TEAM

Surgical teams consist of several team members with different roles and skills. First of all, there is the *surgeon*, who is the head of the team and carries out major parts of the surgery. In most surgeries a *first assistant* helps the surgeon, often a specifically trained nurse (Registered Nurse First Assistant, RNFA). The *anesthetist* narcotizes the patient and monitors vital life functions during the surgery. A *scrub tech* is working in the sterile field and handing over instruments to the surgeon, anticipating what tools will be needed next (Svensson, Heath & Luff, 2007; Bezemer et al., 2011). Further, a *circulator* is needed to fetch instruments from the non-sterile areas and to count sponges and tools throughout the surgery to ensure nothing is left in the patient. The circulator also documents the surgery in the computer, noting for instance administered medicine. Teaching hospitals like the one that this research was conducted in have *residents* (in their second to fourth year of education as a surgeon-to-be), *interns* (in their first year of education as a surgeon-to-be) and *students*, who yet have to decide whether and what kind of surgery to specialize in. A surgical team thus consists of at least 5 members, in teaching hospitals it is often 8-10 people. Complicated surgeries are usually staffed with several scrub techs and circulators.

All video data was collected with the same surgeon but changing teams. Much like bus and truck drivers, nurses are scheduled to take compulsory breaks and it is not uncommon that they change shifts during a surgery, handing their tasks over to a colleague. I recorded data with 9 different scrub techs, 7 circulators, 4 anesthetists, 3 RNFAs, 3 residents, 2 interns and 4 students.

4.1.2 DA VINCI SURGICAL SYSTEM

The surgical robot used in all robotic surgeries was a Da Vinci Xi Surgical System, which is the most popular robotic surgical system in current use. The robot is used for all kinds of surgery, such as cardiac, colorectal, general, gynecologic, head and neck, thoracic as well as urologic surgery. The system consists of three components: patient cart, console and vision cart. The patient cart (see Figure 2, left) is about the size of a large refrigerator and has four extendable arms that are operating inside the patient. The surgeon controls movement of the arms on the patient cart through the console (Figure 2, middle), which provides a 3D video feed from inside the patient. In teaching hospitals, two consoles are used, so surgeon and resident can take turns with operating. The vision cart (Figure 2, right) contains all computing equipment, a microphone system as well as a screen that displays the video feed in 2D for the team.

Figure 2. The Da Vinci Xi Surgical System. Left: The robot patient cart with four arms, three of which are already covered in sterile drapes. Middle: The consoles through which the robot arms are controlled. Right: Vision cart doing the computations and displaying high-quality video from inside the patient.

4.2 Data Collection

I collected audiovisual data during gynecologic surgeries with and without the Da Vinci robot. The robotic surgeries were hysterectomies (partial/full removal of uterus), oophorectomies (partial/full removal of one or both ovaries) and salpingo-oophorectomies (partial/full removal of one or both ovaries and Fallopian tubes). The open surgeries were vulvectomies (partial/full removal of vulva) and cone biopsies. I used two camcorders (Sony HDR-PJ810, Sony HDR-CX380), two GoPros (GoPro Hero 3+) and an additional high-end microphone (Zoom H1) for the audiovisual recordings. I placed the equipment at different angles in the room in order to capture all activity (see Figure 3). The main camcorder (referred to as “cam1” in the following) was further equipped with an external shotgun microphone (Røde VideoMic Pro). I only gradually brought camera equipment into the setting, after building trustful relationships with the participants, as suggested by Heath and colleagues (2010). This proved as useful strategy, as participants could gradually get used to me and the equipment being present. After the first few visits, nurses started to actively support my research by communicating relevant scheduling information and assisting in picking safe camera locations. Written informed consent was obtained before switching on recording equipment at all times. As no patient information was recorded, I orally obtained consent from all patients before anesthesia administration. I informed the patient that focus lay on the surgical team and camera equipment would only be switched on after the patient was fully draped and therefore not identifiable. All but one patient agreed to having their procedure videotaped. Cameras were usually switched on during preparation of the room, robot docking, teleoperation periods, undocking of the robot and closing of the incisions. I switched cameras off once the patient entered the room until she was fully draped and as soon as the team started to undrape and wake the patient. In total, 68 hours of audiovisual data were collected. I wrote field notes during all visits to the hospital, noting down background information, timecodes of interesting events as well as incidents of participants orienting to the camera gear, as suggested by Heath and colleagues (2010). More details on data collection are provided in Pelikan (2018) and Pelikan and colleagues (in press).

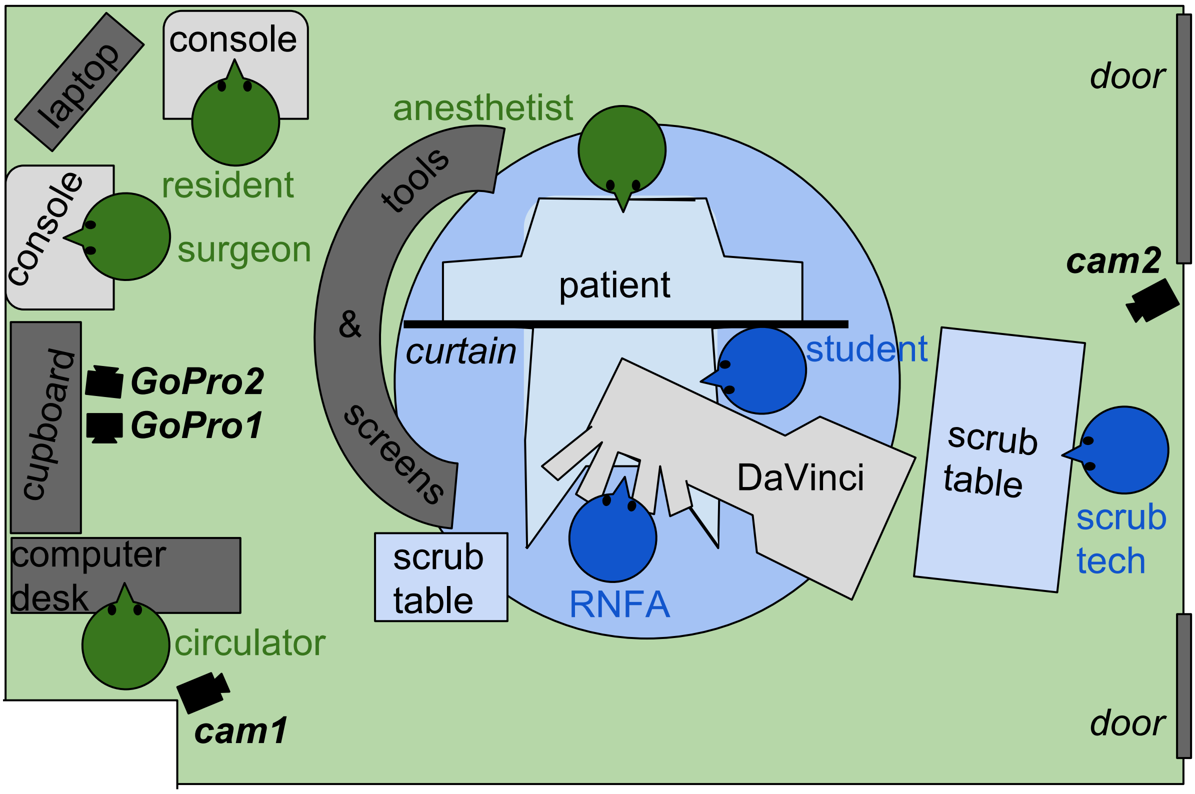

Figure 3. Distribution of cameras in the operating room where most surgeries were recorded.

4.3 Data Quality and Preprocessing

While lighting and noise can largely be controlled in a lab setting, these factors are more unpredictable in the field. During the course of a surgery, lighting varies dramatically. Ceiling lights are switched on during preparation activities as well as start and end of the surgery, resulting in a well-lit scene. Once the surgery begins, large boom lights are switched on to illuminate the surgical area. They are moved around according to the needs of the surgeon and team, resulting in recurrent changes in illumination of the area around the patient. When the surgeon is teleoperating through the robot, the headlights are often switched off, creating a dimly lit scene.

By picking high-quality cameras and switching them to automatic white balance, I was able to address the lighting challenges sufficiently for my analytic purposes. In other field settings, it is often recommended to manually set the white balance to a specific value (Heath et al., 2010). However, in this setting of constantly changing light conditions, this would have resulted in overly bright or dark sequences, forcing me to manually readjust the white balance whenever participants made changes in lighting. As this was not practically possible during the surgery, automatic white balance seemed like a more promising option. While this results in a few blurred frames every time the lighting conditions change, the camera automatically adjusts to these changes.

The surgical setting is also very noisy. The heating, ventilation and air conditioning (HVAC) system runs with a constant rustle, the life support machine beeps rhythmically and electrocautery devices produce a deep humming sound whenever activated. Surgical teams like to play music in the operating room, which adds to the noisy soundscape. Further, the DaVinci robot produces sounds to indicate that it is switched on, that the arms are being moved, when instruments are docked or undocked and when someone is zooming in on the camera image. All these sounds are recorded alongside the participants' speech, resulting in a low signal-to-noise ratio.

Because of the background noise, I preprocessed all audio data to reduce noise and enhance human speech, only thereby making a thorough analysis possible. For this purpose, I first separated the audio stream from the raw video clips (AVCHD format), transcoding it to an uncompressed audio format (.wav) using VLC Media Player[5]. In a second step, I applied noise filtering to the data using Audacity[6], an open source software for audio recording and editing. For each audio file, I defined the noise profile by selecting several seconds containing only the HVAC noise. For a few audio files, it was not possible to define the noise profile from this same file, as there were too many other sounds overlaying the HVAC system noise. In those cases, I took the noise profile from another file recorded with the same recording device on the same day in the same room. Subsequently, I used the noise profile to reduce noise in the entire audio file, using the following values: noise reduction: 12dB, sensitivity: 6 and frequency smoothing bands: 3. I decided to use the same settings for all noise reduction in Audacity to provide a rather fast and easy form of noise reduction, which made it less straining to go through all recorded data. Figure 4 illustrates the effect of noise reduction. For compatibility purposes, I converted raw video data to .mp4 format and analyzed it alongside both original and preprocessed audio in uncompressed format.

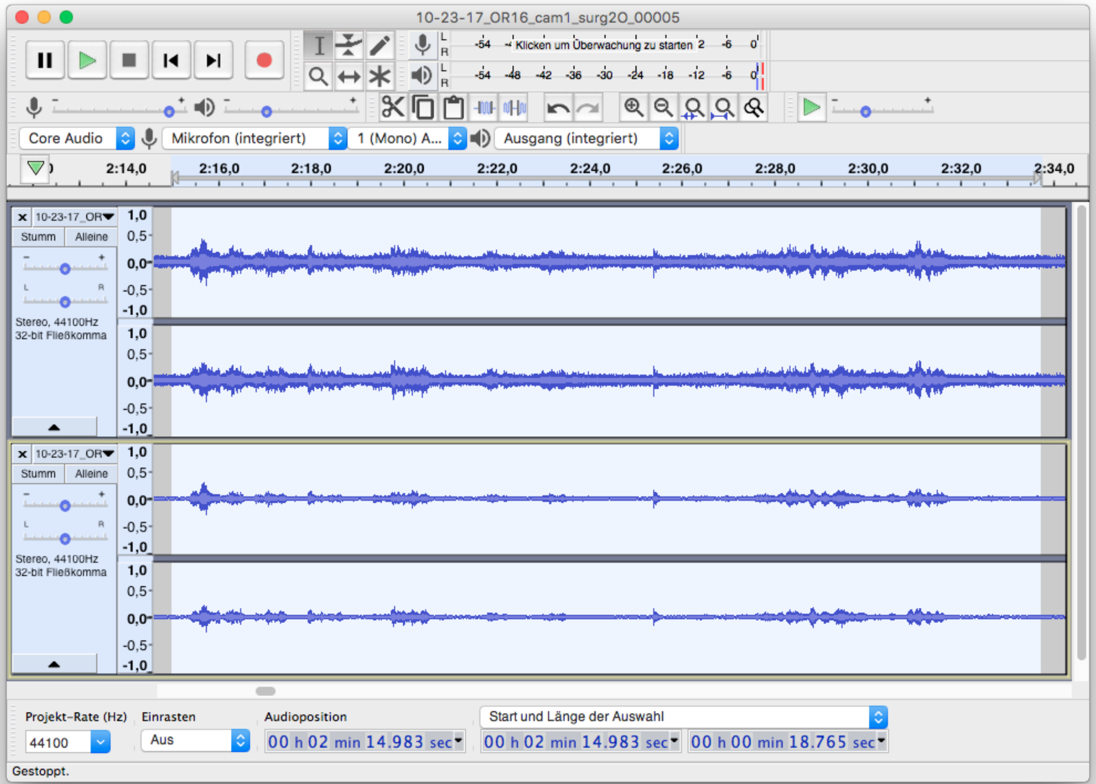

Figure 4. Waveforms of a timeout sequence in raw and noise filtered format. The top two channels show the original stereo waveform, the bottom two channels are noise reduced. In the noise reduced variant, speech patterns are clearly distinguishable from the background noise (flat line). While it was very hard to understand what participants were saying from the original recording, their words are clearly distinguishable in the preprocessed version.

[5] https://www.videolan.org/vlc/
[6] https://www.audacityteam.org

4.4 Data Analysis

Conversation analytic data analysis can be divided into three general phases: (1) preliminary review during which the data corpus is catalogued, (2) substantive review during which all instances of the phenomenon one is interested in are catalogued and (3) analytic review, in which selected fragments are transcribed and analyzed in detail (Heath et al., 2010). As Heath and colleagues (2010) explicate, these three steps do not necessarily have to happen one after another, but rather the researcher may proceed to analytic review before having completed the substantive review, moving back and forth between the two in order to sharpen the analysis and inform the substantive review of new insights, thereby maximizing time spent on actual analysis.

During preliminary review, I sorted all files, renaming them to reflect date of recording, camera perspective and type of surgery in the title. Per open surgery, two to three video files were recorded from the main camera perspective, plus additional files from other camera positions and the additional microphone. Robotic surgeries usually took much longer, resulting in up to eight separate video files per surgery for the main camera alone. For each file, I compiled name of the surgical procedure and main activity (preparation, surgery, clean up). Further, I noted down start and end time of each surgery, making it easier to synchronize data from different recording devices.

I proceeded with a substantive review of the video data recorded with the main camera. The goal of this step is to catalogue all instances of a practice of interest. For this purpose, I imported data to ELAN[7], a tool for complex video and audio annotation (Wittenburg, Brugman, Russel, Klassmann & Sloetjes, 2006). I annotated general phases of the surgery: preparation of the room by the nurses, arrival of patient and anesthetist, timeout, start of surgery, end of surgery as announced by the surgeon, suturing, patient waking up, leave of patient, and cleanup) for all surgeries. I further annotated the rough course of events and involvement of actors (surgeon, resident, intern, student(s), anesthetist, scrub tech(s), circulator(s)) along with more detailed annotations regarding common ground, narrowing those down as analysis was proceeding.

The substantive review of all data was intertwined with the actual analytic review, in which I transcribed and analyzed single cases. I initially set out to transcribe instances that seemed interesting, generally dealing with how participants build and maintain common ground. Those transcripts helped to gradually narrow the analysis down towards interactions between the surgeon party (surgeon, resident, intern) and the nurse party (RNFA, scrub techs, circulators), leaving teaching and instructions directed to resident, intern and student aside. This also implied focus on intraoperative actions (Hull et al., 2011), taking place in the time span between time out and end of surgery, as most interaction between those parties happens in this time frame. Scrutinizing those interactions, I found that surgeon and nurses mainly build common ground on what action will be performed next, often negotiating what instrument will be needed for subsequent actions. Systematically reviewing all transcripts that I had produced around the general topic of grounding between surgeon and nurses, I found that almost all of them involved a form of request: requests for action (e.g. for instruments to be fetched or the endoscope to be cleaned; mostly initiated by the surgeon) and requests for information (e.g. what the specimen should be called). Requests for information are quite broad as anyone on the team may utter them and differences between open and robotic surgery do not seem very pronounced. Requests for

[7] https://tla.mpi.nl/tools/tla-tools/elan/, Max Planck Institute for Psycholinguistics, The Language Archive, Nijmegen, The Netherlands.

action however, seem strongly affected by the specific power relations on the surgical team, with the surgeon as head of the team uttering most of them (and nurses generally not requesting the surgeon to perform actions). Comparing my first transcripts on requests for action in open and robotic surgery, I found interesting differences. Therefore, I decided to focus on surgeon-initiated requests for action and I systematically transcribed more instances, which I could easily retrieve with the help of my earlier annotations on the rough course of events. Following my initial focus on common ground, I analyzed requests for action with specific focus on their uptake and fulfillment, as this is where surgeon and team build common ground.

I produced detailed transcripts by replaying small sequences many times in ELAN and watching and listening to the fragment from the perspective of different recording devices. When necessary, I further processed the respective audio track in Audacity to enhance human voices and reduce background noise. However, I always took the original raw recording as ultimate reference. I followed the transcription conventions established by Jefferson (2004) for verbal interaction and by Mondada (2007) for embodied conduct (see Transcription Symbols). Following conversation analytic practice, asking the question "why that now?" (Schegloff & Sacks, 1973) helped to build an understanding of why participants carry out specific actions at specific times, as they might be referring back to previous actions and projecting possible next actions (see more on the concept of sequentiality in section 2.1.1). I built two broad collections, one of requests in open surgery and one of requests in robotic surgery. In a first step, I compared similar instances and deviant cases within each collection, aiming to develop an understanding of general patterns for each type of surgery. In a second step, I compared between these collections, again assembling instances that shared similarities and scrutinizing those that showed differences. Close comparison of cases where open and robotic surgery differed enabled me to gain a deeper understanding of those practices involved in surgeon-initiated requests for action that are unique to either open or robotic surgery. Reading related literature while working with the transcripts helped to generate ideas and to develop the argument, defining it with respect to existing work.

Requests take a multitude of different linguistic shapes and may even be uttered nonverbally. In surgery, they are sometimes not explicitly produced, as experienced participants anticipate them and project subsequent actions from the preceding course of actions (Mondada, 2014b). In this thesis, I limit the scope to verbally initiated requests, because they can clearly be identified.

4.5 SUMMARY

In this chapter, I introduced the members of a surgical team and provided background information on the Da Vinci surgical robot. Moreover, provided details on data collection, highlighting particular challenges with recording in the operating room and explaining how I addressed them with suitable equipment choices and by preprocessing the data before analysis. Further, I outlined the process of conversation analytic data analysis, which is data-driven and focuses on the production of detailed transcripts, which are assembled into larger collections that support identification of general patterns.

5 ANALYSIS: SURGEON-INITIATED REQUESTS FOR ACTION

This chapter provides a thorough analysis of surgeon-initiated requests for action in both open and robotic surgery. I start out with describing the general practice for uttering and taking up requests for action in open surgery in section 5.1, subsequently contrasting it with the general pattern I found in robotic surgery in section 5.2. Section 5.3 focuses on acceptance of requests in robotic surgery and how this is negotiated in the team. In section 5.4, I scrutinize how acceptance and fulfillment is achieved in open surgery. This is contrasted with robotic surgery in section 5.5, shedding light on how the surgical team deals with trouble in the fulfillment of requests in robotic surgery. I summarize the analytic results in section 5.6.

5.1 REQUESTS IN OPEN SURGERY

In open surgery, surgeon-initiated requests for action follow a simple structure: the surgeon utters a request, often for a tool or a service, which is subsequently fulfilled by the surrounding team members. The excerpts below are examples of typical requests for action in open surgery.

In Excerpt 1, surgeon and intern, a surgeon-to-be, are using sponges to soak blood off the surgical site. During this activity, the surgeon requests another sponge from the scrub tech.

Excerpt 1. 10-30-17_cam1_surg1O_00001_09:06-09:13.

```
->   01   SURGEON     °do you° have ANOther spONGE?
     02               (0.9)
->   03   SCRUB TECH  ((grabs sponge, passes to surgeon))
```

In Excerpt 1[8], the surgeon asks the scrub tech for another surgical sponge, saying “do you have another sponge?” (line 01). The scrub tech, who is in charge of the instruments on the scrub table, takes a sponge and passes it to the surgeon (l. 03), thereby closing the request sequence.

By syntactically formulating the request as a question (“do you have …?”), the surgeon is only indirectly uttering the request, which has been described as a common negative politeness strategy (Brown & Levinson, 1987). Interestingly, the surgeon marks his request in a prosodic way by producing the beginning of his turn slightly more silent and by stressing the words “another sponge” through increased loudness. This may be a means to ensure that the crucial bit of the request is heard by the scrub tech, who is standing about an arm’s length behind the surgeon’s back. The scrub tech fulfills the request immediately and completely nonverbally. As the surgeon and the scrub tech are coordinating the handover, they both are perceptually aware of the fact that the sponge has been passed and closure of the request has been jointly achieved.

[8] For more detailed transcription including pictures, see Transcript I. *Do you have another sponge?* in the appendix.

The following excerpt is of a similar structure but involves more participants who are handing over the requested tool. The surgeon requests a specific type of plier, which is called Adson forceps.

Excerpt 2. 10-16-17_cam1_surg2O_00003_06:47-06:54.

```
->   01   SURGEON     c'n you >(get) me a< A:DSON
     02   SCRUB TECH  ((turns to scrub table))
     03   INTERN      ((turns to SCRUB TECH, holds hand open))
     04   SCRUB TECH  ((passes plier to INTERN))
->   05   INTERN      ((passes plier to SURGEON))
```

In the excerpt above[9], the surgeon requests an Adson forceps, saying “can you get me a Adson” (l. 01). Once the surgeon has uttered the term “Adson”, the scrub tech turns back to her scrub table to fetch the instrument (l. 02). This time it is not only the scrub tech who is involved in fulfilling the surgeon’s request but also the intern, who is mediating the passing from scrub tech to surgeon. The intern turns towards the scrub tech, holding her hand open, ready to grasp the tool (l. 03). The scrub tech passes the plier to the intern (l. 04), who in turn passes the plier to the surgeon (l. 05), thereby fulfilling the surgeon’s request and closing the request sequence.

As in the previous excerpt, the surgeon formulates the request indirectly by syntactically producing a question, thereby employing a typical negative politeness strategy (Brown & Levinson, 1987). He stresses the instrument name, “Adson”, through increased loudness and utters the preceding words with increased speed, making them more difficult to hear, also for the transcriber. Interestingly, the emphasized part of the request is a free-standing noun, which is one of the syntactic forms that Mondada (2014b) reports for requests open and laparoscopic surgery in a French hospital. The surgeon thus clearly marks the crucial part of the request, displaying that it is important to be heard and understood through increased loudness, while producing the rest of the turn significantly less clear. The “you” in the request may be addressed at the intern, asking her to get a forceps from the scrub tech. Uttering the word “Adson” with increased loudness may then be a deliberate design choice by the surgeon, minimizing the collaborative effort by ensuring that the scrub tech will overhear the request, and the intern does not need to repeat the request when turning towards the scrub tech. This is also more efficient with respect to time, as the scrub tech immediately turns to fetch the instrument after the surgeon’s turn and does not need to wait until the intern repeats which tool is needed. By immediately turning towards the scrub table, the scrub tech also displays that the term “Adson” is enough for her to understand what the surgeon refers to.[10] The intern displays her readiness to grasp the forceps by turning towards the scrub tech and holding her hand open, a practice which has also been described by Bezemer and colleagues (2011).

In Excerpt 3 we see another example of a request for action in open surgery, with the surgeon initiating a request for a scissor, which is subsequently fulfilled with the help of several team members.

Excerpt 3. 10-16-17_cam1_surg2O_00003_10:35-10:48.

```
     01   STUDENT     ((starts moving towards scrub tech))
->   02   SURGEON     [get a] [  scisso]r
     03   STUDENT     [some ] [scissors] °for him°
     04               (1.6)
     05   SCRUB TECH  ((passes scissors to STUDENT))
```

[9] For more detailed transcription including pictures, see Transcript II. *Can you get me a Adson?* in the appendix.
[10] The team shares common ground on the instrument names as part of their communal common ground (Clark, 1996).

```
      06    STUDENT     ((holds scissors ready))
      07                (4.8)
      08    SURGEON     ((turns and looks at scissors))
->    09    STUDENT     ((moves scissors to surgical site))
```

In this excerpt[11], the surgeon requests scissors by asking a student to “get a scissor” (l. 02). The student produces a similar request, uttering “some scissors for him” (l. 03) in overlap with the surgeon’s request, as she seems to have anticipated the surgeon’s request. As in excerpt 2, the scrub tech does not pass the scissors to the surgeon herself, but to the student (l. 05), who is a member of the surgeon-party, the group of people who is actively performing the surgery on the patient. Interestingly, the student does not simply pass the scissors to the surgeon but holds them ready (l. 06), waiting for a signal from the surgeon that it is her turn. Almost five seconds later (l. 07), the surgeon finally turns and looks at the scissors in the student’s hand (l. 08). Only then, she moves the scissors towards the surgical site (l. 09).

In contrast to excerpts 1 and 2, the surgeon does not employ any politeness strategy when formulating the request but utters it baldly (Brown & Levinson, 1987). A possible explanation for this may be that noticing the student’s movement towards the scrub tech (l. 01), the surgeon omits polite formulations to save time, reducing the request to a short imperative. However, scrutinizing the student’s actions, a more complex explanation seems likely. Watching surgeon and intern stitch the patient’s wounds, the student anticipates that they will soon need a scissor to cut the thread, as becomes evident in the request uttered by her (l. 02). Anticipating the surgeon’s requests before they are (fully) uttered is not uncommon in surgery, as the course of actions helps participants to anticipate what actions will have to be carried out next (Mondada, 2014b). By adding “for him” to her request in a lower voice (l. 02), the student clearly marks that she is not requesting the scissors for herself, but that she is merely verbalizing the surgeon’s request. In her movement towards the scrub table, the student thus does not only display anticipation of the request, but also already accepts the anticipated joint project by starting to fulfill it. As Rossi (2012) has pointed out in his definition of bilateral requests, the requester is more likely to formulate requests as an imperative when they occur as part of an already established joint project, expecting that the addressee, who already accepted the joint project, will comply with the request. This fits well with what we see here: The surgeon drops polite formulations and formulates the request as an imperative in this context because the student has already accepted the joint project before it was uttered, and is acting to fulfill it. Therefore, an indirect formulation that leaves the possibility to decline the request like in Excerpts 1 and 2 is not needed here and would in fact be contrary to sequential expectations, as the request has already been accepted. While the request is repeated by the student, fulfillment and closure of the request is achieved completely nonverbally, and participants carefully time their embodied actions with respect to preceding actions and anticipated next actions.

In all three excerpts above, participants achieve closure nonverbally in an embodied way. In the majority of cases in open surgery, surgeon-initiated requests for action are fulfilled immediately, following the pattern that is illustrated in these excerpts. The surgeon utters a verbal request, which is subsequently fulfilled by the embodied actions of one or several team members. The general pattern for requests for action that are initiated by the surgeon in open surgery is thus the following:

[11] For more detailed transcription including pictures, see Transcript III. *Get a scissor* in the appendix.

(1) Request
(2) Embodied fulfillment

This structure has also been described by Mondada (2014b) for requests in open and laparoscopic surgery. When formulating the request, the surgeon utters the first pair part of an adjacency pair. In producing the requested action, the team produces the second pair part and fulfills the request. Interestingly, while surgeons in France utter imperatives in the form of free-standing nouns or verbs (Mondada (2014b) and British surgeons formulate their requests as imperatives paired with the word "please" (Bezemer et al., 2011), we see a different practice in this US hospital. The surgeon majorly formulates requests as syntactical questions, thereby employing the negative politeness strategy of being conventionally indirect (Brown & Levinson, 1987). Following Rossi's (2012) argumentation, the surgeon is thereby stressing the unilateral character of the requests, presenting himself as the beneficiary and syntactically leaving the team the freedom to decline the request. The surgeon does formulate requests as imperatives when uttering bilateral requests, in which the joint project has already been established and compliance with the request can be expected. The differences in how European surgeons and a US surgeon utter their requests might point to differences in how surgeons understand the collaboration with their team and respect individual freedom, which likely has a cultural dimension as well.

We have seen that in open surgery, the surgeon proposes a joint project by asking the addressee to perform a particular action for him or her (often passing an instrument). This proposal is taken up by the team simply by starting to perform the requested action. Producing a solely embodied response, the addresses thus accept and fulfill the request in one turn, since producing the first action to fulfill the request automatically serves as a display of acceptance.

5.2 Requests in Robotic Surgery

Interestingly, surgeon-initiated requests for action are following a different pattern in robotic surgery. We will see that while in open surgery starting to carry out the request at the same time displays acceptance of the request, this does not hold for robotic surgery. In the following snippet, the resident who is operating through the robot console asks the first assistant to push the V-Care, an instrument which is vaginally inserted and marks the uterus from the inside, thereby facilitating a straight cut around the uterus in hysterectomies (removal of the uterus).

Excerpt 4. 10-03-17_cam1_surgR_00002_08:43-08:47.

```
      01   RNFA       ((stops leaning onto instrument))
      02   RESIDENT   ((briefly activates cautery))
->    03   RESIDENT   >c'n y'< push it again?
      04   RNFA       (0.5)((slight nod))
->    05   RNFA       sure
->    06   RNFA       ((pushing on v-care))
      07   RESIDENT   ((continues cauterizing, distinctive cautery sound))
```

In this excerpt, the resident, a surgeon-in-training, is in charge of the robot arms and is cauterizing for a longer stretch of time, interspersed with small breaks. During one such break, the first assistant stops leaning onto the V-Care instrument (l. 01). The resident briefly activates the cautery but immediately stops it again (l. 02), asking "can you push it again?" (l. 03), referring to the V-Care. The first assistant nods slightly (l. 04), an action which the resident cannot see from the console, and responds "sure" (l. 05). She immediately starts to push the V-Care, by leaning onto it with her full weight. Pushing the V-

Care results in stretching of the uterine tissue, an action which is captured by the endoscope and therefore visible both on the surgeon consoles and on multiple screens that are distributed through the operating room. She thereby fulfills the request, which becomes evident in the resident's next action: The resident starts cauterizing again (l. 07), an action which can both be seen on the screen and heard through a distinctive sound. The resident thus continues the activity she was doing before initiating request sequence (l. 02).

Much like the surgeon in previous examples, the resident formulates the request in an indirect way by syntactically producing it as a question. She stresses the essential words "push" and "again", while uttering the polite parts at the beginning of her turn with increased speed. As in the examples of requests for action in open surgery, the RNFA is producing the requested action in an embodied way by pushing the instrument (l. 06) and thereby sufficiently fulfills the request. However, unlike in the open surgery examples, the RNFA is producing a verbal response preceding her embodied action. By producing the affirmative response token "sure" (l. 05), she is first verbally accepting the request before actually fulfilling it. This is not a unique case but a prevalent practice in robotic surgery, as we will see in the following excerpts.

In Excerpt 5, the surgeon, who is sitting behind the robot console, requests his first assistant (RNFA) by the patient to take over and vaginally pull out the uterus that he and the resident previously cut.

Excerpt 5. 10-30-17_cam1_surg4R_00009_15:34-18:14.

->	01	**SURGEON**	**°can i° get you to <u>look</u> at it**
	02		**(0.4)**
->	03	**RNFA**	**OKAY**
	04		**(123)**
		commentary	**((RNFA requests towel from SCRUB TECH, moves light, fetches small scrub table, asks CIRCULATOR to fetch lubricant; RESIDENT moves to patient side))**
	05	**RNFA**	**((pulls v-care out))**
->	06	**RNFA**	**((pulls specimen out and places it on small scrub table for inspection by RESIDENT and SURGEON))**

In Excerpt 5[12], the surgeon asks the first assistant to take over, by saying "can i get you to look at it" (l. 01). The first assistant responds by saying "okay" (l. 02), actually shouting rather than only saying it in a normal volume. The first assistant only then proceeds to fulfill the surgeon's request and after preparing his workspace (l. 04), he pulls out the V-Care, an instrument that helps to mark the uterus inside the body (l. 05) and finally the uterus (l. 06) that surgeon and resident previously detached with the help of the robot. This takes more than two minutes, and the surgeon has to remain idle while this is happening. During this time, the resident moves over to the patient, starting to inspect the uterus once the first assistant places it on the table.

As in the previous examples, the surgeon chooses to produce the request in a conventionally indirect and negative polite form. While the crucial part of the request ("look", l. 01) is stressed, the surgeon utters the beginning of his turn with reduced volume, making it more difficult to hear. The first assistant displays his acceptance of the request in a very loud voice, which seems to be a way to ensure that the surgeon can hear what he says. The effort that the RNFA puts into ensuring that his response is heard might indicate that this acceptance statement is quite important.

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[12] For more detailed transcription, see Transcript IV. *Can I get you to look at it?* in the appendix.

This is in line with Randell and colleagues' findings (2017) who report that in robotic surgery, requests are explicitly accepted when they involve actions that the surgeon cannot see on the screen. Affirmative response tokens like "yeah" and "okay" are generally not uncommon in request sequences. Rauniomaa and Keisanen (2012) suggest that participants in ordinary conversation employ such affirmative response tokens when they are asked to do something, but they are still busy with another activity. In ordinary conversation, participants may thus use these minimally verbal responses to display acceptance of a request while at the same time putting the fulfillment on hold until they have finished the ongoing activity. We could argue that because closure of the request takes several minutes and cannot be seen by the surgeon, the first assistant is assuring the surgeon that he will comply with the request, putting the actual fulfillment on hold. However, this does not explain why the first assistant in Excerpt 4 is responding "sure" before actually starting to push, an action which is immediately visible on the screen. Further, in Excerpt 5, the first assistant is not busy with any other activity that he first has to finish. In fact, he immediately becomes active, uttering several requests himself, asking the nurses for tools that he needs to fulfill the surgeon's request. He thus does not put fulfillment of the surgeon's request on hold, but rather starts it right away – it just involves several preparatory steps. Pulling the specimen out always takes some time and the surgeon is very much aware of it. We may therefore argue that the surgeon (and other team members) do not perceive fulfillment as delayed but very much on time, and the first assistant's actions display immediate uptake. As we will see in the next example, participants indeed explicitly verbalize possible delays in fulfillment of the requested action in a separate turn[13].

In Excerpt 6, the surgeon asks the resident, who is located by the patient-side to do suction. Much like dentists, who use their suction device to keep the teeth clear of saliva, surgeons use suction to maintain visibility of their working field. The resident accepts the request but continues, adding that she first needs to untangle the cables.

Excerpt 6. 10-23-17_cam1_surg4R_00009_18:12-18:48, 10-23-17_cam2_00002_24:16-24:52.[14]

```
      01   RESIDENT   ((grabs suction device, starts untangling cables))
->    02   SURGEON    suck that out
      03              (0.3)
->    04   RESIDENT   yeah
      05   RESIDENT   °untanglin' it°
      06   RESIDENT   (5.5) ((finishes untangling and inserts suction))
      07   SURGEON    here, see?
      08   RESIDENT   (.) yah
      09              (1.0)
      10   SURGEON    >go ahead<
      11              ((RESIDENT does suction at various locations guided
                      by SURGEON))
      12   SURGEON    that's fINE
      13   SURGEON    (0.2) >let's keep it< like that
      14   RESIDENT   (7.0) ((takes suction out))
```

[13] See also Excerpt 9 for an example in which the addressee declines acceptance of the request and puts fulfillment on hold until she has finished her current activity.

[14] Transcript based on video data from cam1 and cam2; recordings on each camera were started at different time points.

In this excerpt[15] the surgeon asks his resident who is currently positioned by the patient to "suck that out" (l. 02). It is common that either first assistant, resident or intern insert and activate the suction every once in a while, to clear the operating side of blood and other body liquids. The resident already seems to have anticipated that the suction device will be needed soon, as she grabbed it a few seconds before the surgeon initiated the request (l. 01). She responds "yeah" (l. 04) and thereby explicitly displays that she accepts the proposed joint project of performing the requested action. However, she continues her turn, adding "untangling it" (l. 05), indicating that she first needs to sort the cables of the suction device before inserting it into the body (l. 06). Sorting of the cables causes a brief delay compared to the amount of time it typically takes to move the suction tip into the patient's abdomen (and thereby into the surgeon's visual field). While the instrument is not visible to the surgeon at the console when it is outside the body, it becomes visible once it is inserted through the holes in the abdomen and captured by the endoscope. The surgeon utters "here, see?" (l. 07) once the resident has inserted the suction, and after she has confirmed that she sees where saying "yah" (l. 08), the surgeon tells her to "go ahead" (l. 10). The surgeon subsequently guides his resident to do suction at different bodily locations (l. 11; details in the appendix), until he finally indicates "that's fine" (l.12) and terminates the joint project by uttering "let's keep it like that" (l.13). As the activity is finished, the resident takes the suction device back out of the body (l. 14).

Like in Excerpt 3, the surgeon is not employing any politeness strategies but utters the request baldly (Brown & Levinson, 1987), possibly expecting the resident to already have anticipated this request. The resident accepts the request by saying "yeah" (l. 04), similarly as in Excerpts 4 and 5. However, she adds the utterance "untangling it" (l. 05), which seems to serve as an account for why there is a delay until fulfillment of the request becomes visible. We thus see that when participants are busy with another activity and have to put the request on hold, they provide an explanation in an additional turn, separate from the affirmative response. Rauniomaa and Keisanens' (2012) account, which treats affirmative response tokens as display of putting fulfillment of the request on hold, thus does not seem to hold for the institutional setting of robotic surgery. Another explanation is provided by Rossi (2012), who mentions explicit acceptance preceding fulfillment as response to unilateral requests, which are usually uttered in an interrogative form. This might seem to account for the affirmative response tokens in Excerpts 4 and 5, which are produced in response to interrogative request formats. However here in Excerpt 6, the request is not uttered as a question but as an imperative (l. 02), thus constituting a bilateral request, and the resident's acceptance statement (l. 04) would not be necessary according to Rossi (2012). Moreover, the requests in open surgery (Excerpt 1 and Excerpt 2) would require an affirmative response as well, since they are formulated as questions – but participants only fulfill them nonverbally. Thus, Rossi's (2012) distinction into unilateral and bilateral requests is not helpful for explaining why participants consistently produce affirmative response tokens in robotic but not in open surgery.

In their large study on robotic surgery, Randell and colleagues (2017) provide another account of why participants in robotic surgery display explicit acceptance of requests before starting to fulfill them. They suggest that requests are explicitly accepted in cases in which it takes some time before requested actions become visible for the surgeon, which fits here in Excerpt 6 as well as for Excerpt 5. Interestingly though, we have seen in Excerpt 4 that participants also explicitly accept requests when the requested action immediately becomes visible on screen, an aspect that Randell and colleagues' (2017) explanation does not account for. A possible explanation may lie in the finding that it is not only

[15] For more detailed transcription, see Transcript V. *Suck that out* in the appendix.

the surgeon who cannot always monitor what the team is doing in robotic surgery, but that the team is also sometimes unaware of what the surgeon sees and does (Pelikan et al., in press). Surgeons sometimes take their heads out of the console to talk to each other or to relax their eyes from the straining 3D vision, especially when they are waiting for other team members to finish their tasks. They might be closing their eyes or focusing their attention on another area of the visual display than where fulfillment of a request becomes visible[16]. In the same way that the surgeon cannot see the team, team members cannot monitor whether the surgeon knows that they have started to fulfill the request, which could explain why they produce an affirmative response token also in cases when fulfillment happens very fast, as they are thereby ensuring that both parties know that the joint project has been established.

In Excerpts 4-6, I have presented typical request sequences as they occur in robotic surgery. In contrast to the 2-part request structure in open surgery, requests follow a 3-part structure in robotic surgery. While the surgeon's verbal requests are similar to open cases, the addressees employ a different practice when taking up the surgeon's request in robotic surgery. They first verbally accept the request and only then proceed with the fulfillment, which is often embodied. Surgeon-initiated requests for action in robotic surgery thus follow the general pattern described below:

(1) Request
(2a) Verbal acceptance (through affirmative response token)
(2b) Fulfillment

While affirmative response tokens have been associated with delayed fulfillment of requests (Rauniomaa & Keisanen, 2012) and explicit acceptance of interrogative, unilateral requests (Rossi, 2012) in ordinary conversation, this does not seem to apply to the institutional setting of surgery. A likely reason for the production of verbal acceptance statements in robotic surgery seems to be that the surgeon cannot see the team's embodied conduct in the operating room while he or she is visually immersed into the patient's body (Randell et al., 2017). However, this does not account for why team members also display explicit acceptance when requested actions immediately become visible on screen. My earlier finding (Pelikan et al., 2017) that in robotic surgery, the team also does not see what the surgeon sees may provide a helpful account for this, as not only the surgeon needs to know that the addressee is fulfilling the requested action but the requestees also need to know themselves that the surgeon knows that they are complying with the request. Producing an explicit verbal response also in cases where the surgeon is likely to see fulfillment of a request immediately on screen may thus serve to reach joint closure, ensuring that both the surgeon and the addressee know that the request is complied with, and surgeon and addressee know of each other that the other shares this knowledge.

Using the property of downward evidence in language (Clark, 1996), this can be explained in the following way. In open surgery, acceptance of the request becomes evident in embodied fulfillment, which the surgeon can see by looking at the addressee (or may even perceive in his or her peripheral vision). Visible embodied fulfillment of requests in open surgery provides downward evidence that the addressee A is accepting the proposed joint project, that A correctly understood what the surgeon meant by uttering a certain request, that A heard correctly what the surgeon said, and that A was attending to the surgeon's speech. In robotic surgery in contrast, the surgeon is visually dislocated from the operating room, leaning his or her head into the console to view the abdomen of the patient,

[16] The surgeon's view of the endoscopic video in the robotic console is overlaid with information on the robot instruments.

and thereby cannot monitor the team members' embodied behavior unless it is captured by the endoscope. Therefore, the surgeon has no evidence on whether A accepts and takes up the request, whether A understood the request in the way the surgeon intended it, whether A heard what the surgeon was saying or whether A was even paying attention to what the surgeon said. Explicitly accepting the request addresses this problem: by producing an affirmative response token, A displays she has attended to the surgeon's speech and that she has heard what the surgeon said sufficiently well (otherwise A would ask for repetition). We might even go one step further and argue that in producing an affirmative response token, A also displays her understanding of the surgeon's utterance as a request: If producing an affirmative response token is accepted as common practice for responding to requests, it also displays the surgeon's utterance was understood sufficiently well for the current purposes (otherwise A would ask for clarification[17]). Upon hearing the affirmative response token, the surgeon can thus assume that his or her request was heard, understood and is complied with. As team members cannot fully monitor the surgeon's actions but can assume that the surgeon hears what they say through the microphone system, explicit verbalization also supports their own reflexive understanding: when producing an affirmative response token, team member can assume that the surgeon knows that they are complying with the request. Thereby, they reach joint closure and build common ground on the uptake of the request.

Since verbal acceptance statements in response to surgeon-initiated requests are persistent in the data from robotic surgery, we will now take a closer look at cases in which these statements are not immediately produced. As we will see, verbal acceptance is treated as conditionally relevant and participants work hard to arrive at the mutual understanding that they are engaged in a joint project.

5.3 NEGOTIATING ACCEPTANCE OF REQUESTS IN ROBOTIC SURGERY

In the following excerpt, the surgeon asks the resident to take a grasper. Unlike in the previous excerpts, the resident does not immediately produce an accepting response, but instead remains silent. Additional work from the surgeon is needed before the resident finally produces an affirmative response token.

Excerpt 7. 10-23-17_cam1_surg4R_00009_10:02-10:07, 10-23-17_OR94_cam2_00002_16:06-16:11.

```
      01    SURGEON     do you wanna uh TAKE A GRA:SPER
->    02    SURGEON     (.) >so you c'n go an< HOLD THIS °for me°
->    03    SURGEON     (0.2) i appre[ciate] it
      04    RESIDENT                 [S↑U↓RE]
```

In this excerpt[18], the surgeon asks the resident to take a grasper, asking her "do you wanna take a grasper" (l. 01). Since the resident does not produce an accepting statement, the surgeon quickly continues his turn by saying "so you can go and hold this for me" (l. 02). The crucial bit of why the resident should take the grasper is marked by the surgeon speaking louder when uttering "hold this"

[17] 10-23-17_cam1_surg4R_00010-03:41-03:50. Scrub tech asks for clarification of which bags the surgeon means.

```
      01    SURGEON       probably wanna get these out
      02    SURGEON       °can i° get a ↑littl' ba:g
      03                  (1.5)
->    04    SCRUBTECH2    the easy bags?
      05                  (0.9)
      06    SURGEON       little bag
      07    SCRUB TECH    okay
```

[18] For more detailed transcription, see Transcript VI. *Do you wanna take a grasper* in the appendix.

and even stressing the word “hold”. In contrast, the words “for me” at the end of the turn are uttered in a lower voice than the surrounding speech. The resident remains silent and the surgeon proceeds, saying “I appreciate it” (l. 03). During this utterance, the resident finally produces the affirmative response token “sure” (l. 04) in overlap with the surgeon’s talk. She utters it with a prominent prosodic contour, first rising her intonation and then lowering it again.

As in previous excerpts, the surgeon utters the request in an interrogative format and the crucial bit of the request is prosodically marked by increased loudness (“take a grasper”). By phrasing the request as “do you wanna” it sounds more like an offer (e.g. “do you wanna go to the beach?”), and possibly, the resident does not understand it as a request that needs to be accepted. When the resident does not produce a response at the transition-relevance place, the surgeon continues his turn, and provides an explanation why the resident should take the grasper: to go and hold a piece of tissue (“this”) for the surgeon. Explaining why one is requesting something is considered as positive politeness strategy in the literature (Brown & Levinson, 1987), as it stresses the cooperative aspect of both being part of the activity. However, with the last two words of the turn, the surgeon does the opposite, clarifying that this is not an offer and that he will be the beneficiary of the requested action (Couper-Kuhlen, 2014; Clayman & Heritage, 2014). Stressing that he will be the beneficiary (while at the same time providing an explanation), the surgeon may be appealing to his right to utter requests as the head of the surgical team. As the resident still does not take the turn, the surgeon adds “I appreciate it” (l. 03), a phrase that is usually produced *after* a request has been accepted (see e.g. Clayman & Heritage, 2014, p. 63). The surgeon explicitly displays that he would appreciate the resident’s help, which seems to increase the presentation of the surgeon as beneficiary of the request. During this turn, the resident finally accepts the surgeon’s request with the affirmative response token “sure” (l. 04). Interestingly, she produces this not only with increased loudness but also with an interesting prosodic contour, possibly acknowledging that her response is produced “late”. The surgeon had to extend his turn two times before the resident confirmed that she heard the request and that she will produce the desired action.

Delays in acceptance as described above occur more frequently. In the following example, the surgeon also requests a grasper to be used at the patient-side to hold tissue. This time however, the request is not addressed directly at the intern, the person who will manipulate the grasper, but at the scrub tech, who will pass the grasper to the intern.

Excerpt 8. 10-02-17_cam1_surg3R_00008_19:17-19:21.

```
      01    SURGEON     >so she c'n< take the GRA:SPER
->    02    SURGEON     (.) to HOLD THIS
->    03    SURGEON     (0.2) it’s gonna help me
      04    SCRUB TECH  °°alright°°
```

In this excerpt, the surgeon requests a grasper, saying “so she can take the grasper” (l. 01). While he is requesting the grasper for the intern (“she”), he seems to be addressing the request at the scrub tech, who has to pick the grasper from her scrub table and pass it to the intern. As the scrub tech does not respond, the surgeon continues his turn, saying “to hold this” (l. 02). Again, the words “hold this” are marked by increased loudness, so they are clearly hearable. The scrub tech does still not produce a response, and the surgeon adds “it’s gonna help me” (l. 03). This is when the scrub tech finally produces the affirmative response token “alright” (l. 04) in a very low voice.

As in Excerpt 7, the surgeon requests a grasper for his patient-side apprentice, so she can hold a piece of tissue. This time, the surgeon does not formulate the request as a question, but as an assertion, which is also considered as negative politeness strategy (Brown & Levinson, 1987). As in previous excerpts, the surgeon is stressing the important parts of the request "take" and "grasper", uttering the word "grasper" with increased loudness. The beginning of the turn is formulated with increased speed. Differently than in the excerpt 7, the surgeon is not addressing the resident or intern by the patient, but he is referring to the intern in the third person ("she", l. 01). It is not quite clear why he does so, one reason may be that the intern is new and he wants the scrub tech to supervise her. Another reason could be the scrub tech's location: she is positioned behind the surgeon's back in this procedure, while in most other cases, the scrub tech is located at the far end of the room, where the surgeon would not hear her response. Possibly, the formulation of this request with the scrub tech as direct addressee and the intern as implicit addressee (the request implies that she should get ready to take the grasper) also results in unclarity of who should respond to the request. As in Excerpt 7, the surgeon details that the grasper is needed to hold something. Giving this explanation can be considered as positive politeness strategy, appealing to the team that the request is uttered for a good reason (Brown & Levinson, 1987). As an accepting response is still not produced, the surgeon continues his turn, and this time produces another explanation, saying "it's gonna help me" (l. 03). Like in Excerpt 7, he thereby stresses that he will be the beneficiary of the requested action (Couper-Kuhlen, 2014; Clayman & Heritage, 2014) and thereby unmistakably displays that the statement is a request (to which he is entitled as head of the team). The scrub tech acknowledges this by finally producing the affirmative response token "alright". She does so in a very low voice, and as we will see in Excerpt 10, it is not heard by the surgeon.

We have seen that the surgeon sometimes has to work quite a bit to have the other verbally accept his requests. In Excerpt 7 and 8, the request could be immediately fulfilled, and the addressee produced an affirmative response token when finally acknowledging the surgeon's request. In the following excerpt, the surgeon asks the first assistant to clean the endoscope. However, she has to put the request on hold because she is changing into a fresh sterile gown and thus is currently nonsterile, prohibiting her from touching the patient.

Excerpt 9. 10-03-17_cam1_surgR_00003_08:24-09:24, 10-03-17_ZOOM0011_01:45:46-01:46:46.

```
      01   SURGEON   #would you-
           im        #im1
->    02   SURGEON   uh: (.) do liss a favor
->    03   SURGEON   an' clean the camera >fer her<
      04             (1.5)
->    05   SURGEON   she got it spattered
      06             (2.0) ((INTERN and RNFA looking at each other))
      07   RNFA      um:::
      08   RNFA      (.) ONE SECond
      09   RNFA      (0.3) i'll be r↑ight there
      10             (0.8)
      11   INTERN    yes
      12   INTERN    in a second
      13             (24.5) ((CIRCULATOR2 brings fresh gown, RNFA puts it
                     on, SCRUB TECH helps RNFA to put on fresh gloves,
                     CIRCULATOR1 closes gown, RNFA moves to patient-side))
      14   RNFA      #CLEANING CAMERA
           im        #im2
```

```
15    SURGEON     (0.2) yah
16                ((RNFA cleans camera, teaches INTERN how to do it))
```

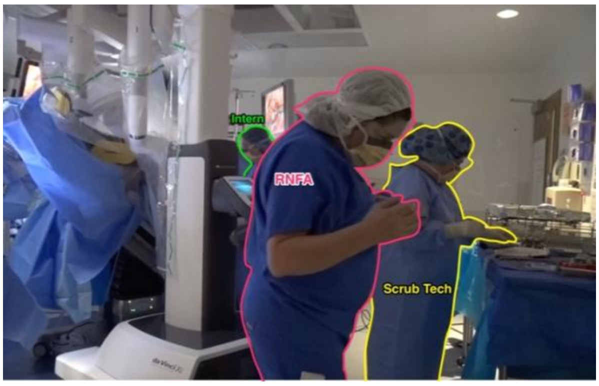

Image 1

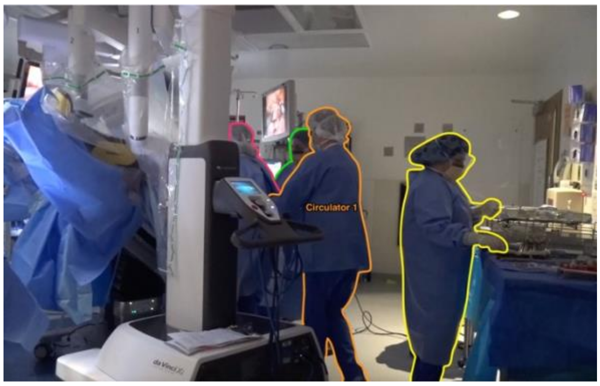

Image 2

In this excerpt, the surgeon requests that the endoscopic camera should be cleaned. The first assistant is tasked with cleaning the endoscope whenever the lenses get too dirty but she just took off her sterile gown, which was full of blood stains after she vaginally pulled out the dissected uterus, and she is waiting for the nurses to fetch a fresh sterile gown for her (see Image 1). As the surgeon is sitting by the consoles with his back to the entire scene, he cannot see this. He starts out saying "would you" (l. 01), hesitates, saying "uh" (l. 02) and then after a short pause continues his sentence as "do Liss a favor" (l. 02). Liss is the resident's nick name[19]. He continues his turn, and formulates the actual request, saying "and clean the camera for her" (l. 03), uttering the words "for her" with increased speed. The first assistant does not produce a response and after 1.5 seconds of silence, the surgeon produces an explanation, saying "she got it spattered" (l. 05). First assistant and intern look at each other during another 2 seconds silence, before the first assistant finally produces a response. Instead of producing an affirmative response token, she says "um" (l. 07), stretching the utterance to last for almost a second. She continues saying "one second" (l. 08) in a very loud voice, making an effort to ensure the surgeon at the other end of the room can hear her. After a brief silence, she promises "I'll be right there" (l. 09). The intern, who is closer to the robot's microphone system repeats the first assistant's response for the surgeon, saying "yes, in a second" (l. 11-12). As soon as the RNFA has put on her sterile gown, she moves over to the patient, one of the circulators running behind her to close the gown (see Image 2). She utters "cleaning camera" (l. 14) in a loud voice before she detaches the endoscope and takes it out of the patient's body to wipe it, which the surgeon accepts by saying "yah" (l. 15).

As in previous examples, the surgeon formulates the request as a question: "Would you do Liss a favor and clean the camera for her?" (l. 1-3). Interestingly, he avoids the pronouns "I/me" in this request and presents the resident as beneficiary (Couper-Kuhlen, 2014; Clayman & Heritage, 2014). Avoidance of the personal pronouns "I" and "me" has been associated with negative politeness (Brown & Levinson, 1987). When the first assistant does not accept the request, the surgeon adds an explanation as in Excerpts 7 and 8, thereby switching to a strategy that has been described has positively polite (Brown & Levinson, 1987). When the surgeon provides the explanation that the camera needs to be cleaned because it is dirty, it becomes clear why he was presenting the resident as beneficiary of the request: it was her who got the camera spattered (l. 05). As the surgeon has already identified the beneficiary twice in this excerpt ("do Liss a favor", l. 02; "for her", l. 03), he does not need to explicitly

[19] All names are pseudonyms.

reinforce it when producing the explanation “she got it spattered” (l. 05). Yet, by stressing that it was her who got the camera dirty, rather than saying for example “it is dirty”, the surgeon refers back to his earlier turns, thereby maintaining focus on the resident as beneficiary. While this request is presenting the resident rather than the surgeon as beneficiary, it still takes a similar shape as Excerpts 7 and 8: When the request is not accepted, the surgeon produces an explanation, and stresses the beneficiary, thereby making explicit that it should be understood as a request (Couper-Kuhlen, 2014; Clayman & Heritage, 2014). In this excerpt, the first assistant is hesitating to produce her response, leaving a long silence between the surgeon’s first pair part and her response (l. 06). Silence after the FPP of an adjacency pair has been associated with dispreferred responses (Pomerantz, 1984). Indeed, the first assistant does not accept the request, which is a dispreferred response to requests (Rauniomaa & Keisanen, 2012). Instead, she indicates that she cannot carry out the request immediately (she has to defer the request until after she has put on her sterile gown but does not explicitly say this). Interestingly though, when the intern repeats the information for the surgeon, she accepts the request saying “yes” (l. 11) and then displays that its fulfillment will be delayed to “in a second” (l. 12). This is similar to the response we have seen in Excerpt 6, when the resident accepts the request but indicates a delay in fulfillment in a separate turn.

So far, we have seen that participants in robotic surgery respond to requests with affirmative response tokens to accept the proposed joint project. If the addressee does not verbally respond to the request, the surgeon reformulates the it until it is accepted by the addressee. As we have seen, the surgeon does so by providing an explanation, which may be considered positively polite (Brown & Levinson, 1987) and explicitly stating that he himself (or another member of the robot-operator party) is the beneficiary of the requested action, thereby unmistakably uttering it as a request (Couper-Kuhlen, 2014; Clayman & Heritage, 2014), to which the surgeon as head of the team is entitled.

We have seen, that the surgeon works hard to make the addressee produce a verbal response. In the continuation of the request sequence in Excerpt 8, we will see that an explicit response is conditionally relevant, and absence of a verbal response causes interactional trouble. In the excerpt below, the surgeon has provided an explanation and explicitly presented himself as the beneficiary of the request. While the scrub tech responds with an affirmative response token, it is apparently not heard by the surgeon. This leads to trouble in the interaction, as the surgeon explicitly needs to ask for confirmation that his request was heard.

Excerpt 10. 10-02-17_cam1_surg3R_00008_19:17-19:28.

```
      01   SURGEON     >so she c'n< take the GRA:SPER
      02   SURGEON     (.) to HOLD THIS
      03   SURGEON     (0.2) it’s gonna help me
      04   SCRUB TECH  °alright°
      05   SCRUB TECH  (2.4) ((picks grasper from scrub table))
->    06   SURGEON     >did y'< HEAR me?
      07               (0.4)
->    08   SCRUB TECH  yah,
      09   SCRUB TECH  we’re comin' in
      10               (0.7) ((moves toward robot))
      11   SCRUB TECH  the grasper ((holding grasper out for INTERN))
      12   INTERN      (1.4) ((takes grasper from SCRUB TECH))
```

As we have seen in Excerpt 8, the surgeon requests a grasper (l. 01-03) and the scrub tech responds by saying “alright” (l. 04) in a low voice. In this excerpt[20], the scrub tech is starting to fulfill the request and picks up the grasper from the scrub table. However, as the surgeon is sitting with his head in the console, he cannot see that she is taking up the request and apparently he has not heard her response. After more than two seconds of silence (l. 05), he asks “did you hear me?” (l. 06), indicating that he is still waiting for verbal acceptance of his request. The scrub tech finally produces the affirmative response token “yah” (l. 08), followed by “we’re coming in” (l. 09).

Formulating the request, the surgeon is proposing a joint project. He suggests that the scrub tech should give the intern a grasper so she can hold a piece of tissue. As we have seen before, in robotic surgery the practice of accepting such a joint project is to produce a verbal affirmative response token. Thereby, requester (the surgeon) and addressee (here the scrub tech) share common ground that they are indeed working on a joint project together. In this case, however, the surgeon does not seem to have heard the scrub tech’s response. The fact that the scrub tech has accepted the joint project is thus not part of their common ground: From the scrub tech’s perspective, she and the surgeon are engaged in a joint project and she starts fulfilling her part (the requested action). From the surgeon’s perspective however, the acceptance of the joint project is still pending as he has not heard the scrub tech’s response. Surgeon and scrub tech thus have a divergent understanding of the current situation. The missing display of acceptance (from the surgeon’s perspective) needs to be addressed before they can continue, and the surgeon is trying to obtain evidence that the scrub tech takes up the proposed joint project (Clark, 1996). Interestingly, his question “did you hear me?” (l. 06) suggests that the surgeon assumes trouble in hearing.[21]

In Excerpts 7-9, the surgeon was working on getting from state 3 to state 4 (from understanding to uptake) and he was doing so without disrupting the activity. As this does not seem to help in this excerpt, he assumes trouble at level 1 (hearing/attending to utterance) and explicitly questions the scrub tech about it. This may seem surprising at first sight, since there could also be a problem with correctly identifying what the surgeon is saying (transition from state 1 to state 2) or with understanding what tool the surgeon means (transition from state 2 to state 3). However, this scrub tech is very experienced and has passed the grasper without trouble many times, so she should clearly know what the surgeon is referring to. Concerning trouble in hearing correctly, the surgeon has deliberately designed his turn in such a way that “grasper” was clearly hearable and if the scrub tech would not have heard correctly, she could have asked for confirmation. So as the scrub tech is (seemingly) not producing a response even after the surgeon extended his turn several times, he must assume that she has not heard his invitation to a joint project. Interestingly, the scrub tech does not only confirm that she heard the request (l. 08), which would be enough to display acceptance. But she also explicitly displays that she has understood the request correctly, when saying “we’re coming in” (l. 09), indicating that she is carrying out the relevant next action: after picking up the grasper, it has to be inserted into the body, where the surgeon will be able to see it on the endoscopic camera image.

Assuming trouble with hearing is a typical response to the absence of a conditionally relevant second pair part to an adjacency pair (Schegloff, 1968). As Mondada (2014b) has stressed, requests are first pair parts of adjacency pairs and (acceptance and) fulfillment is the conditionally relevant second pair

[20] For more detailed transcription, see Transcript VII. *So she can take the grasper* in the appendix

[21] Note that the surgeon does *not* take his head out of the console, turn around and look whether the scrub tech is fulfilling the request. This may be too costly, as it would automatically deactivate the robot arms, and would he have to reactivate them again by putting his head into the console.

part. As we have seen, participants in robotic surgery do not produce affirmative response statements as optional addition to fulfillment, but the surgeon tries strongly to get the team to commit to the proposed joint projects. This indicates that an affirmative response token (or more generally, an explicit verbal response (Randell et al., 2017)) is conditionally relevant. If it is still not produced, it is noted as absent and the surgeon confronts the addressee of the request, thereby disrupting the ongoing activity, as we have seen in Excerpt 10.

5.4 Negotiating Acceptance and Fulfillment of Requests in Open Surgery

As I have demonstrated in 4.1., in open surgery requests are usually accepted and fulfilled with one single action. The surgeon requests e.g. a sponge and the addressee accepts the proposed joint project by starting to pass the sponge, which at the same time fulfills the request. However, also in open surgery this does not always happen smoothly. First, trouble may occur with uptake of the joint project, when the addressee does not start to fulfill the request. Second, team members may recognize the request and display acceptance by starting to act but fail to fully understand what the surgeon meant when proposing a joint project.

In the following excerpt, the team is doing a cone biopsy, in which they are cutting a cone-shaped piece from the uterus. This is done with a loop-shaped electrode, which exists in different sizes and is selected during the surgery. In the following excerpt, the surgeon is requesting those loops to be fetched, so he and his intern can pick one.

Excerpt 11. 10-23-17_OR16_cam1_surg1O_00001_08:27-08:36.

```
->  01  SURGEON     we gotta go <pick our loop>
    02  SURGEON     ((to STUDENT)) (0.2) she had c i s spray
->  03  SURGEON     (.) so (.) let's go pick our loops
    04              (0.3)*(0.9)#(0.2)**(0.5)#
        surgeon          *looks left **looks right-->>
        im                      #im1          #im2
->  05  SURGEON     d'you %have the- *(0.4)#(0.3)%*
        circulator        %gets up from his stool%
        surgeon                      *   gesture    *
        im                                 #im3
```

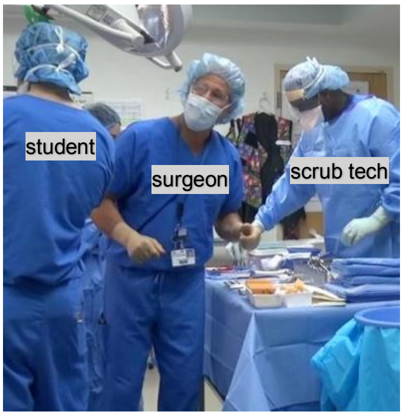

Image 1


Image 2

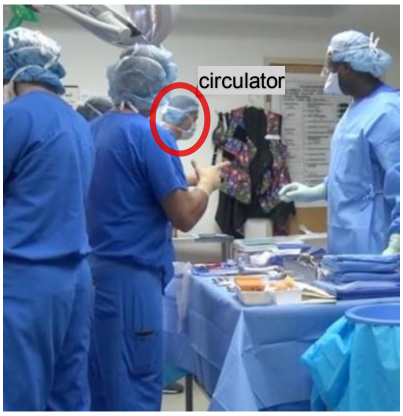

Image 3

In this excerpt[22], the surgeon indicates that it is time to pick the loops for the cone biopsy by saying "we gotta go pick our loop" (l. 01). He does so while looking at the patient, and it is not entirely clear whether he is saying this to the student, who is watching the procedure and located to the surgeon's left or whether this is addressed at the circulator, who will need prepare several loops for the surgeon to pick from. The surgeon continues providing medical information, indicating that the patient got a specific medication by saying "she had CIS spray" (l. 02). As his earlier request is not taken up, the surgeon repeats it in a slightly modified way, saying "so let's go pick our loops" (l. 03). However, the circulator, who should be fetching the loops remains seated at his desk. The surgeon turns around and starts looking around the room, to the right (Image 1) and to the left (Image 2), apparently searching for the circulator. When he has spotted the circulator at his desk, he is reissuing the request, saying "do you have the" (l. 05) accompanied by an iconic gesture (Image 3). Finally, the circulator gets up (l. 05; Image 3), which can be interpreted as a display of acceptance: he is considering the joint project and is willing to fetch the loops.

The surgeon utters his first request in a very implicit way, formulating it as "we gotta go pick our loop". Like in previous excerpts, the important words "pick" and "loop" are stressed, even though they are uttered with increased speed. It seems that the utterance serves two goals: it seems to be directed primarily towards the student, providing him with information about next steps in the procedure, but it also serves as a request addressed at the circulator. However, the circulator does not understand that he should become active. The circulator and scrub tech that the surgeon is working with in this scene are usually working in plastic surgery and struggle with their tasks throughout this procedure. With a practiced gynecologic team, the surgeon's implicit request "we gotta go pick our loop" might already be sufficient for the circulating nurse to anticipate the next action (Mondada, 2014b) and to understand that she needs to fetch the loops from the nonsterile area. During the subsequent turn, the surgeon seems to give the circulator time to react, but as the circulator remains idle, the surgeon reformulates the request to "let's go pick our loops". Again, the crucial parts are prosodically marked, as the surgeon stresses the words "go pick" and "loops". This formulation can be considered as positively polite, since the English phrase "let's" is an inclusive we form that stresses that both the requester and the requestee are involved in the activity (Brown & Levinson, 1987). However, this request format is still not clear enough for the circulator to understand, so the surgeon reformulates the request to "do you have", choosing a conventionally indirect format, which unmistakably indicates that it is a request (Brown & Levinson, 1987). Finally, the circulator gets up and moves towards the area where the supplies are stored, which displays acceptance and willingness to fulfill the request, and as the surgeon sees this, he stops reformulating the request.

Note that there is no talk from the circulator in this sequence. Even if the joint project is not immediately accepted and the surgeon needs to repair his utterance several times until the circulator displays that he understood it as a request, the embodied conduct of the circulator is enough to signal acceptance of the request. This is in stark contrast to the examples in robotic surgery, in which verbal confirmation is conditionally relevant to build common ground that the joint project is taken up. The circulator continues to struggle with fulfilling the request, but they ultimately succeed in their joint project, incrementally building a shared understanding of what the surgeon means and the circulator

[22] For more detailed transcription, see Transcript VIII.Let's go pick our loopsSo she can take the grasper *Let's go pick our loops* in the appendix.

understands and thereby increasing their common ground until it is sufficient to reach closure of the request.

As we will see in the following sequence, while the circulator has gotten up and has accepted the joint project, he does not seem to have understood exactly what he needs to do to fulfill the surgeon's request. Surgeon and circulator gradually reach mutual knowledge of what is needed in the following excerpt, which is continued from Excerpt 11 above. The surgeon requests a selection of loops, from which he can choose the ones he wants to use for this particular surgery.

Excerpt 12. 10-23-17_OR16_cam1_surg1O_00001_08:36-09:19.

```
      06                 (1.0)
      07   CIRCULATOR    °is it% in [there]°
           circulator          %walks to box-->
->    08   SURGEON                  [there] should %%be a selection
           circulator                             -->%%searches box-->
->    09   SURGEON       like (0.8) loops f'r that%
           circulator                            -->%
      10                 (0.4)
      11   CIRCULATOR    okay
      12                 (38.0)
                         ((CIRCULATOR leaves OR, SURGEON starts chatting with
                         INTERN until CIRCULATOR comes back))
```

The circulator is moving towards a box with supplies, saying "is it in there" (l. 07) in a low voice. He thereby displays that he does not seem to know where the requested loops are. The surgeon immediately reacts and clarifies the request once more, saying "there should be a selection, like loops for that" (l. 08-09). The circulator, who had been searching through the box stops his activity and says "okay" (l. 11) before leaving the operating room for a while (l. 12).

The circulator's conduct clearly displays that he has not entirely understood the request. He is looking for the loops in a random box, and even verbally displays his unsureness by uttering a syntactic question "is it in there", although he is the one who should know where the loops are. Based on the visual and verbal conduct the surgeon further details the request and explains that "there should be a selection, like, loops for that" (l. 08-09). The surgeon formulates the request as a general statement, describing what should be the case, which is also considered a form of negative politeness (Brown & Levinson, 1987). Apparently, this is enough for the circulator to understand where those loops may be located and he leaves the operating room to fetch them. Interestingly, he does produce an affirmative response here, saying okay before he leaves the surgeon and the rest of the team to wait. This seems more in line with Rauniomaa and Keisanen (2012), who suggest that participants in ordinary interaction produce affirmative response tokens when putting fulfillment of a request on hold because they first have to move to a different location.

When the circulator comes back with the box of loops, he has fulfilled the first part of the request, fetching the loops. However, he still needs to present the surgeon with a selection of loops from which the surgeon can choose. As the circulator apparently has no experience with how this should happen, the surgeon is guiding him through the fulfillment of the request by producing carefully timed explanations as he sees that the circulator is struggling to fulfill the request.

Excerpt 13. 10-23-17_OR16_cam1_surg1O_00001_09:19-09:37.

```
      13    CIRCULATOR  alright ((comes back, puts box down))
      14                (0.6)
->    15    SURGEON     let’s
      16                (0.4)
      17    CIRCULATOR  *which uh::
            surgeon     *walks to circulator-->


->    18    SURGEON     (.) let’s see, be[cause i  ha]ve a look at it (0.3)*
            surgeon                                                      -->*
      19    CIRCULATOR                   [it’s sayin']
->    20    SURGEON     (0.3) yeah
->    21    SURGEON     i’ve got them so i %could see
            circulator                     %selects three packages-->
      22    CIRCULATOR  (.) o:h
      23                (4.6)
      24    SURGEON     which are various individual choice%
            circulator                                  -->%
->    25    SURGEON     %(0.8) so let’s see
            circulator  %presents three packages-->
      26    SURGEON     the choi*ce is
            surgeon             *........-->
      27    SURGEON     (.) it’s that one an' that one*%
            surgeon     .........point.......point,,,*
            circulator                            -->%
```

In this excerpt, the circulator comes back and puts the box with the loops down, saying “alright” (l. 13) to indicate that he is ready for the next steps. He starts looking through the different packages in the box when the surgeon seems to be initiating another request, saying “let’s” (l. 15). The circulator utters “which uh” (l. 17), displaying that he does not know what he needs to do. The surgeon interrupts the circulator’s speech and now seems to produce the turn he was trying to produce earlier, saying “let’s see, because I have a look at it” (l. 18). During his turn, the surgeon is walking towards the circulator (l. 17-18), underlining his intent to look at the loops. However, the circulator still does not seem to understand, and utters “it’s sayin” (l. 19) in overlap with the surgeon’s turn. The circulator is thereby verbalizing his current activity: he is reading the labels of the packages in the box. By saying “yeah” (l. 20), the surgeon displays some sort of agreement and reformulates his request, saying “I’ve got them so I could see” (l. 21). While he is uttering this, the circulator starts selecting several packages (l. 21-24) and he responds “oh” (l. 22) after the end of the surgeon’s turn, which seems to signal that he has finally understood what the surgeon wants him to do. While the circulator is collecting three different packages in his hand, the surgeon adds “which are various individual choice” (l. 24). When the circulator has finished picking loops from the box, he holds the packages out for the surgeon to look at (l. 25), thereby finally fulfilling the surgeon’s request. Interestingly, the surgeon now repeats the earlier request to see the loops and utters “so let’s see” (l. 25) and continues to announce his selection by saying “the choice is” (l. 26) and then “it’s that one and that one” (l. 27), pointing at the respective package every time he utters “that”.

The surgeon starts to produce a new request, saying “let’s”, but does not finish his turn. In the evolving silence, the circulator takes the turn and indicates that he does not know what to do by saying “which, uh”, stretching the “uh” for almost a second. As the circulator displays that he still does not know how to fulfill the surgeon's request, the surgeon produces his full request, starting with "let's see" (l. 18) Using the phrase "let's", the surgeon again chooses an inclusive we, which is considered positively polite (Brown & Levinson, 1987). However, he immediately continues to explain that he really means "I" instead of "we", saying "because I have a look at it" (l. 18). While starting the request in a positively polite form presenting the circulator and himself as cooperators, the surgeon clarifies that he is the sole beneficiary as he continues his turn. The circulator does not display that he understood that the surgeon has to look at the loops himself but starts reading the labels on the packages and indicates this by uttering "it's saying", seeming to attempt to somehow fulfill the surgeon's request. The surgeon who has now moved to the circulator and box of loops seems to indicate through his affirmative statement that the current action of the circulator is not entirely wrong and continues to produce another explanation of his request, saying "I've got them so I could see", stressing again that he himself wants to look at them. This is when the circulator understands the request, as he displays through is utterance "oh". While the circulator assembles a selection of loops in his hand, the surgeon provides another explanation of why he needs to see the different packages (l. 24), possibly also for the student and intern who are with him. When the circulator has finished selecting different loops and holds them out for the surgeon, the surgeon reutters his initial request "let's see", as if now taking a fresh, more successful attempt at reaching closure of his request. Formulating his request for the selected loops as a general statement saying "the choice is that on and that one", the surgeon employs a negative politeness strategy (Brown & Levison, 1987) again.

The circulator is inexperienced in this particular type of surgery and does not immediately understand the surgeon's request. Nevertheless, they manage to reach closure of the joint project that the surgeon initially proposed: he requested a selection of loops that he could pick from and the circulator ultimately presents this selection. Surgeon and circulator build common ground incrementally, aligning what the surgeon means and what the circulator understands in a step by step process. The circulator takes up the joint project after a few additional turns, when the surgeon clearly addresses him by using the pronoun "you". After understanding that he should fetch a box with different loops, the circulator leaves to fetch the loops but it turns out that he has still not understood that he should produce a selection of different packages, which the surgeon wants to look at and subsequently pick from. Therefore, complete fulfillment and thus closure of the request requires more actions from the surgeon, and the surgeon reformulates and clarifies his request multiple times before it is finally understood by the circulator, as is indicated by his utterance "oh". Only after this understanding is reached, the circulator is able to fulfill the request, which he does by presenting the surgeon with a selection of three different packed loops. As we have seen, surgeon and circulator sequentially reach closure of the joint project. Their actions display understanding of the previous actions and project subsequent actions, e.g. when the displayed understanding is not in line with what the speaker meant, the speaker reformulates the initial turn. While this exchange takes more than one minute (which is a considerable amount of time considering that a cone biopsy typically does not take more than 30 minutes in total), the inexperienced circulator still succeeds at fulfilling the request. They succeed because they incrementally build common ground, the surgeon adjusts to the understanding that the circulator displays, and reformulates the request when seeing that the circulator is still not holding the packages out as needed. The surgeon thus guides the circulator through this unfamiliar task. As we will see in chapter 4.5., this is very different in robotic surgery.

In teams that have become well attuned by working together more regularly, incremental guidance can be achieved largely nonverbally. In the following excerpt, the surgeon is asking his intern to wash the tip of the Cusa, a machine which is used to ablate tissue during a partial vulvectomy. The intern should wash the Cusa in saline, a solution of sodium chloride (table salt) in water.

Excerpt 14. 10-30-17_cam1_surg1O_00001_08:47-09:00.

```
->  01  INTERN         ((stops ablating tissue with Cusa,
                       distinctive ablating sound stops))
    02  SURGEON        (0.2) *°you can wash°
        surgeon-gaze         *look@intern-->
    03                 (.)§(0.3)#*(0.2)
        intern            §turn2cusa-->
        surgeon                  *point@scrubtable-->
        im                      #im1
    04  SURGEON        s#aline §§(.) * (.)§
        intern            -->§§look@cusa§
        surgeon                -->*
        im              #im2
    05                 §(0.2)#(0.2)*+(0.2)#(0.2)§
        intern         §      look@surgeon      §
        surgeon                  *point@scrubtable-->
        scrubtech                 +head2surgeon-->
        im                   #im3         #im4
    06  SURGEON        #§>tha%t #way<#**
        intern          §turn2scrubtable-->
        scrubtech2           %point@scrubtable-->
        surgeon-gaze               -->**look@patient
        im             #im5      #im6  #im7
    07                 (0.5)++§§* (0.3) ++(0.7)%(0.5)+
        intern             -->§§walk2scrubtable
        surgeon              -->*
        scrubtech        -->++turn2table++move2table+
                                      -->%
    08  SCRUB TECH     +(0.2) he§re+ >i saw it<=
        scrubtech       +rHreachtable+
        intern               -->§
->  09  INTERN         %§=oh there#
        scrubtech2     %point@scrubtable-->
        intern          §rH2scrubtable-->
        im                       #im8
    10                 *(0.2)§(0.3)+(0.2)%
        intern           -->§
        surgeon        *turn2scrubtable-->
        scrubtech                  +bowl2intern-->
        scrubtech2                    -->%
    11  SURGEON        (clean it) in saline
->  12                 (0.3)§(0.4)*++(0.3)§§(0.6)+(2.0)§
        intern              §bendovertable§§clean cusa §
        surgeon               -->*
        scrubtech               -->++release bowl +
```

Image 1

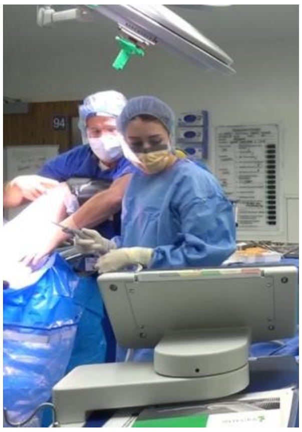
Image 2

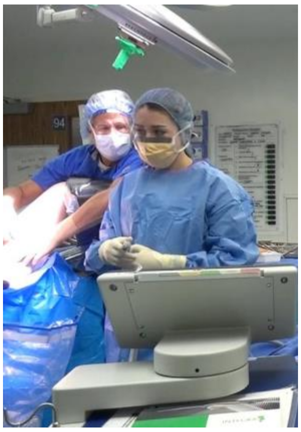
Image 3

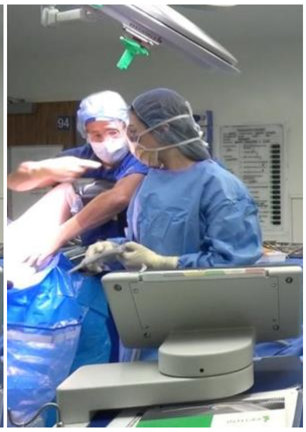
Image 4


Image 5


Image 6

Image 7


Image 8

In this excerpt, the surgeon tells the intern “you can wash” (l. 02), requesting her to wash the tip of the Cusa. She immediately takes up the request and starts moving, turning towards the Cusa machine (l. 03, Image 1). The surgeon, who is following her with his gaze, reacts to this by pointing at the scrub table, displaying that she should turn there (l. 03, Image 2) and uttering the word “saline” (l. 04), possibly to help her to remember what to do. As a first-year surgeon-in-training, the intern is still learning the procedure and while enthusiastic to accept the surgeon’s request as displayed in her body movement, she does not seem to fully understand the request. The intern looks at the machine, but as she cannot find what she should do, she starts turning back towards the surgeon (l. 05, Image 3). When she is gazing at the surgeon, he repeats his pointing gesture, this time more intensely than earlier (l. 05-06, Images 4-7). The surgeon moves his hand back and forth while pointing at the scrub table, uttering “that way” (l. 06) while he is pointing. The intern follows his hand with her gaze and turns towards the scrub table. In the meantime, the scrub tech, who is also still learning and who is taught by scrub tech 2, also displays that she does not seem to understand her involvement in the activity. She started looking at the surgeon when he was pointing at her scrub table. Her teacher, scrub tech 2, also starts pointing at the scrub table when the surgeon utters “that way” and she continues to point when the surgeon withdraws his hand and turns his gaze back to the patient (l. 06-07, Image 7-8). The intern starts walking to the scrub table, and the scrub tech follows her. While they both gaze at the scrub table, the scrub tech utters “here, I saw it” (l. 08). She starts reaching out towards a bowl on the table. As she is moving her hand forwards, scrub tech 2 starts pointing again, probably towards the correct bowl, and the intern displays that she understood by uttering “oh there” (l. 09) and also moving her right hand towards the scrub table. After a while, the surgeon turns from the patient towards the scrub table. While the scrub tech is passing the bowl with saline towards the intern, the surgeon reinforces and clearly utters his request by saying “clean it in saline” (l. 11). The intern, who now seems to have fully understood the request, leans forward and cleans the tip of the Cusa in the bowl (l. 12).

The excerpt shows how surgeon and intern build common ground on what action should be done next and what the surgeon means by his initial request “you can wash”. The request is formulated as an assertive but also involves the words “you” and “can” as in the indirect requests in earlier examples. In contrast to excerpt 11, the intern does not struggle with recognizing the surgeon’s utterance as a proposal for a joint project. In fact, she immediately displays acceptance by starting to move. However, she has not fully understood the request and first turns towards the Cusa machine instead of the scrub table. The surgeon tries to help her by naming the liquid that she should wash the instrument in (“saline”), thereby hinting that she should turn towards the scrub tech and scrub table, as this is where saline is usually to be found. She does not seem to understand what the surgeon is referring to and turns back to him for help. When she is gazing at the surgeon, he starts pointing back and forth towards the scrub table, underlining his deictic gesture with the words “that way”. The intern gradually turns into the direction indicated by the surgeon. The surgeon is thereby reorienting the intern’s body through his deictic gesture. At this point, the scrub nurses join the project as well: As the intern is turning towards the scrub table, the experienced second scrub tech starts pointing towards the bowl with saline on the scrub table, thereby directing intern and her apprentice scrub tech towards the right location. The scrub techs become involved in the sensemaking process that is needed to reach fulfillment of the request, as the scrub tech should prepare the bowl with saline on the scrub table. She spots the bowl first and displays that she did so by saying “here I saw it”. She moves her hand towards it, and finally the intern also spots the bowl, which she indicates by saying “oh there”. The surgeon joins the team by the scrub table and similarly as in Excerpt 13, he repeats his request once more before it is finally completed, this time in a slightly modified form, saying “clean it in saline”.

As we have seen, participants finely coordinate, using gaze, gesture and their bodies when negotiating fulfillment of a request in open surgery. They incrementally build a shared understanding, displaying their understanding and adding explanations as lack of understanding becomes evident. In experienced teams, this sensemaking process happens in an incremental and largely embodied way, in which verbal utterances are mainly produced to underline the bodily conduct. Team members rely on deictic gestures to highlight particular aspects of the material environment and thereby direct the others’ attention. The struggle does not interrupt the interaction and trouble is not explicitly verbalized. Rather, the team works smoothly, gradually incrementing common ground until the joint understanding is sufficient for fulfillment of the request. As we will see in the following chapter, this is in stark contrast to robotic surgery.

5.5 Negotiating Fulfillment of Requests in Robotic Surgery

In the following excerpt, the surgeon is requesting a particular cauterizing instrument that should be attached to the robot arms, a Maryland Bipolar Forceps, which they commonly refer to as “Maryland”. While the scrub tech initially accepts his request, it later turns out that there is no such forceps in this particular operating room and they need to mobilize additional resources in order to get hold of a Maryland.

Excerpt 15. 10-02-17_cam1_surg3R_00008_13:46-15:09.

```
      01   SURGEON      can i get a: (.) maryland (.) [instead]
->    02   SCRUB TECH                                 [marylands]? (.) okay
      03   CIRCULATOR   what’s that?
      04                (3.8) ((SCRUB TECH looks for Maryland in her tray))
      05                (42.3)  ((no  Maryland  available,  SCRUB  TECH,
                        CIRCULATOR and RNFA discussing what to do))
->    06   SURGEON      you got paralys
->    07   SURGEON      or what’s goin' on [there]?
      08   RNFA                            [ no  ]
      09   RNFA         so we [ gonna bring you a bipolar]
      10   SCRUB TECH         [we gonna get you a bipolar]
      11   SCRUB TECH   an' then we gotta go run
      12   SCRUB TECH   an' get a maryland [from upstairs]
      13   RNFA                            [(            )]
      14   RNFA         °we don’t have them°
      15   SURGEON      they don’t have 'em?
      16                (0.4)
      17   RNFA         we have them, not down here
      18                (23.9) ((nurses continue to discuss,
                         SCRUB TECH gets bipolar ready))
```

In this excerpt[23], the surgeon is asking for a Maryland Bipolar Forceps, saying “can I get a Maryland instead” (l. 01). As in previous examples, the surgeon phrases the request as a syntactical question. The surgeon marks the name of the requested tool by inserting brief pauses before and after the word “Maryland”. The scrub tech immediately accepts the surgeon’s request, confirming her understanding of the instrument name by repeating “Maryland’s?” and accepting the request with the affirmative

[23] For more detailed transcription, see Transcript IX. *Can I get a Maryland instead* in the appendix.

response token “okay” (l. 02). The scrub tech starts searching for a Maryland bipolar forceps in the robot tool tray on her scrub table, which has been prepared by another scrub tech, as she was taking her break earlier. Since she cannot find a Maryland on the scrub table, the scrub tech turns towards circulator to ask her to fetch one from the supplies cupboard. However, it turns out that there is no such forceps in the room[24] and the nurses are discussing what to do and scrub tech and first assistant are explaining to the unexperienced circulator that she needs to make several calls to have all dirty Maryland bipolar forceps cleaned by the sterile processing department immediately. Their discussion is going on for a while, and more than 45 seconds have passed since the surgeon has uttered his request. Normally, grabbing a forceps from the scrub table and passing it along would be completed in this time frame. The surgeon interrupts the nurses’ discussion by asking “you got paralys [sic], or what’s going on there?” (l. 06-07). The first assistant, who is representor (and head) of the patient-side team responds immediately, producing her “no” (l. 08) in overlap with the end of the surgeons’ turn. She proceeds by saying “so we gonna bring you a bipolar” (l. 09), which is echoed by the scrub tech, who produces a similar statement in overlap with the first assistant, saying “we gonna get you a bipolar” (l. 10). The team uses “bipolar” to refer to another type of bipolar forceps, which they use per default. Interestingly, both RNFA and scrub tech do not explicitly state that they do not have a Maryland in the room, but they immediately indicate how they will fix it. The scrub tech continues to provide information on the subsequent steps, saying “and then we gotta go run” (l. 11) “and get a Maryland from upstairs” (l. 12). The first assistant finally utters “we don’t have them” (l. 14) in a low voice. This is when the surgeon reacts, asking “they don’t have them?” (l. 15), sounding slightly alarmed. The first assistant is calming him down, saying “we have them” and clarifying again “not down here” (l. 17). The nurses continue discussion and it later turns out that surgeon and team are still not on the same page about the instrument (the surgeon refuses the bipolar and indicates that he wants to wait for the Maryland, see Transcript IIX in the appendix).

After the scrub tech accepted his request, the surgeon continues cauterizing, with his head in the console and thereby visually dislocated from the surroundings of the operating room. He is largely unaware of what is happening behind his back: that the scrub tech does not find a Maryland on her scrub table, her turn towards circulator and the nurses’ discussion. The surgeon has not heard back from the team for more than 45 seconds, a time frame which is longer than this should usually take. The fulfillment of the request, which has previously been accepted is thus missing, causing the surgeon to react quite dramatically. He does not only explicitly ask for clarification (“what’s going on there?”, l. 07) but also alleges the nurses of being slow, asking whether they have paralysis (l. 06). This is in drastic contrast to the struggles with fulfillment in open surgery, where the surgeon incrementally provides help to reach successful fulfillment of the request and the flow of the interaction is not interrupted.

While surgeon and scrub tech reached joint closure on the uptake of the request, their knowledge of what is happening is drifting apart as the situation unfolds. While the surgeon continues to believe

[24] Some nurses are purely tasked with “giving breaks”, replacing their colleagues for the time of their breaks. In the interviews we conducted as part of the project, one of the nurses who was giving breaks indicated that this is a difficult job, as they quickly have to switch between specialties and do not get the chance to develop specialized skills of the same depth as nurses who are assisting the same surgeries every day. While experienced scrub techs and circulators routinely check the supplies in the cupboard, the inexperienced circulator and scrub tech who was only replacing the other for a limited time frame did not do this.

that the request is taken up and the requested tool will soon be available, the scrub tech adds several pieces of information to her knowledge base: First, she learns that the Maryland is not on her table. Second, she finds out that there is no Maryland in the room. Third, she comes up with a solution (using the regular bipolar instead). This information is all not part of the common ground between surgeon and team, so there is a gap in what the surgeon believes and what the nurses believe (it is unclear to what degree the anesthetist and the intern, who are further away from nurses are aware of the struggles). Differing understandings of the current situation may not be problematic if common ground between patient-side team and console-side surgeon is still sufficient for their current purposes. However, the different understandings may become a problem when the gap becomes too large. The gap then ultimately becomes evident when the surgeon asks "what's going on there?". In robotic surgery, such gaps in common ground can only be addressed by making it explicit and verbally explaining what is happening (see continued excerpt in the appendix for an illustration of how the team continues to struggle to build a shared understanding of what is going on).

The following excerpt shows that gaps in common ground do not only occur in requests for instruments. Shortly after the robot has been docked and the surgery has started, the surgeon asks his resident to move from patient-side to the robot consoles. While the resident was helping to dock the robot and explaining it to a student, the surgeon started to orient himself inside the patient's abdomen and made a few preparatory cuts. As he is ready to start the surgery now, the surgeon asks his resident to sit down next to him at the robot consoles.

Excerpt 16. 10-16-17_cam1_surg3R_00007_12:55-13:48, 10-16-17_cam2_00063_14:18-15:11, 10-16-17_GOPR_3-04_07:41-08:34.

```
      01                 *(2.0)      *
         surgeon         *cauterizing*
      02                 (0.4)
->    03 SURGEON         (    ) >do you wanna< sit down?
      04 SURGEON         (0.2) 'cause you can sit down
      05 RESIDENT        (0.2) he ha
      06                 (1.2)
      07 RESIDENT        acshilly (more ifs/morris)
->    08 RESIDENT        (0.2) yes, i do wanna sit d*own
         surgeon                                    *cauterizing-->
      09 RESIDENT        (              good on this)
      10 RESIDENT        (0.6) (        need to help with)*
         surgeon                                      -->*
      11 RESIDENT        (0.6) if you're okay- if you're okay with that
      12                 (2.0)
      13 SURGEON         that's alright
      14 RESIDENT        (0.4) thank ya
      15                 (22.0)§(8.2)
         resident              §takes off sterile gown and gloves-->
->    16 SURGEON         where are you?
      17                 (1.6)§§(0.6)
         resident           -->§§ moving to consoles -->>
->    18 RNFA            she's comin'
      19 RNFA            >she's< waitin' for you
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In this excerpt, the surgeon asks his resident to sit down, saying "do you wanna sit down?" (l. 03). The resident is not responding immediately, and the surgeon adds "cause you can sit down" (l. 05). The resident laughs (l. 07) and starts producing what looks like a dispreferred response, starting with "actually" (l. 09). She subsequently accepts the requests, and confirms that she will sit down, saying "yes, I do wanna sit down" (l. 08). However, there seems to be something that she first needs to discuss with the surgeon. Unfortunately, her talk is not clearly understandable because the surgeon is cauterizing at the same time (l. 08-10). She might be asking something about involving the student who is standing next to her at the patient-side. The resident closes her turn with asking the surgeon's permission, saying "if you're okay with that" (l. 11). After some silence (l. 12), the surgeon confirms "that's alright" (l. 13) and the resident thanks him, saying "thank you" (l. 14). The resident slowly moves away from the patient, moving past the scrub tech and her scrub table and around the robot. She has arrived at the trash bags and starts to rip off her sterile gown and gloves (l. 15), looking at the surgeon's actions on the screen above her, when the surgeon asks "where are you?" (l. 16). Interestingly, the resident does not respond, but finishes taking off her gown and starts moving over to the robot consoles (l. 17). The first assistant responds to the surgeon's question after more than 2 seconds of silence in which the resident does not take the turn (l. 17), saying "she's coming" (l. 18) and producing something like an excuse for the resident, saying "she's waiting for you" (l. 19).

The surgeon is asking the resident to sit down at the robot consoles with him. As in previous excerpts, the surgeon formulates his request in an interrogative form. Note that like in Excerpt 7, the surgeon formulates the request as "do you wanna X?", making it sound more like an offer than a request. The resident accepts the request, indicating that something needs to be negotiated first and does so after displaying her acceptance ("yes, I do wanna sit down"). The negotiation-sequence that is inserted in between acceptance and fulfillment of the request is closed when the surgeon confirms that it is okay and the resident thanks him (l. 13-14). Thus, the surgeon has good reasons to assume that the resident is on her way and his request will be fulfilled soon. However, after more than 30 seconds, the resident has not arrived at the consoles yet and the surgeon asks where she is. Interestingly, the resident has started with (preparations for) fulfillment of the request, as she is taking off her sterile gown and gloves, a clear sign that she will move to the nonsterile area in which the robot consoles are located. In open or laparoscopic surgery, the surgeon could see that she is undressing, and an explicit verbal investigation would not be necessary, a brief glance at her would be enough. However, in this robotic case the surgeon remains seated with his forehead leaned into the robot consoles and his eyes on the endoscopic camera image that he sees through the consoles. The fact that the resident is almost ready is invisible for him, and he apparently feels the need to make sure she is on her way. It is unclear why the resident is not answering this question, which is clearly directed at her. One reason might be that she is positioned at a point of the room where the microphone system will not pick up her voice very well and the surgeon may not hear her response anyways. Another possibility is that she does not see the need to, since she will soon be passing behind the surgeon and sitting down at her console. The first assistant, who is representing the patient-side team and who is closer to the microphone system, ultimately responds to the surgeon's question, indicating that she is on her way.

As in the excerpt before, we see that the surgeon is struggling with common ground. His request has been accepted, but he has no evidence of the actual fulfillment. The resident herself (and the rest of the patient-side team) share the knowledge that she moved away from the robot to the trash bins, and started taking off her sterile gown. The surgeon in contrast does not have this information, he has no proof that his request is actually being fulfilled. As in Excerpt 15, there is a gap in common ground between surgeon and team, which can only be addressed by verbalizing it and subsequently verbally updating the surgeon's knowledge so that common ground is sufficient for the team's current purposes again.

5.6 SUMMARY

I have analyzed surgeon-initiated requests and their acceptance and fulfillment in open and robotic surgery. In both open and robotic surgery, requests are majorly formulated in an interrogative form, using modal verbs such as “can” and “would” or the verb “do” in combination with the verbs “have” (for objects) and “want” (for actions). Interestingly, the surgeon switches between “can you/would you”, “do you have/do you wanna X” and “can I get X”, thereby stressing either the ability or willingness of the addressee (“you”) or the surgeon who wants something (“I”). A smaller number of requests is formulated as assertions, taking the form “you/she can X”. In excerpts 11 and 13, the surgeon puts stronger focus on the team as collaborators through an inclusive we, uttering requests of the form “we gotta X” and “let’s X”. Finally, there is a small number of imperatives, such as “get X” or simply “X”, where X is a verb in imperative form. Those seem to be preferred in contexts in which addressees (can be expected to) anticipate the request and the joint project has already been established. The described formats are used for both open and robotic surgery, and there is no major difference between requests for objects or services. Interestingly, the surgeon emphasizes the relevant parts of a request by stressing them or uttering them with increased loudness, while often producing the polite parts at the beginning of the request with increased speed or decreased volume. Thereby, the polite phrases are more difficult to hear, contrasting with the emphasized bits of the request that are usually similar to the format of a bald request.

As I have shown, in open surgery requests are accepted and fulfilled in one go, usually in an embodied way. The surgeon orients to the understanding that the addressee(s) display and reformulates the request until it is understood sufficiently well to be fulfilled successfully. Thereby, even inexperienced teams are able to arrive at closure of requests initiated by the surgeon without break downs in the interaction. In robotic surgery, I have demonstrated that acceptance and fulfillment happen in two separate turns. Verbal acceptance of surgeon-initiated requests is conditionally relevant, as it serves as evidence that the joint project is taken up for both surgeon and team. As I have shown, the surgeon reformulates the requests until a verbal response is produced, taking efforts to have the other join the proposed joint project. The surgeon does so by stressing his or her role as beneficiary of the action, thereby reinforcing his or her institutional right to utter requests and have them fulfilled. Participants display acceptance of a request through affirmative response tokens such as “yeah/yes”, “okay”, “sure” and “alright”. Further, in robotic surgery the surgeon has no evidence that fulfillment is in progress until it is completed, and delays in the production of an already accepted requested action result in interactional trouble. I have illustrated how increments in information in the patient-side team that are not shared with the surgeon result in gaps in common ground, which ultimately lead to break-down of the interaction, as becomes evident in the surgeon’s investigative questions (“what’s going on there?” and “where are you?”). These gaps in common ground can only be overcome by verbal explanations, and teams often continue to struggle for a few moments after such break downs of the interaction. Practices for building common ground in robotic versus open surgery thus differ considerably. Teams incrementally build common ground in open surgery, largely relying on embodied action. In robotic surgery in contrast, everything has to be verbalized and failure to do so results in gaps in common ground that disrupt the flow of the surgery. I will discuss these results in the light of existing literature in the following chapter.

6 Discussion

In this chapter, I discuss my findings in the light of literature on requests in surgery and previous work on common ground in surgery. Further, I highlight implications of this work and subsequently present limitations and future work before closing the chapter with a summary.

6.1 Requests in Surgery

We have seen that the surgeon majorly formulates requests in an interrogative form, which is considered negatively polite (Brown & Levinson, 1987). Interestingly, this is different from surgeon-initiated requests that have been described in the literature. Bezemer and colleagues (2011) provide examples of surgeons in a British hospital formulating their requests as “X, please”, a format which I have rarely seen in my data. Mondada (2014b) found that surgeons uttering requests in French and English in a hospital in France design their requests as short imperatives or in the form of free-standing nouns (names of the requested objects, e.g. “scissors”). In the data analyzed here, requests that are proposing a new joint project are usually formulated with redressive action, mainly employing negative politeness strategies (Brown & Levinson, 1987) such as formulating the request as questions. A possible reason for this difference between my data from a US hospital and the studies from France and Great Britain may lie in culture. A detailed analysis of the impact of cultural differences on the format of requests exceeds the scope of this thesis, but I would like to point to the importance of individual freedom in US culture (Hofstede, 1983), which may account for a preference to utter requests as questions, as it formally leaves the other the freedom to decline the request (Rossi, 2012). In France in contrast, power distance is more pronounced (Hofstede, 1980, 1983). The surgeon, who is on top of the hierarchy, may thus be even more entitled to direct the team’ actions than in other countries. In French culture, commanding subordinates through imperatives may not be regarded as a threat to individual freedom, but rather display trust in the other to fulfill their part (Rossi, 2012) in working towards the collective goal. Great Britain is comparable to the US in its individualism and low power distance (Hofstede, 1980, 1983). It thus remains unclear why British surgeons employ different request strategies than in the US adding “please” to their bald requests rather than formulating them as questions.

The data studied in this thesis does contain a few requests that are formulated as imperatives (e.g. “suck that out” in Excerpt 6 or “get a scissor” in Excerpt 3), but these majorly seem to occur when the joint project has already been established. Transcripts V, VI and VII in the appendix provide examples of request sequences in which the surgeon details an already accepted request with imperatives. Interestingly, this is in line with Rossi’s (2012) observations for ordinary conversation in Italian that requests are uttered as imperatives when occurring as part of an already established joint project, while they are formulated as questions when the joint project still has to be accepted. Taking this into account, one could also argue that US surgeons propose a new joint project with every new request sequence they initiate and therefore formulate requests as questions. In contrast, French and British surgeons might regard the entire surgery as an established joint project to which all team members are committed, therefore not considering single request as new projects that need separate confirmation.

As I have shown in the transcripts, the surgeon underlines the relevant bits of the requests through increased loudness or by stressing particular words, and/or by uttering polite additions with reduced loudness or increased tempo. Thereby, the parts that are clearly hearable in fact closely resemble the requests described by Mondada (2014b). Depending on the background noise in the room and the distance between surgeon and addressee, what the surgeon says and participants hear may differ: the surgeon formulates the requests with redressive action (Brown & Levinson, 1987), but it might well be that addressees sometimes hear them as bald requests (ibid.) much like the ones that Mondada (2014b) describes. Interestingly, the format of the requests in both open and robotic surgery most closely resembles some of the examples provided by Randell and colleagues' (2017) for robotic surgery, taking the format "can you X" and "can I X". Randell and colleagues (2017) argue that in robotic surgery, surgeons produce preparatory utterances such as "okay and then" preceding the actual request to secure the addressee's attention. As I have shown, the surgeon in this data stresses the actual (bald) request but produces the preceding polite parts with increased speed or reduced loudness, possibly marking them as less important to be heard correctly. This could be a means to secure the team's attention for the important information that will follow. The actual request is then produced with increased loudness or emphasis, carefully designed to be heard correctly. The seemingly less relevant polite parts may actually be crucial, as they prepare the team for important information to come by drawing their attention to the surgeon's speech. While Randell and colleagues (2017) describe explicit preparation of a request as distinctive for robotic surgery, I have shown that the surgeon prepares requests with polite statements in both robotic and open surgery (see Excerpts 1 and 2). It needs to be investigated further why this is the case. On the one hand, it could be a general practice that has proved helpful in surgery and is now also (possibly more extensively) applied to robotic surgery. On the other hand, it could be a strategy that the surgeon has developed for successful requests in robotic surgery and is now also applying in open surgery. This would be interesting, as it would be an example of a practice that has evolved in computer-mediated interaction that is now applied to face-to-face interaction.

Both Mondada (2014a, 2014b) and Bezemer and colleagues (2011) describe surgeon-initiated requests that are uttered in a multimodal format, with gesture playing an important role. This is largely in line with my findings for open surgery, where the surgeon uses iconic gestures (McNeill, 2005) to replace words (see Excerpt 11) and gaze is employed to negotiate timing of a requested action (see Excerpt 3). In robotic surgery, the repertoire of embodied actions is dramatically reduced, as the surgeons are seated with their head in the console and their hands clinging to the joysticks that are steering the robot arms. Embodied actions thus seem less relevant for initiating requests in robotic surgery. However, while I did not focus on this in this work, I noticed that surgeons use the robotic instruments to point inside the body, a practice which has also been described for laparoscopic surgery (Koschmann et al., 2011; Mondada, 2014b). Surgeons sometimes use these instruments for deictic gestures when providing further instructions on an already accepted request, for instance when pointing to a location where suction needs to be done. I have not analyzed this in the excerpts presented here, but it could be interesting to investigate further how surgeons rely on the robotic instruments to embody their nonverbal actions, making use of the material environment inside the patient's abdomen to challenge limits in nonverbal action during robotic surgery.

Randell and colleagues (2017) suggest that requests in robotic surgery are formulated in several installments and request sequences are therefore generally longer than in other types of surgery (Randell et al., 2017). My findings also suggest that closure of requests in robotic surgery often takes considerably longer than in open surgery. Especially requests that involve change of instruments are typically produced in installments and take several seconds or even minutes to fulfill, as tools need to maneuvered towards a particular location in the abdomen. In Excerpt 6 for instance, the surgeon guides the resident through the body to different locations where she should do suction, extending the request as its fulfillment is already in progress. Transcripts VI and VII in the appendix nicely illustrate how the surgeon first asks the patient-side team to get a grasper and only details the request once they have inserted the grasper into the body (instead of immediately asking them to hold a particular piece of tissue). In this thesis, I have focused on the turns in which the surgeon initiates a request. While there is a difference in how team members signal acceptance (nonverbal in open vs. verbal in robotic surgery), the surgeon's initiating turns are equally long in open and robotic surgery, even taking a very similar linguistic shape. Uttering a request and starting a joint project in robotic surgery thus does not take longer than in open surgery, but the proposed joint project itself often involves more steps and therefore takes more time in robotic surgery.

As we have seen, the surgeon starts to repair the request when the addressee fails to display uptake of the request in some way. This is in line with the literature (Mondada, 2014b). However, there are differences between my findings and the literature concerning the form that this repair takes. Mondada (2014b) describes that surgeons repeat the request in an intensified way, for example by repeating the initial request with increased loudness or tempo (assuming trouble in hearing, which could correspond to level 1 or 2 of Clark's (1996) action ladder). Mondada (2014b) also describes switches from English, which is understood by the remote audience to French, the native language of the surgical team when a request is not immediately taken up (assuming trouble in understanding, level 3 of Clark's (1996) action ladder). In my data from a US hospital, I found differences between robotic and open surgery in how surgeons repair their request when it is not immediately taken up. In open surgery, the surgeon moves from ambiguous formulations to formulations which are unmistakably requests. In robotic surgery, the surgeon provides explanations in which subsequent actions are detailed, thereby justifying the request as relevant. Further, the surgeon is appealing to the addressee for help, and explicitly presenting himself as the beneficiary (Couper-Kuhlen, 2014; Clayman & Heritage, 2014), thereby ensuring that the addressee understands it as a request. Bezemer and colleagues (2011) find that surgeons provide more specific references when the request is not taken up. While I did not find examples of the type that Bezemer and colleagues present, it does not contradict my findings for open surgery. I also found that the surgeon gradually provides more details about a requested object (see Excerpts 11 and 12) and the requested action (Excerpts 13 and 14). The surgeon thus assumes trouble in understanding, and provides alternative references (Bezemer et al., 2011) or more details on how the requested action should be carried out to make sure the addressee understands what the surgeons means (my data). In robotic surgery in contrast, the surgeon does not seem to assume trouble in understanding. For instance, the surgeon does not produce details about e.g. a requested grasper but rather works on convincing the team members to accept the request (see Excerpts 7-9), thus assuming trouble with acceptance of the joint project (level 4 of Clark's (1996) action ladder). If participants still do not provide a display of taking up the request, the surgeon assumes trouble on level 1 of Clark's (1996) action ladder, as becomes evident in Excerpt 10. The reason for this may be that in robotic surgery, team members are usually very experienced and well-coordinated. Inexperienced staff seldomly joins the team unsupervised and scrub techs and circulators that are trained for robotic surgery are always accompanied by a more experienced teacher from their profession, who makes sure that references to instruments are understood and learned. It could be for this reason that in robotic surgery, the surgeon does not repair requests with respect to trouble in understanding (level 3 of Clark's (1996) action ladder) but assumes difficulties on level 4 of the action ladder: acceptance of the joint project. If this fails, the surgeon immediately assumes trouble on level 1 of the action ladder: the addressee must not have heard that the surgeon was uttering something, otherwise they would react. This is different from the repair strategies described in the literature for open and laparoscopic surgery (Bezemer et al., 2011; Mondada, 2014b).

In line with the literature, fulfillment in both open and robotic surgery is usually produced immediately (Bezemer et al., 2011; Heath et al., 2018; Mondada 2014a, 2014b; Sanchez Svensson et al., 2007). While the previous work stresses that fulfillment of requests in surgery is usually done in a nonverbal and embodied way (Bezemer et al., 2011; Heath et al., 2018; Mondada 2014a, 2014b; Sanchez Svensson et al., 2007), this only holds for my findings in open surgery. As I have demonstrated, in robotic surgery participants first produce an affirmative response token to display acceptance before continuing with embodied fulfillment of the requested action. This is in line with Randell and colleagues' (2017) finding that an explicit oral response needs to be produced when the surgeon cannot see the team's actions on screen. My analysis sheds more light on the kind of verbal responses that are produced, namely affirmative response tokens such as "yes", "yeah", "okay", "sure" and "alright". While Randell and colleagues (2017) suggest that explicit responses are only produced or required when participants perform actions off-screen that are not captured by the endoscopic camera, I found that participants seem to produce their affirmative responses independent of visibility of their actions on screen. In Excerpt 4 for example, the pushing action becomes visible on the screen almost immediately after the request has been uttered, but the first assistant is still confirming her acceptance of the request through an affirmative response token. An explanation may lie in the observation that it is not only the surgeon who is limited in monitoring the team's actions in robotic surgery, but also the patient-side team is often unaware of what the surgeon is doing (Pelikan et al., in press). Particularly, team members cannot see where the surgeon is gazing when he or she is immersed into the robot console. Therefore, team members that are nonverbally fulfilling a request in robotic surgery have no evidence on whether the surgeon is aware of their actions, and cannot be sure whether they share common ground on the uptake of the joint project. As team members can assume that the surgeon hears them through the microphone system, producing a verbal acceptance statement may be a means to build reflexive understanding on that a request is accepted. Surgeon and addressee of the request only share common ground on the uptake of the request if the surgeon knows that the patient-side team member is taking up the request and if the team member knows that the surgeon has this information. By producing an affirmative verbal response, team members thus may not only communicate their acceptance to the surgeon but also ensure that *they know* the surgeons knows they accept the joint project.

As I have demonstrated, the team treats explicit verbal confirmation of requests as conditionally relevant, and not producing it causes interactional trouble. This is different when participants have already committed to a joint project and are jointly performing subsequent actions. In these cases, acceptance statements do not seem to be necessary and are usually not produced (see e.g. Transcripts V-VII in the appendix). This is in line with Rossi's (2012) distinction into unilateral and bilateral requests: when participants have agreed on a joint project (unilateral request), subsequent actions that the surgeon instructs as part of the already established joint project do not need to be accepted (bilateral request). Speaking in Randell and colleagues' (2017) terms, my data indicates that after the first part of a longer request has been verbally accepted, subsequent installments do not have to be accepted separately (see e.g. Excerpt 6).

Prior work on requests in surgery has not reported struggles with fulfillment after acceptance of a request as I have found in robotic surgery (see Excerpts 15 and 16). Randell and colleagues (2017, p. 63) provide one example where a surgeon requests a robotic instrument and after it is not appearing on the screen, the surgeon asks, "where is it?" after three seconds of silence. This shows that problems with common ground on fulfillment as I have described here also occur in other hospitals. However, in Randell and colleagues' (2017) data, the surgeon's question seems less problematic, since acceptance had not been verbalized before. In Excerpts 15 and 16, the request had previously been accepted but fulfillment was delayed due to unexpected trouble. To my knowledge, such cases have not been described for robotic surgery before.

6.2 COMMON GROUND IN SURGERY

This thesis contributes to a small body of research that has studied common ground in surgery. Prior work has investigated how anesthesiology teams maintain common ground and prevent errors by providing information and explanations even when they have not been explicitly asked for them (Johannesen et al., 1994). Furthermore, surgeon and resident in laparoscopic surgery have been found to build content and process common ground at different time points of the surgery (Feng & Mentis, 2016) and to employ verbal and embodied means to do so (Feng & Mentis, 2017). Further, it has been investigated how surgeon, resident and a student build common ground on the location of bodily landmarks through verbal and embodied means (Koschmann et al., 2001; Koschmann & LeBaron, 2003). While these papers do not deal with requests for action, they all illustrate how team members gradually build common ground through perceptual events and information that they provide to each other. This is in line with my finding that in open surgery, common ground is incrementally built and carefully adjusted to the emerging course of actions. None of this prior work reports gaps in common ground as I have found in robotic surgery.

Difficulties with common ground in robotic surgery have been pointed out earlier (Cao & Taylor, 2004; Webster & Cao, 2006), which fits my finding that common ground may be more difficult to achieve in robotic surgery. However, Cao and Taylor (2004) report difficulties with settling on a shared terminology, which I could not identify in my data. A reason for this might be that I observed a very experienced team that has developed a shared vocabulary for instruments and actions specific to the robot, while Cao and Taylor studied inexperienced teams in the early days of robotic surgery. Further, Cao & Taylor (2004) report uncertainty as to who should inform or ask for information as source for struggles with common ground. One could argue that failure to immediately produce a verbal affirmative response to the surgeon's requests is due to ambiguities in who should respond in some cases. However, in the teams that I videotaped, the first assistant is clearly assigned the role of representative of the team, taking the turn when no other is selected as addressee (see e.g. Excerpt 15, l. 08-09) or the addressee is not taking the turn (see e.g. Excerpt 16, l. 18-19). So while Cao & Taylor (2004) indicate that robotic surgery may be associated with difficulties to build and maintain common ground, which is in line with my findings, the underlying reasons they present differ significantly from my results. Interestingly though, Webster and Cao (2006) suggest that communicating the state of the robot (instrument disabled/secured) by following a communication script leads to significantly faster performance than interacting freely. The practice of explicitly accepting requests through verbal affirmative responses that I have described here fits well with this finding, as requests are completed in a smooth way when those responses are produced (see Excerpts 4-6) and teams struggle more when such responses are delayed or (supposedly) not produced (see Excerpts 7-10). While Randell and colleagues (2017) do not make the connection with common ground, they also indicate that strategies for explicitly communicating actions and concerns may support effective teamwork, as it allows teams to maintain awareness of what is happening, which also fits with this finding.

Pelikan and colleagues (in press) have pointed out similarities of robotic surgery and distance collaboration. Indeed, difficulties with common ground are less common in collocated teamwork and have traditionally been associated with collaboration over distance (inter alia Cramton, 2001; Hinds & Bailey, 2003; Kraut, et al., 2002; Olson & Olson, 2000). For instance, Cramton (2001) reports difficulties with common ground related to the interpretation of silence in dispersed teams, as silence may mean a variety of things, such as "I agree. I strongly disagree. […] I am having technical problems" (ibid., p. 359). This fits with the problems that surgical teams face – the surgeon does not know whether silence means that the request is taken up and the addressee is about to fulfill the request as in Excerpt 16 or whether there is a technical problem and the team struggles to come up with a solution (as in Excerpt 15). Further, Cramton (2001) indicates that distributed teams face difficulties in building common ground on requests that are only stated indirectly, since the requested action may be more salient to the requester than to the addressee. Participants seem to have adjusted to this in robotic surgery, as the surgeon formulates requests more clearly from the beginning, while in open surgery, requests may be uttered in more implicit way first (see e.g. Excerpt 11), with more information being added incrementally as the addressee displays the need for clarification (see Excerpt 11-14). Further, my findings for robotic surgery nicely fit with Olson and Olson's (2000) suggestions for how teams can effectively communicate when collaborating over distance. They stress that formalizing communication increases the chances for success, such as "making it clear who is responsible in an e-mailed request sent to many people, or that all requests are acknowledged, as in airline pilot communication" (Olson & Olson, 2000, p. 163). The surgical team seems to adopt both of these recommendations: the first assistant is assigned the role of the "default" communicator, responding to the surgeon when the addressee is unclear, and the team acknowledges all requests with affirmative response tokens. So while the surgical team is collocated in the same room and the surgeon can get up from the robot console and walk over to the patient any time, robotic surgery shares similarities with distance collaboration. Interestingly, resulting difficulties with common ground are not only similar to those faced in distant teams but can also effectively be dealt with by communication strategies developed in distributed teams. This thesis thus reinforces similarities between robotic surgery and distance collaboration, which have been pointed out in prior research (Pelikan et al., in press).

6.3 IMPLICATIONS

This work has several implications. First, I have demonstrated how a combination of conversation analysis and Clark's (1996) theory of common ground can uncover details in a team's practice, that are difficult to describe or inaccessible to other analytic methods. Studying teamwork ethnographically (Pelikan et al., in press), me and my co-authors noted struggles with common ground due to difficulties with situation awareness but we were unable to describe how this plays out in detail. Using conversation analysis to study how teams build common ground turn-by-turn (using the example of surgeon-initiated requests for action) enabled me to develop a deep understanding of the difficulties that teams face. Prior work noted differences in communication patterns between robotic and laparoscopic surgery (Cunningham et al., 2013; Lai & Entin, 2005; Nyssen & Blavier, 2009) but was struggling to illustrate underlying reasons. For instance, Nyssen and Blavier (2009) counted acts of communication and found significantly more verbal acts in robotic as compared to laparoscopic surgery. However, they remained speculative on why verbal interaction increases during robotic surgery. Employing the method of conversation analysis, I was able to show the kind of verbal utterances that participants produce and it becomes clear that the observed increase in verbal communication is partly due to the fact that participants need to produce more affirmative responses.

Further, trouble with fulfillment that needs to be negotiated verbally significantly adds to the number of verbal acts in robotic surgery; especially when comparing it to scenes such as illustrated in Excerpt 14, in which participants address difficulties through embodied means, only producing a few verbal utterances to underline embodied actions. Conversation analysis proved to be a helpful method to deepen the understanding of why verbal interaction increases in robotic surgery and why participants struggle with common ground. It may be helpful for studying how technology shapes teamwork in other settings, enlarging the understanding that has been developed with the help of quantitative or ethnographic methods. Further, this thesis proves that a combination of conversation analysis and Clark's (1996) theories on collaborative language use can yield interesting findings. Koschmann and LeBaron (2003) reported difficulties in combining conversation analysis with Clark's (1996) theories, indicating that categorization of each utterance in a transcript into either presentation or acceptance phase is difficult. I have not applied Clark's theories at such a detailed level but rather used Clark's (1996) notion of common ground and action ladders to explain conversation analytic findings. While both approaches use different analytic vocabulary and are distinct in their treatment of mental states, they do not conflict in this analysis but rather produce fruitful results. This thesis shows that a combination of two different approaches that originate in sociology (conversation analysis) and psychology (Clark's theories) can yield interesting insights when combined carefully on a meta-analytic level.

Second, this work extends the understanding of requests in surgery and more generally, in institutional settings. The body of research on requests in surgery is quite small (Bezemer et al., 2011; Mondada, 2014a, 2014b; Randell et al., 2017) and robotic surgery has not been studied at this level of detail so far. Randell and colleagues (2017) are the only ones who studied requests in robotic surgery and they only provide some initial pointers as part of a more general assessment of robotic surgery. Further, Randell and colleagues (2017) did not compare data from open and robotic surgery with the same surgeon. By doing so, I was able to show that the responses to requests in robotic surgery differ significantly from those in open surgery. Further, this work does not only contribute a systematic comparison of requests in open versus robotic surgery, but it also shows how institutional practice for requesting is mediated by technology. Employing a different strategy of responding to requests in robotic surgery, one may argue that participants adapt their interaction to the particular affordances of the technology. Humans have been shown to adapt to robot interaction partners (Pelikan & Broth, 2016) and employ different requests strategies in different institutional settings (Antaki & Kent, 2012; Bowles, 2006; Curl & Drew, 2008; Kuroshima, 2010; Lee, 2011; Raymond, 2014). This thesis shows that humans do not only employ different strategies to respond to requests in different institutional settings (e.g. doctor-patient interaction, vs. ordering in a restaurant, vs. calling an airline service hotline), but also develop different strategies within the same setting (surgery) as they adapt to the specific technology which mediates interaction in the particular institutional setting. This suggests that request practices may change with technology that shapes the context in which they are occurring.

The most important implication lies in the finding that struggles with common ground in robotic surgery are of an extent that is so far only known from collaboration over distance. This has interesting implications for designers of interaction and collaboration technology. The Da Vinci system was initially built for telesurgery, and designers were aiming to enable surgeons to operate from a distance. This initial design goal becomes visible in how teams interact with the robot and it considerably shapes collaboration in the team. As I have shown, the robotic surgery team faces similar struggles as distant teams, even though the surgeon is in the same room. This highlights the importance of the scenario that designers use to imagine how the technology will be used in the future: As my analysis shows, the initial scenario comes back in the design of technology and dramatically shapes interaction between users of the technology. Writing scenarios for how a technology will be used may sometimes seem like a chore that keeps design teams from getting started with the actual work. However, as this thesis shows, it is an important step and designers should carefully think about how the technology will be used in the future, as they have the power to shape how users interact with it. A decade ago, the robot manufacturer Intuitive Surgical Inc was actively engaged in optimizing the Da Vinci robot for telesurgery applications (Garcia et al., 2009; Nguan et al., 2008). Today, the company states on its website “The surgeon performing the procedure is located at a console in the operating room in close proximity to the patient and surgical support staff. Remote surgery, or telesurgery is not a focus of Intuitive’s product design” (Intuitive Surgical, 2018b). If this is true, Intuitive Surgical should adjust to the actual collocated usage of the system, optimizing the design for surgeons controlling the robot in the same room as the patient is located.

6.4 Limitations and Future Work

First of all, I have focused on surgeon-initiated requests for action as one aspect of collaboration in the surgical team. As I have mentioned in section 4.4, other team members also utter requests, mainly requests for information. A typical request uttered by scrub tech and/or circulator is “what’s the name of the specimen?”, as they need precise information on the anatomical location and medical name of the tissue that has been dissected and how it should be stored (frozen, permanent, etc). It could be interesting to study other types of requests as well to validate and extend the current understanding of how surgical teams build common ground in open and robotic surgery. Scrutinizing other aspects of surgical teamwork may further deepen insights on common ground in surgery. As I have pointed out in prior work (Pelikan et al., in press), surgical robots reconfigure surgical teams’ affective practices. Operating room staff is very sensitive to each other’s affective states and surgeons rely on embodied cues to determine whether a student or an intern is comfortable with the situation in open and laparoscopic surgery (Pelikan et al., in press). In robotic surgery in contrast, team members need to verbalize if they are not feeling well, as it is difficult for them to monitor each other’s nonverbal conduct while being spread throughout the room with a large robot at the center that is blocking their view (Pelikan et al., in press). Investigation of how teams build affective ground (Jung, 2017) in open and robotic surgery e.g. through joking with each other is likely to expand the insights on grounding practices in surgery that I have described in this thesis. Since conversation analysis revealed interesting details of how surgical teams build common ground in requests for action, it seems also suitable for studying affective ground and is likely to provide intriguing results.

Second, while I have shown that various team members in different roles respond to surgeon-initiated requests following the same general pattern, I have only looked at requests uttered by one surgeon in this thesis. There may be individual differences between surgeons, especially with respect to gender (Jones, Mowinski Jennings, Higgins & de Waal, 2018). In this study, the (female) residents who were uttering requests from the robot consoles also formulated their requests in the same style as the surgeon, so the general pattern is unlikely to be dramatically different. The differences between French, British and US hospitals that I have pointed out earlier, strongly suggest that my analysis of how surgeons formulate their requests may only hold for surgeons in the USA. Further studies are necessary to find out how surgeons design their requests in other countries, as conclusions about the influence of culture on the formulations of requests in surgery can only be drawn with more data.

Third, I have only focused on surgeon-initiated requests that are verbally formulated. As Mondada (2014b) points out, some requests are not verbalized because they are produced completely nonverbal or because team members anticipate the required next actions from the sequential context. These requests may be more difficult to identify in the data, as the border between what counts as a request and what is simply produced as next action in the sequential context may not be clear cut. Nevertheless, investigating such requests could yield further insights into the fine-tuned coordination of surgical teams. This does not only apply to open surgery, in which team members have a large repertoire of embodied actions to design nonverbal requests. Also in robotic surgery, requests may be anticipated from the context and not uttered as explicit requests. Randell and colleagues (2017) note that experienced first assistants offer assistance when they anticipate actions that need to be done next, an aspect that I also noted in my data but did not focus on in this thesis. Investigating how surgeon and first assistant coordinate in requesting and offering potentially next requested actions is likely to yield interesting insights into how teams coordinate. I noticed in my data that the anticipated next action offered by the first assistant may not always be in line with what the surgeon is intending to request, resulting in discrepancies in the understanding of what should be done next that first need to be discussed before the surgeon determines the next action through a request. Studying this in more detail is likely to yield more insights on how robot console and patient-side party build common ground in robotic surgery.

Finally, I have focused on formulation and fulfillment of surgeon-initiated requests but have not explicitly studied closure of these requests. Mondada (2014b) mentions that request sequences in surgery sometimes feature a closing third turn, in which surgeons display approval of the action and terminate the sequence. It would be interesting to study in more detail how closure of the request sequence is achieved in robotic and open surgery. My data yields some initial pointers on this. For instance, it seems that verbal third turns are not common in open surgery, since the entire fulfillment is negotiated nonverbally (see for instance Excerpt 3, in which surgeon and student negotiate timing of the scissor movement purely through gaze). In robotic surgery, it seems to depend on the type of action that is requested. If the requested action is immediately visible as in Excerpt 4, where the requested push is captured by the endoscope, verbal termination of the sequence is not necessary. The same holds for docking of particular instruments: if the patient-side team inserts a tool into the robot arms, the robot produces a distinct sound and docked instruments are also indicated in the visual interface of the surgeons. In such cases, end of the sequence becomes evident in an implicit way, as the surgeon starts a new activity or continues with the activity he or she was interrupting to utter the request. However, actions such as performing suction do not have an inherent end. In such cases, a verbal third turn may be necessary to reach joint closure of the sequence (see e.g. Excerpt 6, in which the surgeon closes the requested suction activity by saying “let’s leave it like that”). It could be interesting to investigate further how surgical teams reach closure of requests, as in certain cases, the sounds played by the machine may function as a closing third turn. Thereby, it is also highly relevant for design of technology that is used in teams, as distinctive sounds may serve as a proof that an action sequence is finished. This could reduce the time-consuming need to verbally build common ground on closure before proceeding with the next task.

6.5 SUMMARY

In this chapter, I first discussed my findings with respect to prior work on requests in surgery. The negatively polite *interrogative request format* that is prevalent in my data has not been described in the literature on requests in nonrobotic surgery collected in France and Great Britain, which may point to cultural differences. In line with the definition of bilateral requests, my data suggests that requests only seem to be formulated as *imperatives* when they occur as part of a joint project. Interestingly, the *polite formulations* that I found the surgeon to produce with reduced loudness or increased tempo at the beginning of requests could be interpreted as a means to secure team members' attention, according to previous research. My work generally supports the observation that request sequences in robotic surgery are longer than in nonrobotic surgery, but I find that *initiating a joint project takes equally long* in both open and robotic surgery. As reported by others, surgeons initiate *repair* when requests are not taken up. However, I noticed that the surgeon assumes trouble with acceptance or hearing when a request is not complied with in robotic surgery, as opposed to trouble in understanding in nonrobotic surgery. Concerning appropriate responses to requests, my findings are in line with prior work that suggests *explicit acceptance* is required in robotic surgery. However, in contrast to the literature I found participants do produce affirmative response tokens independently of whether fulfillment is immediately visible on screen, possibly to ensure mutual knowledge that the request was accepted. As proposed in earlier research, I also find that when participants share common ground on being *committed to a joint project* already, explicit verbal acceptance is not required.

Second, I discussed my findings with regard to literature on common ground in surgery. In line with my observations for open surgery, none of the work on common ground in nonrobotic surgery reports *gaps in common ground*. Struggles with common ground have been reported for teams that were new to robotic surgery, but previous work has suggested different reasons than I have identified for teams that are well-acquainted with the robot. Interestingly, *explicit communication strategies* similar to what I have found in my data have been suggested as means to address difficulties with maintaining common ground in the earlier research. Finally, I identified similarities in the surgical team's struggle and difficulties with common ground described in the literature on *distance collaboration*.

Third, I presented implications of this work, discussing how a *combination of conversation analysis and Clark's theories on common ground* can yield insights that are largely inaccessible to other analytic methods. I further illustrated how this thesis extends the understanding of *requests in surgery* by systematically comparing requests uttered by the same surgeon in both open and robotic surgery, indicating that request strategies do not only differ per institutional setting but may also be shaped by technology within one setting. Most importantly, however, this work has implications for designers of interaction technology, as it shows how initial *design scenarios* for telesurgery are still visible in today's design of the robot, dramatically shaping collaboration in the team.

Finally, I identified limitations of my work and indicated how they can be addressed by future work. Studying *other aspects of surgical teamwork* beyond requests for action, such as joking within the team, may extend the understanding of how surgical teams build common ground by an affective dimension. Further, recording surgeries with one surgeon in one hospital limits the generalizability of my findings, and especially *cultural differences* need to be researched in more detail. Moreover, I focused on verbal surgeon-initiated requests, disregarding *requests that are anticipated and reformulated to an offer* by team members. My data suggests that such offers could be very interesting to investigate further, deepening the understanding of how surgeon and patient-side team coordinate. Finally, I pointed out that apart from analyzing how surgeon and team initiate joint projects, scrutinizing more closely how surgical teams reach *closure of request sequences* may be interesting for robot designers, as it seems that explicit closing turns are not required when the robot provides automatic feedback on termination of the sequence.

7 CONCLUSION

In this thesis, I investigated how surgical teams build common ground in open as opposed to robotic surgery. Annotating 68 hours of audiovisual material and transcribing selected scenes, I studied in detail how teams negotiate uptake and fulfillment of surgeon-initiated requests for action. I found that in both open and robotic surgery, the surgeon mostly utters requests with redressive action, employing negative politeness strategies in the majority of cases. Requests in robotic surgery tend to be more explicit, while face-to-face interaction in open surgery allows the surgeon to incrementally add information if the addressee displays the need to.

While requests for action are usually fulfilled in a purely embodied way in open surgery, the joint project has to be verbally accepted before it is fulfilled in robotic surgery. Participants display acceptance through affirmative response tokens such as “yes/yeah”, “okay”, “sure” and “alright”, confirming that they have heard the request and are willing to fulfill it. I have demonstrated that these verbal responses are treated as conditionally relevant and the surgeon reformulates the request until the addressee produces a verbal response. While failure to take up a request is treated as trouble in understanding in open surgery, it is treated as hesitation to accept or trouble in hearing in robotic surgery.

Finally, I have demonstrated that in open surgery, surgeon and team build common ground incrementally, and difficulties in fulfilling a request become evident through visual actions. In robotic surgery in contrast, the surgeon only sees actions that are captured by the endoscope and misses a large part of team members’ embodied conduct. If a request has been accepted but is not fulfilled within the expected time frame due to delays or trouble, discrepancies in the understanding of the current situation become too large. This results in gaps in common ground, which disrupt the flow of the surgery and which can only be fixed verbally, after the surgeon has verbalized them.

The surgical team’s struggle with common ground in robotic surgery is similar to difficulties that have been reported for collaboration over distance. In both cases, team members struggle to correctly interpret silence, as it may mean agreement, and that everything is going according to plan or it may display disagreement and trouble that needs to be fixed. The similarities to distance work have important implications for designers of collaboration technology, as the robot was initially designed for teleoperation with the surgeon being at a distance from the team. This work shows that the initial design scenario may become visible even when technology is used in a different context and it may shape collaboration in dramatic and unexpected ways.

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Appendix I: Collection of Transcripts

Surgeon-initiated Requests for Action in Open Surgery

I. Do you have another sponge?

10-30-17_cam1_surg1O_00001_09:06-9:16

```
01     Surgeon     °do you° have ANOther spONGE?#
       im                                       #im1
02                 (0.7)
03                 #+(0.2)+(0.2)+#(1.4)+#
       scrubtech    +head2table +
       scrubtech          +grab sponge+
       im          #im2          #im3    #im4
04                 +(0.1)*(0.3)++(0.1)*#(0.6)#*(0.3)+
       scrubtech   +turn2surgn ++rH fwd, pass sponge+
       surgeon            *head2scrub*       *head2patient-->
       im                                 #im5  #im6
05                 +(0.1)*#*(0.5)+*+     (3.0)      +
       scrubtech   + rH retract  + +spongetwo2table +#
       surgeon       --> * *lH dwn*
       im                 #im7                       #im8
```

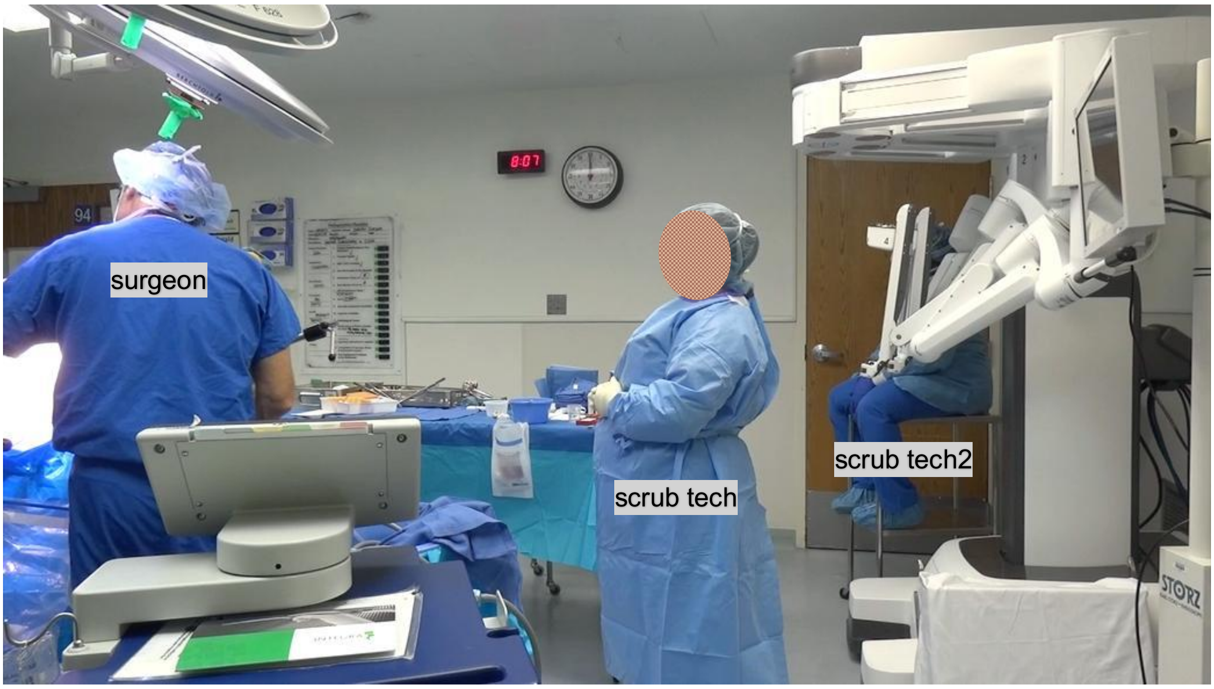


Image 1

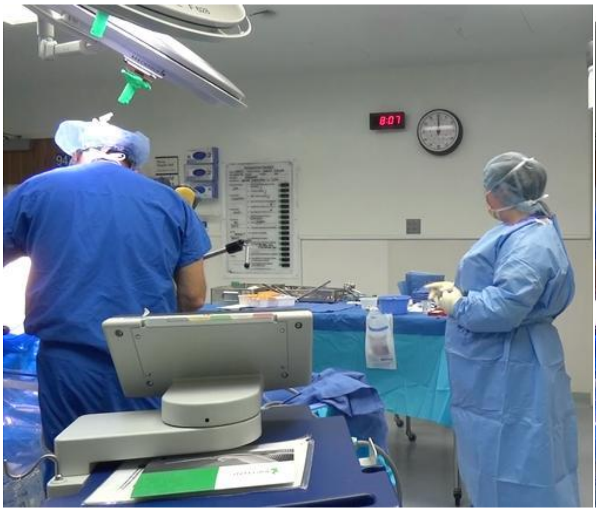
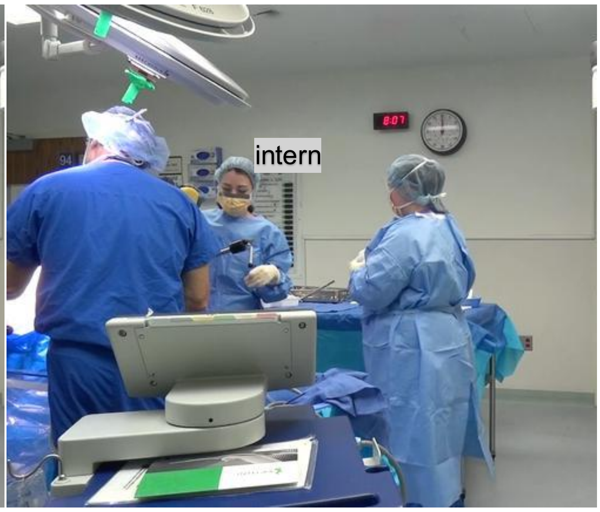


Image 2



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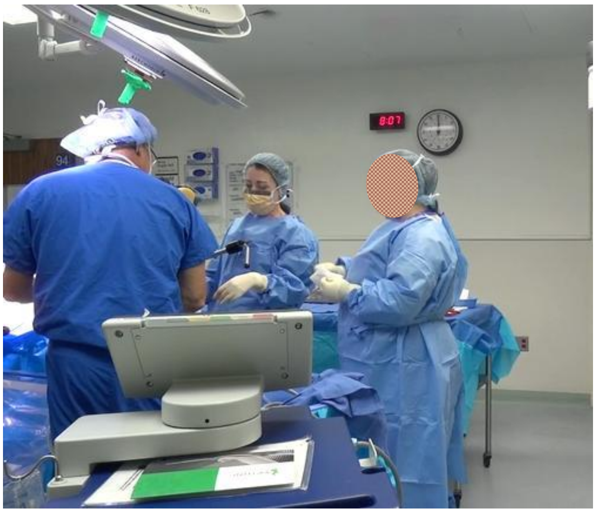

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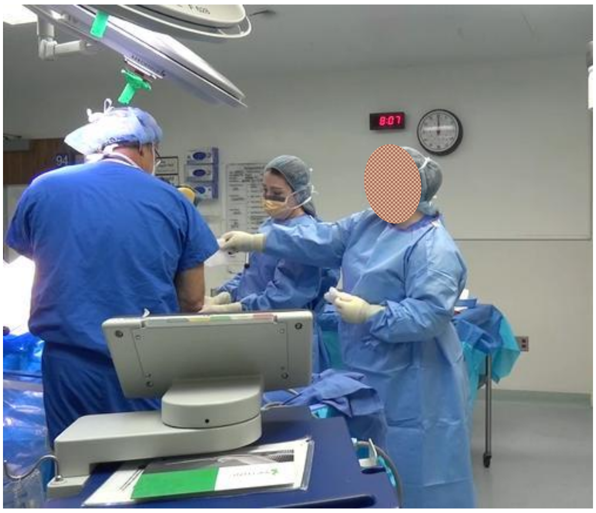

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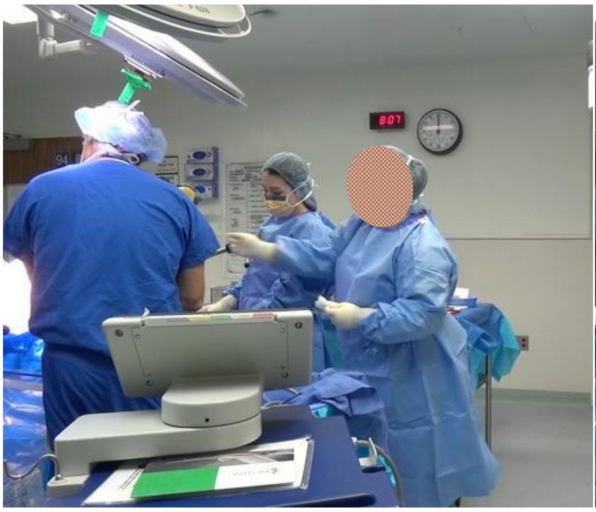

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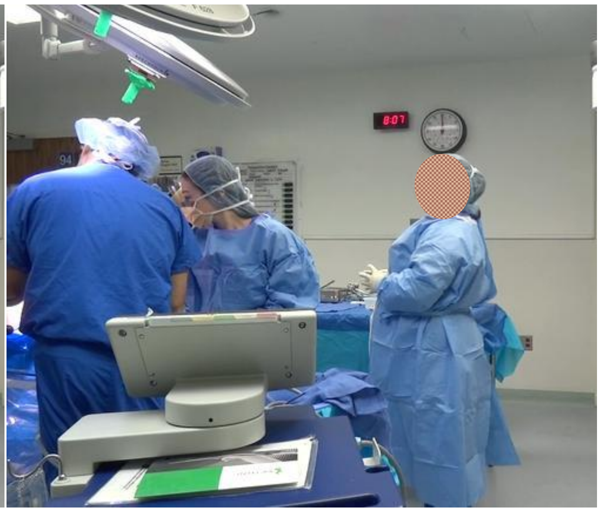

Image 7

II. CAN YOU GET ME A ADSON?

10-16-17_cam1_surg2O_00003_06:47-06:54

```
01    Surgeon    c'n you >(get) me a< #+A:D§SON
      scrubtech                         +head2surgeon-->
      intern                                §turn2scrub, extend lH-->
      im                               #im1
02               (.)+#+   (0.5)   +#+(0.2)§§(0.5)§#§(0.2)++ (0.2)#§ +
      scrubtech  -->+ +head2table + +     grasp plier    ++liftplier+
      intern                          -->§§lH2st§ § hold lH open §
      im              #im2          #im3           #im4            #im5
03               +  (0.4)   ++(0.4)#*(0.3) ++§(0.1)**(0.2)+§
      scrubtech  +plierlH2rH++plier2intern ++   handover  +
      intern                                 §  handover   §
      surgeon                          *  head2scrub  **look@scrub-->
      im                            #im6
04               +(0.1)#§(0.4)*#*(0.2)+  (0.6)  *§§* (0.6)  §(0.5)*#
      scrubtech  +      rH retract     +
      intern           §   plier2surgicalsite   §§retractlH§
      surgeon              -->* *gazefollowplier*  * turn2patient *
      im                #im7    #im8                                 #im9
```

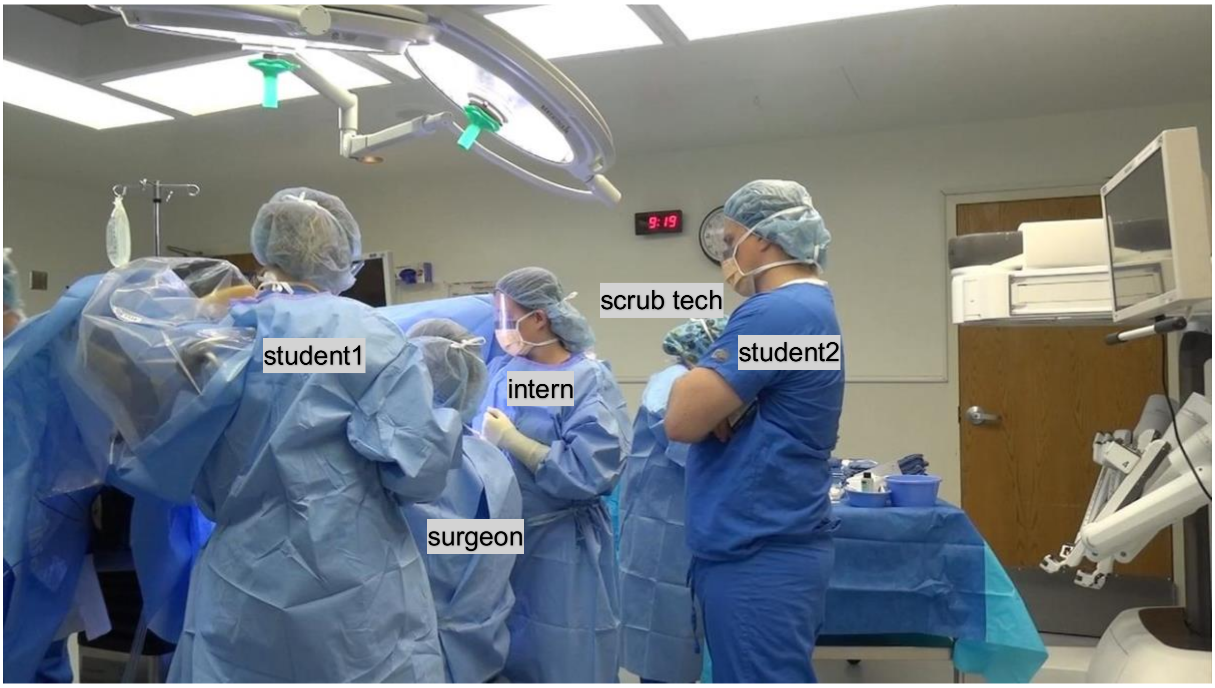

Image 1

Image 2

Image 3

Image 4

Image 5

Image 6

Image 7

Image 8

Image 9

III. GET A SCISSOR

10-16-17_cam1_surg2O_00003_10:35-10:48

```
01   Surgeon    $#*(0.2) [get #a] [  scisso ]r*
     student1   $,,,,,,,,,,,,,walk2scrubtech-->
     surgeon      *,,,,,,,,,,,,look@stu1......*
     im           #im1          #im2
02   Student1           $[ some ] [sci$ssors] °for (him)°$
     student1           $ slight nod  $
     student1                                       -->$
03              #$ (1.6)    $$   (2.5)    $
     student1    $wait@table$$move2patient$
     im         #im3
04              #$(0.6)$ (0.7)#(0.7) $ (2.8)
     student1    $hold scissors ready -->
     intern             $look@scissors$
     im         #im4            #im5
05              *(0.3)#$$(0.4)* # (0.7) #$$     (0.9)     $#
     surgeon    *look@scissors*
     student1       -->$$scissors2patient$$retractscissors$
     im               #im6       #im7     #im8                  #im9
```

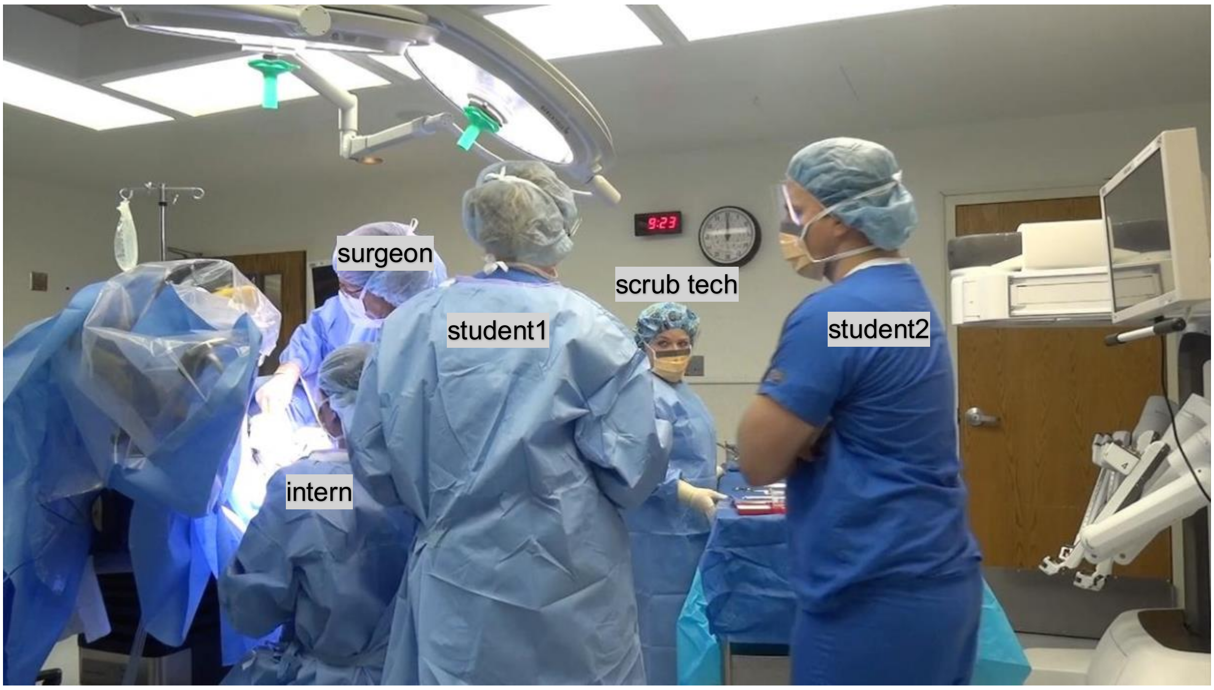

Image 1


Image 2


Image 3


Image 4


Image 5


Image 6


Image 7

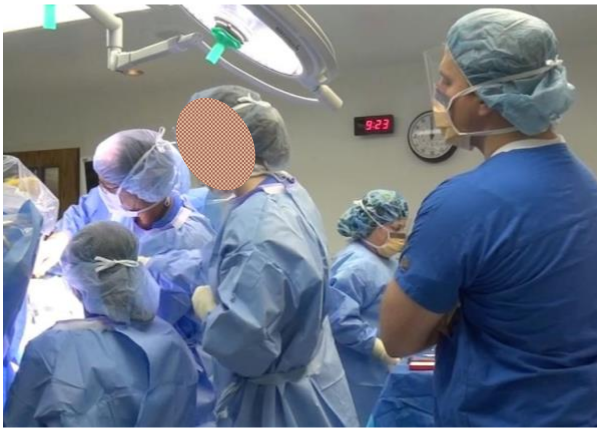
Image 8

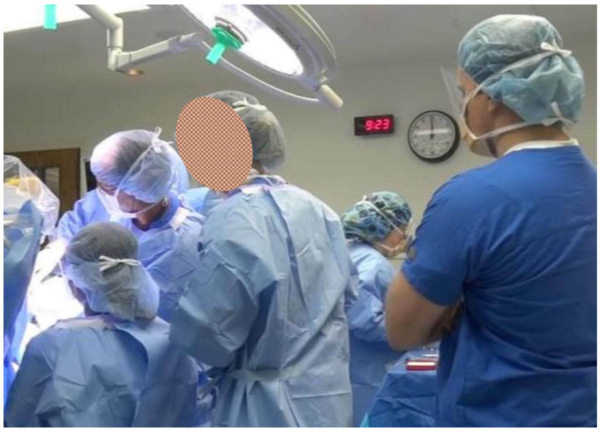
Image 9

Surgeon-Initiated Requests for Action in Robotic Surgery

IV. Can I get you to look at it?

10-03-17_cam1_surg4R_00009_15:34-18:14

```
01    SURGEON     °can i° get you to look at it
02                (0.4)
03    RNFA        OKAY
04                +  (1.6)   +
      rnfa        +turn2scrub+
05    RNFA        °can i take°
06                +  (0.3)  ++ (0.4)
      scrubtech   +turn head++get up-->
07    RNFA        take a: uh:+ (.) towel
      scrubtech           -->+
08                (118)
      commentary  ((RNFA moves light, fetches small scrub table, asks
                  CIRCULATOR to fetch lubricant; RESIDENT moves to patient
                  side))
09                (3.6)
      commentary  ((RNFA pulls vcare out))
10                (34)
      commentary  ((RNFA pulls specimen out and places it on small scrub
                  table for inspection by RESIDENT and SURGEON))
```

V. Suck that out

10-23-17_cam1_surg4R_00009_18:12-18:48 10-23-17_cam2_00002_24:16-24:52

```
01    RESIDENT    ((grabs suction device, starts untangling cables))
02    SURGEON     suck that out
03                (0.3)
04    RESIDENT    yeah
05    RESIDENT    °untangling it°
06    resident    (5.5) ((finishes untangling and inserts suction))
07    SURGEON     here, see?
08    RESIDENT    (.) yah
09                (1.0)
10    SURGEON     >go ahead<
11                (12.6)
      commentary  ((RNFA asks surgeon about specimen in the meantime))
12    SURGEON     that's fine
13    SURGEON     (0.2) guess you can, let's do it peacefully
14                (2.4)
15    SURGEON     see that debris >just a little< over there
16                (2.0)
17    SURGEON     that's fINE
18    SURGEON     (0.2) >let's keep it< like that
19    resident    (7.0)  ((takes suction out))
```

NEGOTIATING ACCEPTANCE OF SURGEON-INITIATED REQUESTS FOR ACTION IN ROBOTIC SURGERY

VI. DO YOU WANNA TAKE A GRASPER

10-23-17_cam1_surg4R_00009_10:02-10:35, 10-23-17_OR94_cam2_00002_16:06-16:39

01	SURGEON	do you wanna uh TAKE A GRA:SPER
02	SURGEON	(.) >so you c’n go an< HOLD THIS °for me°
03	SURGEON	(0.2) i appre[ciate] it
04	RESIDENT	[S↑U↓RE]
05		(13.9) ((RNFA asks RESIDENT to check ports))
06	SURGEON	((cauterizing))
07	RESIDENT	i come
		((inserts grasper))
08	SURGEON	((stops cauterizing))
09		(4.6)
10	SURGEON	move it up down here
11		(1.7)
12	SURGEON	like thA:T
13	RESIDENT	i just go underneath it?
14	SURGEON	yeah
15	SURGEON	(0.2)
16	RESIDENT	>goin’ up<=
17	SURGEON	=HOLD it up
18	SURGEON	there’s a big CHUNK in there

VII. SO SHE CAN TAKE THE GRASPER

10-02-17_cam1_surg3R_00008_19:17-20:06

01	SURGEON	>so she c’n< take the GRA:SPER
02	SURGEON	(.) to HOLD THIS
03	SURGEON	(0.2) it’s gonna help me
04	SCRUB TECH	°alright°
		((picks grasper from scrub table))
05		(2.4)
06	SURGEON	>did y’< HEAR me?
07		(0.4)
08	SCRUB TECH	yah,
09	SCRUB TECH	we’re comin’ in
		((moves toward robot))
10		(0.8)
11	SCRUB TECH	the grasper
		((holding grasper out, INTERN grabs it))
12		(24.4) ((SURGEON cauterizing))
13		((SCRUB TECH moves over to robot help INTERN))
14	SCRUB TECH	COMIN’ IN
15		(3.3)((SURGEON stops cauterizing, zooms out))
16	SURGEON	yah, grab over here
17		(1.2)

18	SURGEON	like here
19		(1.3)
20	SURGEON	grab them
21		(0.9)
22	SURGEON	pull them towards you
23		(1.1)
24	SURGEON	‘s more like that
25	SURGEON	that’s fine
26		(2.1)
27	SURGEON	((starts cauterizing))

NEGOTIATING ACCEPTANCE AND FULFILLMENT OF SURGEON-INITIATED REQUESTS FOR ACTION IN OPEN SURGERY

VIII. LET'S GO PICK OUR LOOPS

10-23-17_OR16_cam1_surg1O_00001_08:27-09:37

```
01    Surgeon      we gotta go <pick our loop>#
      im                                      #im1
02    Surgeon      (0.2) she had c i s spray ((to student))
03    Surgeon      (.) so (.) let's go pick our loops
04                 (0.3)*(0.9)#(0.2)**(0.5)#
      surgeon           *look2left  **lookright-->
      im                      #im2          #im3
05    Surgeon      d'you %have the- *(0.4)#(0.3)%*
      circulator         %gets up from his stool%
      surgeon                       *   gesture   *
      im                                  #im4
```

Image 1

Image 2

Image 3

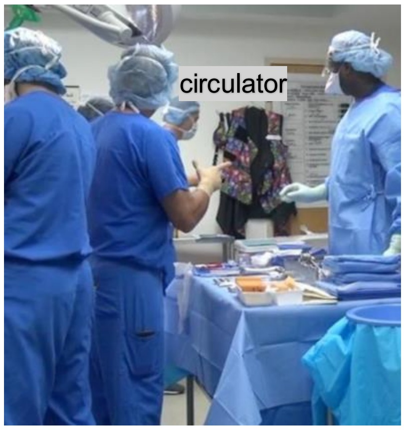

Image 4

```
06                 (1.0)
07    Circulator °is it% in [there]°
      circulator        %walks2box-->
08    Surgeon                 [there] should %%be a selection#
      circulator                             -->%%searches box-->
      im                                                         #im5
09    Surgeon    like (0.8) loops f'r that%
      circulator                        -->%
10               (0.4)
11    Circulator okay
12               (38.0)
                 ((CIRCULATOR leaves OR, SURGEON starts chatting with
                 INTERN until CIRCULATOR comes back))
```

Image 5

```
13    Circulator alright# ((comes back, puts box down))
      im                #im6
14               (0.6)
15    Surgeon    let's
16               (0.4)
17    Circulator *which uh::#
      surgeon    *walks2circulator-->
      im                    #im7
18    Surgeon    (.) let's see be[cause i  ha]ve a look at it (0.3)*
19    Circulator                 [it's sayin']
      surgeon                                                    -->*
20    Surgeon    (0.3) yeah
21    Surgeon    i've got them so i %could see
      circulator                    %selects three packages-->
22    Circulator (.) o:h
23               (3.6)#(1.0)
      im              #im8
24    Surgeon    which are various individual choice%
      circulator                                 -->%
25               %(0.8)
      circulator %presentthreepackages-->
```

```
26    Surgeon     #so let's see
      im          #im9
27    Surgeon     the choi*ce is
      surgeon             *point2chosenones-->
28    Surgeon     (.) it's #that one an' #that one*%
      surgeon                                  -->*
      circulator                                -->%
      im                   #im10          #im11
```

Image 6

Image 7

Image 8

Image 9

Image 10

Image 11

NEGOTIATING FULFILLMENT OF SURGEON-INITIATED REQUESTS FOR ACTION IN ROBOTIC SURGERY

IX. CAN I GET A MARYLAND INSTEAD

10-02-17_cam1_surg3R_00008_13:42-15:35

```
01   SURGEON     can i get- u:h
02   SURGEON     >push tht<
03   SCRUB TECH      °d’ y’° have another bipolar p[lease?]
04   SURGEON                                   [just] u:h >pause, push up<
05   SURGEON     can i get a: (.) maryland (.) [instead]
06   SCRUB TECH                                     [marylands]? (.) okay
07   CIRCULATOR  what’s that?
08               (3.8) ((SCRUB TECH looks for Maryland in her tray))
09               (42.3) ((no Maryland available, SCRUB TECH, CIRCULATOR
                 and RNFA discussing what to do))
10   SURGEON     you got paralys
11   SURGEON     or what’s goin’ on [there]?
12   RNFA                           [ no  ]
13   RNFA        so we [ gonna bring you a bipolar]
14   SCRUB TECH        [we gonna get you a bipolar]
15   SCRUB TECH  an’ then we gotta go run
16   SCRUB TECH  an’ get a maryland [from upstairs]
17   RNFA                           [(           )]
18   RNFA        °we don’t have them°
19   SURGEON     they don’t have ‘em?
20               (0.4)
21   RNFA        we have them, not down here
22               (23.9) ((nurses continue to discuss,
                 SCRUB TECH gets bipolar ready))
23   SCRUB TECH  alright (0.3)
24   SCRUB TECH  we gonna switch off your bipolar
25               (0.7)
26   SURGEON     what’s THAT?
27   SCRUB TECH  can you switch out your bipolar?
28   SCRUB TECH  er er bipolar penetrating, till we get the maryland
29               (0.6)
30   SURGEON     >°turn that°<
31               (1.6) ((cauterizing))
32   SURGEON     uh maybe >i don’ really know<
33   RNFA        is [it workin’?]
34   SURGEON      >°[you saved me]°<
35               (5.7)
36   SURGEON     alright, it is sCOLDING again
37   SURGEON     so uh whatever
38               (0.4)
39   SURGEON     i- i can wait for the -
40               (0.9)
41   SCRUB TECH  okay ((walking back to scrub table with bipolar))
```