

Unpacking Exam-Room Computing: Negotiating Computer-Use in Patient-Physician Interactions

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ABSTRACT

The presence of computers – especially desktops – takes significant time and attention away from patients during medical visits. As a result, patients may feel disengaged and disregarded. In this study, we examined the impact of using “Computer-on-Wheels” (COWs) in exam-rooms. We found physicians constantly reorienting and resituating exam-room computers to different positions during the three stages of a medical visit: communication-intensive phase, lecturing phase and ordering phase. We refer to this behavior as micro-negotiation of computer-use. Analysis of its usage patterns, as well as physician and patient perceptions, show that micro-negotiations facilitate eye contact expression and encourage patient participation in medical visits. In addition, we identify two tensions and two unintended benefits resulting from micro-negotiations. These findings lead us to consider new modes of negotiation in the exam-room that could alleviate the tensions identified while enabling physicians to continue enjoying micro-negotiation benefits in their work practice.

Author Keywords

Exam-room Computing, Electronic Medical Record (EMR), Patient-Physician Interactions, Eye Contact, Micro-Negotiation

ACM Classification Keywords

H.0 [information systems], K.4.3 [organizational impacts] J3.Life and Medical Sciences: Health, Medical Information Systems

General Terms

Human Factors

INTRODUCTION

Recently, the prevalence of computing in the medical field has been growing such that computers are not only seen at a clinic’s front desk and doctor’s office, but also in the exam-room – a semi-private space where patients intimately share

their illnesses, discomforts, and feelings with their physicians. The use of computers in the exam-room has drastically changed patient-physician dynamics. Fewer and fewer doctors are holding paper-charts and are immersed in an emotional two-way conversation strengthened by constant eye contact with their patients. Instead, computers are now situated in between the patient and the physician, impacting both the content and the quality of medical communication in the exam-room.

Indeed, the presence of exam-room computers takes significant time and attention away from patients [5, 10, 11]. Previous studies indicated that patients often feel disregarded and disengaged when their physicians use computers in front of them [16]. In some cases, computers are even considered as third agents during medical visits that take equal, if not more, attention from physicians [11]. As a result, trust and rapport between the physician and the patient may diminish [13]. Understanding how communication behaviors are facilitated or impeded by the co-existence of computer systems is an urgent issue in the HCI field, especially when interacting with computers is directly related to the content and quality of patient care.

Many studies [4, 5, 10] treat computers as static, non-movable artifacts that are always placed in fixed positions during the entire medical visit. Compared to paper charts, computer-use lacks the unique advantage of supporting **micro-mobility** during medical visits [9]. Micro-mobility allows easy portability, foldability, and flexibility of using paper charts in the conversation process, since it can be placed at different locations to facilitate flexible readings and writing activities, and also encourage gestures and remarks that are centered on the paper record. Heath and Luff note, “**the ecological flexibility of the record is a resource in a range of activities, and assists the communicative flexibility of the doctor.**”

To understand the impact of EMR systems on patient-provider interactions in the exam-room environment, we conducted a 6-month field study in an outpatient clinic. Interestingly, physicians in this clinic all engaged in what we call **micro-negotiation** activities to reorient and resituate the exam-room computers to different positions in order to foster patient engagement and effective delivery of information – much like the advantages of micro-mobility

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CHI 2011, May 7–12, 2011, Vancouver, BC, Canada.

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afforded by paper records. In addition, the EMR system leveraged unintended uses of the system, such as control over consultation time and concealment of subjective information from patients. The findings suggest that computer systems are not always placed in a static position; instead, they are often negotiated to different modes to facilitate various exam-room activities.

RELATED WORK

Numerous medical studies have suggested that the use of computers in medical consultations often lead to a feeling of disengagement among patients, since a large portion of the visit time and physician attention is spent on computers [5, 10, 11]. Specifically, consistent gazing at computers may significantly reduce the exchange of socio-emotional information from patient to physician – one critical aspect of patient visits that correlate with medical information comprehension and patient-provider relationship [10, 11]. Indeed, when computers are involved in the communication process, non-verbal cues such as eye contact [13, 19], gestures [3, 12], and positions [21] become critical in constructing human-relationships for both collocated and distributed parties.

Exam-room communication may be greatly impacted by the spatial display of computers, since these orientations may influence non-verbal behaviors such as eye contact and gestures [15]. Early static-positioned desktop computers often interfered and hindered communication in the exam-room [4, 10]. In a study similar to ours, Frankel et al. [5] identified two spatial orientations: tilting the screen to the patient's side facilitates communication, while turning the screen to the provider's side hinders communication. Nevertheless, one single display was used throughout the entire medical visit, and position switching was not identified in these studies. Rather, computers in these studies were treated as static, non-movable artifacts that were always placed in fixed positions during the medical visit. In addition, these studies simply took "screen sharing" as a constant benefit to information comprehension and "screen hiding" as a hindrance to effective communication without situating computers in the various activities and practices occurring in a medical visit.

Prior HCI literature often considers medical settings as harsh environments for patients to access information. For example, breast cancer patients have difficulty using and accessing information in exam-rooms, partially due to the lack of collaborative document viewing solutions [18]. In a similar line of research, Wilcox [20] piloted patient-centric information displays and suggested sharing EMR records with patients in hospitals. Other studies focus on the mobility [9] and documentation [7] aspects of medical system use in the exam-room. Seldom do studies examine and compare concerns from both the patient and the provider side. To our best knowledge, this study is the first to explore computer-based micro-negotiations in the exam-room while considering both the patient and the provider.

METHODOLOGY

We conducted qualitative field studies in an outpatient clinic affiliated with a large healthcare organization located in Southern California. The main purpose of the study was to understand the impact of computer systems on patient-provider relationships in outpatient clinics. Approximately 180 hours of field observations and 16 patient interviews were performed over the course of 6-months. IRB approvals from both the field site and the university were obtained prior to data collection.

Field Site

The outpatient clinic where this study was conducted is affiliated with a large healthcare organization known for its pioneering work in EMR system adoption and advancement. In addition, this particular clinic is a pilot site for the entire region. Many newly introduced systems are internally piloted at this clinic first, and then deployed to the rest of the region. These advantages provide a unique opportunity to understand behaviors of EMR system usage and its impact on patient-provider interaction in an outpatient setting.

Data Collection

The majority of data was collected on the second floor of the clinic – the primary care unit. Of the 9 primary care physicians employed by the clinic, 5 were shadowed in this study. The gender and years of practice of each participating physician varied: 2 females and 3 males, with a range of 3-18 years of family medicine experience. Physician proficiency with the EMR system ranged from technology "champions" for the entire region and medical directors, to experienced physicians and a new doctor who recently joined the clinic. The diverse backgrounds of participated physicians helped us uncover common practices across different EMR usage behaviors.

During shadowing sessions, researchers followed individual physicians for entire shifts. Physicians were shadowed both in their private offices and exam-rooms where patients were present. Patients' permission was obtained before entering the exam-rooms. The researchers passively stayed behind the scenes writing down notes related to technology-use and patient-physician interactions in the exam-room. Physicians were informally interviewed to explain their work practices when patients were not around. Observations in physician offices were conducted through a think-aloud manner, where researchers sat at the back of the office observing physicians' behaviors while the doctors explained their activities and the reasons behind the tasks they were doing. Data from the interviews and observations were noted using paper and pen on-site, and then transcribed in more detail later. In total, 70 hours of observations were dedicated exclusively to physicians, during which 140 medical visits were examined.

To better understand the technology used in our field site, we also enrolled in two EMR training classes during the study. The first training was a 2-day session aimed at

teaching basic EMR skills prior to employee adoption of the EMR system. The second 2-day training session was called “pathway to proficiency.” It was intended for experienced doctors who were eager to improve their EMR skills from “technology champions” – fellow doctors who were experts in EMR usage. Topics covered in this second training included computer documentation, workflow optimized for EMR integration, and customized patient messages. These training classes provided us more than simple participant observations of the EMR system in a test-environment. Rather, they provided us insight into what doctors and other medical staff were doing during actual exam-room computing moments.

Additionally, 16 semi-structured interviews were conducted with patients to understand their concerns about technology’s impact on interactions with primary care physicians. Patients were recruited through physician referrals and all interviews were conducted on-site in a conference room after each patient’s medical visit. The interviews lasted approximately forty minutes in length and involved questions falling into five categories, one of them being, “computer-use in the exam-room.” The timing of the interviews guaranteed that patients could share their fresh memories about exam-room computing. Among the 16 interviews, 9 were male and 7 were female, all between the ages of 27-72. All interviews were recorded and later transcribed for further analysis.

Data Analysis

Data collected in the study was analyzed using grounded theory [8] to uncover recurring patterns in the interactions involved with exam-room computing. We first extracted the observation notes related to computer-use in the exam-room and categorized them into three types based on behavioral patterns. We identified the three types of micro-negotiations by associating them with medical visit activities. We then coded the entire observation data using the identified themes. Interview data related to exam-room visits were also coded to gather patients’ perceptions about computer-use in the exam-room.

FINDINGS

Overall, both healthcare providers and patients in our study applauded the ability to use computers in the medical consultation process. Our analysis shows that much of their appreciation resulted from activities of negotiating computer use to facilitate the interactions between patient and physician. What follows is a description of the typical exam-room set-up at our clinic and a typical medical visit scenario. We then introduce three modes of “**micro-negotiation**” – exclusive, collaborative, and neutral – that enhance patient-provider communications.

Exam-room Set-Up

The exam-room is a semi-private environment designed for the sharing of patient health information with their providers. As shown in Figures 1 and 2, the majority of

exam-room space is occupied by an exam table. The EMR system is often situated on a mobile wheel cart – typically called “computer on wheels” (COW).

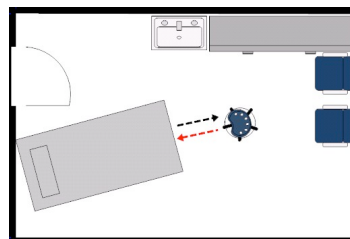


Figure 1: Typical Exam-Room Layout (pre-EMR integration). The arrows indicate line-of-sight between patient and physician, inferring consistent eye contact.

Prior to the use of computers in the exam-room, the relatively compact design of the exam-room created an environment that facilitated conversation when physicians and patients were within each other’s personal space [6]. Patients could sit on the exam table or in the chairs, depending on the patient’s illness or the physician’s preference. However, no matter where the patient sat in the room, the physician’s position was always relatively close to the patient.

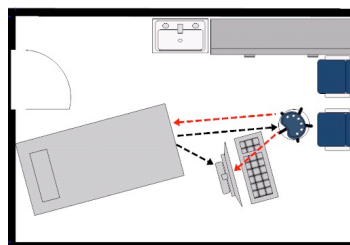


Figure 2: Typical Exam-Room Layout (post-EMR integration). The computer is in exclusive viewing position and as indicated by the line-of-sight arrows, eye contact switches from computer to patient and back.

Due to the EMR’s integration into the exam-room, the COW distances physicians away from patients and forces physicians to only sit in patients’ social spaces [6]. Due to the COW’s dependency on electrical power, it is always situated in a corner of the exam-room where an electrical outlet is nearby. This connection anchors the COW in a relatively fixed location, allowing only small movements and adjustments. In this paper, we refer to these small-scale movements as **micro-negotiation** of computer-use. Most micro-negotiations witnessed in our study involved coordinating the spatial display of the COW in between the physician and patient to facilitate better interactions.

Patient-Physician Interaction: A Snapshot

We use the following scenario¹ to demonstrate how slight computer-screen repositioning can facilitate and improve patient-physician interactions in the exam-room.

¹ This scenario is based on one field observation.

Shelly² was sitting on the exam table waiting for Dr. Weber. The computer was turned-on and placed to the left side of the table. After entering the room, Dr. Weber sat down face-to-face with Shelly. He adjusted the computer to situate it between him and Shelly. The computer was now directly facing the doctor, with the back of the monitor facing the patient.

Dr. Weber logged into the system and started inquiring about the patient's symptoms and the reasons for her medical visit today. Shelly looked very frustrated and complained about how difficult it was for her to continue working with this undiagnosed allergy. As soon as Shelly started talking, Dr. Weber typed in her symptoms and other information into the notewriter section in the EMR system. He began searching previous office visits when he heard Shelly mention her previous lab tests. His eyes were constantly switching from Shelly's to the computer screen and back during the conversation.

After Shelly finished talking, Dr. Weber turned the screen so that it was facing Shelly directly, and moved his stool closer to one side of the exam table so that they were both facing the computer screen. He pointed to a line highlighted on the screen and explained what it meant. Shelly looked at the lab results on the screen while Dr. Weber explained.

After the physical exam, the doctor moved his stool back and repositioned the screen in the same direction with patient's eyesight. This time the screen was facing both the doctor and the patient. Shelly could lean over to the side to see the screen if she chose to. The doctor worked on putting in orders for medications and lab tests.

As is clearly shown in this scenario, the COW was negotiated in three distinct positions during the medical visit. It was first shown **exclusively** to the physician, then turned over to the patient's side for **collaborative** viewing, and then shifted to a **neutral** position for optional patient viewing. It is through the negotiation of spatial displays that physicians can better communicate and engage with their patients. These three modes of negotiating spatial displays are by no means an individual behavior; all physicians shadowed in our study demonstrated similar types of behaviors in the exam-rooms.

Negotiating Computer-Use in the Exam-room

In this section, we detail the three types of micro-negotiation and present concerns from both the patient and physician perspective. It is notable that the three modes of negotiations are not a linear process, although they often occur in this fashion. The order and frequency of occurrences can vary for patients; nonetheless, we only observed these three viewing modes in our study.

Exclusive Viewing by Physicians

The majority of time during a medical consultation has the computer exclusively facing the physician. At this time, patients are unable to view screen activities [Figure 3]. This **exclusive viewing** position is unique to our field site, since the use of side-tables and desktop computers would not allow this negotiation in the exam-room. This exclusive viewing typically occurred at the beginning of a medical visit when medical history and symptoms were assessed and possible diagnoses were discussed. At this communication-intensive phase of the medical consultation, it was necessary that the computer screen face the doctor to allow easy capturing of information during the communication, since what was being communicated was either information stored on a patient's record read from the EMR, or new information reported by the patient that needed to be entered into the EMR. Turning the screen exclusively towards the physician allowed both the computer work and the communication work to happen simultaneously. However, to balance both forms of work, physicians often switched their attention back and forth between the computer and the patient.



Figure 3: Example of Exclusive Viewing. Left: Dr. Vu engages in communication and eye contact. Right: Dr. Vu is typing notes while talking to the patient. In both images, the patient is unable to see the screen.

When taking notes during medical consultations, not only did physicians capture the medical discomfort and medical history, but also found it imperative to note socio-psychological information that could be relevant to their medical judgments. They usually tried to capture all information in their notes, such as what was described in the previous scenario: not only did Shelly inform Dr. Weber about her allergy symptoms, she also told him about how the ailment affected other parts of her life like her job, and how the symptoms emotionally affected her (e.g. frustration). All of this additional information needed to be entered into her medical record in order to justify some of the orders prescribed for Shelly. In another medical visit observed during the study, a patient described how she was emotionally bothered after her mother passed away, and how she felt discomfort when various small breakdowns occurred at her home over the previous two weeks. In this case, the doctor had to note down all of these detailed descriptions since anti-depression medications were considered to relieve the patient's stress. Such medications could not be prescribed without sufficient psycho-emotional information to justify their intentions.

² All names used in this paper are pseudonyms.

Other than typing information into the system, physicians also checked previous records and addressed issues when it became necessary. For instance, when a patient briefly mentioned her recent visit to urgent care, the physician immediately stopped typing notes and started checking the visit summary. Knowing what happened during the previous visit helped the current assessment, and improved communication with the patient as a result. On another occasion, a patient complained about a specialist who did not contact her for two weeks about a lab test. As a result, it became the primary care physician's responsibility to check on that test result immediately and address the issue while the patient was present. However, checking the test result involved a certain amount of computer work that drew attention away from the patient.

For physicians in the study, this exclusive viewing was the best computer position, where the spatial display of the system allowed them to engage in both the computer work and the medical conversation without having to change their own body position. As one physician told us:

I have to make sure to make eye contact with them all the time. That's why you see me there, sometimes I look at them when they talk, and sometimes I lean over at the side of the EMR and try to give them my full attention. – Dr. Park

All physicians we observed were fully aware that “eye contact” was an essential part of communication. For them, eye contact was a critical channel for them to establish communication and trust with their patients. Despite most patients enjoying the instantaneous retrieval of information afforded by the exam-room computers, some noted that computers make the visit process less personal. For example, a patient named Rosa complained about her previous physician who focused too much on the computer – the primary reason she switched to her current doctor:

“There's times when I've been in the exam-room where they hardly looked at me at all, they were basically looking at the computer screen the entire time and that kind of made me feel ... it just felt very impersonal. I didn't like that.” - Rosa

The exclusive viewing of micro-negotiation afforded a way for physicians to mutually engage in both communication and computer work, but the use of computers in this position may give patients a feeling of disengagement during the conversation process.

Collaborative Viewing with Patients

During medical visits, physicians often swung the computer screen to the patient's side, inviting patients to view their medical record along with the doctor. In our observations, this **collaborative viewing** by the physician and patient occurred mostly during the lecturing phase of the medical consultations. Most of the lecture involved explaining lab results, displaying x-ray and CT scans, and discussing fluctuations in disease management over long periods of

time. During the lecturing phase, direct eye contact and conversation became a secondary concern to joint-interaction with information shown on the computer screen. During this stage, physicians explained the meaning of the results through not only verbal instruction, but also gestures. These additional forms of communication via gestures and electronic display of images reinforced doctor's recommendations on how to improve and better manage patient health.



Figure 4: Example of Collaborative Viewing. Dr. Vu pushed the computer to the patient's side and invited the patient to check an abnormal lab result.

Showing the screen to patients is considered one of the most effective patient-centered care strategies during medical visits [5], and was highly recommended to all physicians during the “pathway to proficiency” training classes. Collaborative viewing was also highly regarded by patients during the interviews. Jacob, a patient interviewed in the study, told us:

Think about this: what if ... you've possibly had a brain tumor... so then what about if an MRI had been done, and the results came back to indicate negative – you don't have that. But you're still carrying the fear. So you go see your doc, and he's able to get that MRI right up on his screen. You see it in almost real-time. You can see the breathing, this, that ... but you know what? You can't see a tumor. So, you feel kind of uh ... relieved. - Jacob

For Jacob, viewing medical results on the computer screen may clarify confusion, simply because seeing it on the screen made it real.

Physicians also used collaborative viewing to teach patients how to interpret results. Many times we saw physicians tell patients while they pointed to the screen, “X-ray is completely clear. See this part, very clear.” The x-ray image on the screen served as evidence to confirm what was said by the physician. In addition, the image also provided patients a chance to see what “clear” meant in reading x-rays – an opportunity to gain exposure to the medical knowledge and to learn from the case discussion.

In contrast to the previous two examples where viewing medical images quelled fears and concerns, viewing abnormal readings on the computer screen could alert patients to serious conditions that need immediate attention. Patients would be more attentive to physician

recommendations if reinforced by abnormal images and lab results from their medical record.

Beyond reading lab results and learning new medical knowledge, collaborative viewing could even help patients participate in their own medical visits. One example we observed indicates how patients may begin taking a more active role when they are able to view their medications on the computer screen. Charlie, a patient with a long history of chronic diseases, needed to verify his medications with Dr. Vu. Because of the large number of medications prescribed in the past, Charlie had no idea what he was currently taking. Rather than going through the long process of naming each medication, Dr. Vu simply swung the screen to Charlie and asked him to point out the medications he was still taking. This example shows how collaborative viewing of the computer screen could invite patients to work together with doctors to validate information on the patient's medical record. Joint engagement in this collaborative work could enable patients to actively participate in their own medical visits.

Though most patients appreciate the collaborative viewing position, it is notable that this position does not facilitate medical communication like what was described earlier in the exclusive viewing position. In addition, what is shown on the screen is carefully selected by physicians, and is merely a snapshot of the patient's medical record. What is displayed on the screen does not encompass all notes or activities conducted during the medical visit.

Neutral Viewing

In addition to the previous two forms of micro-negotiations, we also uncovered a third mode of negotiation – **neutral viewing** – where a computer screen was optionally viewable by the patient. This neutral viewing coincides with the position described in previous literature [4, 10, 11] when the desktop is used in exam-rooms. However, in our study, this position frequently occurred at the end of medical visits when the doctors' primary activities were entering lab orders and medication prescriptions into the EMR system. We referred to this period of time as the ordering phase.



Figure 5: Example of Neutral Viewing. The patient can adjust his posture to see the screen if he chooses to.

In this neutral position, physicians usually sat at the patient's side with the computer screen facing the doctor. Patients were not able to see the screen activities directly,

but simple posture adjustments allowed the patient to view the computer screen (e.g. turning the head or body 45 degrees while sitting). As is shown in Figure 5, Dr. Vu is typing notes into the EMR. The patient, who sits in the chair, can read lines on the computer screen without much effort if he turns his body slightly to the right.

Neutral positions often involved intensive computer work with little conversation outside of one-sided think-aloud instructions to inform patients of orders being made, and small discussions with the patient when they had questions about what the doctor was ordering. As a result, neutral viewing required no eye contact between the physician and patient, except when medical questions were raised by the patient. In these instances, doctor-gaze switched from the computer screen to the patient to facilitate conversation.

In our observations, some patients preferred to sit in the chair instead of on the exam table, either due to preference or to physical movement limitations. Patients who sat in the chair indirectly forced physicians to keep neutral viewing for almost the entire visit [Figure 5], since this position made the possibility of exclusive viewing difficult. As indicated by Ronaldo – a patient we interviewed in the study, this neutral viewing often lead to patients peeking at the screen, trying to learn what the doctor was doing on the computer. In this case, during the entire medical visit:

“I am trying to see, I'm trying to figure out if you're doing something that has nothing to do with me ... I mean, I have internet at work so, you know, so sometimes you get an email and something pops up and you're interviewing a person but then the email says "urgent" so you kind of like click on the email and all of a sudden my attention is no longer to you and it's to the email.” - Ronaldo

Indeed, curiosity of what the doctor is doing is the driving motivation for patients trying to view the screen. Although most patients expressed little concern about what their physicians were doing behind the computer, some patients told us that they were “curious what's being typed” (quote from interviewee Curtis). Patient curiosity in seeing the computer screen may expose the doctor's entire behavior on the EMR to the patient, which is not favorable for physicians. For doctors, the concern is not about whether patients will see them checking email or searching the Internet. Not a single case in our observations involved physicians working on non-patient care work in the exam-room. However, physicians were often concerned about exposing their computer activities completely in front of patients, especially those who considered themselves “non-technology savvy.” For example, a young physician tried to enter a common medication into the system, but the seemingly easy task took him almost 20 seconds. At that time, the computer was in neutral position and optionally viewable by the patient. Even though she was unsure whether the patient witnessed her awkward computer activities, Dr. Sung complained afterwards:

“The new medical assistant set-up the computer using her job code, and somehow the medications are under a different order [sigh]. It took me that long to find it. He [the patient] must have thought that I don’t know which one I should prescribe.”

– Dr. Sung

When medicine is practiced through computers, technological proficiency and medical knowledge may not be easily distinguished. Such was the case in the previous example. Physicians’ fear of technological inadequacy surrounds this scenario, such that computer inefficiency implies lack of medical expertise to the patient, potentially resulting in the doctor’s loss of control and authority in the exam-room. For this reason, patient exposure to doctors’ computer-reliant work activities can make physicians nervous, making this situation an area of caution and concern for medical practitioners. It is also worth noting that this situation is not a problem during the collaborative viewing position since doctors are only inviting patients to view their lab results or medication, instead of incomplete working notes and potentially subjective information typed in during medical interviews.

DISCUSSION

What has been suggested in our study is that each mode of micro-negotiation is often associated with one part of the medical visit, and each mode serves different goals. How to negotiate computer use in the exam-room is largely dependent on the activities carried out and the belief that there is no single best-fit spatial display for the entire medical visit.

Exclusive viewing typically occurs at the beginning of a medical consultation when intensive conversations are carried out regarding patients’ illnesses. The doctor’s goal is to understand what troubles the patient, while it is the patient’s goal to convey the sickness’ symptoms as clearly as possible. Exclusive viewing position supports both of these goals by allowing the doctor to record notes and conduct conversations simultaneously.

Collaborative viewing is usually intended for the middle of a medical visit when the doctor hopes to educate the patient on how to manage symptoms and how to halt further progression of a disease. Patients have similar aims in wanting to become healthy – a direct result of understanding a disease and knowing how to treat it. To no surprise, this position supports both of these goals by making the EMR a “common information space” where doctors and patients can converse about the disease through verbal instructions and gesturing at the screen [2, 14].

Neutral viewing often occurs at the end of a medical consultation when doctors engage in ordering work on the EMR system. At this stage, physicians’ focus is primarily on interacting with the computer, since the doctor’s goal at this point is to respond to their assessments via prescription and lab orders. Neutral viewing allows physicians to focus

on computer work while enabling patients to view the computer screen if they choose to.

Tensions in Exam-Room Computer Usages

The use of computers may also cause tension in negotiating human contact and screen-sharing during medical visits. Detailed analysis of these issues provided in this section may lead us to consider new modes of micro-negotiation that could potentially alleviate these tensions.

Tension in Negotiating Human Contacts

Previous literature [10, 11], as well as the findings from our current study, both indicate that the co-existence of computers in face-to-face medical consultation might create tension regarding human contact negotiation. Doctors must engage in note-taking and record-checking from time to time despite patient preference to have constant human contact. In our study, the primary reason for physicians to negotiate computer positioning was to make frequent switches in eye contact from computer to patient. This behavior is necessary in the exam-room, since constant viewing of the computer screen was not favorable for patients, nor was the drastic postures changes desired by doctors. No doubt that using computers during face-to-face consultations will result in less human contact between two collocated persons, such as the case in [18]. However, it is notable that the use of paper records also involved moments where the physician redirected attention (and gaze, likewise) away from the patient and to the paper documents. Nevertheless, using paper records in the exam-room appeared to be less disruptive in comparison to computer systems. This may be partially due to the size, activity, and monitor-direction of exam-room computers.

First, using computers such as the COWs inevitably extends the spatial proximity between patients and doctors. Prior to use of exam-room computers, typical exam-room conduct between a physician and a patient usually occurred at less than a meter’s distance apart. According to Hall [6], this distance situates the physician and the patient within each other’s personal space during conversations. In contrast, the size of COWs is similar to desktop computers. Situating the COW in the middle of this two-way conversation forces the doctor to reside further away from the patient. Consequently, the doctor is now at the outer periphery of the patient’s personal space, and many times, even as far as the patient’s social circle. This extended distance caused by computer placement can certainly contribute to the impersonal feeling, since communication and connection is improved when two parties are spatially closer.

Secondly, the computer layout may act as a physical barrier between patients and physicians, creating a literal disconnect in human contact. Looking back to paper record usage, physicians looked to paper records placed on their arms during conversations, but this behavior seldom created feelings of disengagement. This was most likely due to the small size of paper records, making them less of a physical

barrier. In addition, patients were able to maintain a consistent gaze with the doctor even as they were looking down at the paper record. As a result, the behavior of looking up and down during medical visits was perceived as natural. In contrast to paper, computers physically block human contact as physicians engage in documentation work behind the monitor. Thus, the advantages of paper in negotiating human contact become clear.

Tension in Negotiating Screen-Sharing

In addition, findings from our study reveal a tension in negotiating screen-sharing during medical visits. Our analysis shows that though it is desired by most patients, viewing activities on the physician's screen for the entire medical visit may not be appropriate or favored by the physicians who work on the EMR. As evident in our study, sharing certain medical information on the EMR with patients may change the exam-room dynamics and provide patients a sense of participation. For instance, the collaborative viewing mode is carefully designed to transform patients from passive listeners to active participants during medical visits. In contrast, not being able to view the computer screen made many patients suspicious of what doctors were doing behind the monitors.

Nevertheless, the problem of screen-sharing is deeply rooted in the nature of EMR system usages in the exam-room, as well as the medical record drafting process. Though desired by most patients, not all details of medical records are sharable. Medical records stored in the EMR system not only contain patients' factual information such as diagnosis and lab results, but also large amounts of professional messages and notes that may include subjective information and unconfirmed hypotheses. When physicians check these records in the exam-room, they are able to see other medical professionals' assessments and opinions in their progress notes stored in the EMR. This information, however, may not be appropriate for patients to read, since unconfirmed diagnoses or subjective information may lead to panic and result in distrust among patients, especially for those who have severe diseases. In addition, the notes typed in the exam-room may be incomplete or inconclusive at that moment. As we saw in our observations, many of the notes were pieces of information captured in the conversation for the sake of generating complete and conclusive notes after the visit. These working-notes are strictly used by doctors to reconstruct the medical scenarios later on, and as a result may be meaningless or even misleading for patients to view in the exam-room.

Interestingly, we found that patient desires for viewing screens may not be grounded in trying to read the medical record line-by-line. Instead, many of them expressed that they were just curious to know what their doctors were doing behind the monitors, or worried that physicians were disengaged during the conversations. This feeling of curiosity and disengagement may be less commonly seen

during paper record usages. Seeing physicians write on paper records reassures patients that what their doctors are doing is indeed related to their medical visits. This shows that despite a desire to have more transparency during the medical consultation process, patients may not need to read what is typed behind the monitor.

Managing Exam-room Behaviors via Micro-Negotiations

Micro-negotiation activities are originally deployed to maintain eye contact and engage patients in the medical visit. Surprisingly, we found it is also used to enhance physician control over the medical interview process – a consequence that was not envisioned when the system was first introduced. These unintended uses of exam-room computers show how technology is appropriated to facilitate work practice in the exam-room environment. Interestingly, these behaviors are a direct result of the size and display issues that created the aforementioned tensions.

Protecting Screen Activities

As noted earlier, viewing screens in the exam-room are beyond simply sharing patient medical records; it also involves exposing physicians' entire computer activities to patients. Indeed, these activities displayed on the computer screen may not be appropriate for patients, since they include both subjective information and other professional behind-the-scene messages. As a result, physicians in our study sometimes take advantage of the size and direction of the display to protect their screen activities from being seen by patients. For example, physicians often use the exclusive viewing position to keep away private notes that are especially preliminary during the early part of the examination.

More interestingly, we found exam-room computers also serve as a physical facilitator in maintaining physicians' authorities in front of patients, especially when computer skills constitute part of the professional image of qualified physicians [15]. For that matter, this unintended use was commonly employed among physicians who considered themselves “non-technology savvy,” like new EMR adopters or older physicians. Such was the case with Dr. Sung, when she was afraid that lack of technological proficiency would be mistaken as lack of medical expertise, since medical expertise and computer skills are now reflected through computer-based activities demonstrated on the screen. Hiding the screen means patients can not see these computer activities, in turn preserving physician authority while in front of them.

Thus, the bulky size of exam-room computers that were deemed as physical barriers by patients turned into physical protectors for physicians, allowing increased confidence by hiding unskilled computer usages in the exam-room.

Controlling Timing of Medical Visits

Similar to a previous study that discovered how physicians used computers as a way to “time-out” during the

consultation [1], time-control mechanisms were also found in our study. Micro-negotiation of computer-use allows physicians to better manage the length and content of patient conversations. The need for this sort of time management resides in a doctor's full appointment-schedule for the entire day combined with a 20-minute time restriction on medical consultations. Prolonged patient interviews could result in a delayed schedule for later visits. Therefore, controlling the time of a visit by only addressing the chief complaint is critical for physicians to maintain appointment punctuality and manageable schedules. Then again, many patients we observed were eager to share their socio-emotional feelings and as many as seven to eight different illnesses with their primary care physician during a single visit. Doing so resulted in an unnecessarily long medical visit with lacking focus on more important topics.

In these situations, micro-negotiation of computer-use becomes a strategy for physicians to better control the pace of visits, since telling patients directly would hurt their feelings and their relationships with doctors. Many times we saw physicians turning screens over to patients, as a sign of inviting them to view lab results, and as a mechanism for preventing over-elaboration on unnecessary information. Physicians would also actively change topics through inquiry of symptom-driven issues they noticed in the EMR system, such as "*I saw you had an ER visit last week,*" or "*what about your last visit with Dr. Choi.*" Furthermore, when too many unrelated issues were discussed in the exam-room, typing-notes behind the scenes instead of nodding to patients became an unobtrusive way for physicians to control the timing. This practice benefitted physicians, since more notes completed in the exam-room meant less documentation work in the office after the visit.

As clearly indicated in this section, the size and display-direction of exam-room computers creates both tensions and unexpected benefits in exam-room consultations. This dichotomy suggests that we consider new modes of negotiations that could alleviate the tensions while affording the advantages identified in the current study.

DESIGNING FOR NEW FORMS OF NEGOTIATIONS

In this section, we first revisit the concept of "micro-mobility" proposed by Luff and Health more than a decade ago [9]. With respect to the advantages of micro-mobility, paper records serve as a facilitator in the conversation process, since it can be held, placed, and reoriented in multiple positions and angles. Micro-mobility can also be used to foster joint gestures and remarks in the exam-room. In contrast, the general desktop computer can seldom be micro-moved given the older pretext that they are large and immobile. Contrary to previous literature that explores the immobile use of portable systems in medical settings [17], COWs at our field site allowed relatively fixed but micro-scale movements that we referred to as "micro-negotiations." Doctors negotiate the positions of the computers to facilitate face-to-face communication, note-

taking, patient lecturing, and other exam-room activities. These activities happen in various stages of a medical visit and are associated with different modes of computer-use. For example, showing the screen to patients is beneficial during the lecturing phase of a medical visit, but not when incomplete working notes are displayed on the screen. Thus, the findings suggest that the previously-touted solutions for exam-room computing, such as using surface computing techniques to project entire screen activities to patients during medical visits [18], may not be appropriate for the varied phases, contents, and activities associated with a medical visit. Instead, there is a need for new forms of negotiation that support these exam-room dynamics, especially for the purpose of ensuring sufficient human-contact and information-transparency (when appropriate) during patient-provider interactions.

In particular, parallels can be made between computer micro-negotiations and paper-chart micro-mobility, in the sense that both mediums can be reoriented to different angles to allow doctors to show records while maintaining a sense of transparency and human-contact. A comparison of paper- and computer-use indicates that not only could exam-room computers be turned at different directions; the screens that typically block human contact could also be negotiated to different angles to alleviate the tensions observed in our study. For example: pushing the screen lower in exclusive viewing position could still allow physicians to engage in computer work while simultaneously facilitating constant, uninhibited contact with patients. Similarly, moving the screen up could allow doctors continued concealment of sensitive information or protection of behaviors without having to tilt the monitor left or right. In addition, future system designs could empower doctors to project to patients the screen – or even a selection of windows – during medical visits.

These potential new modes of negotiations differ from the three positions discussed in this paper, and could be layered atop pre-existing negotiations adopted by the physicians at our field site. What we suggest here is by no means the only new negotiation modes to be adopted. Rather, it is an implication leading to the design of other innovative forms of negotiation that could address concerns uncovered in our study, such as conversation, learning, human-contact, emotion, transparency, privacy, and authority. These factors influence the interaction between patients and physicians, and ultimately challenge the use of computers in the exam-room. Exploring novel interactional modes to support effective exam-room computing will prove to be equally beneficial to both medical practices concerned with patient wellness, and the HCI research community as a whole.

CONCLUSION

In this work, we examined the use of COWs in the context of patient-physician interactions in the exam-room. We found that exam-room computers are negotiated in three unique positions to serve different purposes in a single

medical visit: exclusive viewing, collaborative viewing, and neutral viewing modes. The practice of micro-negotiations lead to positive means of managing eye contact while engaging patients to take more active roles in the care process. In addition, micro-negotiations are appropriated as a tool for physicians to control the timing of medical visits, as well as to protect their screen activities from patients. Nevertheless, the co-existence of computers in the exam-room also has the reverse effect of drawing physician attention away from the patient, making the examination less personal and increasing patient curiosity of what the doctor is doing behind the screen. The findings of this study call for new forms of computer-based micro-negotiations to leverage issues of communication, patient education, human-contact, emotion, transparency, privacy, and authority during the patient-provider interaction process.

ACKNOWLEDGMENTS

We thank Drs. John Mattison, Yang Huang, John Yang, Ming Y. Chen, Michael Y. Lee at Kaiser Permanente and the clinicians, staff, and patients participated in our study. Thanks to our anonymous reviewers and ACs for their constructive comments.

REFERENCES

1. Als, A.B.. The desk-top computer as a magic box: patterns of behaviour connected with the desk-top computer; GPs' and patients' perceptions. *Family Practice* 14, 1 (1997), 17-23.
2. Bannon, L., Bødker, S. Constructing common information spaces. In *Proceedings of ECSCW 1997*, Kluwer Academic Publishers, (1997), 81-96.
3. Bekker, M.M., Olson, J.S., Olson, G.M. Analysis of gestures in face-to-face design teams provides guidance for how to use groupware in design. In *Proceedings of the Symposium on Designing Interactive Systems (DIS) 1995*, ACM Press (1995), 157-166.
4. Bensing, J.M., Roter, D.L., Hulsman, R.L. Communication patterns of primary care physicians in the United States and the Netherlands. *Journal of General Internal Medicine* 18, 5 (2003), 335–342.
5. Frankel, R., Altschuler, A., George, S., Kinsman, J., Jimison, H., Robertson, N.R., Hsu, J. Effects of exam-room computing on clinician-patient communication: a longitudinal qualitative study. *Journal of General Internal Medicine* 20, 8 (2005) 677-682.
6. Hall, E. *The Hidden Dimension*. Anchor Books, New York, NY, USA, 1966.
7. Heath, C., Luff, P. Documents and professional practice: “bad” organizational reasons for “good” clinical records. In *Proceedings of CSCW 1996*, ACM Press (1996), 354 – 363.
8. Glaser, B. G. and Strauss, A. L. 1967. The discovery of grounded theory: Strategies for qualitative research. Aldine de Gruyter. , Hawthorne, NY.
9. Luff, P., Heath, C. Mobility in Collaboration. In *Proceedings of CSCW 1998*, ACM Press (1998), 305-314.
10. Makoul, G., Curry, R.H., Tang, P.C. The use of electronic medical records: communication patterns in outpatient encounters. *Journal of the American Medical Informatics Association* 8, 6 (2001), 610-615.
11. Margalit, R.S., Roter, D., Dunevant, M.A., Larson, S., Reis, S. Electronic medical record use and physician-patient communication: an observational study of Israeli primary care encounters. *Patient Education and Counseling* 61, 1 (2006), 134-134.
12. Morris, M.R., Huang, A., Paepcke, A., Winograd, T. Cooperative gestures: Multi-user gestural interactions for co-located groupware. In *Proceedings of CHI 2006*, ACM Press (2006) 1201-1210.
13. Nardi, B. A. Beyond Bandwidth: Dimensions of Connection in Interpersonal Communication. *Computer Supported Cooperative Work* 14, 2 (2005) 91-130.
14. Reddy, M., Dourish, P., and Pratt, W. Coordinating Heterogeneous Work: Information and Representation in Medical Care. In *Proceedings of ECSCW 2001*, ACM Press (2001), 239-258.
15. Ridsdale, L., Hudd, S. Computers in the consultation: the patient's view. *The British Journal of General Practice* 44, 385 (1999), 367-369.
16. Roter, D.L., Frankel, R.M., Hall, J.A., Sluyter, D. The expression of emotion through nonverbal behavior in medical visits. Mechanisms and outcomes. *Journal of General Internal Medicine* 21, 1 (2006), 28-34.
17. Tang, C. & Carpendale, S. Evaluating the Deployment of a Mobile Technology in a Hospital Ward. In *Proceedings of CSCW 2008*, ACM Press (2008), 205-214.
18. Unruh, K.T., Skeels, M., Civan-Hartzler, A., Pratt, W. Transforming Clinic Environments into Information Workspaces for Patients. In *Proceedings of CHI 2010*, ACM Press (2010), 183-192.
19. Vertegaal, R., Weevers, I., Sohn, C., Cheung, C. GAZE-2: conveying eye contact in group video conferencing using eye-controlled camera direction. In *Proceedings of CHI 2003*, ACM Press (2003), 521-528.
20. Wilcox, L., Morris, D., Tan, D., Gatewood, J. Designing patient-centric information displays for hospitals. In *Proceedings of CHI 2010*, ACM Press (2010), 2123-2132.
21. Yamashita N., Hirata K., Aoyagi S., Kuzuoka H., Harada Y. Impact of Seating Positions on Group Video Communication. In *Proceedings of CSCW 2008*, ACM Press (2008), 177-186.