"So that's the ureter." The Informal Logic of Discovering Work

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Introduction

Modern surgery is in certain ways a living contradiction. On the one hand, it is a specialized enclave, a place removed where highly-honed skills and complex technologies are applied to accomplish seemingly miraculous feats of reconstruction and healing. On the other, it is what might be conceived of as a "shop floor" in the sense developed by Garfinkel (2004)—that is, a mundane workplace in which established procedures are repeatedly and routinely carried out. As with all shop floors there is a continuing concern with standardization with a view toward improving the consistency of the end product. As a strictly practical matter, however, every body entered is a *terra incognita*, a place where the familiar may be difficult to recognize and where the unexpected is sometimes to be found. In this way, the practical work of surgery resists standardization. Surgeries, for this reason, inevitably involve discovery and, hence, the potential relevance of our current study to a special issue on the work of discovering.

Norwood Russell Hanson entitled his last paper "An Anatomy of Discovery" (1967)—an ironic selection given our current project and choice of materials![1] He presents Mallory's identification of a new kind of beetle as a paradigm case of making a discovery:

> "[H]e slips and kicks loose a rock under which there languished a purple bug, with a golden dollar sign on its backside. Mallory notices the heretofore undetected beast. Mallory, then, surely discovered that 'dollar-sign' bug. His must have been a discovery, without question." (p. 325)

Using an encyclopedia as his primary source, Hanson notes that the range of things discovered is quite broad indeed, e.g., the planet Uranus, radioactivity, that a mathematical proof proposed by Poincaré contained a flaw, Millikan's discovery of a positron (which he took to be a proton). Hanson was centrally concerned with how we describe such diverse matters, with, what he termed "the informal logic of discovery talk" (p. 324). He argued that, depending on the nature of the matter discovered, different kinds of "discovery locution" (p. 330) may be needed.

A different approach to investigating discovery talk, and discovering work, was employed by Garfinkel, Lynch and Livingston (1981). Instead of inquiring into how we talk about discoveries after the fact, Garfinkel et al. examined how a particular discovery was brought about. They analyzed an audio recording produced at an astronomical observatory on the night of the first sighting of an optical pulsar. Captured on the tape are the voices of the two astrophysicists, Cocke and Disney, credited with making the discovery. We hear them discussing what they see on an oscilloscope

[1] We thank one of our anonymous reviewers for bringing this article to our attention.

screen as they conducted their carefully-calibrated, data-collecting "runs" on the night sky. Garfinkel et al. reported:

> "After Disney's announcement of the 'pulse', he and Cocke mention developingly-observed 'properties', such as 'it's right bang in the middle of the period'; 'it really looks like something (from here) at the moment'; 'it's growing too'; and 'it's growing up the side a bit too'. The optically-discovered pulsar is referenced as a locally embedded phenomenon whose 'properties' are come upon in a developing sequence of locally pointed noticings." (1981:149)

What Cocke and Disney saw on the oscilloscope screen came to be known in a new way. It became a referable matter through their talk and embodied actions.

The materials upon which Garfinkel et al. conducted their study had certain limitations, the most crucial being that while they were able to *hear* Cocke and Disney as they made their observations, they could not *see* them. This meant that the subjects' positioning with respect to the equipment and each other, their points, gestures, and other visible actions were unavailable for study. Clearly, discovery and discovering work are not exclusively linguistic phenomena.[2]

Using video-based materials, Roschelle (1992) was able to study some of these embodied aspects of discovering work. He documented how two high school students, Carol and Dana, came to understand what they were seeing and doing in a new way. The students were conducting simulated ballistics experiments at the computer. By Roschelle's reckoning, their newly developed understanding bore a resemblance to a physicist's conceptualization of acceleration.[3]

Unlike Cocke and Disney, Dana and Carol did not publish a paper proclaiming their discovery. Acceleration and velocity are, after all, pretty well-established phenomena. It was a discovery for them, however, and one that was produced as novel within *their* shared experience. Roschelle's account goes beyond analyzing the participants' talk to include an analysis of what was available to them on the computer screen and their gestures and other visual conduct.[4]

Hanson's chosen example, the uncovering of the 'dollar-sign' bug, was a little unusual. As we see in the examples provided by Garfinkel et al. and Roschelle, discoveries are often preceded by careful planning and preparation and are also often brought about as collaborative efforts. In the present study we seek to better understand how discoveries are produced within a context of joint activity. We are centrally interested in the resources employed by participants to produce a thing or process or relationship as a discovery. We take this to be part and parcel of the work of discovery. Our goal is to give an account of the "informal logic" of these practices and we will endeavor to do so using materials gathered during the

[2] This is not intended as a criticism of the Garfinkel et al. study. They did what they could with the materials that were available to them, but made very clear that their orientation was to the participants' "vulgar competencies"—that is, "*embodied practices* whose efficacy has achieved an ordinariness and 'equipmental transparency' that allows no call for credentials" (p. 140, n. 26; emphasis added).

[3] Roschelle actually describes the students' achievement in terms of "collaborative conceptual change" rather than discovery. See Koschmann and Zemel (2009) and Greiffenhagen and Sherman (2008) for further discussion of the relationship between conceptual change and discovery.

[4] Also see Koschmann and Zemel (2009) which revisited the Roschelle materials.

performance of a particular surgery conducted at a teaching hospital.

Data

"Ureter, ureter, where's the ureter?"

In the analysis to be presented here we focus chiefly on the interaction between two members of a surgical team—ATT and RES[5].

Also present at the table are a medical student (CLK) and a scrub nurse, but it is the interaction between ATT and RES that primarily draws our attention. RES is a surgeon-in-training, a "resident," and is functioning as the operating surgeon on this case.

ATT, though operating as the first assistant, is an attending surgeon legally responsible for ensuring that the operation is carried out safely. So, the lines of authority and responsibility are complex. Given these complexities and the highly consequential nature of the work, it is a perspicuous setting for studying how matters discovered are managed by the surgical team.

The procedure being performed was an exploratory sigmoidectomy. A sigmoidectomy involves excising a portion of the large intestine and then reconnecting the ends of the divided colon. Hours are devoted to "mobilizing" that part of bowel to be removed. This requires fastidious dissection. Careful decisions must be made about where and what to cut and the operating surgeons must exercise great diligence not to injure viable tissue.

[5] The recording comes from the SIU Surgical Education Video Corpus. Further information with regard to this corpus can be found on the website of the Collaboration and Learning Laboratory: http://www.siumed.edu/call/index.html

At one point in the surgery ATT advises RES, "But you know when you don't know where you are you wanna stay right on the colon" [00:51:02:24]. Their work, at every turn, entails judgments concerning what must be saved and what might be discarded. Some structures encountered along the way may have names (ATT: "(So) that's (0.5) that's the iliacs in there right" [01:06:01:08]) while others do not (ATT: "I don't think that's anything is it?" [00:50:46:20]). As the work proceeds, what is available to be seen within the operative site is constantly changing.

To help coordinate their collective understanding of what they are seeing, periodic inventories are conducted in which relevant landmarks are reviewed (e.g., ATT: "So where are we ((RES's given name))? (0.7) Let's let's look at the left side" [00:40:33:10]). Certain structures, though not a part of the procedure per se, must be positively identified. The ureter is one of these.

Things that might be ureters

Early in the procedure ATT remarks, "So the question is where is the ureter" [00:22:45:04]. Ordinarily, there are two such vessels each connecting a kidney to the bladder. The ureter of interest here is the one that dwells behind the sigmoid colon on the left side of the abdomen. Failure to positively identify it might result in an undetected injury to the structure. As ATT explained, "the big problem comes when the injury is not identified and then the pick up of the injury is late because then the prognosis is significantly worse in terms of higher incidence of loss of the kidney on that side" [00:27:07:07].

This motivates her query here, "Ureter, ureter, where is the ureter?" [00:28:57:15].

Our analysis focuses on how this anatomical structure comes to be discovered for the purposes of this particular case. The procedure is a long one, but the search for the ureter plays out in the first hour. Theoretically one could locate the ureters by simply finding their points of connection to the bladder, the bladder being large and difficult to miss, and then following each back to its respective kidney. In practice, however, this is never done. Surgeons try to avoid exposing the structure itself, preferring to surmise its course while still leaving its protective cover of connective tissue and vasculature intact.

In the interaction that follows, participants produce their activity as a search by referencing its target and articulating its attributes (i.e., appearance, feel, location). ATT asserts, "The ureter's gotta be here. It lives in here somewhere. I think its gonna be right in here"[00:28:17:15].

Her comment does several things. It orients the search. It also raises a caution to proceed carefully since they are operating in the vicinity of the object of concern. Finally, it makes the finding of the ureter relevant *now*, not only in the sense that it is currently findable, but also with the sense that its identification is a priority, a matter of some urgency. As the search progresses, ATT articulates the requirements for taking something to be a ureter. It is a kind of categorizing work. Candidates to the category "ureter" must exhibit certain visual and tactile properties in terms of color, shape, and orientation. The attending asks, "Is that a vessel?" [00:29:23:08].

Her question brings into play the definitional requirement that ureters are a subset of the broader class of vessels. It offers a candidate for consideration, making relevant a confirmation on the part of RES, while simultaneously cautioning all parties to treat it with care. After a few moments, RES replies, "Feels like a tendon" [00:29:54:05], countering ATT's prior characterization.

As the exploratory dissection progresses, the sorting continues. Later, ATT asserts, "That's that's a vessel. That's an artery" [00:30:48:01]. Ureters are vessels, but not all vessels are necessarily ureters.

"So that's the ureter."

Approximately one-half hour into the procedure, a series of exchanges occur that serve as the centerpiece of our analysis. ATT leads the way using a pair of forceps ("pick ups") in her left hand and a right-angled clamp in the other. The tools are used in concert—the forceps to grasp, prod, and pull; the clamp to slide under and separate thin layers of tissue. The clamp also marks places where cutting is required. In this way, dissection is performed as a collaborative effort.

She slides the clamp under a sheet of tissue and opens the jaws, simultaneously stretching the tissue taut and isolating it from the layers below. She then directs the resident to cut it, which he does using an electric cautery instrument. This 2-person maneuver is repeated twice. The exchange was transcribed and is presented in Excerpt 1.[6]

ATT's phrasing here [0:31:51:05] is interesting. In other places she uses different constructions to direct a cutting (ATT: "Get that." [0:03:15:07], ATT: "Take that." [0:04:10:08], ATT: "That there"

[6] Our transcription conventions are based on Jefferson's (2004) pioneering work in studying conversational structure. Descriptions of visually detected action are enclosed in double parenthesis; spoken interaction is presented in bold-face.

[0:34:33:15]) or the coordination might be done without any verbal prompting at all (Koschmann et al., 2005). "Open that up" not only directs an action on RES's part, but also announces that they are moving into a new space. Surgeons speak of *dissection planes*, successive vistas that emerge over the course of an operative procedure. Using the forceps and the angled-clamp, ATT stretches open the recently cut layer of tissue producing a window into the plane that lies behind. After a few moments of study, she addresses a question to the room [0:32:14:28].

> "they are not asked, and are not understood as ordinary information-seeking questions but as making some kind of claim, or assertion, an assertion of the opposite polarity of the question." (p. 2)

The attending's question does not seem to function in exactly this way. It does not seem to deny that the demonstrated object is the ureter. Rather, it makes the demonstrated object into a mentionable, an "it" that the surgeons can talk about as they continue their inspection. It also makes relevant consideration of the possibility that the

Excerpt 1 (#03-013)

00:31:51:05	ATT:	⌈**Open that up.**
00:31:51:05	ATT:	⌊((*slides right-angled clamp beneath tissue and opens jaws*))
00:31:54:07	RES:	((*bisects tissue using cautery tool*))
00:32:02:25	ATT:	((*slides right-angled clamp beneath tissue and opens jaws*))
00:32:06:01	RES:	((*bisects tissue using cautery tool*))
00:32:06:14	ATT:	**°(a'right)°**
00:32:11:03	ATT:	((*spreads tissue open with clamp and forceps*))
00:32:14:28	ATT:	**Is that it right there?**

Her use of prospective indexicals ("that" and "it") and the fact that the attending's question does not appear to be addressed to anyone in particular might suggest that it is designed to be heard as rhetorical.

According to Koshik (2005) such questions "sometimes get answers" but

object could be the ureter without prematurely taking a position on that identification. It operates, in short, as "a proposal for a possible discovery" (Koschmann and Zemel, 2009:231). It is also functions as an ostensive demonstration. This action is presented in Excerpt 2.

Excerpt 2 (#03-013)

00:32:14:28 ATT: **Is that it ⌈right there?**
00:32:15:11 ATT: ⌊((*demonstrates area of interest using the tip of the forceps*))
00:32:18:04 ATT: **Pick ups** (0.7) ⌈**pick ups**
00:32:19:02 RES: ⌊((*opens window in tissue layer using forefinger of right hand*))
00:32:21:14 ATT: ((*receives second pair of forceps from scrub nurse*))
00:32:21:01 RES: **Looks like it**

Hindmarsh and Heath (2000) described how the timing of a deictic element such as *here* or *there* "segments" an accompanying gesture and displays "just the moment at which it is sequentially relevant" (p. 1864). Here ATT's demonstration coincides with the enunciation of the intensifier "right" (see Fig. 1).[7] The gesture, a waving of the tips of the forceps over the area of interest, reveals some of the practical problems associated with seeing in the OR.

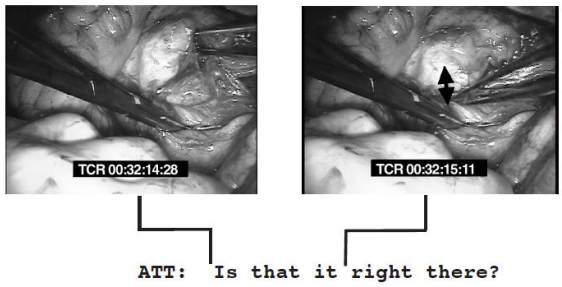

Fig. 1 The attending's demonstration of the candidate structure

The forceps now being employed as a prosthetic pointing device had previously been retracting the recently cut tissue flap. When she releases that bit of tissue to perform the demonstration, it quickly returns to its original place, again obscuring the view of the plane behind. Her gesture, therefore, marks not the object of interest, but rather where the object of interest had *been* viewable just a moment before (see the second panel in Fig. 1). After completing the gesture, she again retracts the tissue flap, not only restoring the earlier view, but also, in doing it at just this moment, performing a second demonstration of where the attention of the team should be directed.

ATT now withdraws the angled-clamp and sets it aside in preparation to receive a second pair of forceps ("pick ups") as shown in Fig. 2. As described in Koschmann et al. (2011), the changing of surgical instruments often marks transitions into new courses of action.[8]

[7] See Koschmann et al. (2011:536) for further discussion of the manifold uses of "right" in the OR.

[8] The passing of tools in the OR is a topic of interest in its own right, but not one that we will be developing here. See Sanchez Svensson et al. (2007) and Koschmann et al. (2012) for further discussion.

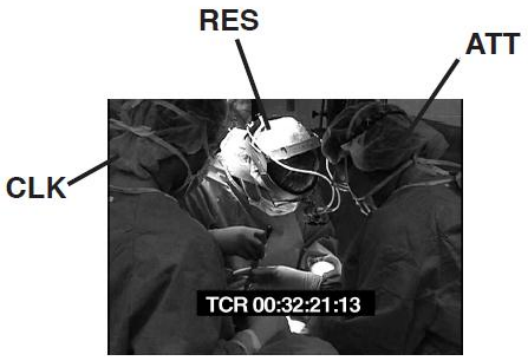

Fig. 2 The attending receives the second pair of forceps

In this case, the angled-clamp, like the forceps held in the attending's left hand, had played a role in spreading tissue to create a view and, when removed, causes that view to be once again lost. The restored forceps held in ATT's left, however, remain in place throughout the tool exchange serving as a place holder within the surgical field. RES, who up until now has been standing by with the cautery tool in his right hand, now sets that tool aside [0:32:17:15] and uses the index finger of that hand to re-open the tissue layer. He leans forward to inspect the region and proffers an opinion [0:32:21:01]. It builds on ATT's prior proposal, but falls short of fully affirming it (i.e., has the visual appearance of a ureter, but still may not be the ureter).

We see an incrementally growing level of commitment to the identification from ATT's initial proposal, to RES's proffered

Excerpt 3 (#03-013)

00:32:21:01 RES: **Looks like it**

00:32:21:22 ATT: **I think ↓that's ⌈it**

00:32:22:08 RES: ⌊((*sweeps forefinger down across area of interest*))

00:32:23:23 ATT: **Don't move**

00:32:24:16 ATT: ((*gently pinches tissue with forceps*))

00:32:26:16 ATT: **God I thought I saw it move**

00:32:27:22 ATT: ((*stretches window open using the two forceps*))

00:32:28:29 RES: **You can ⌈see it (moving)**

00:32:29:10 ATT: ⌊**There it goes ⌈right the:re. =**

00:32:29:24 ATT: ⌊((*demonstrates the orientation of the of the structure using the forceps in her right hand*))

opinion, and now to ATT's assertion that she "thinks" it might be so [0:32:21:22]. Note that even this falls short of an unconditional endorsement, however. This construction allows her to express a higher degree of certainty than that expressed by the resident, but to do so without inhibiting further inquiry into the question. The hypothesis must still be put to the test (see Excerpt 3).

RES performs the simplest test available—he touches the object to see if it has the feel of a ureter.

ATT undertakes a slightly more elaborate experiment. She instructs RES, who throughout has been performing gross retraction with his left hand, to hold very still [0:32:23:25]. She then uses the newly arrived second forceps to gently pinch the object in question (see Fig 3). Ureters are smooth muscle and will, if irritated, twitch. After pinching it and watching intently for 2 seconds, she announces, "God I thought I saw it move" [0:32:26:16].

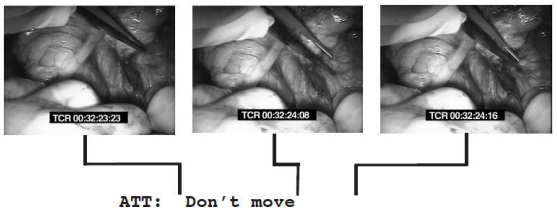

Fig. 3 The 'pinch' of the prospective ureter

Again, her announcement suggests a positive result, but does so in a way that does not preclude further investigation. She repositions the two pairs of forceps to provide a better window on the object in question. RES leans further forward to improve his view.[9] RES and, shortly thereafter, ATT provide confirmation of the movement. ATT's gesture [0:32:29:24] is again coordinated with the intensifier "right" in "There it goes right there" (see Fig. 4). Unlike her prior demonstration displayed in Fig. 1, here her double swipe of the forceps tips follows the orientation of the putative structure.

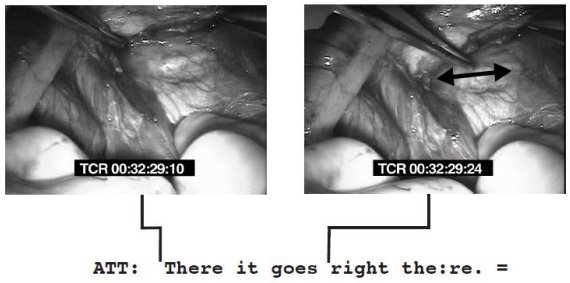

Fig. 4 The attending highlights the movement of the ureter

That would appear to settle the matter. A candidate structure has been proposed and its identity has been confirmed visually, haptically and through direct experimentation. But, there is still a bit more that needs to be done.

The proposed identification has been positively assessed, but the attending now performs a check to see if the performed demonstration was adequate for the least experienced member of the team, the medical student CLK (see Excerpt 4).

It is not enough for them to simply make a discovery; they also need to make instructably visible just *how* the discovery was accomplished.[10]

[9] Our view of the surgical site is provided by a camera attached to his headlamp (see Fig. 2). When RES brings his head closer, therefore, our view is improved as well.

[10] Bjelić (1992) observed that the phrase *discovering science*, as in "The Work of a Discovering Science Construed with Materials from the Optically Discovered Pulsar" (Garfinkel et al., 1981), is double-barreled. He writes, "not only do scientists discover 'facts', they discover the practical contingencies that make possible an observable, reportable, and teachable relation to those 'facts'" (p.

Excerpt 4 (#03-013)

00:32:30:10 ATT: = **>That's the ureter< did'ju see that move?**
(0.5) ((*CLK's given name*))
00:32:32:15 CLK: **(I) can see it on the screen better than I**
⌈**can**
00:32:35:02 ATT: ⌊>**Okay.**< **So that's the ureter.** (0.3) °**Good.**°

ATT asks CLK if he was able to verify the finding for himself. He replies that, though it was difficult to see from his position, he was able to appreciate the demonstration on a remote monitor connected to the camera on the resident's head [0:32:32:15]. This exchange represents an instructional post-expansion of the preceding assessment.

"That's" in the attending's, "So that's the ureter" [0:32:35:02] is ambiguous with regard to tense. If heard as a contraction of "that is", it would represent another ostensive demonstration, but if heard as "that was", it produces a different kind of demonstration.

The so-prefacing and the fact that there is no associated point would argue for the second reading. "So that's the ureter" marks an achievement achieved.

We find ourselves, therefore, at a critical transition where something that had previously been referenced *prospectively* as a possible ureter is now referenced *retrospectively* as a named structure. It has been taken up as a discussable matter.

Though the structure now seems to have been conclusively located, as we see in Excerpt 5, one further test is still conducted.

Excerpt 5 (#03-013)

00:32:35:02 ATT: >**Okay.**< **So that's the ureter.** (0.3)
⌈°**Good.**°
00:32:36:07 ATT: ⌊((*withdraws forceps in right hand in preparation for exchanging tools*))
00:32:37:03 RES: ((*rubs tip of finger over the identified structure and withdraws hand*))
00:32:38:05 ATT: **Awright hhhhhh we found the ureter**

221). Not only are they engaged in producing discoveries, therefore, they are simultaneously engaged in discovering the science in their own practical actions!

ATT's withdrawal of the second forceps [0:32:36:07] presents an opportunity for RES to briefly access the just-identified vessel. His left hand which has been visible on the bottom of the frame in Figs. 1, 3, and 4 continues to operate as a gross retractor, holding back heavier layers of muscle and other tissue from the area of work.

Without opening the rest of his hand, he now extends his index finger. Without comment, he carries out a tactile exploration of the now named object (see Fig. 5). Whether he does so as one final confirmation or whether the resident, as both a recipient of instruction from ATT and as a potential instructor for CLK, does so to demonstrate in his own way the instructability of discovery work as a practical achievement of surgical practice, we cannot say.

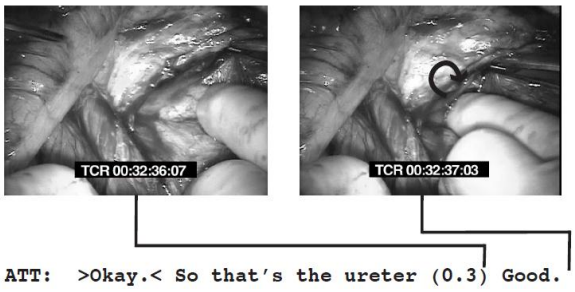

Fig. 5 The resident's tactile investigation of the putative ureter

The anatomical discovery becomes a discovery with the acceptance of the proposal for all present purposes. It is an achievement, but a defeasible one. We might call the object worked into relevance through the strip of interaction just examined, the ureter-for-the-purposes-of-*this*-procedure.[11] It is an object, but it is an *occasioned* object, in the same sense that scientific discoveries are "occasioned productions" (Koschmann and Zemel, 2009).

The Informal Logic of Discovering Work

Implicit to Hanson's treatment of the "discovery concept" is the requirement that discovery events are always, to borrow an expression from Garfinkel et al. (1981), "a first time through" (p. 134). Mallory's detection of a dollar-sign beetle was a discovery by virtue of the fact that the insect's existence had not been previously documented. Clearly, ATT and RES's identification of the ureter-for-the-purposes-of-*this*-procedure does not meet this standard.

Ureters have been a known structure to anatomists and surgeons for centuries. Furthermore, the participants have identified analogous vessels in previous cases many times (dozens for RES and hundreds for ATT). What is our warrant, then, for talking about their activity as an instance of "discovering work?" We observed and documented that the methods employed in identifying some thing as the ureter are recognizably similar to those employed elsewhere where we find participants engaged in the work of discovering something together.

In Garfinkel et al.'s (1981) classic account of the discovery of the optical pulsar, we have an initial noticing (D: "We've got a bleeding pulse here.") followed by what was described in Koschmann and Zemel (2009, p. 208) as "a proposal for a possible discovery" (i.e., C: "You don't suppose that's really it do you?").[12]

[11] See Koschmann, et al. (2011) for further discussion of how anatomical objects are provisionally produced in and through surgical procedures.

[12] See Appendix B of Koschmann and Zemel (2009) for full transcripts.

The proposal makes relevant some sort of analysis leading up to an "assessment" (Pomerantz, 1984), usually an affirmation or rejection. The proposal, its assessment, and the ultimate taking up of the proposed matter in subsequent action represent a process of change in referential practice within discovery. We will refer to this process as a *discovery sequence*. Not all sequences that assume this form are necessarily discovery sequences, but all of the discovery sequences that we have examined do appear to share this organization.

In the simplest possible case, this could be managed in a two-utterance exchange (e.g., A: "Could that be an x?", B: "I believe it could."), where the second turn constitutes both assessment and uptake.[13]

What happened with regard to Cocke and Disney's sighting of the optical pulsar, however, was considerably more elaborate. Following Cocke's initial proposal we find a discussion of the visual properties of the noticed "pulse" (D: "it's right bang in the middle of the period", D: "It's really building up"), planning for future steps (C: "we'll stop after (0.2) and take it out of phase and start over again after this run's over"), predictions of outcomes (C: "we expect two (.) a small pulse and a larger pulse"), and specifications of conditions for acceptance of the proposal, viz. the resolution of prospective indexicals (C: "I won't believe it until we get the second one and until (.) the thing has shifted someplace else"). Garfinkel et al. reported, "The pulsar was in hand between the 21st and 23rd Runs" (p. 136). During Run 22 Disney observes, "We'll have to figure out what this means now." (ibid.).

Though still not explicitly naming the pulse as evidence of a pulsar, his use of the temporal deictic *now* marks an important change in their activity, a transition from observation into the next stages of discovering work. His utterance, therefore, marks an important transition within their local system of reference. What had previously been "evidently vague" (Garfinkel et al., 1981:135), had acquired the status of an established fact, something that exists independently of their inquiry.

Atkinson and Delamont (1977) made a distinction between "hot discoveries," the outcomes of situated inquiries into questions for which no answer is available, and "cold discoveries," the findings of inquiries into settled matters reenacted for pedagogical purposes. Dana and Carol's discovery of acceleration in Roschelle's study would doubtlessly represent an example of "cold discovery" in Atkinson and Delamont's view.[14]

Yet, as documented in Koschmann and Zemel (2009), the organization of Dana and Carol's discovering work is observably

[13] Though the point will not be developed here, certain similarities can be seen between the organization of reference within discovery and E. Schegloff's (2007) description of conversational sequences built on simple adjacency pairs. Like conversational sequences, referential practice within discovery has a contingently-developed organization. Both build out from a base structure that can be extensively elaborated with pre-, insert- and post-expansions. A more conventional CA analysis of Carol's discovery proposal from the Roschelle materials can be found in Koschmann (forthcoming).

[14] It is interesting to note that the discovery of the ureter-for-the-purposes-of-*this*-procedure is neither "cold" nor "hot" by Atkinson and Delamont's distinction, or, perhaps more accurately, it is both. As we mentioned earlier, ureters are a well-established phenomenon. However, the identification of the structure in the surgical setting, though having a clear instructional component, it was not a mere teaching exercise—it had real consequences for the surgical outcome.

more complex, from an analytic point of view, than that of the optical pulsar or of the identification of the ureter described here. There are two discovery proposals, one produced by Carol, the other produced a couple of minutes later by Dana. Both are preceded by "pre-announcements" (Terasaki, 2004).[15]

The two proposals, however, seem to direct attention to different features of what is available to be seen on the computer screen (Koschmann and Zemel, 2009:222-229). And, indeed, the students seem to have some trouble reconciling their different accounts. Nevertheless, we find them later producing this exchange shown in Excerpt 6.

Like Disney's injunction, "We'll have to figure out what this means now", her remark, "can't believe we didn't like think of this," implies that some combination of their two discovery proposals is, at this point, being accepted as having been validated. So, the three-part sequence of proposal, assessment, and uptake is seen here as well. Dana's remark (line 104) marks a change in their referential practices. Matters are now to be perceived (and talked about) in a new way. Something has been discovered.

Two additional points with regard to discovery sequences might be further developed here.

Excerpt 6 (Koschmann and Zemel, 2009, Clip #8, pp. 244-245)

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102   Dana:   =So, but what we didn't realize before.
103   Carol:  Might have to make it little shorter though.
104   Dana:   Can't believe we didn't like think of this all,
              yesterday.
105   Carol:  I know. Makes me feel quite stupid.
```

In their developing understanding of the mechanism underlying the behavior of the simulation software, something seems to have changed. Dana speaks of their prior understanding in the past tense ("what we didn't realize before").

The first has to do with the relationship between these discovery sequences and the naming of things. Naming is an ordered process. One may have some object/action/event in hand and need a sign by which to reference it. This is the familiar kind of naming taken up in various places in the CA literature as word selection (e.g., Sacks, 1978; Schegloff, 1996), formulating practices (Garfinkel and Sacks, 1970:346), or membership categorization analysis (Sacks, 1972). Conversely, one may have a sign (e.g., "optical pulsar," "ureter") and need to instantiate it within the particulars of a given situation. In this way, some thing gets associated with a given name. We see a clear example of this second kind of naming in the identification of the ureter. Here the

[15] There are, apparently, variable ways of preparing the ground for a discovery sequence. Disney notices something on the oscilloscope screen which he labels as a "pulse." Cocke follows up on this with the proposal that the pulse may represent evidence of a pulsar. ATT's proposal, on the other hand, comes with no particular prior noticing or pre-announcement. In that sense, it performs double duty, serving as both a noticing and a proposal for a possible discovery.

procedure calls for a named object and the surgeons' task is to locate it. In the case of the discovery of the optical pulsar, no prior instances of the named category had ever been detected, but the category (and the name) was already there. Other kinds of pulsars were already known (Woolgar, 1976) and pulsars in the optical range were considered as at least theoretically possible. When Disney says, "We'll have to figure out what this means now," therefore, it was clear to all parties what was being referenced by the demonstrative pronoun.

In the case of the Roschelle materials, the situation is quite different. In what we are taking to be the affirmation of the students' respective discovery proposals, they never supply a proper name for what they have apparently discovered. Perhaps this just reflects their more precarious grasp of what they were seeking compared to the surgeons and astrophysicists.

They were not instructed, after all, to look for evidence of acceleration—their task was only to conduct simulation runs using the provided software and formulate a description of what they witnessed. They do, however, have a set of practices for talking about the matter discovered, which they make evident when asked by Roschelle what they had learned (see Excerpt 7).

They developed a better understanding of one feature of the simulation display, but did not have a name ready-to-hand to apply to it. This was as close as they would come to bestowing a name upon it. Their failure to be more explicit takes nothing away from their achievement. It simply highlights the contingent nature of naming as a feature of the discovery process. What distinguishes a discovery sequence from other proposing sequences (e.g., recognitions, simple identifications) is the use of prospective indexicals in the proposal phase and their subsequent resolution through assessment and uptake. This feature can be found in all three of the examples discussed here.

Hacking (1983) described scientific discovery in terms of "representation and intervention." With regard to the three examples of discovering work it might be noted that it is what comes between the proposal and the uptake that makes the participants' conduct recognizably a discovery. If the proposal is followed immediately by an affirmation, this is, at best, a weak example of a discovery sequence or perhaps something better described as a recognition.

There is, however, no discontinuity between the two. Instead, we find a continuum of action organizations ranging from the simplest forms of identification on up to the most sophisticated forms of scientific evaluation.

The complexity arises in the assessment phase. In the examples discussed here, we see inserted between the proposal and

Excerpt 7 (Koschmann and Zemel, 2009, Clip #9, pp. 245-246)

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109  JR:     What did you figure out
110  Carol:  We figured out ⌈what the black arrow ⌈was
111  Dana:                  ⌊Well                ⌊yeah.
```

uptake recognizable forms of discovering work, *interventions* in Hacking's terminology. We see experiments conducted and interpreted. ATT and RES, for example, can be observed pinching and probing the putative ureter. Cocke and Disney make adjustments to their telescope and apparatus to ensure that their findings are not artifactual. Dana and Carol test their theories by running additional simulations.

The situations described here—the discovery of the optical pulsar described by Garfinkel et al. (1981), Roschelle's description of Carol and Dana's discovery at the computer, our present analysis of discovering work in surgery—are quite different in many ways. One of them is an example of science with a big "S" (a "hot discovery" in Atkinson and Delamont's terms), one is a discovery in the service of introducing newcomers to scientific reasoning, and the third is a discovery that occurs in the context of routine practical activity.

By bringing into relief the commonalities that hold with respect to how referential practice is organized across situations, do we run the risk of "obliterat[ing] the specificity of the activities described", to quote one of our reviewers? We think not. Each of these discoveries is the result of an "*essentially* situated inquiry" (i.e, "without remedy or alternative", Garfinkel et al., 1981:135, n. 16, emphasis added). We seek not to put them all in the same box as instances of discovery, writ large, but rather to document the practices whereby participants negotiate a pact to treat some aspect of their shared world in a new way, to treat it as a matter discovered. The interactional methods by which this is accomplished do not emerge *sui generis*. There is a logic that prevails across these situations and that logic arises from the fact that participants organize their referential practices in recognizably similar ways across many situations.

If discovering work is at the heart of what we consider science to be, ATT and RES are producing a kind of science in the OR. To paraphrase Garfinkel et al. (1981), "their science consists of the ureter as the produced practical observability of their ordinary surgical work." Lynch (1993) and others have sought to demonstrate, and we think convincingly, that scientific practice is permeated with ordinary forms of reasoning and action. The analysis presented here seems to gesture toward the same conclusion, but arrives at it via a different path.

Instead of showing that scientific practice is permeated with practical reasoning, we see in the materials examined here that at least some forms of routine, practical activity include features of what is otherwise considered to be one of the earmarks of science.

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