CAN REMOTE OBSERVING BE GOOD OBSERVING? REFLECTIONS ON PROCRUSTES AND ANTAEUS [1]

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ABSTRACT

Remote observing seeks to simulate the presence of the astronomer at the telescope. While this is useful, and necessary in some circumstances, simulation is not reality. The drive to abstract the astronomer from the instrument can have unpleasant consequences, some of which are prefigured in the ancient tales of Procrustes and Antaeus. This article, written in 1992 for a conference proceedings on remote observing, is reprinted here with only slight editorial changes and the addition of a short Afterword. I consider some of the human factors involved in remote observing, and suggest that our aim be to enhance rather than supplant the astronomer at the telescope.

1. Introduction: Why Are We Here?

> "...we need to be reminded of the distinctions between the extraordinary power of science and the fallibility of those who practice it." – *A. Kornberg (1992)*[1]

Most of this meeting has dealt with the interesting problems that arise when we choose to operate a telescope remotely rather than be there in person. Of course, all space observatories must be run remotely, and they have been reasonably successful, but only at a cost that is appalling by terrestrial standards. If we decide to support remote observing at our ground-based telescopes because it is *good* rather than because it is *necessary*, we find ourselves asking questions like: What is good observing? What is the output of a successful observing run? What is meant by "high quality data"? and so on. To complicate matters, the increasing automation of observatory functions suggests to some that the local/remote distinction is unimportant – both observers sit in front of a computer and communicate through it. Can there any difference at all?

Let me approach the answers to these difficult and provocative questions by posing yet another: why we are here? That is, why are we here in person? Why have so many of us faced the perils of airline food and maniacal baggage handlers to sit in a room and hear each other talk? Human speech has such a low data rate that it can be carried comfortably over mere telephone lines, with ample room for illustrations. From the utilitarian view of information transfer our physical

[1]Slightly edited version of an article published in 1993 in "Observing at a Distance", the proceedings of a workshop on Remote Observing, Eds: D.T. Emerson & R.G. Clowes, World Scientific, p. 325.

gathering together here is exceedingly strange. Why didn't we convene remotely? Is there some spooky advantage to proximity over distance?

At NRAO we are building the Green Bank Telescope, which will be operated as a visitor-oriented facility and will support remote as well as local observers. We are supporting remote observing because some of our users think that it will be a good feature, and because it seems inexpensive. But we're not doing it because it will produce better astronomy or better astronomers. No one knows. And no one knows if in the long run it will be a blessing or a curse.

To some, perhaps at older observatories, who routinely struggle with balky, uncontrollable equipment in the depths of longjohn winter nights, the notion that automation could be overdone may seem ludicrous. Even modern telescopes frequently suffer from computer systems that are a hopeless clutter of ad hoc languages and machines communicating with each other poorly, and with the hapless astronomer barely at all. It might not seem credible that astronomy could be done without an astronomer nearby. But the trends to automation and abstraction are firmly in place, and we need to decide how to use these tools before the decision is made for us by default.

The "reflections" that follow are my unsystematic comments on these issues. The view is from the human, rather than from the technical perspective, so I will not discuss what we *can* do, but rather what we *should* do with our limited resources and time. There is probably no observatory that couldn't perform better if it had more money for instrumentation. Should these dollars be spent instead on remote observing? I believe that many of my comments are widely felt but rarely articulated. Some have already been expressed at this meeting, while others come from the vast literature of applied psychology, a literature which includes many ancient fables, for the interaction of people with their creations has always aroused curiosity and passion.

2. Telescopes Produce Responsibility and Skills (and Data)

We want our telescopes to produce good science, and good data are a part, but only a part, of good science.

2.1 Responsibility

> **Responsible**. *adj.* **1**. Legally or ethically accountable for the care or welfare of another. **2**. Involving personal accountability or ability to act without guidance or superior authority. ... **4**. Capable of making moral or rational decisions on one's own, and therefore answerable for one's behavior. **5**. Able to be trusted or depended upon. – *American Heritage Dictionary*[2]

Observational astronomy is more than plucking numbers from the sky – we also assign a reliability to those numbers. When scientists present the results of an experiment they take responsibility for those results by attaching to them the most precious coin of the scientific realm: the individual scientist's pledge to speak the truth.

The definitions of the word “responsible” make it clear that responsibility is something particular to humans. It makes no sense to say that a computer is accountable for its own behavior, or that it is capable of acting without superior authority. In society, responsibility is so important that we do not even credit it to every person: a child or adolescent, no matter how intelligent, no matter how talented or athletically able, might still not be trusted to assume responsibility in some circumstances.

Who takes responsibility for data gathered remotely? Who speaks for its correctness? Take the case of the Westerbork radio telescope. Authors of a successful proposal to use this instrument are often not even notified that the observations are being made. Instead, sometime later they receive in the mail a fully calibrated map of their field. Who is responsible for the correctness of these data? Who knows how to interpret the lowest contour? Who should respond to a referee's comments? In this example, can the remote astronomer be expected to vouch for the data quality? But if not the astronomer, then who?

This is an extreme example of a split between the astronomer who ends up with the data, and an observing specialist who is responsible for what happens at the telescope. Perhaps use of astronomical archives is also in this category. The split is created naturally in most remote observing schemes. I do not want to imply that an astronomer present at the telescope automatically produces correct or responsible data, or that the remote, but attentive astronomer must be utterly irresponsible. No, divided responsibility can exist even in locally operated systems, and to some extent is an inevitable outcome of the complexity of modern observatories. But much observing is done under less than perfect conditions, and proximity to the telescope increases the likelihood that variables of that particular day and time will be scrutinized, that the weather will be noticed if it is unusual, and so on. The more that one has the opportunity to interact with every part of a telescope system, in some literal sense the closer one is to the telescope, the easier it is to be responsible for what occurs there.

2.2 Skills

Anyone who spends time around observatories knows that there are good observers and bad observers. I believe that it is important to give our telescope users the opportunity to become good observers. Someone who actively plays with the equipment, tries out various combinations of things, and constantly iterates on technique, not only gets data and a sense of its correctness, but also develops skills which can make the next data better. The way to become a skilled observer is to participate in the observations as completely as possibly, to seek active control or understanding of every phase of the process; to try to recognize the difference between the basic limitations of an instrument and those limitations which are rooted in style or tradition. It is hard to see how the consumer of Westerbork data described above can even be called an observer, much less a skilled one. And I find it difficult to believe that observing skills can be acquired more easily at a distance (if at all) than in close proximity to the telescope.

The drive for new instrumentation and new techniques usually comes from the most skilled astronomers, for they are not only technically competent, but motivated by specific but ever-changing astronomical interests. They provide new ideas and the impetus to keep our telescopes at the state of the art. We need skilled astronomers, not just observing specialists, and we need to help more astronomers become skilled. Students, especially, must learn about the instruments, and not simply about the control systems that are abstract representations of them.

2.3 Data

Quite often the details really don't matter – the routine data acquired from a telescope without special effort are good enough. The measurement of a high signal-to-noise spectrum, say, or of the flux density of an object, might require no subtlety at all, and might as well be done in a batch process as by a skilled observer (provided that the sky is clear, etc.). But I suspect that it takes considerable experience to be able to decide that an observation will be routine, and it may take several trips to the telescope, by someone, to set up and debug even a "routine" observing procedure.

3. Astronomers and Their Hammers

> "If you give a child a hammer, it will treat everything as if it were a nail."
>
> – *attributed to Abraham Maslow (1908-1970)*

3.1 Hammers Don't Gossip

The Law of the Hammer, as stated by the child psychologist Maslow, has general truth. We tend to define the possibilities for action by the tools we have at hand. We tend to define our choices by the options we are given.

A relevant example is a menu-driven observing program. It is a blessing for the novice who immediately has a list of all possible choices and (via a click on a mouse) a way to effect a choice. Menus are good organizational tools, they enhance efficiency and reduce errors. But they are also dangerous for several reasons, and one is that they don't create, repeat or even understand gossip.

The menu choices at an observatory pertain to real physical devices, observing techniques, and so on. But most front-line observatories are constantly improving all equipment and increasing the understanding and development of new techniques. Also, things break. While it may be possible in theory to keep a telescope control program always totally up-to-date, in practice it is rarely worthwhile to do so. Instead, most observatories implicitly rely on local "experts" to communicate the latest information. Often, the best expert is the person who worked the previous shift.

As an example, consider the VLA, which is so highly automated that it is run by batch processes almost all the time. It is, however, in such a natural state of flux that inside information is frequently essential to get the best data. Visitors are assigned a local expert who advises on the most recent state of equipment, observing strategies, and data reduction schemes. Even so, a VLA observing run is apt to start with the telescope operator's announcing that an antenna or two have been having some difficulties, and have been offline for the last few hours.

Most of us have a natural reluctance to commit opinions to writing or to a computer help file unless they have been checked out and confirmed. But often such raw hunches, rumors and gossip ("Receiver B seemed flaky to me. I couldn't pin it down, and it looks ok now, but you may want to watch it.") are the most important bits of information an observer can get. In automating telescopes, we often try to remove the need for gossip because it is viewed as unnecessary, or even as evidence of a flaw in our system. But we should face the fact that active telescope systems use gossip and inside information to function efficiently, and that gossip evolves as the natural response to the need for extremely current though low-grade news. Of course we want to purge obsolete information from our systems, but why not also accept the role of gossip and plan to use it efficiently? If there is somewhere a general-purpose telescope whose online documentation reflects the current status of the instrument, it is probably a sign that that observatory has spent too much money on software and not enough on new instrumentation.

3.2 But I Thought It Was a Nail!

A more pernicious effect of the problem revealed by Maslow's Law of the Hammer is that over time observers will stop trying to do things that are not listed in the menu. Menu-driven observing encourages menu-driven thinking. I am not talking about intimidation here as much as laziness and ignorance, and the pressure is never overt, but subtle and persistent, very persistent. We need to create a climate in which astronomers imagine new uses of the instrument, combine existing functions in new ways, and tailor the equipment to the task, rather than the other way around. The imagination of an astronomer on-site is often stimulated just by seeing the telescope and its equipment, and recognizing that the current configuration is merely one solution to a problem. We must encourage remote (as well as local) observers to break free of the menus.

Maslow's Law reminds us of another interesting factor: astronomers may use the available tools in ways that were not originally intended or foreseen. We will always be surprised, perhaps pleasantly, perhaps not, by the consequences of human creativity and stubbornness.

3.3 Well, You <u>Should</u> Have Wanted a Hammer.

If remote observing comes to constitute a large fraction of the use of a telescope, I think that there will be a subtle, but tremendous, almost irresistible pressure to discourage equipment and observing methods that don't easily lend themselves to control from a distance. An example which is not as silly as it sounds is that there can never be an instrument on the Hubble Space Telescope that requires frequent tweaking by some technician with a screwdriver. Of course not: the HST has to run remotely. But is it good to be so restricted on our terrestrial telescopes? That is, is it more important that a new device be totally debugged, reliable, and integrated with the system before it gets on the telescope, or that it gets into use, producing results that may drive science in new directions, as quickly as possible? I vote for speed. If we don't pay special attention, we may not even notice that we've created a restriction, a bed of Procrustes (see §11), on which the unusual experiment won't fit, until all the creative users have gone elsewhere.

4. The Mongoose and the Cobra (Science is Subtle)

> "...though Rikki-tikki had never met a live cobra before, his mother had fed him dead ones, and he knew that all a grown mongoose's business in life was to fight and eat snakes." – *Rudyard Kipling (1893)*[3]

> "In the vicissitudes of human experience and development, conflict is an unfailing attribute." – *Jacob Arlow (1985)*[4]

There is a fundamental tension in scientific activities that was alluded to in previous sections but here will be faced head-on. Simply put, the culture of science and the culture of management/administration are not compatible. Like the mongoose, who just can't abide the cobra, and the cobra, whose feelings are reciprocal, the tension is irreconcilable.

A manager has to function smoothly and be reliable. That is the nature of the job. Schedules must be kept, payrolls met, the rent and electricity bill paid. Major random events are definitely not welcome. Scientists, on the other hand, like change. Even though they need to be methodical and plan experiments well in advance, scientists still like change a lot. They rarely do the same experiment over and over. Asked "what equipment will you need for your research next year?" they want to answer "I can't tell. It depends on what happens next month." Managers, understandably enough, find this attitude less than helpful. But if an organization is run for the ease of managers, science dies. We've all heard about the U.S. Government agency that recently asked its scientists to write a report giving their research plans for the next year *including detailed information on all discoveries that would be made.* But on the other hand, I'm not sure that anyone past adolescence would want to work for an organization that refused to act in a fairly predictable fashion.

The point is that science is subtle. There are few reliable ways (other than benign neglect) to encourage it, but many ways to stifle it. Our carefully developed hardware and software tools, intended to enhance scientific productivity, can easily turn into a hammer thrust into the hands of a scientist who very much needs a screwdriver. In particular, we at this meeting are potentially very dangerous to science, for as scientists who are involved in the way observatories are run, we can be both mongoose and cobra. We have the ability to force our particular scientific style on our institutions, for better or worse, and may even do so unconsciously.

Software encapsulates the philosophies of its builders. We need to remember that good science requires extreme flexibility of individual and institution, and we need to value and reward change as much as we do order and efficiency. We have to develop a culture of change in which we become suspicious, and begin to worry, when things remain fixed for too long a time.

Which brings me to the question of how to measure the success of an observatory, or the quality of science that it is doing. This problem is so knotty that most everyone dodges it and concentrates on the more easily quantifiable: papers published, visitors serviced, or even more primitive issues like observing efficiency. I will not argue that telescope systems should be less than maximally efficient, but efficiency itself is not a very selective criterion, for it says nothing about the quality of the data that are being gathered so efficiently, or the worth of the experiments themselves. A skilled observer puttering around a telescope, trying out various schemes and just doing things differently, may discover that the previous dozen observers who gathered their data with high efficiency were getting the wrong numbers. One characteristic of a good observatory may be that it lets its users do *exactly* what they want for the largest possible fraction of the time, even if what they want to do seems horribly wrong or utterly worthless!

5. The Importance of Screwing Up

Another occult belief is that of being always right. Never to err is only possible when insignificant questions are involved. Those who attempt to achieve infallibility consistently will instead achieve essentially nothing at all. In fact they should be reminded of the old wisdom that "who does not know that he is a fool half of the time, is most certainly a fool all of the time". –Fritz Zwicky (1957)[5]

It is important that the observer be able to make mistakes and to screw up an observation, whether remotely or locally. The feedback makes observers more skilled. Also, it may reveal interesting features or possibilities of our systems that were not previously known. But there is no need to belabor the point. Anyone who has ever worked as a scientist knows the basic truth of Zwicky's comments.

We can permit astronomers to blunder around in our observatories, and to screw up in various ways, only if we feel that they have some degree of responsibility. I was very impressed on a visit to Yerkes Observatory to find that there never has been an interlock or limit switch that prevents an observer from driving the movable floor into the back of the great 40-inch refractor. As explained by my host, Lew Hobbs, the knowledge that such a catastrophe could occur through careless use of the controls they hold in their hands, has made the generations of astronomers (and graduate students) who have worked at Yerkes more reliable than any mechanical device could be. While I, personally, would nonetheless install a limit switch, the general lesson is clear. The good use of an instrument requires some responsibility on the part of the user. The best way I know to encourage that responsibility is by the feedback that comes with proximity. The feel of the Yerkes floor rising up, or the wry look on the telescope operator's face when asking an observer "Do you really want to point at the ground?" all heighten the observing experience, enhance observing skills, and contribute to general attention to detail. At the telescope, an error can produce more than an "invalid operation" return code on a TV screen. The feedback is immediate and possibly profound. Steel moves across the sky.

Alarms may sound. Someone at this meeting said that a good remote observing system should allow observers to break the equipment, and I agree, but only if they understand at all times that they have that power, and will be able to *feel* the consequences.

6. The Telescope Operator – Just Another Human

> "In spite of decades of effort and a huge investment of resources, modern computers do not see very well. In any ordinary sense of the word, they don't "see" at all. ... This blindness to ordinary environments contrasts sharply with the success of machine recognition in artificial domains. Computers have long been able to recognize the magnetic letters stamped on checks; modern scanning systems can even "read" (i.e. identify the words in) printed text. It's only the real world that gives them trouble." – *Ulric Neisser (1992)*[6]

The principals in an observing session at the NRAO and many other facilities are the operator, whose main responsibility is to the telescope, and the observer, whose responsibility is to the data. The primary characteristic of both observer and operator is that they are human beings. Humans do certain things very poorly, like stare at a control panel waiting for something to happen, and other things very well, like respond creatively to unfamiliar situations. The issues of remote observing are not too far removed from those of remote operation, as both place distance between man and machine. Much has been written about remote operations in various industrial settings, for in some circumstances lives hang in the balance.

> **FIGHTING BOREDOM**
> FIGHTER PILOTS have G-LOC and transport pilots have B-LOC – boredom-induced loss of consciousness. A Douglas Aircraft Co. test pilot says designers are contemplating installation of a beeper that would sound in the cockpit occasionally. If the crew does not respond by pressing a button or talking, an alarm would sound to rouse them. –*Aviation Week and Space Technology (1991)*[7]

At NRAO we have telescope operators because they improve overall observing efficiency. One could always design a fully-automated system that responded to problems by going through an orderly shutdown and calling for help. The Hubble Space Telescope does this all the time. But more observing gets done if there is someone on the spot to diagnose and perhaps repair routine problems, to help the observer if possible, to take over certain operations so that the observer can get some sleep, and to provide a high level of monitor and control of the entire telescope and its surroundings. Tom Ingerson, in his talk, noted that having a person as part of the telescope system can make a tremendous improvement in the operation of an observatory. Human operators can be the best solution to the problem of how to operate a telescope, but only if we do not expect them to act like machines.

The airline industry is quite familiar with this issue. They joke that the aircraft cockpit of the future will have only two occupants – a pilot and a large dog. The dog is there to bite the pilot if he tries to touch any of the airplane's controls. And the pilot's job? To feed the dog[8]. A similar message is given by the "B-LOC" article reproduced above. The essence of the airline's problem is that computers can fly commercial airplanes better than humans *provided that no unanticipated events occur*. So the aviation companies face the dilemma of having to keep an aircraft crew ready to intervene, at a moment's notice, with their highest level of skill and concentration, in an environment which is mortally boring. Airbus, purveyors of perhaps the most automated commercial aircraft, holds "overconfidence prevention classes" to remind its pilots that even if the computers say that everything is A-OK, the airplane may not be[8].

Many observatories are coming dangerously close to this state right now, and more will be so in the future. The problem is not one that can be cured easily by motivational sessions with the telescope operator. Automation tends to reduce a person's sense of responsibility because the computer appears to have been given charge of the situation. At NRAO we recently debated whether there might be advantages to remote *operations* of the Green Bank Telescope, i.e., to having the telescope operator located in the main lab building rather than at the telescope several miles away. After much thought, I am convinced that this would be a grave error. How can we ask someone to be responsible for a telescope and then place her miles away where she perceives it only at a substantial remove?

"I am what I am and that's all what I am ." – *Popeye the Sailor Man*

There are at least two problems with remote operations which also apply in some ways to remote observing. The first is reflected in the adage: out of sight, out of mind. We really do forget about those things that do not frequently intrude on our consciousness. I was struck by Mel Wright's comment that he has found it necessary to cycle staff from the Berkeley Campus to the Observatory at Hat Creek because people get disconnected from what is going on if they are away from the telescope too long. A telescope operator who communicates with the telescope only through a computer terminal is being taught an unconscious lesson every minute: that his main responsibility is to what is on the terminal; that the real telescope off yonder is secondary, someone else's problem, or worse: an abstraction. This is another manifestation of Maslow's Law. The human tendency to put the "out of sight out of mind" should not be seen as a problem to be overcome by education or training; it is more like our inability to perceive X-rays than my inability to read Chinese – the natural way of dealing with the immense flood of information presented by the senses. We block out what seems not immediately important.

The second problem is that we make poor use of peoples' talents if we restrict their information to what comes over computer terminals, video cameras, microphones, etc., unless it is absolutely necessary. There is no adequate substitute for human beings and their senses when it comes to perception and creativity. While it may seem that remotely controlled devices can convey information that is almost as good as one gets by being there in person, serious efforts in this area have in practice been marked more by failure than by success[6]. The video camera, e.g., is not a good substitute for the eye.[2] For one, our eyes are constantly in motion, driven by a creativity and perception that cannot be replicated by machines. If a telescope operator hears a peculiar noise, he may want to touch a device, or smell it, or look around behind it, all without thinking especially hard or logically about the "search pattern" he is going through. It is not the same as peering through a camera. Our creative tendencies make it difficult for a machine to simulate a person.

Instead of replacing the human, perhaps we should replace the machine. Human beings are designed to be good at creative perception and decision making on the fly, so why waste that ability by restricting an operator to a desk behind a computer several miles away from the action, if he could be on the spot? I suggest that our goal should be to use remote sensing to supplement human perception, not to supplant it.

I do not know how to reconcile the desire for increased automation, and thus increased reliability and control, with the need to keep the operator fully involved with the telescope. The same considerations apply to the observer. Perhaps we should not automate a task unless it produces an **overall** improvement in the telescope system, including the functioning of operator and observer. This approach would deliberately leave certain jobs to be done by people, not machines. Perhaps we should give the operator other duties, such as telescope maintenance, that fill the time and keep her fully in touch with the instrument. Our observatories are run by and for human beings. We should focus our efforts on using and enhancing human abilities, rather than attempting to simulate them.

7. TV is Only TV

> *March 28:* "... we all landed safe & sound, one of our servants (Margaret's maid) excepted, who was very ill on the voyage & is not expected to live ..."
> *June 2:* "Rode over to the observatory in the dark to dinner and got beset by Van Renen's Dogs, a hungry savage pack of 5 or 6 large hounds & curs of low degree, who had all but eaten me & my horse too ..."
> *July 30:* "Rode over to Observatory Botanising & shooting by the way. Shot a large Gull – The Splendor of the flowers in the flats about the Camp Ground is amazing. Swept [the sky] till 3 AM." – *John Herschel (1834)*[9]

Astronomical expeditions of the past were heroic affairs, as much a physical as a mental challenge. At many observatories observing is still strenuous, though we are trying to change this. But is it really wise to seek to turn experimental astronomy into an activity that is indistinguishable from watching TV?

Every once in a while it is good to remember that watching TV engages a very small part of the spectrum of human potential, and to first order, the content of the TV show is not important. In other words, it does not matter if we are watching a computer display or a 1970's sitcom; while watching TV we are essentially at rest,

[2]Again, I am aware that remote sensing is necessary in hostile environments like the core of a nuclear reactor or the vacuum of space. But I am concerned here with situations in which we have a choice, and the environment of most of our terrestrial telescopes is not especially forbidding.

using only our eyes and ears, focusing on a small part of our surroundings. The flickering display induces a metabolic state that has been measured as less energetic than sleep.

To second order, there are differences in muscular activity between using a computer and watching a TV show. The flick of the remote channel changer requires less coordination than light typing on a keyboard. But the difference is still small on the scale of possible human activity.

To third order, there is a qualitative difference in content of a TV screen and a computer screen, and perhaps this is what distinguishes us from the majority of the U.S. population who spend a comparable amount of time staring at a screen. Much creativity can occur in the interaction between programmer and computer, and I doubt that people go into computer science because they like being paid to watch TV. But that is what they end up doing, and forcing others to do. Perhaps it is not a good idea to make astronomers and telescope operators dependent on such a narrow information channel. I find it difficult to believe that human beings are designed to function well in so stupefying an environment without major damage to the body and mind.

8. I Want to be Left Alone

> "An observatory is stocked with human beings, after all, and the isolation that dark, clear skies require is always a potential stress factor. Some adapt, some crack, others just get grouchy." – *Evens and Mulholland (1986)*[10]

The astronomer at the telescope is blessedly free of most of life's distractions. Usually, the phone does not ring constantly, few passers-by disrupt a contemplative moment, and even the choices for lunch are limited. Observatories give one the ability to concentrate on science. This ability cannot be taken for granted for remote observers, many of whom choose remote observing precisely because it allows them to do other things simultaneously. For this reason alone, it is unlikely that the quality of remote observing can ever be as high as that of local observing. In contrast, presence at the telescope encourages a high degree of involvement, especially if the astronomer has had to come some distance or does not use the instrument regularly.

At this meeting there have been discussions of remote observing centers: communication and control facilities situated some distance from the telescope, to which an astronomer would travel to observe. These could give one isolation and focus, and also the context of gossip, and it seems possible that with the proper design and feedback such centers could promote some responsibility for data and instrument. What they do not give is familiarity with the instrument, or more knowledge of it or ability to manipulate it than was anticipated by those who wrote the communications programs. Moreover, even at a remote observing center, can an astronomer who is unfamiliar with the telescope ever really *know* what is happening with it?

9. Why We Should Implement Remote Observing Anyway:

1. It gives us the ability to do short observing projects. There are worthwhile, straightforward experiments that require use of a telescope for only a few hours, or, in some cases, a few minutes. Requiring the astronomer to travel to the telescope produces a threshold for proposal submissions that is unlikely to be crossed for a brief observation. I believe that many more short projects would be proposed if astronomers could be guaranteed a reasonable chance at getting good data without having to travel hours for just a few minutes of telescope time. Remote observing may even open up novel uses of telescopes, e.g., the monitoring of an object for just a few moments every evening.

2. It increases the efficiency of telescope use. If some fraction of all proposals can be run remotely, telescope schedulers will be able to take advantage of particular weather conditions or vagaries of the instrument. At the Green Bank Telescope, where some experiments will require a clear dry atmosphere while others will do quite well in a steady rain, remote observing will allow us to match the program to the contingencies of the weather.

3. It promotes new kinds of collaboration. At this meeting we have heard some amusing stories of remote observers "peering over the shoulder" of a collaborator who is at the telescope. There are also other ways in which collaborations could evolve. Imagine consulting a skilled specialist half way around the world for an opinion, or running several experiments simultaneously on geographically separated instruments. This latter feat is now done routinely in Very Long Baseline Interferometry, but not without considerable help and coordination at each telescope, and with little real-time feedback. We can do better.

4. It will open our instruments to more users. The discipline required to produce a remotely operable telescope system is liable to make that system more friendly and powerful for all users. It may open up a telescope for use beyond the circle of insiders who know the location of the unlabeled switch that turns on the receiver.

5. It may save money? There has been a strong sense at this meeting that implementing a remote observing capability will not save an observatory any money. This may be true if the telescope continues to be scheduled as it was before remote observing was possible. If, however, as I suggest above, new observing forms evolve to take advantage of the new capabilities, then the answer may be different. Large observing collaborations or short projects are now difficult to support because they are too expensive if everyone must come to the observatory.

6. It is always worthwhile to add another tool to the toolbox. It becomes a problem only when, like Maslow's child with a hammer, we mistake the tool for the task.

10. Why We Are Here

By now, the analogy between our travel here to Tucson for this meeting and an observer's travel to a telescope should be clear. A meeting is much more than the presentations. Creative speculation, gossip, rumors and uncensored opinions occupy the spaces between and around items in the formal agenda. Vital information is transferred in casual comments over coffee, comments that might never be made in an open forum. In many cases we arrive at our personal evaluation of the formal presentations only after informal discussions. People who are separated from these interactions miss much of the meeting, even if they absorb the complete agenda.

At a meeting we also have great freedom of action, which would not be the case if we were joined electronically. If we wish, we can look not at the speaker, but at our neighbor who may be frowning or laughing. We are free to poke around the back of a computer, or to leave the room for a private conference with one or two others. This goes on all the time. In *The Wizard of Oz*, the Wizard shouts, "Pay no attention to the man behind the curtain" as his fraud is revealed by the dog who is not content with what is presented to him. While we are at this meeting, we can to some extent manage the flow of information on our own terms. We can see for ourselves. We are not bound by the menu.

More subtle, but possibly more important in the long run, is that at this *meeting* we are *meeting* people. In normal contact we quickly develop a "feel" for the other person, find out whether communication is easy or difficult, establish a level of trust or skepticism. At a good meeting, quite often a shared vocabulary is developed. We come to understand the meaning of certain words by their context and by watching the group react to their use. Words, phrases, metaphors are created and spread throughout the community from the interactions at meetings. A good meeting conveys the same richness of experience as a good party, but usually with fewer morning-after regrets.

There is also the matter of civility. People linked electronically don't behave very well. Anyone who has ever participated in a "phone" meeting, in which several groups communicate only by voice, knows the poverty of these sessions and appreciates the value of proximity. In phone meetings I have watched local folk read a newspaper, engage in a secondary conversation, or make faces or gestures when a remote party has the "floor" – all deadly insults if done in person and all expressing a kind of hostility that I believe is encouraged by the physical absence, the abstraction, of our colleagues. In my experience, phone meetings dehumanize interactions and, though often seemingly necessary and convenient, need to be supplemented by frequent personal contact to avoid creating major rifts in an organization. A similar situation can arise in email. Some colleagues whom I know to be warm, gentle and reasonably open-minded sound aggressive to the point of violence, wild, irresponsible and outright bigoted in their email.

Communication is never easy, even in person where we have access to the full range of the senses and plentiful redundancies of speech and gesture. In the highly filtered world of telecommunications, it is all the more difficult. It seems that distance diminishes everything. That's why we're here.

11. Reflections on Procrustes and Antaeus.

> "Every time I come up with what seems like an original thought, it turns out that some damn Greek said it first." – *Anonymous*

Procrustes

"I cannot stop to tell you hardly any of the adventures that befell Theseus on the road to Athens. It is enough to say that he quite cleared that part of the country of the robbers, about whom King Pittheus had been so much alarmed. One of these bad people was named Procrustes; and he was indeed a terrible fellow, and had an ugly way of making fun of poor travelers who happened to fall into his clutches. In his cavern he had a bed, on which, with great pretense of hospitality, he invited his guests to lie down; but if they happened to be shorter than the bed, this wicked villain stretched them out by main force; or, if they were too tall, he lopped off their heads or feet, and laughed at what he had done, as an excellent joke. Thus, however weary a man might be, he never liked to lie in the bed of Procrustes." – *Nathanial Hawthorne (1851)*[11]

Antaeus

"There was one strange thing about Antaeus, of which I have not yet told you .... whenever this redoubtable Giant touched the ground, either with his hand, his foot, or any other part of his body, he grew stronger than ever he had been before. The Earth, you remember, was his mother, and was very fond of him, as being almost the biggest of her children; and so she took this method of keeping him always in full vigor. Some persons affirm that he grew ten times stronger at every touch; others say that it was only twice as strong. But think of it! Whenever Antaeus took a walk, supposing it were but ten miles, and that he stepped a hundred yards at a stride, you may try to cipher out how much mightier he was, on sitting down again, than when he first started." – *Nathanial Hawthorne (1851)*[11]

Astronomy

"Such an attempt can take one of two antithetical forms: a search for purity or a search for self-enlargement. ... The desire to purify oneself is the desire to slim down, to peel away everything that is accidental, to will one thing, to intensify, to become a simpler and more transparent being. The desire to enlarge oneself is the desire to embrace more and more possibilities, to be constantly learning, to give oneself over entirely to curiosity, to end by having envisaged all the possibilities of the past and of the future." – *Richard Rorty (1986)*[12]

As individual scientists, we seek to reduce, isolate, extract, the laws from the tumultuous phenomena. Our accomplishments are judged on the narrowest of grounds. But our scientific institutions, our observatories, even the way we approach our research, must be more expansive.

Several months ago the computer system that I had used for some years was shut down and a modern workstation "with 100 times the power" was placed on my desk. In one blow all my programs were rendered inoperable, though admittedly the new computer could do wondrous things such as chirp like a cuckoo clock, display the latest weather map of the South Pacific, and produce a running graph of the fraction of the CPU power being used (which is usually near zero since it does not know how to run any of my programs). I accept its power, efficiency, and ultimate utility. I'm learning C++. But when asked to "name" the machine so that it could be referenced over the network, the choice was obvious. It is called Procrustes.

Then there is Antaeus. For us, the most interesting part of the tale occurs at his death in battle with Hercules, who recognized that Antaeus, as the son of the earth, drew his strength from frequent contact with it. Every time Hercules flung Antaeus down, he rose renewed and stronger.

We find ourselves doing astronomy from a variety of motives, but they are usually positive: we find it intellectually stimulating and a fascinating way to lead a life. The challenges are not trivial. Few of our colleagues have entered astronomy because they could not succeed at the practice of law or made a mess at real estate sales, and so decided to settle for second best: the life of a scientist. Observational astronomy has its own special attractions. It can involve elements of physics, electronics, structural engineering, optics, mathematics, computer science, photography, and may require luck and the ability to work without sleep, alone in the cold. Why would someone do such things?

Hercules defeated Antaeus by separating him from the source of his strength. He held Antaeus up in the air away from the ground, and Antaeus so removed was hardly Antaeus at all. His strength diminished, he became too weak to fight, was crushed, and flung aside.

We experimental scientists can also become intellectually weakened by distance, by separation – transformed into consumers of data, not producers, and, like Antaeus, held away from the source of our strength, wither and fade. We are neither unprecedented nor unique in our situation, nor in the struggle to prevent our tools from diverting us from the reasons we made them in the first place.

12. Acknowledgments

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14. Afterword: June 2005

The paper reprinted here, at the persistent urging of Dr. Paul Schechter, was published in a rather obscure proceedings of a small conference on remote observing held in 1992. The meeting was abuzz with wonderful schemes for transmitting telescope control information over vast distances, but as the days progressed, it struck me that the priorities were being set not by the community of researchers – the ostensible beneficiaries of all this work – but by those interested in designing and implementing the systems. So when I was asked on short notice to give one of the summary talks, I took the somewhat contrary, playful tone of suggesting that just because something *could* be done did not mean that it *should* be done without considering the consequences to creative research, or the cost compared to other worthy uses of the same limited funds. Not that I was opposed to modernizing telescope controls, but neither was I convinced that remote observing was the straightest path to greater astronomical discovery.

Talking was easy, but writing it up for the conference proceedings took real work, and a lot of reading. With the help of acquaintances in other fields, and a bit of reckless disregard for my own professional reputation, this article emerged. The entire episode was challenging, nerve wracking, enlightening, and uncomfortably intimate. Like most papers in conference proceedings, this one seemed destined to be forgotten, and in fact, to my knowledge it has never been cited in another publication. Not even once.

And yet, *Can Remote Observing be Good Observing: Reflections on Procrustes and Antaeus* has had a vigorous life and a wide circulation, an astonishingly wide circulation considering that for most years it has not been available in electronic form. I have received a regular stream of communications from people who stumble on it one way or another. Some whose opinion I respect don't like it at all, but more typical is the report from a colleague that copies of the paper appeared in every mailbox at her observatory at a time when it was considering a major reorganization. Some letters approach fan mail, which I am usually too embarrassed even to acknowledge, and every time I see Paul Schechter he makes me promise to make this paper available on astro-ph for wider distribution. So here it is.

Hands-Off Observing: 2005

Instead of posting this lightly edited reprint, I should have revised the paper entirely, for a lot has happened since 1992 when the the paper was written and the Internet was young. The Green Bank Telescope is open for business, and "Doing Science Remotely" is listed as one of *Science* Magazine's "Breakthroughs of the Year" (Science 2004, 306, 2011). There is the nascent National Virtual Observatory and a slew of robotic telescopes, while Westerbork – my poster child for hands-off astronomy – has been encouraging its users to become more involved with the instrument. Blogs, chat rooms and wikkis offer new avenues for gossip. Isolated graduate students, who spend their days 'observing' from their Department basement, are now trying to put together credible applications for postdoc positions. And from the world of Sociology, Reeves and Nass have published their profound and wickedly funny studies on human-computer interactions, in a book (*CSLI Publications, 2002*) which should be required reading for anyone who uses a computer or watches TV.

Parts of *Procrustes and Antaeus* now seem dated and even quaint, and its focus on radio astronomy a bit parochial. Also, I have spent much of the last decade as a manager of an astronomical facility and have crossed and now recrossed the Mongoose-Cobra divide, gaining a new appreciation for the vital but conflicting roles of each species. That adventure taught me that few things are cheaper than talk, and that you shouldn't bother to take seriously the advice of anyone who won't make the effort to actually visit your facility. As Texas Bix Bender says, "You can pretend to care. You can't pretend to be there." In the last dozen years I have been asked several times to report on discoveries "that will be made" and was engaged in a struggle over remote telescope operations, which I lost.

So were I to begin this article afresh, it would certainly be different. But lacking the time and interest right now to do the necessary scholarship, I have resisted the urge to revise except for minor tweaking of language. Anyway, I suspect that a real revision won't be possible for another decade, when our profession is likely to be dominated by astronomers who have as little involvement in the acquisition of their data as they do in the harvesting of their food. Shortly after writing this article, I listened to a prominent astronomer describe his plan for a new, state-of-the-art facility where real astronomers would be kept safely outside the gates and the telescopes run by observing specialists, who would give the astronomers the data they needed. In 1993 that model sounded to me like an attempt by supercilious managers to consolidate their power and stifle creativity, and it still does today, no matter how often it is repeated.

'Hands-off' observing may be part of a larger trend which goes by the buzzword 'outsourcing': the often-necessary delegation of responsibility to others for everything from auto repair and music making, to cooking and child rearing. Why should astronomy buck this tide? Or is it 'multitasking'? Several colleagues have patiently explained to me that remote observing is the solution to the conflict they have between classroom responsibilities and research: one can graft an observing session onto the daily routine: teach by day and observe by night. If they are correct, then what I initially suspected might be simple fear of travel turns out to be an even simpler alchemical desire to fabricate time!

Of course, the issue is broader than remote vs. local. It could be described equally well as hands-off vs. hands-on; indifferent vs. conscientious; distracted vs. alert; routine vs. creative.

Observations

In anticipation of writing an eventual sequel to *Procrustes and Antaeus* I often set aside relevant literature discovered in the course of other reading. There's lots. Here's a sample.

> In some ways modern science can be seen as the push to erase individual, craft skill from the scientific workplace, to ensure that no idiosyncratic local, tacit, or personal knowledge leaks into the product... Yet recent work in the sociology of science and engineering keeps discovering traces of craft in the modern scientific commodity. Some lab technicians have "golden hands" ...; some engineers are "wizards" ...; some physicists have "physical intuition".
>
> – Susan Leigh Star in *The Right Tools for the Job, Princeton Univ. Press, quoted in Science 1993, Vol. 260, 245.*

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> "Normally, observing is a craft", says Robert Kirshner of the Harvard-Smithsonian Astrophysical Observatory. "The way you learn is through trials," he says. You figure out what you did wrong and try again. "With the Space Telescope you don't get any trials," he says. If an observation goes wrong, an astronomer may have to wait months for a second chance.
>
> ...One suggestion that has come out..., he says, is that the [Space Telescope Science] Institute assign each outside observer a kind of caretaker and guide. "We need a person at the Institute responsible not only for the bureaucratic paper maze but also the meaning of the observations," says Kirshner – someone who understands the ultimate goals of a project and makes sure the researchers get the data they need.
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> – Faye Flam in *Space Telescope Institute: Inside the Black Box, Science 1993, Vol. 260, 1716.*

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> **Look at the raw data.** There is no substitute for viewing the data at first hand. Take a seat at the bedside and interview the patient yourself; watch the oscilloscope trace; inspect the gel while still wet. Of course, there is no question that further processing of data is essential

for their management, analysis and presentation. The problem is that most of us don't really understand how automated packaging tools work. Looking at the raw data provides a check against the automatic averaging of unusual, subtle, or contradictory phenomena.

– D. Paydarfar & W.J. Schwartz *An Algorithm for Discovery, Science 2001, Vol. 292, 13.*

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I loved reading about these experiments and tried repeating some of them for myself — our Hoover was a good substitute for Boyle's air pump. I loved the playfulness of the whole book, so different from the philosophical dialogs in *The Sceptical Chymist.* (Indeed, Boyle himself was not unaware of this: "I distain not to take notice even of ludicrous experiments, and think that the plays of boys may sometimes deserve to be the study of philosophers").

– O. Sacks 2001, in *Uncle Tungsten: Memories of a Chemical Boyhood; Knopf.*

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...children discover new thinking strategies while succeeding at a task, as well as while failing at it... children who come up with several problem-solving strategies, even wrong ones, frequently learn more than those who generate just one or two strategies, even correct ones.

– B. Bower in *Science News 2001, Vol. 159, 172.*

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The content of life is limited by the amount of information we can process through attention. In this sense attention, or psychic energy, is our most scarce resource.

– M. Csikszentmihalyi 2004 in *Psychology and Consumer Culture, American Psychological Assn. p. 91.*

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By tradition, impatience is a vice. Haste makes waste. Even if our technological world seems inspired by the modernist calculations of Benjamin Franklin, we can all think of a few remaining human activities that cannot profitably be rushed. "There are two cardinal sins," Kafka said, "from which all the others spring: impatience and laziness." There's the paradox — maybe it's laziness, not industriousness, when we succumb to the economics of time.

– James Gleick 1999, in *Faster: The Acceleration of Just about Everything, Pantheon.*

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I actually removed a book from my syllabus last year because I couldn't figure out how to PowerPoint it... When I read this book I thought, my head's filled with ideas, and now I've got to write out exactly what those ideas are, and — they're not neat.

– C. Nass quoted by Ian Parker in *The New Yorker, May 28, 2004, p 76.*

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Bullet outlines dilute thought. – E.R. Tufte 2004, in *The Cognitive Style of Powerpoint*

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[a collaboratory is] a virtual entity created by means of a computer network... A collaboratory cannot replace the richness or the commitment engendered by face-to-face interactions. As in other collaborative arrangements, concerns surrounding trust, motivation, and normative practice for data access, ownership, and acknowledgment can hinder collaboratory function.

S. Teasley and S. Wolinsky, *Scientific Collaborations at a Distance, Science 2001, Vol. 292, 2254.*

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What seems most obvious is that media are *tools*, pieces of hardware, not players in social life. Like all other tools, it seems that media simply help people accommodate tasks, learn new information, or entertain themselves. People don't have social relationships with tools... We now think our intuitions were wrong, however. People respond socially and naturally to media even though they believe it is not reasonable to do so, and even though they don't think that these responses characterize themselves...

...people are not evolved to twentieth-century technology. The human brain evolved in a world in which *only* humans exhibited rich social behavior, and a world in which *all* perceived objects were real physical objects. Anything that *seemed* to be a real person or place *was* real.

People have done amazing things in our labs. They have taken great care not to make a computer feel bad, they've felt physically threatened by mere pictures, and they've attributed to an animated line drawing a personality as rich as that of their best friend. It eventually occurred to us that people were not doing these things because they were childish, inexperienced, distracted or because they needed a metaphor. We had to acknowledge that these responses were fundamentally human, and we had to acknowledge that they were important.

Psychologically, the PC is not terribly different from the TV... Claims about amplified responses to new media are often exaggerated. Our research is a reminder that we can cry when we read, and we can be bored in a virtual world. Social and natural responses come from people, not from media themselves. Ultimately, it's the pictures in our heads that matter, not the ones on the screen.

– Byron Reeves & Clifford Nass 2002 in
The Media Equation, CSLI Publications

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Boy, for a Nobel Prize winner, Philip Anderson doesn't know much about experiments... he pooh-poohs the notion that thought processes can interfere with physics. Any experimentalist could have told him that he is wrong. If you turn your back on an electronic counter, it will certainly start counting backwards. If you go to the bathroom, the temperature regulator is sure to fail. If you start a scan and then go to lunch, the stepper motor will invariably jam just after the door closes. And if you should dare to take a vacation, there is no limit to the disasters that can happen. – P. Kolodner in *Physics Today, October 1991, p. 146*

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A couple of years ago I moved my big *Random House Unabridged Dictionary* from a shelf to a table that I pass a dozen times a day. Within days, I was using the dictionary more frequently than before. On a long vacation ... I observed that the act of moving my bike from the garage where I "safely" kept it (rusting) to the back steps – a move of about 10 yards – caused usage to shoot up instantly. Why? Being there.

– Tom Peters, in *Forbes ASP June 3 1996, 148.*

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You can pretend to care. You can't pretend to be there.

– Texas Bix Bender *(quoted in Tom Peters 1996)*