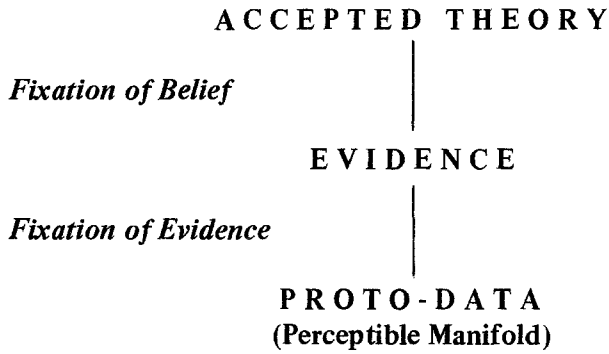
Human Studies 11:133–169 (1988)

The fixation of (visual) evidence

K. AMANN
K. KNORR CETINA *
Center for Science Studies, University of Bielefeld, P.O. Box 8640, D–4800 Bielefeld, FRG

1. Introduction

The fixation of belief, or consensus formation in science as sociologists are wont to call it, refers to a process whereby theories or theoretical hypotheses come to be accepted as fact in a community of specialists. In this paper, we shall be concerned with the fixation of "evidence" or of "sense data", a slice in the process of fact construction:



According to the standard view of science (Mulkay, 1979: Ch. 1), sense data are what we obtain when we test theories through experiments, and sense data tell us whether a particular theory is likely to be correct. This view has been undermined by the Du-

* We are grateful to Michael Lynch for his very helpful comments and suggestions.

hem-Quine thesis of underdetermination, according to which data can never conclusively prove or disprove a particular theory.[1] And it has been challenged by the claim that what counts as appropriate evidence in a theoretical controversy is itself negotiated during the controversy, hence evidence cannot serve as an independent arbiter of scientific belief (Collins, 1975). However, these challenges of the standard view deal only with the degree to which evidence is, from a logical point of view, pertinent to theory choice. They are not concerned with how sense data may be problematic in ways other than in relation to what they achieve in theory debates.

But are sense data problematic? Consider that in the natural sciences evidence appears to be embodied in visibility; in a literal sense, it is embodied in what we can see on a data display. Thus understood, the notion of evidence is built upon the difference between what one can see and what one may think, or have heard, or believe. Among these modes of relating to an object, only seeing bestows on objects an accent of truth. But does it really? And can we consider seeing as a primitive (in the sense of unconstructed), "truth-transporting" activity? We know of course that processes of seeing are subject to cultural and historical conventions, and that what participants see may depend on the institution of seeing involved (Gombrich, 1960). In regard to science, Kuhn (1970) has argued that consensual ways of seeing are maintained through shared paradigms, consisting of rules and standards for correct scientific practice. Under this view, what scientists observe should be grounded in their complex commitments to particular research traditions. Yet in the science we study, the problem appears not to be, as Merleau-Ponty said (1962:78), that "what you see depends on where you sit", but rather "nothing is more difficult than to know exactly just what we do see". Whatever role perceptual grammars may have in shaping what counts as evidence in disciplinary traditions, these grammars do not resolve the manifold problems associated with visual sense data in day-to-day laboratory work. The point is that just as scientific facts are the end product of complex processes of belief fixation, so visual "sense data" – just what it is scientists see when they look at the outcome of an experiment – are the end product of socially organized procedures of evidence fixation.

When we mention "seeing" in this context, we do not just mean sensory activation by some perceptible manifold-out-there. Most arguments which relate to "seeing", for example Quine's point about the equivocality of ostension in identifying visual objects (1960) and Campbell's attempted rebuttal (1986), presume a relationship between "seeing" and the linguistic reference to objects: "to see" an object is to recognize and at the same time to linguistically identify an object. But, what if these objects are, as they appear to be in science, *visually flexible phenomena* whose boundaries, extension and identifying details are themselves at stake? The problem for scientists is not the equivocality of ostension or the impossibility of being certain that a "translation" into language is correct. Instead, for practicing scientists, the difficulty of coming up with a translation in the first place is the prime concern. When we refer to processes of evidence-fixation, we refer to processes of developing and solidifying such translations.

In this paper, we offer an initial description of the kinds of mechanisms and processes involved in evidence-fixation. The data presented derive from an ongoing laboratory study[2] of molecular genetics conducted since September 1984 at the Center for Molecular Genetics, Heidelberg, FRG. The group studied works on transcriptional control mechanisms, that is on DNA regulatory elements which can dramatically increase transcriptional activity during the transcription of DNA into RNA and which, for that reason, are relevant to the understanding of normal and abnormal cell growth. The group publishes regularly in journals such as *Nature and Science*; it is one of the leading research units in the area on a worldwide basis. The leader of the group, who is also a Professor at the University of Heidelberg, and its core-members spent several years in the United States, and two American post docs were employed in the unit during the period of observation. The Center is basically financed by government sources; the research is done by post docs, doctoral students, and students working toward the equivalent of an M.A. Most of the examples presented in this paper derive from a series of interconnected experiments involving a particular method of RNA preparation ("Sl analysis").

2. Sense-data and evidence

To begin with, we will introduce a distinction between the "data" recognized in the laboratory and the "evidence" published in scientific papers.[3] In the molecular genetics lab we describe, there are at least three different modes of practice through which materials in the laboratory are visually inspected, and through which seeing becomes a distinct, specially marked activity in the stream of laboratory shop work:

1) The first mode of practice involves techniques of manual and instrumental *enhancement*, such as in simple cases, holding a test tube against the light to assess the progress of a biochemical reaction, or taking a polaroid photograph (which participants call "fast picture") of an electrophoresis gel to check on the position of DNA fragments or the success of a plasmid construction.
2) The second occasion for visual inspection centers around "*data*" – which in the study of transcriptional control mechanisms and many other molecular genetics fields are mostly visual traces generated by radioactively marked DNA or RNA fragments separated in an electrophoresis gel on which an X-ray film has been exposed. The following exhibit (see Exhibit 1) offers an example of an autoradiograph film as it appears in the laboratory.[4]
3) The third set of practices revolves around "*evidence*", by which we mean the data actually included in scientific papers or shown in oral presentations. Data become evidence only after they have undergone elaborate processes of selection and transformation.

Now seeing becomes problematic only in the second case, when scientists deal with "data". The distinguishing characteristic of the first set of practices is that they tinker with the conditions that improve the visibility of certain materials. But the visual materials themselves appear unproblematically readable, and the pictures created on this level have only *local* relevance. They are not normally discussed at length among participants or displayed in the papers produced. Any problems with "enhance-

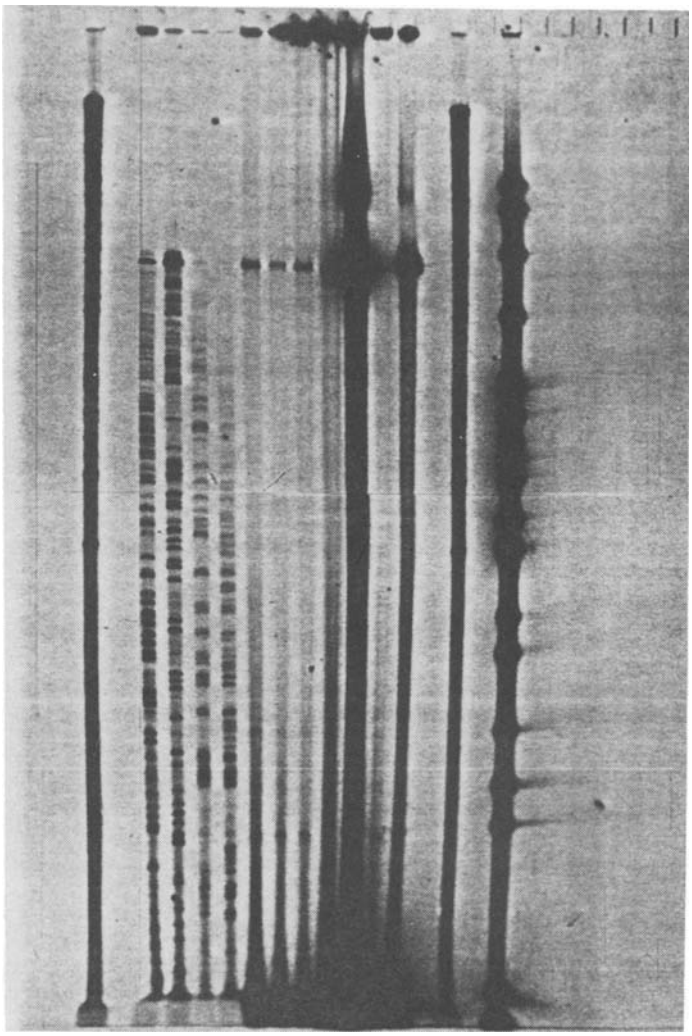


Exhibit 1. Example of an (unedited) autoradiograph film as it appears in the laboratory

ments" tend to get quickly resolved, and they are treated as significant only in regard to the control function they perform.[5] The instrumental techniques involved have sunk into the background of taken for granted devices in the pursuit of other, more "interesting" matters. Not so with "data". The autoradiograph data which are the focus of the second set of practices lie at the very center of scientists' attention, and they form the core of the papers produced. The distinguishing characteristic of visual data is that they are not, like the "enhancements" mentioned before, treated as unproblematic displays of visual objects. Data act as a *basis for sequences of practice* rather than observation at a glance. They are subjected to extensive visual exegeses, rendering practices which attempt to achieve *the work of seeing what the data consist of.* The question of interest to the analyst in these visual exegeses is "what do we see". The image, here, becomes a "workplace" (Lynch, 1985b) for participants in seeking an answer to this question. The sociologically interesting phenomenon is that *seeing is work*. But what sort of work?

3. The machinery of seeing

Characteristically, autoradiograph displays appear in the laboratory when an author retrieves them from the film room where they were exposed for a number of hours or days, and starts to inspect them against the light. (See Exhibit 2)

Other researchers present in the laboratory are attracted by such events, gather around the visual materials, finger the documents and gaze about their surfaces. As they examine the film, scientists begin a series of verbal exchanges. This is where language becomes relevant in the present context. But note: the resulting perceptual identification is not just the product of *language*, it is the product of conversational *talk*. What difference does this make? When embedded in talk, "seeing" is interactively accomplished. Thus the process is not just a semiotic process, in the sense of involving a translation into a generalized system of signs. Nor is it mainly a cognitive or interpretative process in the sense of involving individual conceptual decoding. Instead, the process has a *speech act* and particularly a *dialogical* or *interactive* structure.[6]

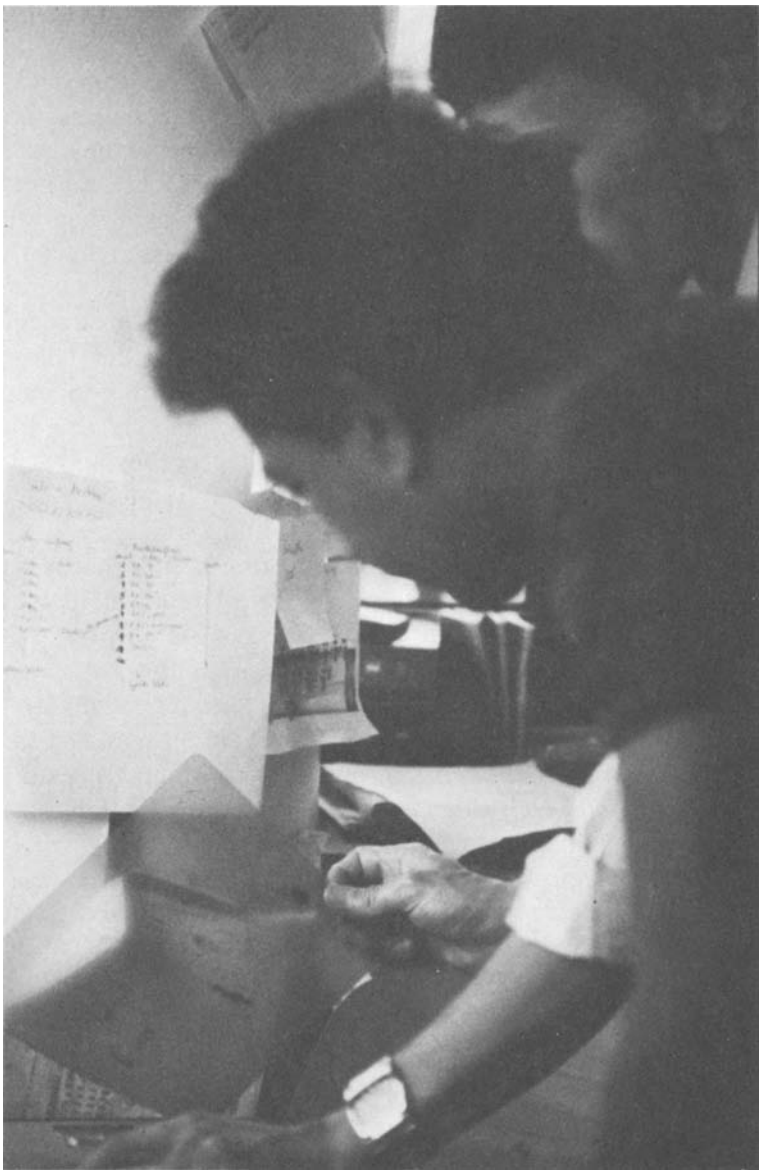


Exhibit 2. Participants looking at an autoradiograph film against the light

Thus, when practitioners encounter the "external world" in terms of the sense data described, the *machinery of seeing is talk*. This talk has several specific characteristics: First, image analyzing talk is *attached to objects*, specifically to the data displays ("films") which are the subject of the exchanges. Image analyzing exchanges are not just "about" an object; they are also "with" an object. One might say that participants interact not only with each other but also with the object to which they attach their comments. Significantly, the objects addressed by participants are also manipulated during these exchanges. The operation performed, the detail observed, complement the utterances as concrete but non-verbal "phrases". Furthermore, the talk produced appears to some degree to be *organized by* the documents inspected. This *documentary organization of talk* is also found when scientists discuss the content of the papers they are writing, as presumably it is whenever talk is concretely related to objects which exhibit their own semiotic organization.

A second characteristic of image analyzing talk is that it is embedded in a *series of exchanges* which are interconnected by one or several related displays. Related displays are displays which derive from replications or slight variations of the same experimental procedure. Participants tend to return repeatedly to the same or related displays to discuss their content, a feature of shop exchanges made possible through the continued accessibility of participants to each other while they work in the lab. Participants may vary in these exchanges: *it is the image which integrates the series*, not the continuity of speakers. Serial exchanges of this sort indicate practitioners' *occasional presence* to complex situations and the *local* and transient character of most problem solutions. Participants do not seem to resolve issues raised by the features of an image once and for all. Instead, they repeatedly "visit" a problem, thus continually reopening cases that, as judged by an outside observer, seem to have been closed by a definitive conclusion the last time the problem was considered.[7]

There are also more general characteristics of shop talk which might be noted, for example the phenomenon indicated before that the substance of the talk is interactively or collaboratively produced. Speakers' contributions remain oriented to each other

within conversational turns of roughly equivalent length, such that the substance of the talk is the outcome of joint conversational work. Ostensibly, what is achieved in these transactions is technical work and not, to borrow a distinction by Goffman (1971: 147–148) ritual or relationship work (though the latter may be performed through the former). What is the pattern of interactional organization in these exchanges? We want to offer some observations on the interactional shape of film talk and on the conversational devices participants employ in performing image analysis work.

4. The interactional organization of image analyzing talk

First the pattern of interactional organization. When two or more participants gather around an autoradiograph display in the lab, they face the task of finding their way about the film – that is, of identifying various black and white bands on the film and the objects these bands represent (see Exhibit 1 above). In general, practitioners go about this task by asking a series of questions. These typically refer to where on the film are the following constituents:

- the "marker", a known construct usually inserted into the first and/or last lane of the electrophoresis gel. The marker supposedly yields a known pattern of bands which serves as a measuring stick for the length of the DNA and RNA fragments under investigation;
- the "probe", a radioactively labelled DNA fragment to which RNA is hybridized and which appears in all lanes in a specific position;
- the "starts", that is the expected bands which indicate the molecules separated in the gel run;
- the "length" of these items, that is the position of the bands on a vertical scale as determined by external reference tables that indicate the expected "length" of the marker bands;
- in addition, there occur opening questions which determine the general nature and identity of the film, the stage of the analysis, the display a film compares to, etc.

With different displays, different objects may become relevant, such as "windows" (white spots) on "footprints"; yet typically there are inquiry sequences through which practitioners attempt to specify the geography of the display. In exchanges between two or more persons, questions are always posed to the author of the film by a recipient as he or she seeks to learn more about the film. Students of institutional encounters such as medical interviews, calls to the police or classroom interaction have found that the person asking questions (the doctor, the police, or the teacher) appears thereby to dominate the encounter by placing limits on the placement and the content of recipients' responses (e.g., West 1983).[8] In contrast, the inquirers in film talk do not appear to exert, by adopting the role of the questioner, such power. At least on the face of it, the roles seem to be reversed: it is the person questioned who controls a valuable good, namely relevant information, whereas the questioner seeks to obtain a share in this good. Furthermore, there appears to be agreement among practitioners as to the questions which must be asked. Thus the questioner is not at liberty to shape the interaction by carefully choosing and editing his or her question. If there was no interaction, the author of the film would have to raise and answer the same questions, as ln. 323 of the following, monologic exchange indicates (the author, distracted by what he sees on film, apparently takes no notice of other parties' contributions). The exchange also illustrates the initial phase of an inquiry sequence: It begins by an inquirer (He) asking a general identity and recognition question (→ ln. 319) not answered by the author (Er) and continues by the questioner asking for the location of the marker (→ ln. 325) and the probe (→ ln. 326, 328). As his questions remain unanswered, the inquirer reverts to another sequence opener (→ ln. 329), i.e., to the question about the film to which the other film compares (about the experimental series to which the film belongs):[9]

(160102 85p98)

→	319	He	and, what is this?
	320	Er	ha, over night ((exposed)), exactly like last time. And what do you see ((holds up film))? Nothing! ((Pause))

→			Where is the probe anyway?
	324	Ni	simple enough, there is nothing on it
→	325	He	these are the markers, aren't they? Left and
→			right. This is the probe?
	327	Er	((remains silent))
→	328	He	this is the probe?
	329	Er	((remains silent))
→	330	He	which ((film)) does it compare to?
	331	Er	((annoyed)) what do you mean, which does it compare to?
		((Etc.))	

Note that inquiries into the geography of the film are sequentially structured in terms of a series of questions posed in a certain order (the identity recognition question is posed before the marker question, which in turn is posed before the probe-question; the question for the location of the starts comes last). Authors do not offer summary accounts of all the relevant information they possess in regard to the identity of the bands on film. This is one example of the more general phenomenon that complex problem situations appear to become *interactionally dissolved* in shop talk. In cases of image-analyzing talk, there is a perfect reason for this interactional dissolution. While authors of films have an informational advantage over non-authors, as acknowledged by their being consulted by the latter, they have few ready-made answers, and must find their way around the film at hand by inspecting the image just as non-authors must. If the questions indicated above could be readily answered, film analysis exchanges would presumably have a straightforward and readily intelligible structure including the following segments:

1. An *opening sequence* comprising a summons (such as a non-verbal display of the film which has the effect of a summons on participants within reach) and/or a verbal news announcement or news request followed by an answer.
2. An *information-gathering question-answer sequence* resulting in a specification of the geography (identity of the bands) and perhaps of the architecture (how the image was "built") of the film.

3. An *evaluative sequence* resulting in an evaluation of the expected bands, the actual results of the experiment.
4. A *resolve* or *performance recommendation* based upon the evaluation of the film which indicates the actions to be taken in subsequent experiments or in preparing the material for publication.

The whole exchange would have the character of a newsreport/newscommunication elicited by receivers, or of a collegial information-sharing encounter among fellow workers engaged in roughly similar tasks. However, we cannot offer an example of such an exchange. While fragments of the above structure can be found in all appropriate encounters, not one of the exchanges recorded is "*whole*" in the sense of displaying the projected structural form. The structure of actual film talk is characterized by the absence of a distinctly marked evaluation sequence and by a pattern of diversions from the remaining central piece, the inquiry sequence. The questions in this piece provide something of a skeleton which holds the conversation together; but they also serve as pegs on which a variety of other segments hang. Why these diversions? Because sooner or later, the author of the film appears to be unable to provide a satisfactory answer to the questions and the inquiry sequence gets stuck. Other conversational devices take over and propel the exchange for variable periods of time in a different direction. The side sequences[10] thus formed which break the inquiry sequence apart account for the "garland" structure of real time film talk. (See Diagram 1)

The left side of the diagram exhibits the projected path through an image analysis task as posed by autoradiograph displays in the lab observed, while the right side offers a schematic representation of the garland-structure of actual film talk. Projected paths are straightforward, recognizably rational, but nonetheless conventional[11] "throughways" through an image. However, we can only pursue them if nothing distracts our attention, and if there are no obstacles which force us to take a detour. Participants attempt to pursue projected paths; they continually initiate and return to the inquiry sequence in film analysis exchanges. Thus projected paths are also empirically recognizable, seemingly preferred forms of interactional organization and not merely sequences of steps

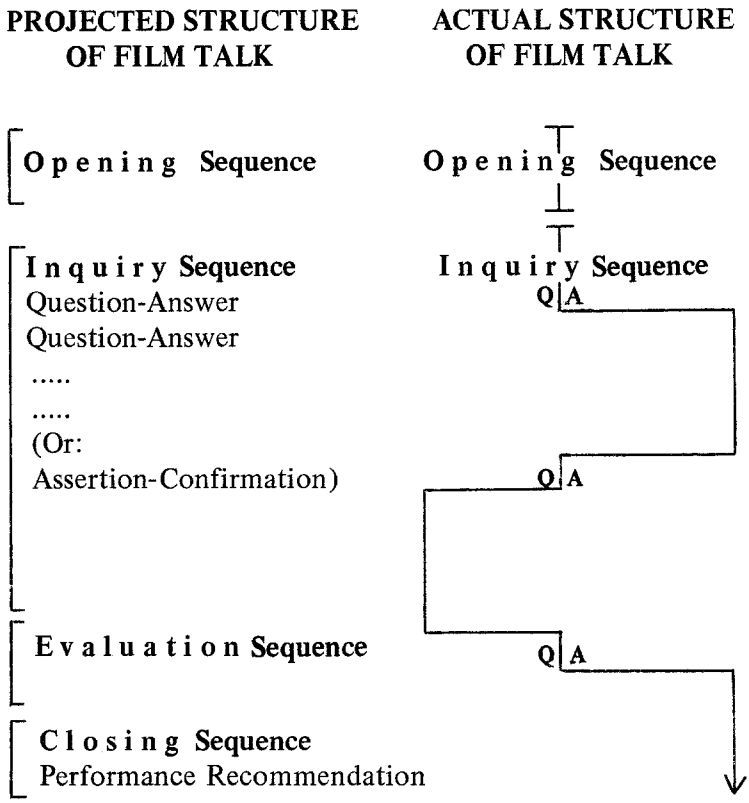


Diagram 1

that follow "logically" upon each other. Yet, for the reason indicated above, in real time passages through an autoradiograph film participants get caught up in side sequences, which make up the bulk of a series of exchanges.

What happens in these side sequences? Conversational devices other than the inquiry sequence take over the exchange. Three patterns of talk are particularly notable: in our understanding, these are general, inference producing devices employed in many problem situations.[12] Elsewhere we have called them procedural implicature, optical induction and the oppositive device (Amann and Knorr Cetina, 1988a). In the present case, participants "slide into" one or the other of these patterns as they run into problems with identifying and interpreting the bands on the film.

5. Conversational devices employed in image analyzing exchanges

5.1 Procedural implicature

Consider first the *procedural implicature* device.[13] This pattern is, in a sense, a variant of the inquiry sequence adapted to another use. It is employed to derive non-obvious conclusions from mute experimental outcomes by means of an inquiry into the procedures through which these outcomes have come about. In a nutshell, the exchange consists of a series of question-answer and/or assertion-confirmation adjacency pairs (pairs of utterances in which the first utterance constrains the second, as in a question which "demands" an answer) which access and make public indexical information from eyewitnesses of a phenomenon. As before, the author is not asked to provide a summary assessment of the situation. Rather, he or she is consulted in an iterative, stepwise fashion as a *living archive* of the details which constitute the time-space geography[14] of the film. The pattern may be followed by a conclusion in the form of an interpretation ("this means ...") or of a performance recommendation ("I would ...", "you've got to ..."), and it is frequently initiated by a statement which discloses some problematic occurrence or information.

The following example is the first of two interrogatory series (ln. 114–122 and 126–141) separated by a candidate interpretation (ln. 114). The series is part of an exchange which attempts to establish which of the bands on the film are correct "starts" and which are the "probe" or false starts. The procedural inquiry (→) is initiated after Ea indicates where approximately, in his opinion, the start side should be (ln. 110ff.)

(15018505ffp3)

	110	Ea	somewhere there. This is CAT and this has to be away. <u>There</u>! somewhat shor/ somewhat longer, merely 10 basepairs, right? More over <u>there</u>! This would be the level of
→	114	Jo	what probe is this?
	115	Ea	polyoma-CAT
→	116	Jo	I don't quite understand it yet. The/ this ha/ this was done with SV40, the polyoma?

	118	Ea	transfected. Transfected. And when I knock it down with my probe/
→	120	Jo	this is then knocked down with your probe?
	121	Ea	yes, and then I get only/ then I only get CAT protected ..
x	122	Jo	then this up to eco would have/
x	123	Ea	to be CAT

After two more turns in which Jo and Ea elaborate this interpretation, the inquiry pattern continues:

→	126	Jo	Could it be that you have a bad homology somewhere? Between your DNA and the probe?
	128	Ea	how do you mean
→	129	Jo	if, let's say you cloned in a way such that at the hindIII-cut...there was a missing homology ...I/ I don't know your clones/ if you'd/ 10 basepairs at the hindIII mark or s/ or 5 base-pairs/
	134	Ea	but there is/ in there/ the hindIII side has been changed into a bglII side
	136	Jo	yes
	137	Ea	on this is cloned, polylinker. and into <u>that</u> I cloned
→	139	Jo	right and you took the <u>same</u> probe for the separation of strands?
	141	Ea	of course
	142	Jo	yes/ this can/ sure/ this can be through/ this can come about
x			if you have a missing homology at the
x	145	Ea	now listen, the
x	146	Jo	hindIII- side
x	147	Ea	problem is as follows ((Etc.))

Notice the overlaps (x) as conclusions are collaboratively produced (ln. 122ff.) or rejected (ln. 142ff.), and the fact that answers to a procedural question may take more than one turn (ln. 132f., 135). The latter switches the question-answer pattern to one of assertion and confirmation (ln. 132–134, 135–136 (first word only)).

5.2 Optical induction

Optical induction is a curious hybrid between visual operations and conversations.[15] With procedural implicatures, participants rely on the interrogation carried out to produce features of the history of a phenomenon which aid in object identification. With optical induction, in contrast, it is the image itself which prompts these features. In pursuing a procedural history, participants depart, for the time being, from the display which is the object of their talk. In performing optical inductions, participants concentrate on the image. Optical induction is a pattern which, for the most part, *consists of visual operations carried out through talk.* The linguistic means, however, are not question-answer adjacency pairs or assertions and confirmations, but sequences which include *formulations* of details of the bands on film mixed with interpretations. As participants inspect visual features of the film, as they pay attention to and compare the details of these features, they establish and reject candidate identifications of visual traces, and they do so in the sequential fashion typical of collaborative talk. The procedure is not linear, however. As participants move between traces in attempting to establish the identity of some bands by reference to others, they have frequent occasions to return to the same spot and to revise previous interpretations. Presumably, optical inductions occur in all image analyzing contexts, including those in other areas within and outside of science. The following example illustrates how participants' visual operations on the film (ln. 352–364) lead to certain interpretations (i.e., which band is the probe, that there is a transcript and where it is located; ln. 366–372), and how these interpretations in turn give rise to a new round of visual operations (ln. 371f.).

(1401188505ffp7)

352	Ea	(...) if you look at it ((points to film)) these run three times higher, okay? the difference here is a centimeter, this one, of this size
355	Jo	yesyes
356	Ea	okay. these up there don't even have half ((a centimeter)). You can do what you want, we just measured it. They're not on the same level.

The differences are very variable, depending, on the size of the fragment.

361 Jo if you shift this parallely with the others, right, like that, that way, that way, this is nonetheless not running on the same level as this

364 Ea no, this isn't on the same level, granted. I am not saying (it is), but I say/ this is/ say/

366 Mi but if these run on the same level, this greatly suggests, doesn't it, that this is the probe.

368 Ea sure this is the probe. But then I also know that I've got a transcript which runs all the way through

371 Jo but this can be this/ this one here. That is this band here.

((Etc.))

Which bands run "on the same level" is not obvious from what one sees on the display, as the transcript indicates. Participants must work out the looks and location of visual traces as much as they must work out which experimental variables the black and white spots on the film represent. How are they doing this? By shifting and otherwise manipulating visual traces (e.g., ln. 361) and by comparing the signs which appear in different locations (e.g., ln. 352). But also by taking some signs at face value for the time being ("if this is this then that is that..."), and by going back and forth between the geography and the architecture of the display (between the location of bands on film and the way the experiment was set up). As the above exchange continues, Ea counters Jo's proposal as to which bands might be the transcript/probe (ln. 371) by reference to the experimental design (ln. 373, 376):

371 Jo but this can be this/ this one here. That is this band here.

373 Ea but that's something else, wait, don't mix things up.

375 Mi yes but I mean, still/

376 Ea that's a different promoter, rightsh

In many respects, an autoradiograph film is like a maze designed

by one participant in which the designer nonetheless finds him/herself lost. To locate a way out of the maze, participants identify and compare visual clues, point out where it might continue, follow some paths and recall the design of the maze to evaluate leads. Occasionally, they clash with each other about the direction to take. Then the pattern of talk becomes adversarial, and another routine of talk takes over the conversation.

5.3 The oppositive device

Possible turning points where the exchange could become adversarial are found in the above excerpt. For example, consider the counterproposal in ln. 371 or other contributions opening with a potentially oppositive "but...". Yet these possibilities are not taken up by participants as they work their way through the film in the above segment of talk. More suggestive examples of adversarial episodes are found elsewhere in the above exchange. To some extent, oppositive patterns of interaction "feed upon" or overlay other conversational patterns. This is because oppositive patterns are not only adversarial, they are also heavily argumentative; and participants may raise procedural questions or draw visual inferences in the service of their argument.[16] Oppositive patterns often start by one participant objecting against the proposal made by another. They continue by participants arguing with and negotiating about each others' candidate accounts of issues raised in the encounter. Like the other patterns mentioned, oppositive patterns occur in a variety of shop situations. In image analysis exchanges, oppositive episodes are likely to exhibit features of optical induction, as participants argue in terms of visual clues and operations. In the following exchange, which is part of the above series of conversations regarding the location of the probe and the starts on the film, such segments are found throughout the transcript. Consider the beginning (ln. 56–57) and then again ln. 63 and 67ff. of the transcript, in which the opponents compare their films and produce visual inferences (ln. 71ff.) while at the same time arguing about how preparatory conditions involving different salts influence the appearance of bands:

(1401198505ffp2)

56	Ea	if you want to say that you're seeing plus minus 5, I will start laughing
58	Jo	these are/ the longer they are the/
59	Ea	you're saying, these are early early and two a/ five bases away is
61	Jo	naw, first, I let my gels run longer
62	Ea	haha
63	Jo	and besides with me these are 309, and this is 305 to 310 ((points to his film))
65	Ea	ah, but they are running the wrong way!
66	Jo	they run on the same level!
67	Ea	((ironic)) 305 and 309 run on the same level, right!
69	Jo	((impatiently)) listen, this up there is 520
70	Ea	uhuh
71	Jo	and hence this would be, if you take this to be 404, approximately 450. This means you would/
74	Ea	naw, might as well be 480. It starts there/
75	Jo	but you would thereby def/ thereby require, that you have 70/ a difference of 50 to 70 basepairs because of the salt!
78	Ea	man, this has something to do with the length of the gel run!
		((Etc.))

Note that what you see on an autoradiograph display depends on "what makes sense" in terms of experimental conditions and theoretical presuppositions. For example, in ln. 75 Jo objects against Ea's claim that the length of a band (its position on the film) is 480 by referring to the magnitude of the effect certain experimental variables (salt) should make. Note also that the point of such adversarial dialogue is not, as one might assume, the persuasion of one participant by another or the negotiation of firmly held opinions until a compromise is reached. First, participants develop their contributions as they go along in response to problem features they become aware of; they may not hold the respective opinions in advance. Second, the purpose of

these exchanges appears not to be to reach an agreement among opponents, but to use their disagreement to produce novel (not previously obvious) features of the phenomenon discussed. For example, there is little effort on the part of participants in these exchanges to reconcile their differences. More generally speaking, there exists in these situations a *preference for disagreement* in contrast to the preference for agreement students of verbal encounters in other institutions, for example in doctor-patient interactions, have found.[17] Significantly, many adversarial exchanges do not end with an agreement but nonetheless produce a conclusion on which participants can proceed. Furthermore, even when an agreement is reached, this does not mean that the problem has been solved, as illustrated by the frequency of what one might call "negative solutions" – ways of undoing the problem without solving it. For practical purposes, results can be achieved which do not require a solution to the conceptual problem involved. Examples of such forms of remedial measures are proposals for different kinds of redressive action, such as for not showing the problem in a publication. Remedial measures are often proposed as free-standing solutions, that is as solutions which are not logically derived from the preceding exchange.

In sum, all patterns discussed above are inference producing devices that are interactionally accomplished, and they are initiated when the inquiry into the geography of the image collapses because bands are missing, occur in the wrong places, or display some other peculiarity which cannot be readily explained. Film talk begins as outlined in the projected structure. Indeed, the best indication of the relevance of the projected structure is participants' continued attempt to implement this structure (for example, they do not start by asking where the problem lies). But the final form of the exchange may look as in the following sample conversation:

OPENING SEQUENCE
Film is presented to a recipient
INQUIRY SEQUENCE
Q – A | Inquiry about *kind of data* on film
Q – A | Inquiry about *marker*; Problem: marker not seen
|Oppositive exchange

(Argument about the appearance of the marker terminated by the next answer)

– A Author offers second marker as an identifiable alternative

Q – A Inquiry about length of 2nd marker; Problem: still unclear

– A Author offers *probe* and length of probe as identifiable

Optical induction
(Attempt to derive length of marker-bands and probe-bands from visual inspection; 1st round)

Q – A Inquiry about the *kind of constructs*; Problem: bands not visible

Procedural implicature
(Reconstruction of procedures used in RNA preparation ending with performance recommendation)

Q – A Inquiry about how the fragments were "cut"; Problem: recipient offers alternative answer, namely that bands are *starts*

Oppositive exchange
(Arguments about whether certain bands are probe that is partially cut or secondary starts; no agreement)

INTERRUPTION

(Performance recommendation)

JOINING OF ANOTHER SPEAKER

Q – A Inquiry about the length of marker/probe; Problem: length still unclear

Optical induction
(Attempt to determine length of marker-bands and probe-bands by visual inspection and reference manual; 2nd round; ending with performance recommendation re.probe)

INTERRUPTION

Procedural implicature
(Reconstruction of length of marker-bands)

INTERRUPTION

(Performance recommendation regarding marker)

Much of what goes on in the exchange should be self explanatory from the above summary representation. The first "diversion" from the inquiry (*Q*uestion – *A*nswer) sequence comes about when the newsrecipient, who had been summoned to join in the inspection of the film by the author holding the film under his nose, rejects the latter's account of why the marker is not visible. The diversion is a short adversarial episode about whether the author's account is warranted. The inquiry sequence resumes when the author answers the marker-question indirectly by pointing out that there is a second marker on the film which offers no problems, but is arrested again by the question for the length of the marker, which the author cannot answer. He offers instead that he knows the location and length of the probe, thereby anticipating the next question in the sequence and initiating the second diversion: an attempt by both participants to infer the length of the marker-bands and the bands of the probe by going back and forth between these bands. A question about the kinds of construct inserted in certain lanes, which is prompted by participants noticing the absence of expected bands, briefly returns the dialogue to the inquiry sequence,[18] and then thrusts it back into another side sequence, when the recipient thinks the answer raises procedural problems. The next diversion from the inquiry sequence, a longer oppositive episode, follows suit: the recipient proposes an answer which differs from the author's, and the latter objects. Both this and the previous side sequence end with performance recommendations. In the final section, another member joining the exchange sets off round 2 of the length of the marker-and-the-probe induction performed on the film. When the author tells him he does not know the length, round 1 (2nd side sequence) turns out to have provided only a provisional answer. In the end, round 2 appears not to be definitive either; it terminates with performance recommendations for further inquiries necessary to satisfy this question.

To sum up this section, we want to draw attention to several features of the overall pattern of interaction in film analysis exchanges:

i. The inquiry sequence, heart of the projected pattern and glue for the actual one, remains incomplete. It may be completed

in other rounds of talk, but single exchanges tend to get stuck in one of the side sequences;

ii. All inserted problem discussions (side sequences or diversions from the "projected path") tend to have recognizable closures, often performance recommendations;

iii. The "inserts" or "diversions" which split up the inquiry sequence constitute the bulk of the exchange;

iv. Problems emerge interactionally when questions cannot be readily answered or when answers are objected to by another party to the exchange;

v. Pauses and interruptions when other speakers raise a different topic have structural significance. They mark possible transition points to other patterns, precede conclusions and the like;

vi. Participants appear to accept specifications they have worked out only provisionally, as indicated by the fact that there is always the possibility that they may return to the same issue (say the length of the marker and the probe) at a later occasion and work through it in another round of shop talk.

6. Analyzability

What is at stake in these verbal exchanges is the analyzability of the visual image and not, as one might assume, the fit between previous theoretical hypotheses and the data obtained. What participants do when they talk is to negotiate the identity of the thick and thin bands or the blank spots on the film, by examining the features of the experiment which make the film analyzable. Analyzability is not just imposed upon the visual record by labelling the record and other techniques. Rather, it is *built into* the record from the beginning, through the way the experiment is designed.[19] In the case of autoradiographs of electrophoresis gels, these built in features include comparative standards such as:

i. Markers of length; i.e., fragments with known patterns which serve as a kind of measuring stick for the length of the resulting DNA and RNA fragments.

ii. A "blue marker"; which is a blue stain added to all lanes of the gel. When the gel is run, the blue signals, by appearing at a par-

ticular position, indicate that the separation of fragments in the reaction mixture has occurred.

iii. An "internal standard"; that is, a fragment inserted into all slots of the gel to assure the comparability of various parts of the experiment and to allow for the quantification of results.

iv. Finally, additional lanes may include familiar constructs whose patterns are known for purposes of comparison.

In addition, there will be positional clues such as slots or pockets which indicate which substance has been run through which column of the gel, and glued-on labels manually transferred from the electrophoresis plates to the film. All of these result in a kind of grid reminiscent of Dürer's drawing machine,[20] a reading grid designed to fix (make readable) the signal within the matrix it provides. (See Exhibit 3)

The grid formed by the markers, known constructs, internal standards and positional clues of an electrophoresis gel does not consist of a system of geometric coordinates like Dürer's machine but of in vivo biological specimen reactions: it is *of the same order and kind* as the traces obtained from the signal, and part of the *embodied optics of the experiment* conducted. As a consequence, the grid itself must first be read – the marks it creates on an autoradiograph film must be positioned and identified – and this as we found in the last section proves to be as problematic as the identification of the signal itself. In fact, there is no difference whatsoever in kind between the visual work necessary to identify the grid and the work required by the signal, and scientists make no distinction between these classes of variables as they work through the film. But why does the identification of the markers and comparative standards, which are included in the gel *to help locate and fix the signal* in the matrix they provide, create such a problem? Why, more generally speaking, is *analyzability* the problem and not, or in any case not at the bench, the theoretical meaning and interpretation of the data obtained?[22] Participants blame a variety of occurrences during the experiment for this situation. The most common are:

1. *Mix ups*: markers of length may get mixed up so that participants do not know which marker has been inserted into which

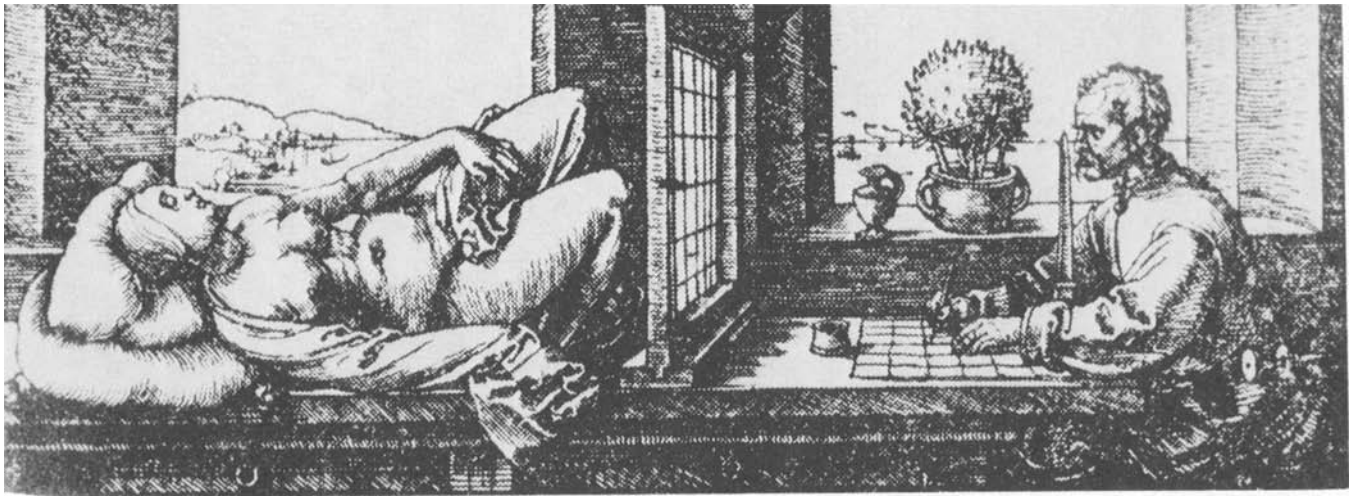


Exhibit 3. Reproduction of Dürer's picture of "The drawing grid" (*Source*: Jeaggli and Steck, 1969). In looking over a nodge and through the grid at his object, the painter can presumably locate every detail of what he sees on the grid of geometric coordinates. By transferring the resulting points to their equivalent location on the grid of the drawing table the painter creates an "objective" and "exact" rendering of the object

lane, or one of them may even have been forgotten. Lanes with different substances in the gel matrix may get mixed up, or the substances may not have been inserted in proper sequence.

2. *Manipulation problems*: The internal standards, the markers or known constructs included for comparison, may not have been "hot enough" (not radioactive enough), which renders them invisible or ambiguously visible compared with other bands. Known constructs may not have been "pure", causing them to suddenly yield patterns of bands different from those expected and documented. Bands may not appear or may spill into each other because the film has been exposed for too short or too long a time. When the film has been exposed for too short a time, the pockets on top of the gel which mark different lanes are not visible on the film, which makes it difficult to tell the top from the bottom of the film. The blue marker added to all lanes may run all the way through the gel and spill into the buffer solution when the apparatus is not turned off in time.
3. *Apparatus problems*: The voltage field generated during electrophoresis may not have worked properly, thus causing the bands on the film to deflect. As a result, it may no longer be clear which bands lie on the same level (have the same length). The plates between which the gel is inserted may break and part of the gel may become torn off.

Though some of these problems would in principle be avoidable, in practice they occur routinely. It appears that participants' practices are governed by principles other than those desirable from a methodological or epistemological point of view. For example, mix ups become understandable if one considers that, for reasons of "time" and in response to various demands of expediency, participants frequently handle 2–3 gels simultaneously, each of which displays approximately 20 different substances. Conceivably, some of the problems which occur could be eliminated by as simple a measure as the replication of the procedure, but, in practice, scientists attempt to use the results despite of the problems they exhibit. Why? They may not have the materials needed for a replication readily available, or may not have the time to obtain the materials and perform the work. And they cite the fact that any replication brings with it the danger

of further problems. In practice, it seems, participants prefer a principle of variation over replication.[22] If the procedure has to be repeated, or so scientists argue, one might as well try out some variations which conceivably offer an improvement upon the previously obtaining situation.

Not all of the difficulties are "avoidables". To give a simple example, whether the marker is hot enough (radioactive enough and hence adequately visible on the film) depends on the strength of the other signals obtained. If they turn out to be weak then the marker will appear too hot. But the strength of the signals cannot be predicted precisely in advance. It is part of the experimental question to obtain information about the strength of the signals. Thus, to optimize the procedure, information would be needed that is contingent upon the outcome of the experiment, yet to obtain unequivocal results, the procedure would have to be optimized. Unambiguously visible data, whether signal or reference variables that make up the grid, are likely to be unattainable in this situation.

How is this ambiguity eliminated? The case analyzed in the last section suggests that the procedure is one of *embedding*. The details of the grid are identified by reference to the visibilities the grid variables display relative to each other, to their procedural history and to the experience of other participants. The shape and boundaries of the signal are identified by reference to the grid and equally to historical and experiential matters. The contexts invoked by these references constitute a web of meaning within which the data become fixed. In terms of Campbell's (1986) analogy of the cup and saucer it would appear that it is not the unambiguous entitivity of these objects which "edits" their linguistic designations. Instead, scientists proceed as if they were identifying cup and saucer by determining that the occasion is one of a tea party, and it is working this out which makes them fall back on talk.

7. Evidence

Is anything to be gained by moving from data to "evidence"? As indicated before, data become evidence, i.e., the data included

in scientific texts, only after they have undergone an elaborate process of transformation. Significantly, the autoradiographs displayed in molecular genetics' papers are not identical to the troubled images (data) on which the work of seeing is performed in the laboratory. Further work is needed to arrive at figures that are self-explanatory and self-evident, as required by the research group's director; figures whose meaning is recognizable without consulting the accompanying text, figures which carry meaning on the face of them. What further work? Nearly all published images are carefully edited *montages* assembled from fragments of other images.[23] The original images are sometimes different exposures of an autoradiograph film taken from a single experiment, and at other times exposures from different experiments or runs of a gel. The resulting montages display at least three analytic orderings:

1. They rely on the *methodical production of a perspectival* (3-dimensional) *order* which puts the signal into the foreground and the "noise" into the background. The activities through which this perspectival order is construed are mundane. They consist of the following practices:
   - cutting off, at the top and bottom of a visual display, bands considered as artifacts, as unclear, or simply as irrelevant to the "message" to be conveyed;
   - manipulating the exposure time of films or photographs of films to enhance the visibility of bands judged to be significant, and to decrease the visibility of unexplained traces;
   - selection of the lanes from several runs of gels which best display the features proposed. These lanes are cut out (some scientists insert an additional marker in the middle of the gel in order to have a lane in which to cut) and glued together.

The following exhibit shows a montaged autoradiograph upon which the above manipulations have been performed. The lines inserted mark the cuts and the clippings from which the present figure was assembled. (See Exhibit 4)

The result of the above manipulations is a montage of relatively "clean", "pure" or "beautiful" signals according to aesthetic criteria which specify, in an area of research, what counts as a

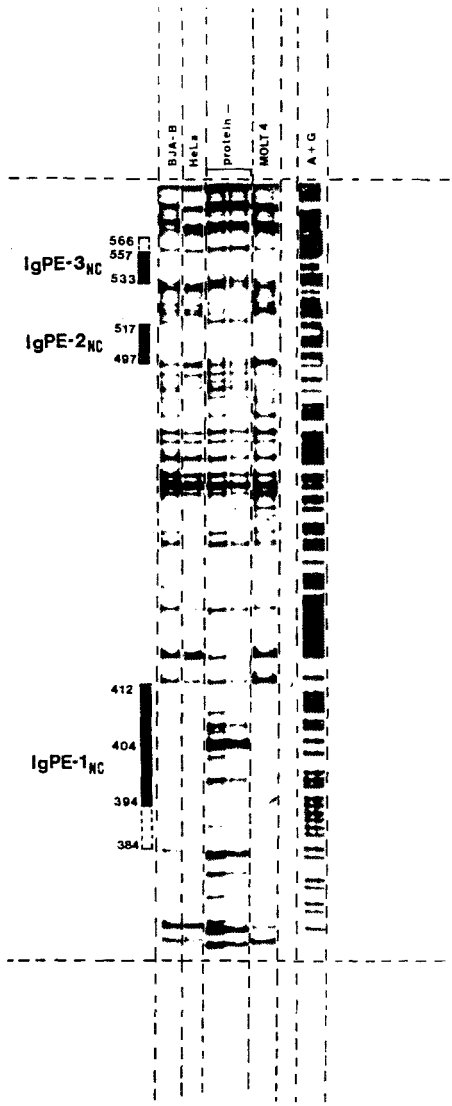


Exhibit 4. Montaged autoradiograph display assembled from various original films. The lines indicate the cuts participants made in piecing the display together. Note also the pointers (bars) and labels at the edges of the image. Compare this autoradiograph with the unedited film reproduced in Exhibit 1

"good" figure. Note that such judgments are not extrinsic to scientists' judgments on *what* the figure reveals.

2. The second ordering imposed upon the film displays the signal *within a matrix of other signals*. This manner of exhibiting the signal provides for the analyzability of results in terms of comparisons between signal and reference lanes, and thereby for an evaluation of the consistency and coherence of results. This ordering is achieved by some of the same methods as the perspectival order: fragments of bands from different runs or experiments are cut out and glued together *as if* they were emanating from the same experiment and run, the embodied optics of the gel run is *reconstituted* through the careful composition of traces in a documentary display. Some of the vertical cuts in Exhibit 4 (marked by lines) indicate such fragments. Thus, the display format is that of the grid described earlier, with the difference that the grid is the post hoc result of image composition.
3. Finally, autoradiograph figures composed to present "evidence" rely on the use of "*pointers*". These are marks added to the image which suggest a particular reading of the display by indicating some features as significant and ignoring others. Typically, they consist of arrows, brackets, lines or other visual clues inserted at the boundaries of the image. Additional aids in inducing desirable readings of a figure are of course the title and written explanations which frame the image.

Now to avoid misunderstanding, let us stress that we are not suggesting here that the evidence thus created is purely fictional – however fabricated it may be. But neither does it correspond to the "data" or signals obtained in the laboratory. Rather, this montage is a members' way of visually reproducing *the sense of "what was seen"* which is an *upshot* of participants' shop talk negotiations; an accomplishment of – not a precondition for – their work. Talk attached to (in the sense of Section 4) visual materials was crucial insofar as it provided participants with candidate formulations of the reality they "saw".

A final note. It is important to realize that the aesthetically enhanced, montaged version of this reality – evidence – is not the

end of the story. Evidence, i.e., visual objects that have been trimmed and fixed, are retransformed into "data" when these objects are critically inspected by an audience, the readers of the evidence. In other words, evidence tends to become problematic once more when it is seriously considered by informed scientists or competitors in the field. The inspections performed by participants on published visual displays provide an occasion in which the flexibility of visual objects is highlighted once again. Images (visual evidence) do not function in the literature in the way one might assume; that is, by reducing the indexicalities of the text, by displaying the data unequivocally, by adding the certainty of proof which the text can only refer to, but not "show". Quite to the contrary. Images, perhaps more than texts, provide infinite opportunities for visual exegesis, thereby functioning to keep the discussion open, not closed.

8. Conclusion

To conclude this paper, consider the following summary of the process of evidence fixation. (See Diagram 2)

This paper has emphasized the difference between "data" and "evidence" as a means of distinguishing between different modes of practice through which visual objects are constructed in the stream of laboratory shop work. We have found that in the science studied, processes of seeing appear to be interactionally dissolved in shop talk, and we have focussed upon the conversational routines and inference machineries in terms of which seeing becomes socially organized in talk. Conversational inference devices are employed as participants run into problems in recognizing visual objects, in determining, that is, the identity of the black and white bands exhibited on autoradiograph films. With the help of these conversational devices, participants develop a sense of "what was seen" on these data displays. Through montage, this sense of what was seen is transformed into evidence. Both processes constitute what we have called the fixation of evidence. Evidence is the aesthetically enhanced, carefully composed rendering of flexible visual objects that, through the meandering interrogatory processes

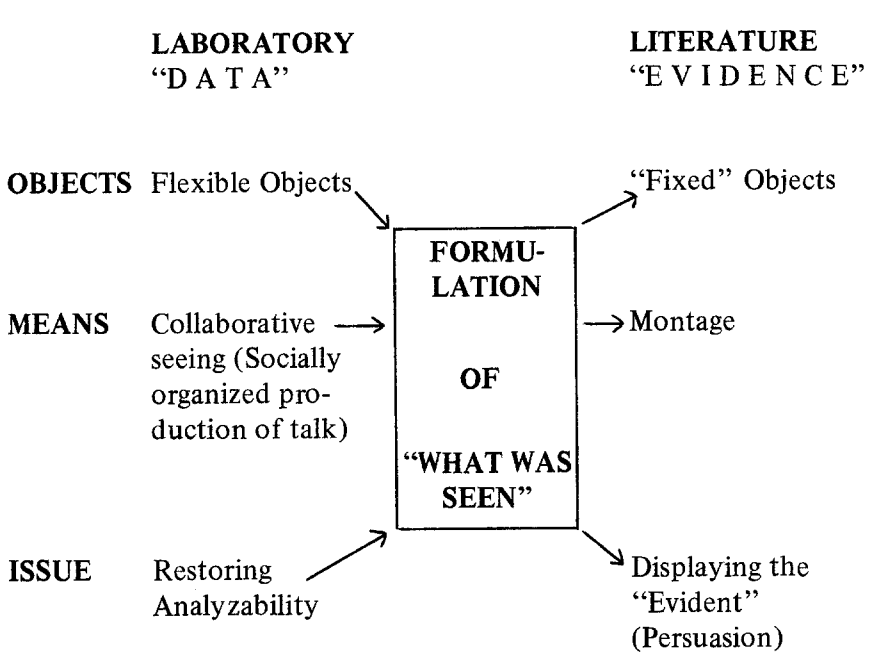


Diagram 2

of image analyzing talk, have been "embedded" and entrenched in procedural reconstructions, local experiences and in the landscape of the data display.

We have tried in this study not to miss the interactional work of seeing, through which proto-data – ambiguously visible unidentified data traces – are transformed into "data", and we have touched upon the practices through which these data are mounted as evidence in publishable papers. It remains for future research to demonstrate how published evidence is deconstructed and retransformed into questionable data when these papers are read; when the evidence is inspected by the wider audience in a specialty field.

Notes

1. See Grunbaum (1960) for a summary and critical discussion made by Duhem and Quine.
2. Laboratory studies are based upon *in situ* observations of scientists at work in their laboratory and upon other ethnographic methods. For some of the major laboratory studies published so far see Knorr Cetina (1981); Latour and Woolgar (1979); Lynch (1985a); Traweek (1988) and Zenzen and Restivo (1982). For a discussion of the assumptions and results of these studies see Knorr Cetina (1983). For an overview over recent developments in science studies in general see Knorr Cetina and Mulkay (1983).
3. These distinctions are embodied in scientific practice, but they are not made by practitioners in these terms. For example, scientists may refer to the proto-data inspected in the lab as "evidence", and they call the displays published in the literature "data". Moreover, the distinctions are fuzzy, not sharp. Our purpose in drawing a line between "data" and "evidence" is to draw attention to different modes of practices participants employ in regard to visual materials. It is not to propose a taxonomy of these materials.
4. For an introduction to electrophoresis methods and to autoradiograph data see any textbook in molecular genetics, for example Alberts et al. (1983).
5. This is not to say that "enhancements" may not become the subject of sustained inquiry if practitioners feel that such attention is warranted. However, such attention is the exception rather than the rule. When it occurs, it can prove to be important, and turn around a whole line of inquiry.
6. For an earlier laboratory study that deals with scientists' shop talk on a more general level see Lynch (1985a). For a discussion of the characteristics of shop talk as a communicative form in the sciences we currently study see Amann and Knorr Cetina (1988b).
7. For a detailed description of processes of decision making and consensus formation in the laboratory see Amann and Knorr Cetina (1987).
8. For an attempted rebuttal of this finding see Eglin and Wideman (1986).
9. By conversation analysis standards (e.g., Sacks, Schegloff and Jefferson 1974:731–34) the following data are fairly grossly transcribed. We have neglected overlaps and omitted indications of the length of pauses, and we have not transcribed explosive aspiration, "latching" or prolonged prior syllables. We believe, however, that the transcriptions are adequate for the level of analysis we attempt in this paper, and we hope that they are easier to read for the audience to whom the paper is addressed. The following transcribing conventions were used:

   / "Interruption".
   ( ) Single parentheses indicate the transcriber was not sure about

the words contained within parentheses. Empty parentheses indicate talk inserted in or before passages relevant to the case presented.

(( )) Double parentheses indicate comments by the transcriber.

? Rising intonation.

10. The notion "side sequence" does not adequately capture the fact that "diversions" from the inquiry sequence dominate in real time film analysis exchanges.
11. As judged from the fact that the patterns of interactional organization found may not be the most efficient way of solving the problems posed, and by the fact that other patterns (other passages to the goal) can be readily imagined.
12. For an interesting study of how the production of inferences relies on vehicles other than "thought" in everyday situations see Lave (1987).
13. The name of the pattern borrows from Grice's notion of "conversational implicature" (1975) mentioned before and from Cicourel's work on "procedural knowledge" (e.g., 1974; 1975; 1978).
14. The expression borrows from Giddens (1984).
15. We are indebted to Karl Heinrich Schmidt for the name of the pattern.
16. For an example of this form of optical induction, see Amann and Knorr Cetina (1988b).
17. For a different finding in regard to science see Lynch (1985: Chs. 3–5). The notion "preference for agreement" is used in two ways in the relevant literature: On the one hand, it refers to formal agreement, as in sentences beginning with "Yes, but..." which are usually polite versions of disagreements. On the other hand the notion also refers to a more general tendency to express agreement with a speaker's utterance and to keep to oneself possible disagreements with his/her opinion. We are using the notion in the *latter* sense. See Brown and Levinson (1978), Pomerantz (1975) and Sacks (1973).
18. In this case the problem arose out of the visual work performed in the side sequence rather than out of a question posed in the inquiry sequence. This and other idiosyncracies of image analyzing exchanges are not atypical. Rather, they show that real time film talk is often more messy than suggested in Section 4 of this paper. More messy in the sense that it includes such idiosyncracies, but also "orderly" in the sense that the idiosyncracies exhibited can usually be explained. In the present case, visual work on the film naturally raises the possibility that things will be noticed (and subsequently pursued) which have nothing to do with the original goal of the optical induction.
19. For a similar finding in regard to a neurosciences research project see Lynch (1985b:52). Lynch talks about pre-linguistic modes of order production built into visual records, and about "endogenous" geometries of cellular material being exposed and brought into alignment with "exogenous" graphic formats. We are concerned with the "pre-docu-

mentary" optics of the experiment that embodies scientists' concern with the analyzability of their data.

20. Dürer's grid had a slightly different purpose, as the figure-legend indicates. For a detailed interpretation of Dürer's grid, see among others Kutschmann (1986).
21. Theoretical interpretations may become a problem when participants write up their results, when they discuss what to say and what data to include in the papers they produce.
22. In this paper, we cannot discuss the issues raised by these observations. For more details see Amann and Knorr Cetina (1987). For a discussion of replication in experiments in physics see Collins (1975).
23. For an interesting paper on how natural objects are made visible through montages see Lynch (1985b).

References

Albert, B., Bray, D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D. (1983). *Molecular biology of the cell.* New York and London: Garland.

Amann, K., and Knorr Cetina, K. (1987). *Consensus formation in the laboratory*. University of Bielefeld, Bielefeld, Mimeo.

Amann, K., and Knorr Cetina, K. (1988a). Thinking through talk: An ethnographic study of a molecular biology laboratory. In R.A. Jones, L. Hargens and A. Pickering (Eds.), *Knowledge and society: Studies in the sociology of science past and present*, Vol. 8. Greenwich, CT: JAI Press.

Amann, K., and Knorr Cetina, K. (1988b). Werkstattsgespräche in der Wissenschaft: Am Beispiel der Molekularbiologie. In H.G. Soeffner (Ed.), *Sprache und Gesellschaft*. Frankfurt/M.: Campus Verlag.

Brown, P., and Levinson, S. (1978). Universals in language usage: Politness phenomena. In E. Goody (Ed.), *Questions and politness*. Cambridge, MA: Cambridge University Press.

Cicourel, A. (1974). Interviewing and memory. In D. Cherry (Ed.), *Pragmatic aspects of human communication*. Dordrecht: Reidel.

Cicourel, A. (1975). Discourse and text: Cognitive and linguistic processes in the study of social structure. *Versus: Quaderni di Studi Semiotica* (September – December).

Cicourel, A. (1978). Language and society: Cognitive, cultural and linguistic aspects of language use. *Sozialwissenschaftliche Annalen* 2:325–359.

Collins, H. (1975). The seven sexes: A study in the sociology of a phenomenon, or the replication of experiments in physics. *Sociology* 9:206–224.

Campbell, D. (1986). *Models of language learning and their implications for social constructionist analyses of scientific belief.* Paper presented at the Annual Meeting of the Society for Social Studies of Science, Pittsburgh, Pennsylvania.

Eglin, P., and Wideman, D. (1986). Inequality in professional service encoun-

ters: Verbal strategies of control versus task performance in calls to the police. *Zeitschrift für Soziologie* 15(5):341–362.

Giddens, A. (1984). *The constitution of society.* Berkeley: University of California Press.

Goffman, E. (1971). *Interaction ritual.* New York: Anchor Books.

Gombrich, E.H. (1960). *Art and illusion.* Princeton, NJ: Princeton University Press.

Grice, P. (1975). Logic and conversation. In P. Cole and J. Morgan (Eds.), *Syntax and Semantics*, 3: *Speech Acts.* New York: Academic Press.

Grunbaum, A. (1960). The Duhemian Argument. *Philosophy of Science* 27(1):75–87.

Jaeggli, A., and Steck, M., Eds. (1969). *A. Dürer. Die kunsttheoretischen Werke* Bd. 1: *Underweysung der Messung, Nürnberg 1525.* Zürich.

Knorr Cetina, K. (1981). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science.* Oxford: Pergamon Press.

Knorr Cetina, K. (1983). The ethnographic study of scientific work: Towards a constructivist interpretation of science. In K. Knorr Cetina and M. Mulkay (Eds.), *Science observed: Perspectives on the social study of science.* London and Beverly Hills: Sage.

Knorr Cetina, K., and Mulkay, M., Eds. (1983). *Science observed: Perspectives on the social study of science.* London and Beverly Hills: Sage.

Kuhn, T. (1970). *The structure of scientific revolutions.* Chicago: University of Chicago Press.

Kutschmann, W. (1986). *Der Naturwissenschaftler und sein Körper.* Frankfurt/M.: Suhrkamp Verlag.

Latour, B., and Woolgar, S. (1979). *Laboratory life: The social construction of scientific facts.* London and Bevery Hills: Sage.

Lave, J. (1987). *Arithmetic practice and cognitive theory: An ethnographic inquiry.* Berkeley: University of California Press.

Lynch, M. (1985a). *Art and artefact in laboratory science: A study of shop work and shop talk in a research laboratory.* London: Routledge and Kegan Paul.

Lynch, M. (1985b). Discipline and the material form of images: An analysis of scientific visibility. *Social Studies of Science* 15:37–66.

Merleau-Ponty, M. (1962). *The phenomenology of perception.* London: Routledge and Kegan Paul.

Mulkay, M. (1979). *Science and the sociology of knowledge.* London: George Allen and Unwin.

Pomerantz, A. (1975). *Second assessments: A study of some features of agreements/disagreements.* Unpublished Ph.D. Dissertation. Division of Social Sciences, University of California, Irvine.

Quine, W.v.O. (1960). *Word and object.* Cambridge, MA: MIT Press.

Sacks, H. (1973). *Current research in conversation analysis: The Preference for agreement.* Paper presented at the Summer Institute for Linguistics, Ann Arbor, Michigan.

Sacks, H., Schegloff, E.A., and Jefferson, G. (1974). A simplest systematics

for the organization of turn-taking for conversation. *Language* 50:696–735.

Traweek, S. (1988). *Buying time and talking space: The culture of the particle physics community*. Boston: Harvard University Press.

West, C. (1983). 'Ask me no questions...'. An Analysis of queries and replies in physician-patient dialogues. In S. Fischer and A. Todd (Eds.), *The social organization of doctor-patient communication*. Washington: Center for Applied Linguistics.

Zenzen, M., and Restivo, S. (1982). The mysterious morphology of immiscible liquids: A study of scientific practice. *Social Science Information* 21:447–473.