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Down to the wire: The cultural clock of physicists and the discourse of consensus

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ABSTRACT

This study examines how deadlines and time limits for conference talks organize the discourse of consensus among collaborating experimental and theoretical physicists in a university laboratory Six months of videotaped observations, including two cycles of conference talk preparation, indicate that, as the date of an upcoming conference nears, several things happen (a) Co-authoring physicists usually have not achieved agreement on all aspects of the findings (b) They nevertheless direct their energies to constructing a hybrid presentation rhetoric that satisfies the co-authors and fits the talk to the official conference talk time limit (c) In the process of working through matters of rhetoric – what to say, what to display visually, what to leave out, and in what order the information should be presented – the physicists construct a working consensus on matters of physics theory and experimental data explaining the properties and dynamics of the physical universe (Scientific discourse, consensus, temporal organization, rhetoric)*

Every community constructs and attends to temporal orders (Whorf 1956, Heidegger 1962, Bourdieu 1977, Zerubavel 1981, Ricoeur 1988, Aveni 1989, Gell 1992), and scientific communities are no exception Career schedules, project cycles, conference deadlines, and conference talk time slots, among other temporal orders, form the cultural clock of working scientists Time is thus not only an object that scientists measure, it is also a cultural artifact that organizes their work and discourse This essay examines how the cultural clock of physicists is marshaled to achieve consensus in one research laboratory While other studies of science emphasize that coming to consensus closure on a claim depends on AVAILABILITY of resources – namely techno-scientific equipment, a large skilled laboratory staff, and funding to conduct extensive research[1] – the present ethnographic study of laboratory deliberations suggests that consensus closure may be a product of SCARCITY of a resource, namely time. In particular, it documents how finite time frames, in the form of looming conference deadlines and well-regulated conference talk time slots, organize the discourse of consensus among co-authoring scientists. Edging closer and closer to conference dates, and recognizing the need to streamline their argument to fit time constraints, the scientists observed in this study worked through critical disagreements. The movement toward consensus was facilitated not only by the collective sense of urgency, but also by the scientists' focus on the rhetoric of the presentation.

Our analysis of the interrelation of the exigencies of time and the discourse of consensus is based on recorded observations of a group of university physicists working in the broad area of condensed matter physics, in particular on disordered magnetic systems.[2] This group of physicists sees itself as unusual in that it includes both theoreticians and experimentalists, who collaborate on and co-author research enterprises.[3] In talking with members of his laboratory, Ron, the group director, characterized this integrative orientation as a quintessential AMERICAN physics tradition:

> Ron: This is a difference in tradition between Europe and the United States ... There is– in Europe there is a: uh lo:ng tradition about the separation between experiment and theory ... They don't do: what we do here.
> ((*lines omitted*))
> The theorists do the theory and the experimentalists do the experiments and that's it.

Thus Galison (1987, 1997) documents how World War II acted as a catalyst for close collaboration among theoreticians, experimentalists, and instrument engineers on specific defense projects, e.g. radar. This work configuration in American physics has endured in particular laboratories to the present day. According to Galison, scientists in hybrid research enterprises developed lingua francas to bridge differences in expertise and in ways of thinking and acting. Theoretical, experimental, and instrumental physicists in certain laboratories created simplified "foreigner talk" versions of their respective discourses to exchange ideas with one another. These communicative practices established localized links and formed new subfields of physics that lie at the boundaries of several scientific subcultures.[4]

Galison calls for in-depth studies of codes and modes of communication in hybrid scientific laboratories. The present analysis is an exercise to this end. It examines how deadlines and conference talk time limits mobilize a group of experimental and theoretical physicists to work through some of their differences and construct a hybrid conference presentation.

SEASONAL CONFERENCE DEADLINES AND PRESENTATION TIME LIMITS

Cycles of varying scope organize science as an activity and profession – including professional meeting cycles, career cycles, laboratory project cycles, grant cycles, cycles of interest in a domain of inquiry, and epistemic cycles of scientific assertion, among others.[5] The focus of this study is on cycles of disagreement and agreement in relation to the professional conference calendar. Members of Ron's laboratory attend to a calendrical cycle of scheduled conferences and deadlines relevant to the field of solid state, condensed matter physics and to research on disordered systems, including spin glasses.[6] This cycle includes several types of meetings, as defined by the *Meeting News* of the American Physical Society (APS): General Meetings, Divisional Meetings, Topical Meetings, Sectional Meetings, and Sponsored Meetings.[7] Some meetings are relatively fixed in the seasonal calendar, while the dates of others fluctuate. In the period of field observations, this university-based laboratory organized its activities in terms of an 11-month conference calendar; see Table 1. Like the agrarian calendar (see especially Bourdieu 1977), the calendar of physicists organizes professional practices in terms of recurrent cycles of conference labor, with intermittent periods when conference activity slacks off. Conferences tend to cluster in late September–November and March–August; September and December are relatively fallow periods. From time to time members of Ron's laboratory bring up the topic of possible conferences to attend.[8] For example, in October, in the middle of one of

TABLE 1. *Conference calendar for Ron's laboratory (1990–1991)*

Season	Month	Activity
Fall	September	Begin academic year
	October	Rehearse and work out disagreements for MMM conference talks
		Discuss which summer conferences to attend
		MMM meeting end of October
	November	Determine who will submit abstracts for APS March Meeting
		Write and submit APS March Meeting abstracts
		APS March Meeting abstracts due end of November
Winter	February	APS March Meeting Program Bulletin appears
		Rehearse and work out disagreements for APS March Meeting conference talks
		Determine who will submit abstracts for ICM summer meeting
Spring	March	Write and submit ICM abstracts
		ICM abstracts due early March
		Rehearse and work out disagreements for APS March Meeting conference talks
		Trento Meeting on Fractals mid-March
		APS March Meeting end of March
	May	Notification of ICM abstract acceptance
		Rehearse and work out disagreements for ICM conference talks
Summer	June	Rehearse and work out disagreements for ICM conference talks
	July	ICM Meeting

their weekly lab meetings, one of the graduate students, Miguel, lists conference possibilities for the summer period, with an eye to their abstract submission deadlines:

Miguel	There's uh m MMM[9] [June June eighteen,=
Ron	[Oh yes yes yes
Ron	=The- thee=
Miguel	=then ICM,[10]
Ron	Where's ICM
Miguel	In uhm I think it's in Scotland
	(0 5)
Miguel	And there are- ( ) uh- lots of uh ( ) conferences in Europe in September
	(0 2)
Miguel	Prob'ly satellites of that one
	(1 2)
Ron	Wo w
	((lines omitted))
Miguel	Now The reason why I'm talking no w (0 4) is because (0 4) the deadlines for most of all these conferences will be mid-January

Decisions about the conferences to which abstracts should be submitted interact with issues of project time and career time. Does a member feel sufficiently confident in the research findings to go public? Will project funding be available to cover conference expenses? Will attendance conflict with other career demands, e.g. writing a dissertation? After the decision is made to submit abstracts for a particular conference, lab members bring abstract drafts to their weekly meetings for Ron and others to critique. Once the abstracts are accepted and the conference draws near, a portion of each weekly meeting is dedicated to talking through and eventually rehearsing the conference presentations. In this way, along with a focus on current research, an orientation to upcoming deadlines permeates the life of the laboratory. Consensus is accomplished within this calendar of conference deadlines.

In addition, the physicists are ever mindful of time constraints on the conference talks themselves (Jacoby 1997). For most conferences, the time limit for submitted talks is 10 minutes with 2 minutes for questions, and these limits are strictly enforced. For example, at the beginning of every submitted talk at the APS March Meeting, the session chair sets a dial-type kitchen timer to ring after 8 minutes have elapsed and then resets the timer to ring two minutes later.[11] In the six months of our observations of Ron's laboratory, NONE of the 15 conference talk rehearsals finished neatly at the end of 10 minutes.

The conference talk limit is a challenge for presenters, given that talks are to be delivered more or less extempore (Jacoby 1992, 1997). At physics conferences, presenters essentially talk the audience through a set of overhead transparencies that constitute a condensation of the overall argument. These transparencies variously display graphic representations, mathematical formulae, electron microscopic photographs, and telegraphic statements referring (inter alia) to the talk outline, prior research, models, protocols, measurements, theoretical fits, and conclusions. The transparencies allow the audience to see more information than is mentioned in the presenter's stream of talk. At the same time, they segment and focus the talk into manageable units.

The time limit problem is usually the first issue taken up when the group gives feedback following a run-through. For example, in delivering the first criticism after Miguel rehearses a conference talk, Ron points to his watch on the table and says:

Ron: You are g– y'know? [By my watch it was–

Before Ron completes this turn, Miguel overlaps Ron's talk with an admission of being overtime:

Miguel: [Well I was thirty seconds: uh::

Ron responds with the evaluation that even 30 seconds is a serious problem:

Ron: That's disastrous.
I mean uh (.) if I was yer (0.2) chairman
I would stand up an' (.) just cut you off.

In mentoring novice graduate students, Ron sometimes details the ideal conference talk format and pacing. For example, after a poorly managed run-through by a student who had never before presented at a conference, Ron advises:

Ron: I want you to take the first minute,
(0.8)
say what it is you're going to say,
(.)
I want you to give an eight minute talk,
(0.4)
And then I want you to use the la::st minute
describing what it is you've said.
((*lines omitted*))
That's the way you do a ten minute ta:lk.

The 10-minute constraint is also often used to justify cutting out material entirely, using a more concise formulation of an argument, and transferring information from the talk to the visual text of the transparencies (Jacoby 1997).

ACCOMPLISHING A WORKING CONSENSUS

The working out of agreement spans different scales of time and space, but we are interested in the relatively private, backstage process whereby collaborating scientists deliberate – for days, weeks, and months, in face-to-face meetings and through e-mail – over the acceptability of their procedures and the meaning of their findings, until they reach a WORKING CONSENSUS on their discovery. This consensus is local and practical; it allows researchers to design the next experiment or to produce the next abstract, conference talk, or article.[12] The working consensus reached for a conference presentation may also be temporary; final consensus closure among the co-authors may not be fully worked out until the last revision of a paper for publication.[13]

Working consensus thus often dissolves as discussions and laboratory activities progress, but for however long it lasts, it serves as a "for all practical purposes" frame for scientists' protocols and interpretations. That is, scientists may adopt a collective position and at the same time be aware that this position may need future refinement or revision. This cycle of resolution and dissolution of positions is a familiar one in "science in the making," where knowledge at the frontier of research is still subject to critical evaluation. Indeed, lack of consensus is a hallmark condition of scientific practice.[14] Studies of individual labs have noted that collaborating scientists swing back and forth between doubt and certainty as they struggle to persuade themselves and each other that they have a discovery worth publicizing. What is constituted as a finding, discovery, or acceptable laboratory procedure is a continuous categorization problem for scientists themselves as they interact with one another.[15] As will be delineated in this study, this process of negotiating the meaning and value of a scientific idea or procedure involves continuous reporting and reformulation both of one another's words and of graphic representations (Shapin & Schaffer 1985, Latour & Woolgar 1986, Goodwin 1994, Gonzales 1996).

Our longitudinal study of six months of professional collaboration and two cycles of conference talk preparation in Ron's laboratory indicates that, as an upcoming conference nears, the following things happen:

(a) The physicists usually have not achieved agreement on all aspects of the physical findings relevant to their particular project.

(b) The physicists nevertheless direct their energies to constructing a hybrid presentation rhetoric that satisfies the co-authors and fits the official conference time limit.

(c) In the process of working through what they consider to be MATTERS OF RHETORIC – what to say, what to display visually, what to leave out, and in what order the information should be presented – the physicists construct a working consensus on what they consider to be MATTERS OF PHYSICS: theory and experimental data explaining the properties and dynamics of the physical universe.

The weekly laboratory meetings of Ron's group were largely dedicated to discussing research in progress, with members reporting their progress, raising problems, expressing doubt, and working out research plans. Such deliberations were punctuated routinely by periods in which members fashioned formal statements of their current thinking, e.g. for grant proposals, conference abstracts, manuscripts for publication, and conference talks. At these moments the challenge for members was to suspend informal probing of physics in order to inscribe a document which encoded their current collective thinking. In the case of conference talks, the inscription process involved preparing overhead transparencies and rehearsing draft versions of the talk to laboratory colleagues, who in turn offered detailed feedback on all aspects of the performance (Jacoby 1997). In the weeks prior to an upcoming conference, the agenda of meetings was almost wholly given over to this process. Of the 23 meetings recorded, 7 were devoted to rehearsals for upcoming conferences. That is, the lab members treated conference preparation as a break in their scientific activities, wherein time constraints necessitated urgency, practicality, and devotion of a significant proportion of the laboratory work cycle to "down to the wire" rhetorical honing of scientific presentations.

The decision to suspend deliberations about matters of physics and to go into rehearsal was initiated by the laboratory director, who was ever mindful of looming conference dates. Underlying this decision was an assumption that, despite any loose ends and lingering uncertainties, the work was sufficiently sound to be publicly presented. The onset of conference talk rehearsals thus marked a turning point in the physicists' deliberations, away from a primary focus on matters of physics and toward matters of rhetoric. This shift was manifest in the feedback following rehearsal run-throughs, wherein the overwhelming majority of comments concentrated on timing, delivery, wording, and design of the presentation. We shall show, however, that this overt focus on the technical, even cosmetic, details of the conference presentation became a resource for returning to and resolving (for the moment) unfinished business regarding matters of physics.

RHETORIC AND PHYSICS

Rhetoricians have long argued that form and content cannot be separated, even in science,[16] but the physicists in this study often distinguished matters of rhetoric from matters of physics. In the present study we treat the term *physics* as the physicists used the term, namely as a category covering the physical processes in the universe, as in "O:kay let's get back to **physics**"; "If there were some **physics** to be seen below twelve kelvin (0.2) we cannot see that"; "There's another effect of this (.) ultimately on the: (.) on the **physics** of the system." In formal and informal discourse, the term *physics* was often contrasted with "unphysical", "artifactual" phenomena resulting from mathematical error or experimental procedure.[17] In this context, *physics* was imbued with positive value, standing for the systematic ways in which the natural world works, the explication of which constitutes the object of physicists' entire research enterprise. *Physics* was also contrasted with technical professional expertise, e.g. how to run equipment, how to package a conference talk, and how to write a professional paper. Here too *physics* was given more positive weight than practical and rhetorical expertise. In the excerpt below, Ron distinguishes *physics* from practical knowledge when he adjures a graduate student that there is more to learning an experimental procedure than manipulating equipment:

Ron: It's more than just running thee (.) the piece of equipment. .hh I want you to understand the **physics**. ... 'cause I mean ... you're not a technician, ... you're (.) a graduate student.

Here Ron sets up an evaluative matrix in which *physics* is matched with being a "graduate student," while "running ... the piece of equipment" is matched with being a mere "technician." Ron elevates *physics* using the comparative "more than," while downgrading the running of equipment with the minimizing adverb "just."

Similarly, in the next excerpt, Ron distinguishes the core physics content of a just rehearsed conference talk from its rhetorical structuring:

Ron [I have a pro b[lem
[((*removes glasses*))
[((*Miguel looks at Ron*))
((*Ron lays glasses on table*))
(0 2)
[with your ta lk,
[((*Ron puts hand to forehead*))
[(0 4)
[((*Miguel looks down*))
uh not with the ( ) the **physics** in it,
but with the >la ck of references to anybody else's work <

Here Ron begins by stating that he has a problem with Miguel's talk. However, rather than going straight to the problem ("the >la:ck of references to anybody else's work.<"), Ron inserts a statement of what the problem is NOT ("not with the: (.) the physics in it"). In so doing, Ron downgrades the gravity of the upcoming critique by ruling out the worst-case scenario, i.e. a problem with the "physics."

We propose that the physicists' differential weighting of physics and rhetoric enables them to accomplish a working consensus. We have noted that certain matters of physics are often unresolved at the time when rehearsals of a conference talk begin. We suggest that physicists obliquely address lingering problems of physics, which they treat as serious, through attention to problems of rhetoric, which they treat as important but less serious than problems of physics. This path allows the physicists to confront one another on a less serious plane of discourse. Suggestions framed as rhetorical in nature are treated as relatively feasible to execute in the time remaining before the conference deadline. Our observations suggest that, while certain matters of rhetoric remain on this less serious plane, attention to rhetoric is often just a first step in a longer deliberation leading to matters of physics. What at first is treated as a rhetorical problem – e.g. how many dots should be drawn on a graph to be displayed in a conference talk – can evolve into a physics problem – e.g., what those dots represent in terms of observed or extrapolated physical processes. This shift from the rhetorical to the physical is a robust practice in the deliberations among co-authors as they work out their conference presentations together. Thus, when a member of the team comments on the design or wording of a viewgraph, he or she focuses those present on that piece of the presentation, which in turn allows discussion to migrate to other topically relevant matters, including matters of physics.

CONFERENCE COUNTDOWN

To illuminate how attention to rhetoric and time – in particular, scarcity of time – organizes consensus on physics, we turn to deliberations surrounding an upcoming presentation and paper on the dynamics of spin glasses, co-authored by

Ron, Miguel, and two colleagues in France, Maurice and Jean. While Ron is currently Miguel's dissertation chair, Maurice had mentored Miguel when Miguel carried out research in the laboratory that Maurice heads in France. Indeed, Miguel's in-progress dissertation draws on the experimental research he conducted with Maurice. For the upcoming conference talk, the authors are:

(1) Miguel Experimentalist, graduate student, first co-author, conference presenter
(2) Ron Theoretician, lab director (US), chair of Miguel's dissertation, second co-author
(3) Maurice Experimentalist, lab co-director (France), former mentor of Miguel, third co-author
(4) Jean Experimentalist, lab co-director (France), fourth co-author

While Jean is listed on both the conference talk title page and the subsequently published article, he is never referred to in e-mail or face-to-face deliberations in Ron's laboratory. From this perspective, Jean is a silent co-author. Our study of the accomplishment of consensus focuses on the three active, communicating co-authors.[18]

Within solid state physics, a spin glass is understood to be a type of disordered magnet. Like a multi-flavored popsicle that has been melted and refrozen, a spin glass is a solid solution – a crystalline alloy consisting of a small percentage of randomly distributed magnetic ions in a non-magnetic metal, whose atomic spin configurations are unstable and susceptible to changes at an extremely slow rate (Ford 1982, Stein 1989, Brown & Grüner 1994).[19] Research on spin glasses has revealed new types of magnetic order (i.e. disorder) never recognized before.

The physicists' co-authored research attempts to demonstrate how temperature differentially affects the atomic spin configurations of a spin glass, e.g. silver manganese. The co-authors are proposing an experimental protocol for testing the predictions of theoretical models of spin glass dynamics. A general claim they intend to put forward at the upcoming conference is that, as temperature decreases, more energy is required to change the spin configuration – and, as temperature increases, less energy is required. The requisite energy needed to transform a spin configuration is called a "barrier height" (also referred to as "delta"). A specific claim they are exploring is that the barrier height drops to zero at Tg, the transition temperature at which a system becomes a spin glass. This claim is based on extrapolations from their actual measurements.

In the analysis that follows, laboratory interaction is traced in terms of time remaining until the conference presentation. The conference countdown framework reflects the import of impending deadlines to the construction of consensus among the co-authors of the spin glass paper. Specifically, we trace how, in the two weeks prior to an upcoming conference, the co-authors of the spin glass research report moved from disagreement to working consensus concerning the viability of the claim that barrier heights drop to zero at Tg. In the course of their deliberations – with the conference date looming, and the 10-minute conference talk limit constraining them to eliminate certain material from the presentation – we see that (a) the theoretician, Ron, gradually moved closer to the more conservative position of the experimentalist co-authors, eventually deciding to eliminate the specific claim altogether; and (b) a turning point in effecting this transformation from disagreement to a working consensus occurred when the physicists focused their attention on the design of the graphs and the discourse of the presentation.

TIME TO CONFERENCE: TWO WEEKS

Two weeks before the MMM conference on October 30, 1990, where Miguel is expected to present a co-authored talk about the spin glass research, the three primary co-authors don't agree on the scope of their claims. In their laboratory meeting on October 17, Miguel reports to Ron that Maurice has e-mailed objections to inferential claims made in Miguel and Ron's latest draft of the research paper. Voicing Maurice's position, Miguel emphasizes that, because the spin glass configurations change so slowly, no experimental procedure (including their own) can test all the possible configurations predicted by current theoretical models. He points out that they have actual measurements for only a small fraction of the theoretical predictions and only for relatively short time periods, and cannot with certainty make the claim in the draft that the barrier height drops to zero at Tg. Miguel aligns with Maurice's position and further raises the possibility that, within the short time observed, some of the readings may be an artifact of the time it takes to warm up the equipment and begin measurements.

After listening to this report, Ron initially is unwilling to give up the theoretical inferences drawn from the experimental results:

Miguel: I don't (0.2) think that you can conclude anything from not seeing any aging effect for very small Ts[20]
((*lines omitted*))
Ron: **I'm not prepared to give that u:p yet.**

After substantial discussion ensues, Ron proposes that the data appear to him to be "consistent" with the claim. To this Miguel displays a mitigated agreement, rephrasing Ron's wording "is consistent with zero" with "can tend to zero":

Ron: The data that you: are exhibiting it seems to me just looking at it
(0.2) **is consistent with** zero: at Tg for delta.
(1.0)
Miguel: It **ca:n tend** yeah (.) **tend** to zero

Ron goes on to argue that, while they may not be able to "prove" their claim conclusively from the data, it is "suggested":

Ron: >Let me just turn the whole question around.<
.hh Ca:n your data **pro:ve** (0.4) <that delta i:s> zero at Tg.<and the answer is **no::.**
(.)
but it's **suggested**
(0.2)
Miguel: Oh– (e–)
Ron: of a very s– that delta– (0.5) >**could** go to zero at Tg.<

Later in the meeting, despite the lack of consensus among the co-authors, Miguel rehearses the spin glass conference presentation for the first time. Toward the end of the run-through, Miguel echoes his own and Ron's somewhat converging, modified stances concerning the theoretical claim that the barrier height could go to zero at Tg. In the excerpt below, he uses three linguistic structures to mitigate the claim. First, he prefaces the claim with the disclaimer that the experimentalists did not actually observe what he is about to claim ("of course we could not do: that"). Second, the claim is presented in a complement clause under the scope of the matrix clause "we hope." Third, the main verb of the claim itself is the verb *tend*, a form of mitigation that he had used earlier in his deliberations with Ron:

Miguel And we can see that as we cool down
(0 3)
thee uh difference in size between the barriers increases
(0 3)
and uh (0 3) ts (0 3) eh eventually uh
>**of course we could not do: that**< but uh
(0 5)
we uh (0 2) we **hope** that these uh (0 2) that as the temperature gets closer to Tg all these barriers **tend** to uh ( ) zero

Most of Ron's comments to Miguel after this run-through concern the fact that the talk runs overtime. He begins by summarizing how long it took Miguel to get through certain parts of the talk:

Ron Uh m it's already uh (0 5) **twelve and a half– twelve and a quarter minutes.**
uh now I did some timing as you went through it
((*lines omitted*))
It took **two and a half minutes** for your hierarchical picture
(0 8)
An' it took **three minutes** for you to discuss aging

Ron then proposes an elaborate plan to reduce the running time of the presentation. In so doing he also makes clear to Miguel that the issue of timing is closely tied to making room for the theoretical significance to get across:

Ron And then– I don't think it makes any sense to define Hamming distance
Just don't bother with it
Cut it out 'Cause you never use it anyway
((*lines omitted*))
You can't ↑ do it I mean **twelve minutes**
Miguel That's what I claimed (That)/(And) there was no way I could pack all this material
[( )
Ron [Well I **I am trying to cut this down right now so that you ca:n say something,**
'Cause I think not to say something (0 2) **means that you measured d delta dT.=Big deal.**
((*lines omitted*))
Now so I would start with the aging, and cut it down from **three minutes to a minute**
(0 5)
It shouldn't take you **three minutes** to talk about aging
((*lines omitted*))
Then go to the hierarchical model,
(0 2)
A nd ( ) sho w what you r u– your protocol is

(0 8)
Try to use as much of the pıcture
h you should be able to do thee agıng and the hıerarchıcal model **in four minutes an' not five and a half.**
(1 0)
And then uh the Hammıng dıstance just forget about So then I've already saved you (0 2) uh **fo:r one and a half minutes two and a half minutes** I've saved you
( )
Whıch ıs fine because ın fact you ran (0 2) to uh **twelve and a quarter minutes.**

After these extensive time management suggestions, Gary, an experimentalist post-doc in the laboratory team, criticizes Miguel's formulation of the claim about barrier heights at Tg as being too strong. Even though Miguel voiced a mitigated version of the theoretical claim, from Gary's perspective, Miguel seemed to be forcing an interpretation on the data:

Gary	Thee only comment I have ıs that ( ) when you show the delta versus T
	(0 6)
Gary	The lıne that goes down lıke thıs?
Mıguel	Yeah
	( )
Gary	You saıd uh
Mıguel	"I hope"
Gary	Yeah "I hope delta goes to zero" I I
Mıguel	[Yeah I
Gary	[**From an experimentalist point of view don't ( ) force thee interpretation on the data**

In this exchange, it is interesting that Miguel antıcipates Gary's objection to the words "I hope" in formulating the claim.[21] Gary then prefaces the nature of his objection with the phrase, "From an experimentalist point of view," evoking the professional identity that he and Miguel share. This preface is followed by a cautıonary imperatıve, "don't (.) force thee interpretation on the data," evoking the standards of experimental work which Gary feels Miguel violated in couching the claim as "I hope delta goes to zero."

At this point Ron responds to Gary's objection by arguing that, nonetheless, a claim can be made. He offers a rhetorical solution that further mitigates the certainty of the claim:

Ron You ca n say however tha t thıs ıs **not inconsistent** ( ) wıth the **fact** that delta **might** go to zero at T– at Tg

In effect Ron's mitigation resembles comedian Woody Allen's comment, "I'd like to leave you with a positive statement. But I can't. So let us take two negative statements" (Allen 1964). Earlier Ron argued that the data are "consistent" with the theoretical claim, but here he uses the double negative "not inconsistent." In arguing that there is nothing in their data that contradicts the theoretical claim, Ron aligns with the possibility that the data "might" be consistent with the theoretical claim. Nonetheless, Ron frames the mitigated claim as a "fact." To this formulation, Gary agrees, saying "Yeah. yeah. That's okay ... I agree with you."

TIME TO CONFERENCE ONE WEEK

On October 23, 1990, one week prior to the MMM conference, Miguel receives another e-mail from Maurice, wherein Maurice continues to maintain that the data are over-interpreted After replying to Maurice, Miguel electronically forwards an excerpt of Maurice's message to Ron, along with his own commentary Ron's message back to Miguel contains a chronologically nested sequence of messages (a) the forwarded excerpt (in French) from a message posted earlier that day BY MAURICE TO MIGUEL, (b) the commentary message (immediately above and below the French text) FROM MIGUEL TO RON, (c) the reply message (at the top of the document) FROM RON TO MIGUEL This electronic text is reproduced in Figure 1 [22]

In this e-mail exchange,[23] we see the next scene within this unfolding scientific drama, fueled by time pressures and subdisciplinary divergences The three co-authors, one week before the public performance of their latest work, still do not see eye to eye on the interpretation of their findings ("Je trouve que tu interpretes trop les donnees")[24] or on the format of their presentation ("As you can see, he doesn't want to go beyond the actual facts at the MMM presentation On the other hand you want to skip the analysis part and go to the interpretation") In addition to the imminent conference deadline, the 10-minute time slot for the conference presentation is seen as a reality that renders it impossible to satisfy divergent priorities of the co-authors ("After all there is no time to do both in 10 min") Miguel's concern with running overtime is not unfounded As we have seen, his last rehearsed presentation ran two and a half minutes overtime, and he still hadn't gotten to his conclusions

In his commentary, Miguel makes explicit that he feels caught between two mentors who hold divergent views of what is essential for the upcoming presentation [25] Maurice can't tell for sure if the interpretation is warranted without seeing step-by-step how the physical interpretation was derived from the experimental measurements For the paper and the presentation that they are co-authoring, he urges Miguel not to leap prematurely to the interpretation, but rather to present the raw data first with a discussion of margins of error ("D'ABORD les resultats bruts (avec la discussion sur les barres d'erreur)") in an impartial manner ("montre les resultats d'abord de facon impartiale") and only then to attend to the more theoretical facets of the argument ("propose ton analyse et tes fits apres") [26]

Although Maurice's message to Miguel raises problems with both the physics and the rhetoric of their co-authored work, Miguel's message to Ron reformulates this message to highlight a RHETORICAL dilemma As the presenter of the spin glass conference paper, he has a 10-minute time limit for his talk and cannot address both Maurice's and Ron's orientations within this time constraint Furthermore, while Maurice argues for a particular rhetorical ordering and balance between data and interpretation, Miguel reformulates Maurice's position as more extreme and narrow ("As you can see, he doesn't want to go beyond the actual

Date:	Tue, 23 Oct 90 22:06 PDT
To:	"MIGUEL XXXXXXXX (XXX)XXXXXXX; 825" <XXXXXXX>
From:	Ronald Xxxxxx— <XXXXXXX>
Subject:	Re: SPIN GLASS PAPER

Dear Miguel: You are caught between two opposite extremes. Let's discuss it tomorrow. Since Maurice won't be at MMM, we can do what we think correct, and not worry too much. Ron

--------------------TEXT-OF-YOUR-MAIL--------------------

>Date:	Tue, 23 Oct 90 15:08 PDT
>To:	XXXXXXX
>From:	"MIGUEL XXXXXXXX (XXX)XXXXXXX; 825" <XXXXXXX>
>Subject:	SPIN GLASS PAPER

>PR. XXXXXX,
>THIS IS A PARTIAL COPY OF MAURICE'S BITNET TODAY:
>---
>Je suis perplexe devant les resultats. Je crois qu'il n'est
>pas necessaire que tu telephones aujourd'hui, plutot vers la
>fin de la semaine avant la conf. (si les finances de l'xxxx
>la permettent encore!!)
>Je trouve que tu interpretes trop les donnees. Je ne veux pas dire
>par la que ton interpretation est fausse, elle est peut etre
>correcte, mais il faut que tu presentes D'ABORD les resultats
>bruts (avec la discussion sur les barres d'erreur). Ceci est vrai
>pour le FAX que tu m'as envoye. Tu me donnes des barres d'erreur
>sur les fits mais pas sur les donnees Brutes. Ma remarque est
>vraie aussi pour ta presentation a MMM, montre les resultats
>d'abord de facon impartiale, propose ton analyse et tes fits apres.

>AS YOU CAN SEE, HE DOESN'T WANT TO GO BEYOND THE ACTUAL FACTS
>AT THE MMM PRESENTATION. ON THE OTHER HAND YOU WANT TO SKIP
>THE ANALYSIS PART AND GO TO THE INTERPRETATION. AFTER ALL THERE
>IS NO TIME TO DO BOTH IN 10MIN. COULD YOU PLEASE DISCUSS WITH
>MAURICE WHAT WE SHOULD BE TALKING ABOUT DURING THE CONFER-
>ENCE. I ASKED HIM, ALSO, TO DO THAT WITH YOU. THANKS.
>MIGUEL.

FIGURE 1: E-mail October 23, 1990.

facts at the MMM presentation. On the other hand you want to skip the analysis part and go to the interpretation").[27]

Miguel is the primary researcher on this project, the first author of both the presentation and the paper, and the conference talk presenter; however, he does not communicate to Ron a possible solution to this dilemma.[28] Instead, he assumes a stance of impartiality and defers to his two mentors to sort it out between themselves ("Could you please discuss with Maurice what we should be talking about during the conference. I asked him, also, to do that with you.")

In his reply message, Ron accepts Miguel's reformulation of the problem ("You are caught between two opposite extremes"), but counter-suggests that the two of THEM sort out a correct solution ("Let's discuss it tomorrow. Since Maurice won't be at MMM, we can do what we think correct, and not worry too much"). In so doing, Ron transforms the decision-making arrangement that Miguel previously constructed into one where it is Ron and Miguel who should come to consensus, since they are the ones going to the meeting. Ron seems to opt for a "distance principle" as a basis for resolving Miguel's dilemma. From Ron's perspective, he and Miguel have priority of decision: Miguel will be doing the show, and Ron will be present in the audience to help field queries and challenges.[29] In other words, Miguel and Ron will be taking the public heat, so they are the ones who need to feel especially comfortable with the presentation.

SIX DAYS TO CONFERENCE

The following day at the lab meeting, Miguel revoices the rhetorical and epistemic split among the co-authors:

Miguel	The question is Maurice wants to stick to thee uh ( ) to the **fac[ts**
Ron	[°to the da–° the **facts**
	(0 3)
Miguel	A nd you want to gi ve eh (0 5) an **interpretation** more than (0 2) going throu gh thee whole procedure

Miguel displays alignment with Maurice's point of view:

Miguel It is **true** what he's saying

But he also displays alignment with Ron's contention that the theoretical implications make the experimental results interesting to physicists:

Miguel: I myself have no idea what to do
((*lines omitted*))
I am comfortable with both
(0 5)
And **I think it's much more interesting to talk about thee interpretation rather than the results from a physicist's point of view.**
(0 2)
uh
(0 2)
but (0 2) again I'm not the only one (0 2) who's an author here=So I want to please everyone

In the ensuing discussion, Ron tells Miguel that (a) he can't please everyone; (b) Maurice is not going to be at the conference; and (c) Maurice has not said that the interpretation is wrong, only that it is based on extrapolations that can never be tested. In other words, Ron's position continues to be that it is reasonable to infer from the experimental measurements the theoretical claim that the barrier height might go to zero at Tg and that this claim should be argued in the presentation. He is unwilling at this point to accommodate any further to the experimentalist preference for only "stick[ing] to the facts."

However, the story does not end with this divergence. Rather, Ron does move gradually closer to the experimentalist position. This movement co-occurs with a shift in activity, namely from a discussion of co-authors' positions on theoretical inferences to a discussion of rhetoric – specifically, a discussion of how best to represent data in the graphs produced on overhead transparencies for the conference talk. That is, the focus of attention becomes the rhetoric of graphic design.

When Ron examines the graphs that Miguel has prepared for the talk, he sees that (a) they DISTINGUISH ACTUAL MEASUREMENTS FROM EXTRAPOLATED PROJECTIONS ONLY THROUGH BRACKETS (see Figure 2); and (b) actual measurements take up only A SMALL PORTION of each line (the line between each set of brackets).

As Ron and members of the lab evaluate the graph and redraw data points and lines on the blackboard, Ron begins to empathize more with the experimentalists' caution concerning the relation between data and theoretical inferences. This shift in perspective may well be facilitated by the activity of collaboratively con-

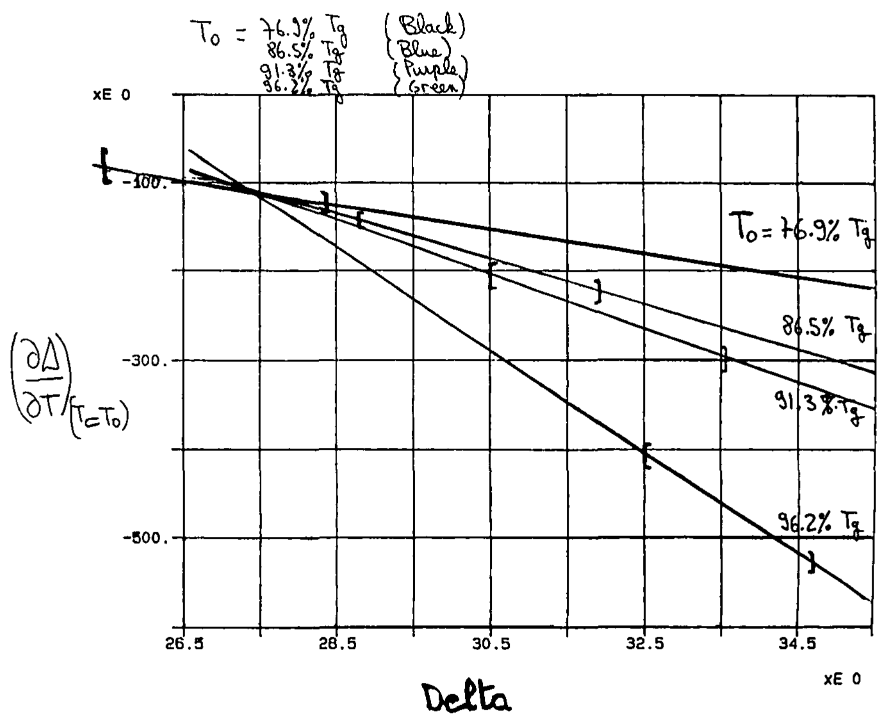

FIGURE 2: Original spin glass graph on October 24 (reproduced with permission).

structing graphs through talk and gesture (Ochs, Jacoby, & Gonzales 1994; Ochs, Gonzales, & Jacoby 1996). That is, graphic representation appears to be just as important a resource for constructing a working consensus as words are.[30]

Ron is the first to go to the board to sketch an alternative design for the graphs. His main modification is to use solid lines only for those portions of the curves that represent actual measurements, and dashed lines for those portions that represent extrapolated projections.[31] As he finishes sketching, Ron comments:

Ron:	So that's **ho:nest**. That says– that's what you **mea[sured**=
Miguel:	[Oh yeah.
Ron:	=and the rest of these are **extrapolations**.=
Miguel:	=Yeah.

A theoretical post-doc, Jeremy, makes further redesign suggestions, sketching a graph that distinguishes measurements from extrapolations based on a logarithmic scale.

In the course of this activity, the physicists overcome somewhat the experimental–theoretical impasse concerning the strength of the theoretical claim about barrier heights at Tg. The original graphs, with their solid lines indicating spin glass dynamics in the region of Tg, had made reasonable a theoretical inference about barrier heights in this region. Looking at the revised graphs, which distinguish more clearly extrapolations from actual measurements, Ron drops the original theoretical claim that barrier heights go to zero at Tg and instead recommends a more modest claim – i.e. one not tied to the specific temperature Tg – which is inferrable from the experimental measurements:

Ron: And I would simply <sta::te tha::t> **from the data**
(.)
it appea:rs from the measurement region<I think u*h Maurice is right.
.hh **From the measurement region there appears to be a very ra:pid growth of barrier height**
(0.2)
period.

The addition of "period" following the claim is Ron's way of advocating a more curtailed theoretical argument for the upcoming presentation.[32] This curtailment and explicit acknowledgment of Maurice's judgment as correct ("Maurice is right") evidences an important step in constructing a discourse of consensus across the subdisciplines of experimental and theoretical physics.

FIVE DAYS BEFORE CONFERENCE

The next day, Miguel performs another run-through of the spin glass talk, in which he makes no claim that the barrier height goes to zero at Tg. Furthermore, in this run-through Miguel displays two redesigned graphs, one based on Ron's suggestions and one on Jeremy's suggestions. Both distinguish actual measurements from extrapolations (thick horizontal line vs. thin vertical lines, and cross-hatched lines vs. lines dotted by small circles). As Miguel talks through one of these graphs, he differentiates actual measurements from extrapolations. When he introduces the second redesigned graph, he points out that the experiments can access only "a very narrow ra:nge" of barrier heights:

Miguel	And this is what I'm showing he re, This uh (0 7) delta (0 3) in a logarithmic sca le, ( ) versus T over Tg·, hh And I'm showing here the e– only thee e– **thee experimentally accessible delta:s.** **You can see it's a very narrow ra:nge.**

In this run-through, Miguel's synthesis of the previous day's comments constitutes a rhetorical shift, closer to the cautious experimentalist position about data displays and the viability of a theoretical claim (concerning barrier heights at Tg) based on only a "very narrow ra:nge" of "experimentally accessible" barrier heights.

Miguel's run-through runs overtime again. Although he tries to take another 30 seconds to summarize, Ron cuts him off, saying, "You will not use another thirty seconds." Ron then goes on to suggest how to cut the talk even further. In the course of making these rhetorical suggestions to solve the overtime problem, Ron aligns even more closely with the experimentalists, especially Maurice's position. To save Miguel time, he makes two recommendations· (a) that Miguel eliminate one of the graphs displaying extrapolated temperature-dependent barrier heights; and (b) now admitting that "Maurice is absolutely right," that Miguel eliminate the extrapolations on the second graph and display ONLY the measured data. The implication here is that if the extrapolations are eliminated from the graphs, they will not be discussed in the talk itself.

Ron	Okay I think I know how to do it for you ((*pulls chair to table*)) Okay (0 2) uhheh hh First thing ( )
Miguel	What do I need to skip
Ron	Thee uh temperature dependence of the barrier height It's completely unnecessary
Miguel	uh This one here? (0 6)
Ron	Yeah
Miguel	Okay
Ron	**And also all those extrapolated lines on the previous (one).** (0 5) **Maurice is absolutely right.** (0 3) **It's totally unnecessary.** All you need [(is)
Miguel	[Oh for ou r **timing purposes?**, °Yeah °
Ron	Yeah ((*lines omitted*)) Just show the lines ((*lines omitted*)) **Just show what you measured.**

However, despite this noticeable accommodation by Ron to the experimentalists' reservations about the claim that barrier heights go to zero at Tg, Ron does not advocate foregrounding only experimental protocol, measurements, and results in the upcoming talk. Rather, in his continuing feedback on the presentation run-through, he advocates a strong theoretical framing for the talk. As he said on October 17, the point of the talk is to say something of theoretical import ("I am trying to cut this down right now so that you can say something. Because I think not to say something (0.2) means that you measured d delta dT.=Big deal."). After two meetings (October 17 and 24) in which Ron and members of the lab revised what to display on the graphs, what to delete, and what to say in the presentation, Ron casts the experimental protocol in the context of theory and redefines the theoretical point of the talk.

Ron's point of departure is the theme of elegance. He links elegance first with good theoretical interpretation, specifically with the interpretation he sees as being at the heart of their spin glass talk:

Ron First of a ll ( ) this is an **elegant** (0 7) uh m **interpretation.**

Immediately Ron contrasts such elegance with the inelegant opening of Miguel's run-through:

Ron A nd it deserves **a better start** than you gave it
(0 3)
uh When I introduced you what you said wa s (0 2)
"Ye s ( ) yea h, ( ) so I will talk abou t"
(0 6)
Okay?,
( )
Now– ( ) **that's not exactly an elegant beginning** ( ) **to: what is really a very elegant ta:lk.**

Ron then proceeds to provide a more elegant opening, with rhetoric that is gracious and which articulates clearly the theoretical significance of the research:

Ron hh When you're introduced (0 2) say "thank you" (0 4) for being introduced, ( ) and say "the purpose ( ) of my talk ( ) is to ( ) sho w that we are no w abl e ( ) **using a hierarchical model,** (0 2) **to:** ( ) **measure dynamics in spin glasses,** (0 5) **whi:ch** ( ) **can be compared directly with theoretical** ( ) **calculations."**
(2 8)
'Cause that's what you're doing.=
Miguel =Mm hm
((*lines omitted*))
Ron Just say "tha.nk you , hh my purpose in presenting this material is to sho w hh tha t (0 5) for once, or at la st, **or as a consequence of our– our experiments:, .hh we are no:w able to measure quantities which can be directly compared with theory.**
(1 0)
For the dynamics of spin glasses "
(0 4)
That in itself is a bombshell.

This rhetorical suggestion for how to make the presentation opening more "elegant" turns out to construct an important shift in the newsworthiness of the physical argument. Whereas earlier, the talk foregrounded BOTH the novelty of the protocol and specific new claims about barriers at Tg and other temperatures, Ron now articulates the sufficiency of the former to stand alone as the theoretical news of the conference presentation. As Ron expresses it, the development of an experimental protocol based on a hierarchical model makes it possible to measure barrier heights that can be directly compared with theoretical simulations of spin glass dynamics, and "That in itself is a bombshell."

TIME, RHETORIC, AND CONSENSUS

The face-to-face and electronic deliberations that took place among the co-authors of the spin glass research illustrate how physicists construct claims and negotiate a "for-the-time-being" working consensus despite the divide between experimental and theoretical subcultures. We have tried to show that these accomplishments are situated with reference to a cultural clock that organizes the activities of professional physicists. Like the agrarian calendar, a seasonal calendar of physics conferences mobilizes the labor of members of this profession. Our ethnographic observations of one group of collaborating scientists strongly suggest that physicists do not first iron out all the problems in their research project and then commit themselves to a public report; instead, they constantly submit abstracts to conferences, then proceed to work on unsolved problems as conference deadlines draw near. In the final days before a conference, pressure mounts to resolve particular remaining disagreements about matters of physics among the co-authors. In this sense, the cultural clock drives consensus.

In addition to conference deadlines, the 10-minute presentation time limit challenges the co-authors to put forth their findings and arguments in an economical manner. When Miguel e-mails Ron that "There is no time . . . in 10min" to satisfy both Maurice's experimental and Ron's theoretical preferences, he voices the view that the co-authors' problem is rooted in the practicalities of time and rhetoric. Moreover, when the spin glass presentation runs overtime in rehearsal, the problem of time becomes the rationale for discussing the re-ordering, redesigning, condensing, and deleting of material.

As the pre-conference rehearsals get underway and the physicists attend to matters of rhetoric, they overcome an epistemic impasse concerning matters of physics. Prior to Miguel's rehearsal of the spin glass presentation, the experimentalist co-authors (Maurice and Miguel) had urged caution in making a claim about extrapolated barrier heights at a particular temperature; but their theoretician colleague (Ron) defended the claim as reasonable, even though it could not be verified experimentally. The resolution of this classic epistemic conflict is achieved incrementally as the physicists attend to the wording of the claim (e.g. "it's suggested," "this is not inconsistent (.) with the fact") and to the design of graphs that relate to the claim. Each rhetorical decision mitigates the certainty of the claim and elevates its "honesty" ("So that's ho:nest. That says that's what you measured and the rest of these are extrapolations"). Eventually the theoretician suggests that the much mitigated claim and relevant graphs be eliminated altogether from the presentation, the time limit problem being given as a reason ("Oh for ou:r timing purposes?" "Yeah. ... Just show what you measured").[33] As he makes these rhetorical shifts, the theoretician voices alignment with the experimentalists ("Maurice is absolutely right"). However, he situates this alignment primarily with regard to matters of rhetoric: Rather than citing the experimentalists' concern with matters of physics – the tenuous relation of certain extrapolated temperature-dependent barrier heights to actual measurements – as the reason to delete this information, the theoretical physicist agrees to their lack of importance ("It's totally unnecessary") for the major point they are now putting forward.

Throughout these deliberations, the graduate student presenter, Miguel, plays a critical role in developing the hybrid experimental/theoretical genre of the conference paper.[34] As a disciple of both a theoretician and an experimentalist, he mediates between them, displaying deference to both, even to the point of claiming willingness to accommodate to whatever his mentors think is best. However, the co-authored report derives primarily from the experiments that Miguel has conducted for his dissertation research; and a close look at the deliberations indicates that Miguel skillfully and successfully defends the experimentalist position, yet at the same time displays a strong commitment to theory. A common practice among physicists is for graduate students to prepare drafts of co-authored talks. In Miguel's case, the task is particularly challenging in that the graduate student must integrate the theoretical and experimental perspectives of the co-authors into a blueprint for a hybrid presentation genre. In this sense, the graduate student plays a central role in bringing about cross-fertilization and innovation in matters of rhetoric and matters of physics. As detailed and forceful as they are in their feedback, Maurice (from afar) and Ron and the rest of the laboratory group (at hand) must rely on Miguel's drafts as their point of departure. The hybrid character of the presentation reflects and constructs not only a cross-disciplinary coalition among the co-authors, but also Miguel's own professional identity as an experimental physicist who has been mentored by a theoretician and an experimentalist. When he performs this hybrid presentation, Miguel embodies and publicizes this hybrid identity.

As in Galison's accounts of scientific trading zones, the experimental and theoretical physicists in this study found ways to use graphic representation, talk, and e-mail to communicate across subdisciplinary lines and to jointly construct a research presentation that draws on both domains of expertise. Mindful of the conference deadline and the presentation time limit, the theorist gave up what he considered to be a reasonable and significant theoretical inference, by deleting it from the presentation. In exchange, the experimentalists traded their preference for foregrounding the inductive process ("montre les resultats d'abord de facon impartiale, propose ton analyse et tes fits apres"). Eventually, they acceded to the theorist's suggestion that the presentation begin "elegant[ly]" with the "bombshell" announcement that the co-authors have developed a theory-driven protocol that allows measurements to be directly compared to theoretical predictions of spin glass dynamics.

Thus is a working consensus forged as theorists and experimentalists come down to the wire of deadlines and time limits for public reports. For the moment, that is. In the aftermath of the conference, freed from the task of constructing a presentation rhetoric, the co-authors reopened their ongoing discussion on the meaning of measurements and the grounding of theory in their spin glass research.

NOTES

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[1] See Fujimura 1987, Latour 1987, Lynch & Woolgar 1990

[2] Our research team videotaped a university physics laboratory from October 1990 to April 1991 Throughout this period of observation and afterward, we interviewed each member of the laboratory team These interviews included tutorials on topics the members were researching as well as personal histories of their experiences as working physicists In addition, we amassed a large archive of e-mail correspondence, drafts of research papers in progress, conference talk transparencies, grant proposals, and publications by members of the group and by colleagues with whom they interacted Our contact with members of the group is ongoing through electronic communication In 1993 one of the authors (Jacoby) attended the American Physical Society March Meeting and recorded three of the original laboratory members delivering conference presentations

[3] The names of the physicists in our study are pseudonyms The following is a key to the transcription conventions used in the transcribed excerpts of the physicists' interactions

hh	inbreath
hh	outbreath
underline	emphatic stress
boldface	talk and interaction of immediate analytic interest
	sound stretch
(0 2)	pauses in seconds and tenths of seconds
( )	micropause (less than 0 2 seconds)
((comment))	non-vocal action or transcriber's comment
	falling intonation
?	rising intonation
,	continuing or listing intonation
?,	slightly rising intonation
[	onset of overlapping talk or non-vocal action
]	end of overlapping talk or non-vocal action
( )	inaudible talk
(guess)	doubtful hearing
(guess)/(guest)	alternative doubtful hearings
bu–	cutoff sound or syllable
°you°	low volume talk
>well<	speeded up talk
<well>	slowed down talk
CAPS	loud volume talk
↑	sudden pitch rise

*	vocal fry
=	closely latched talk
	omitted talk
(h)	laugh token

[4] This is not to deny, of course, the problems and conflicts which may surface when different subcultures of the field collaborate External problems may arise with regard to the securing of funding, the targeting of abstracts to particular conferences, and the refereeing of manuscripts submitted for publication Internal conflicts may also come to the fore as collaborating physicists argue among themselves This article attends primarily to the latter situation

[5] See Kuhn 1970, Fleck 1979, Hacking 1983, Knorr-Cetina 1983, Lynch 1985, Shapin & Schaffer 1985, Latour & Woolgar 1986, Latour 1987, Traweek 1988, Haraway 1991, Collins 1992, Biagioli 1993, Galison 1997

[6] Spin glasses are "magnetic alloys where the [atomic] spins on the impurities become locked or frozen into random orientations below a characteristic temperature" (Ford 1982)

[7] General Meetings include what is known as the "March Meeting," the largest annual meeting of physicists in North America (approximately 4800 papers), and the "Joint April Meeting" with the American Association of Physics Teachers (AAPT), Divisional Meetings correspond to the specialization divisions within the American Physical Society (APS), e g Plasma Physics and Fluid Dynamics, Topical Meetings focus on specific topics within specialization divisions, e g Shock Compression of Condensed Matter Physics, Sectional Meetings gather physicists from particular geographic regions, Sponsored Meetings are those sponsored by entities other than the APS, e g the General Conference of the Condensed Matter Division of the European Physical Society

[8] Most deadlines are listed in the American Physical Society *Meeting News*, but others are publicized through circulars and e-mail

[9] "MMM" refers to the Annual Conference on Magnetism and Magnetic Materials

[10] "ICM" refers to the International Conference on Magnetism

[11] APS invited conference talks are 25 minutes long with 5 minutes for questions In the period of our recorded observations, only 10-minute talks were rehearsed at the laboratory's weekly group meetings These rehearsals were carefully timed by the laboratory director, Ron, who would lay his watch on the table and monitor it during the rehearsal run-throughs Typically, after 8 minutes, Ron would give a hand signal to the presenter that 2 minutes remained At 10 minutes he would signal that time was up

[12] Such a locally accomplished decision-making process is no different from what Garfinkel 1967 characterizes as the ongoing practical reasoning that all members of society utilize in interpreting and constructing the social order See also Garfinkel et al 1981, Lynch 1982, Lynch et al 1983, Lynch 1985, Lynch & Woolgar 1990, Lynch 1991

[13] The process whereby scientific controversy is eventually brought to closure has come to be known as "blackboxing" – a metaphorical analogy borrowed from cybernetics by Latour 1987 to characterize what happens when previously contested matters attain the status of accepted fact As Latour describes the metaphor's origins, "The word 'black box' is used by cyberneticians whenever a piece of machinery or a set of commands is too complex In its place they draw a little box about which they need to know nothing but its input and output" (1987 2–3)

When newly designated facts, artifacts, and explanations become accepted in science, Latour argues, matters which have previously been closely examined and argued become unproblematic, fixed, certain, given, and taken-for-granted Thus, once consensus is achieved about some aspect of the natural or physical world, the phenomenon paradoxically fades from view, as if enclosed in a "black box," while the co-authors' or community's attention moves elsewhere But this is not to say that once the box is "closed," all opposition evaporates or that scientific controversy will never re-open on the topic in question On the contrary, many historical case studies examined in the literature illustrate cycles of construction and deconstruction of scientific consensus See especially Kuhn's (1970) discussion of the particle theory vs the wave theory of light and Fleck's (1935/1979) tracing of incommensurate etiological theories of syphilis from the Middle Ages to the 20th century

[14] Cf Kuhn 1970, Fleck 1935/1979, Hacking 1983, Knorr-Cetina 1983, Laudan 1984, Lynch 1985, Shapin & Schaffer 1985, Latour & Woolgar 1986, Latour 1987, Traweek 1988, Cole 1992, Collins 1992, Pickering 1992, Biagioli 1993, and Galison 1997

[15]See Garfinkel et al 1981, Lynch 1982, Lynch et al 1983, Lynch 1985, Woolgar 1990, Amann & Knorr-Cetina 1990, Galison 1997

[16] Cf Scott 1967, Latour 1987, Bazerman 1988, Prelli 1989, 1990, Gross 1990, Myers 1990, Pera & Shea 1991, Cherwitz & Darwin 1995

[17] Lynch 1985 stresses that deciding what is to be considered a finding or an artifact is an in-situ continuous categorization problem for scientists as they interact with one another and practice their laboratory procedures

[18] We do not know if Maurice conferred with Jean in the course of the ongoing deliberations with Miguel and Ron

[19] A "spin" is the intrinsic angular momentum of an electron (also called a "magnetic moment") (Hurd 1982) "Glass" refers to the disorder in the orientations and interactions of the spins in an alloy (Stein 1989)

[20] "T" in this context refers to experimentally measured time intervals

[21] In his run-through, Miguel actually used the words "we hope" rather than "I hope " Gary's objection focuses on the entailments of the verb *hope* rather than the subject of the verb

[22] In the electronic text, pseudonyms are used to protect the privacy of the participants, and identifying information (surnames, e-mail addresses, institutional acronyms) has been masked with *X*'s

[23] A translation of the French message is as follows

> I'm confused by the results I don't think you have to phone today, rather around the end of the week before the conf (if xxxx finances still allow it!!) I think you over-interpret the data By that I don't mean that your interpretation is wrong, it may be right, but you have to present the raw findings FIRST (with the discussion of error bars) This is true for the FAX you sent me You give me error bars for the fits but not for the raw results My comment is also true for your presentation at MMM, first show the results in an impartial manner, show your analysis and your fits afterward

Here "MMM" refers to the annual physics conference on Magnetism and Magnetic Materials, "PDT" refers to Pacific Daylight Time, "conf " refers to 'conference' "Error bars" are vertical lines drawn on a plotted curve which indicate the upper and lower boundaries of a measurement's margin of error "Fits" are comparisons between the curves of experimental measurements and the curves of predictive mathematical models of the same phenomenon

[24] There are no accents or cedillas in the original electronic message

[25] Note that, in the message, Miguel addresses his present mentor (Ron) with the deferential title of professor ("Pr ") plus his last name We know from other electronic correspondence that he addresses his other mentor (Maurice) by his first name Ron is somewhat senior to Maurice in age In addition, as noted, Miguel has worked side-by-side with Maurice in conducting experiments (both in Ron's laboratory and in Maurice's laboratory), and Maurice also socialized a great deal with Miguel when he spent time as a visiting scholar in Ron's laboratory Ron, a theorist and busy university administrator, meets regularly with Miguel to discuss ongoing work but is not present during the routine running of experiments From informal interviews, recordings of laboratory meetings, and e-mail correspondence, we know that this sociolinguistic asymmetry does not hold when Miguel refers to each of his mentors When referring to (rather than addressing) Ron or Maurice, Miguel treats them equally, sometimes referring with first name and sometimes with last name only Generally Ron and Maurice use first names to address and refer to Miguel and to one another Note as well that Ron signs his message to Miguel as "Ron "

[26] Note that Maurice's advice encodes a worldview in which measurements (experimental results) are impartial to theory – a controversial view that has received considerable attention in science studies (e g Kuhn 1970, Fleck 1935/1979, Hacking 1983, Shapin & Schaffer 1985, Lynch & Woolgar 1990, Haraway 1991, Lynch 1991, Collins 1992, Galison 1997)

[27] The e-mail exchange allows for its own form of reported speech (Voloshinov 1971, Banfield 1973, Bakhtin 1981, Coulmas 1986) Prior messages can be reproduced verbatim for a reader juxtaposed with interpretive revoicings of the message ("As you can see ") The written electronic messages are also routinely embedded as reported speech in the face-to-face deliberations among laboratory members See Goodwin 1994 for a discussion of the interpenetration of written and spoken texts in the construction of professional knowledge

[28] See Traweek 1988 for a lucid discussion of how one's position along a career path is integrally tied to expectations concerning the role one plays in the laboratory and in the larger professional community

[29] Miguel and Ron are also the first and second authors of the presentation, while Maurice is third author

[30] Cf Lynch & Woolgar 1990, Goodwin 1994, Hutchins 1995

[31] Note that the modifications to the graphic representations parallel and amplify the hedged modifications made to the language of the presentation of ideas

[32] See Myers (1990 41–100) for a penetrating analysis of how arguments made in manuscripts of biological research are rhetorically transformed in response to referee comments and criticisms Myers argues that this textual negotiation with outside gatekeepers plays an important role in getting one's research claims accepted by the larger scientific community

[33] Ron's predeliction to align more closely with the experimentalists may be linked to his non-first-author status

[34] See Bazerman 1988 for insightful analysis of the historical development of the scientific genre of the written experimental report See also Prelli's discussion (1989 236ff) of how Watson & Crick 1953 crafted the interpretive rhetoric of their famous article announcing the double-helical structure for DNA with an eye to experimental data emanating from rival research laboratories

REFERENCES

Allen, Woody (1964) *Woody Allen Recorded live at Mr Kelly's, Chicago* New York Colpix Records

Amann, K , & Knorr-Cetina, Karin (1990) The fixation of (visual) evidence In Michael Lynch & Steve Woolgar (eds), *Representation in scientific practice*, 85-121 Cambridge, MA MIT Press

Aveni, Anthony (1989) *Empires of time Calendars, clocks, and cultures* New York Basic Books

Bakhtin, Mikhail (1981) *The dialogic imagination Four essays* Austin University of Texas Press

Banfield, Ann (1973) Narrative style and the grammar of direct and indirect speech *Foundations of Language* 10 1–39

Bazerman, Charles (1988) *Shaping written knowledge The genre and activity of the experimental article in science* Madison University of Wisconsin Press

Biagioli, Mario (1993) *Galileo courtier The practice of science in the culture of absolutism* Chicago University of Chicago Press

Bourdieu, Pierre (1977) *Outline of a theory of practice* Translated by Richard Nice Cambridge & New York Cambridge University Press

Brown, Stuart, & Gruner, George (1994) Charge and spin density waves *Scientific American* 270 50–56

Cherwitz, Richard A , & Darwin, Thomas J (1995) Why the "epistemic" in epistemic rhetoric? The paradox of rhetoric as performance *Text and Performance Quarterly* 15 189–205

Cole, Stephen (1992) *Making science Between nature and society* Cambridge, MA Harvard University Press

Collins, Harry M (1992) *Changing order Replication and induction in scientific practice* Chicago Chicago University Press

Coulmas, Florian (1986) *Direct and indirect speech* Berlin Mouton de Gruyter

Fleck, Ludwig (1935) *Entstehung und Entwicklung einer wissenschaftlichen Tatsache Einführung in die Lehre vom Denkstil und Denkkollektiv* Basel Schwabe (Translated as *Genesis and development of a scientific fact* Chicago University of Chicago Press, 1979)

Ford, Peter J (1982) Spin glasses *Contemporary Physics* 23 141–68

Fujimura, Joan H (1987) Constructing "do-able" problems in cancer research Articulating alignment *Social Studies of Science* 17 257–93

Galison, Peter (1987) *How experiments end* Chicago University of Chicago Press

——— (1997) *Image and logic The material culture of microphysics* Chicago University of Chicago Press

Garfinkel, Harold (1967) *Studies in ethnomethodology* Englewood Cliffs, NJ Prentice-Hall

———, Lynch, Michael, & Livingston, Eric (1981) The work of a discovering science construed with materials from the optically discovered pulsar *Philosophy of the Social Sciences* 11 131–58

Gell, Andrew (1992) *The anthropology of time Cultural constructions of temporal maps and images* Oxford Berg

Gonzales, Patrick (1996) *The talk and social organization of problem-solving activities among physicists* Ph D dissertation, University of California, Los Angeles

Goodwin, Charles (1994) Professional vision *American Anthropologist* 96 606–33
Gross, Alan G (1990) *The rhetoric of science* Cambridge, MA Harvard University Press
Hacking, Ian (1983) *Representing and intervening Introductory topics in the philosophy of the natural sciences* Cambridge & New York Cambridge University Press
Haraway, Donna (1991) *Simians, cyborgs, and women The reinvention of nature* New York Routledge
Heidegger, Martin (1962) *Being and time* New York Harper & Row
Hurd, C M (1982) Varieties of magnetic order in solids *Contemporary Physics* 23 469–93
Hutchins, Edwin (1995) *Cognition in the wild* Cambridge, MA MIT Press
Jacoby, Sally (1992) The interactive evolution of graphic displays for a physics conference talk Paper presented at the International Conference on Discourse and the Professions, Uppsala, Sweden
——— (1997) *Science as performance Socializing scientific discourse through the conference talk rehearsal* Ph D dissertation, University of California, Los Angeles
Knorr-Cetina, Karin (1983) The ethnographic study of scientific work Towards a constructivist interpretation of science In Knorr-Cetina & Mulkay, 115–40
———, & Mulkay, Michael (1983), eds *Science observed Perspectives on the social study of science* London Sage
Kuhn, Thomas S (1970) *The structure of scientific revolutions* Chicago University of Chicago Press
Latour, Bruno (1987) *Science in action* Cambridge, MA Harvard University Press
———, & Woolgar, Steve (1986) *Laboratory life The social construction of scientific facts* 2nd ed Princeton, NJ Princeton University Press
Laudan, Larry (1984) *Science and values* Berkeley University of California Press
Lynch, Michael (1982) Technical work and critical inquiry Investigations in a scientific laboratory *Social Studies of Science* 12 499–533
——— (1985) *Art and artefact in laboratory life A study of shop work and shop talk in a research laboratory* London Routledge & Kegan Paul
——— (1991) Method Measurement – ordinary and scientific measurement as ethnomethodological phenomena In Graham Button (ed), *Ethnomethodology and the human sciences*, 77–108 Cambridge & New York Cambridge University Press
———, Livingston, Eric, & Garfinkel, Harold (1983) Temporal order in laboratory work In Knorr-Cetina & Mulkay, 205–38
———, & Woolgar, Steve (1990), eds *Representation in scientific practice* Cambridge, MA MIT Press
Myers, Greg (1990) *Writing biology Texts in the social construction of scientific knowledge* Madison University of Wisconsin Press
Ochs, Elinor, Gonzales, Patrick, & Jacoby, Sally (1996) "When I come down I'm in the domain state" Grammar and graphic representation in the interpretive activity of physicists In Elinor Ochs et al (eds), *Interaction and grammar*, 328–69 Cambridge & New York Cambridge University Press
Ochs, Elinor, Jacoby, Sally, & Gonzales, Patrick (1994) Interpretive journeys How physicists talk and travel through graphic space *Configurations* 2 151–71
Pera, Marcello, & Shea, William R (1991), eds *Persuading science The art of scientific rhetoric* Canton, MA Science History Publications
Pickering, Andrew (1992), ed *Science as practice and culture* Chicago University of Chicago Press
Prelli, Lawrence, J (1989) *Rhetoric of science Inventing scientific discourse* Columbia University of South Carolina Press
——— (1990) Rhetorical logic and the integration of rhetoric and science *Communication Monographs* 57 315–22
Ricoeur, Paul (1988) *Time and narrative* Chicago University of Chicago Press
Scott, Robert L (1967) On viewing rhetoric as epistemic *Central States Speech Journal* 18 9–17
Shapin, Stephen, & Schaffer, Simon (1985) *Leviathan and the air pump Hobbes, Boyle, and the experimental life* Princeton, NJ Princeton University Press
Stein, D L (1989) Spin glasses *Scientific American* 261 52–59
Traweek, Sharon (1988) *Beamtimes and lifetimes The world of high energy physicists* Cambridge, MA Harvard University Press
Voloshinov, V N (1971) Reported speech In Ladislav Matejka & Krystyna Pomorska (eds), *Readings in Russian poetics Formalist and structuralist views*, 149–75 Cambridge, MA MIT Press

Watson, J D , & Crick, F H C (1953) Genetical implications of the structure of deoxyribonucleic acid *Nature* 171 942–67
Whorf, Benjamin (1956) *Language, thought, and reality* Cambridge, MA MIT Press
Woolgar, Steve (1990) Time and documents in researcher interaction Some ways of making out what is happening in experimental science In Lynch & Woolgar (eds), 123–52
Zerubavel, Eviatar (1981) *Hidden rhythms Schedules and calendars in social life* Chicago University of Chicago Press