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Making Classifications (at) Work: Ordering Practices in Science

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ABSTRACT: To make and use classifications is human; at least in the discovery sciences, these activities involve high degrees of uncertainty. Drawing on ethnography and conversation analysis of videotaped scientists, the activities of classifying and making classifications are analyzed considering four types of situations that arise when there is certainty or uncertainty about the object to be classified and the classification scheme to be used. For example, a group of scientists may be able to make perceptual distinctions between entities (fish or photoreceptors) without being able to provide an operational definition for making such distinctions. As a collection, the different analyses of everyday scientific work articulate classification as a physically and temporally situated and socially distributed activity that does not achieve to eliminate uncertainty and inconsistency but tends to minimize contradiction.

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At an environmental open-house event, May 1998.—Karen, a water technician working at a local farm, walks visitors around the walls of the room where she displayed one years worth of graphs from her pen-chart recorder connected to a water-level monitoring device. At one point, one can see a sudden spike in the graph. Karen points to the spike and says, “This is a clogged pipe.” At another part of the chart, Karen points out the presence of a tiny peak preceding the main peak. She says, “So, what this blip means then is that when we get a rainfall—we had quite a bit there—the north arm, the water from the north arm comes off faster.”

A graduate class on qualitative research methods, January 2001.—To explore the analysis of video-based data with the students, I have brought a clip featuring three boys building an “earthquake-proof” tower from drinking straws.[1] One boy makes some suggestions but the two do not seem to listen. A fourth boy approaches the group, says “So you are building an earthquake-proof tower,” and then, as the three continue to be immersed in their task, walks away. Asked what they had seen, the graduate students volunteered comments including, “An instance of ostracism,” “Leadership,” and “A case of two ganging up on the third.”

My key chain.—There are three rings enjoined, each containing a range of keys. The first ring only holds university-related keys, the second all those keys related to house and car, and the third ring those related to the bicycles (including the two keys for locking the bicycles in the roof rack).

In a fish hatchery at a stand where coho fry were marked, June 2001.—I observed a worker who sorted the fry, which were evidently processed differently. But I could not see how on what basis she sorted the fish; nor could the worker tell me in so many words how to classify other than by telling me “Just watch!” I began to watch. After about half

[1] The clip had also been subject of an analysis by nine science educators, with divergent views of just what could be seen on the tape. The results of these analyses can be viewed at http://unr.edu/homepage/jcannon/ejse/kamen_etal.html.

an hour, I began to hypothesize whether a particular specimen would be put into the left or right trough, or ended up in the central bucket. Initially, I was off in more than 50% of the cases, but became increasingly accurate. When I finally arrived at classifying more than 90% of the smolt correctly, I realized that I could not articulate myself the grounds on which I separated them.

To classify is human—all four situations are examples of classification as massive, mundane, and transparent activity. Karen points to a graph yet talks about the pipe that feeds the water-monitoring device—the spike has become transparent, a way of ordering her world, the farm and its water supply. The graduate students assign the video clip to specific categories that they and their culture provide for ordering and making sense of interactions and classrooms. My key chain is an example of, perhaps idiosyncratic, ordering of our personal environment, which assures rapid and efficient copying in a complex world. There are, though, not just similarities across these situations. In the first two situations, categories are clearly social, common to social groups of various sizes; the third situation is an example of highly individual and idiosyncratic classification; in the final situation, classification occurs but is not communicable. Whereas Karen shares the classification of the graphical spike with her employer and with the technician at Environment Canada who analyzes and transforms the graph into a water volume chart, the classification scheme underlying my key chain may not describe any other situation. In each situation, the classification system at work allows a pigeonholing of facts whose reconstruction is facilitated by their membership to a class with certain properties. In this article, I am concerned with classification as a social practice rather than with those instances where we develop highly personal ways of ordering the world without ever coming to share them with others.

Knowledge, its storage and availability through searchable databases, exists in terms of a large but not infinite number of facts; fast access requires systematization, which is achieved through categorization. Categories and processes of classification are central to any knowledge society, and therefore inherently of interest to sociology. But how do we bring order to the world, both in the presence and absence of established categories? Classification-in use and classifying activity are ordinarily unproblematic and invisible. Karen, my students, and I all engaged in classification without thinking about it as such. In fact, we no longer distinguished the classification schemes and the names associated with them from the things that we classify. The schemes and their names have become transparent allowing us to directly deal with things in the world. Categories and the things they classify have become conflated—there is no longer a distinction between the map and the territory it describes.

To date, much of the work on classification has been done in the domains of philosophy (e.g. Smith 1999) or computer science and artificial intelligence (e.g. Gruber 1995). The resulting discussions, however, are highly formal treatments of classification theory. At the same time, and curious given the massiveness and pervasiveness of the phenomenon, there are few studies empirical studies of the production, use, and impact of classification as everyday work practice (Bowker and Star 1999). Who makes classifications? When and how do they emerge as part of the normal, everyday activity people engage in? When and how do these classifications stabilize (at least locally)?

This paper is concerned with finding answers to these questions, and particularly with the microphysics of classification making and classification use in the ordinary, everyday, and mundane work of scientists. The two questions latent in the title of this article, “How do they make classifications at work?” and “How do they make classifications work?” framed the present study.

APPROACH AND METHOD

In this article, which arises from the same tradition of science studies that engendered the several other studies that appeared in this journal (e.g. Collins 1998, Pickering 1993), I draw on five years of fieldwork that broadly concerned the work and learning of biologists from their undergraduate years to their everyday practice. As part of this fieldwork, I established (with some help from a graduate research assistant) an extensive library of videotapes that feature practicing scientists, postdoctoral fellows, graduate students (M.Sc., Ph.D.), and advanced undergraduate students (doing honors degrees) in the process of doing research, including data collection and interpretation.

In my fieldwork, I draw on different modes of participation to learn about the practices in the respective sites. I prefer to use some form of apprenticeship as an ethnographic fieldwork method (e.g. Coy 1989); during the period of negotiating access to a particular site, I offer to serve as a field or laboratory assistant. Participation in the ongoing work with the purpose of getting the day's work done allows a new participant in a practice to acquire the familiarity with relevant objects and events that characterizes the members of the particular community of practice. Working as an apprentice or as an assistant in everyday work practice provides a perspective from within; it particularly yields an understanding for the temporal constraints of the practice that are unavailable to the fly-on-the-wall observer participant. The fundamental assumption underlying this research approach is that one cannot truly understand a particular "form-of-life" (Wittgenstein 1958; Winch 1958) unless on participates in the practice, an assumption central to Marxist sociological (Bourdieu 1980) and social-psychological thought (Holzkamp 1991).

Over a three-year period (1997-1999), I conducted fieldwork among ecologists, which involved serving as a field assistant in a camp. There, my research assistant and I helped in particular one research group by capturing lizards, skinks, rubber boas, and garter snakes. Our main informant was a doctoral student (pseudonym Samantha) in her fourth through sixth years of doing independent research. Although we also interviewed Samantha during the summer fieldwork, most of my data consist of observations recorded in fieldnotes, photographs, audiotaped conversations in and about fieldwork, and videotapes of data collection in the field and laboratory. Frequently, there were other field assistants present as well so that the videotapes and audiotapes feature naturally occurring conversations about the salient topics at hand. During the winter periods, which Samantha spent on the main campus, I formally and repeatedly interviewed Samantha about different aspects of her research, in particular about her analysis of the data. I attended local and international conferences where Samantha presented her work, and where I was able to audiotape her interactions during poster sessions. I collected videotapes featuring Samantha as she presented the results of her research in a number of different venues (departmental seminar, regional graduate student conferences, etc.). I also obtained copies of field notebooks, proposals, draft papers, and many other documents that Samantha produced in the course of constructing a life history traits and natural history of a particular lizard species (e.g. Roth and Bowen 1999). In some instances, I was unable to engage in fieldwork because of institutional commitments. In such situations, I opted for a particular style of ethnography in which a research assistant with appropriate training (e.g. M.Sc. biology and MA sociology) worked on site, sending daily reports, photographs, documents, etc. I returned more theoretically oriented reflections and comments or requests for further data collection. Interacting in this manner puts pressure on the “part native” to make explicit any of his tacit assumptions.

My second and third data sets were generated as part of a collaborative project with a professor of experimental biology who specializes in fish vision. Our collaboration is part of a larger project that attempts to understand coastal communities that are under stress because their traditional modes of garnering an income in some resource based industry (forestry, fishing, or metallurgy) has been eliminated—a smelter is no longer economically viable, fish stocks have plummeted leading to a fishing moratorium, etc. The purpose of the specific study is (a) to better understand the timing of the physiological changes that salmonid fishes undergo as they prepare for life in the ocean and (b) to understand the interaction of local hatchery and scientific knowledge once information is exchanged between the hatchery and the scientific laboratory.

The two parts of the study are integrally related because, from the biological perspective, we are interested in particular forms of local knowledge and practices that might be of relevance to the scientific work, such as the local knowledge with respect to the life history traits and natural history of hatchery and wild salmon populations. Such information is also important for designing feasible research that takes account of and capitalizes on local contingencies—for example, makes use of trips intended for lake fertilization, a practice to increase food to wild salmon populations, to get access to these populations. As part of my project, I identify relevant knowledge and practices through interviews and ethnographic fieldwork and to make them available to the biological research. At the same time, I conduct ethnographic work in the laboratory in order to evaluate whether and how the contact with local knowledge interacts with and modify extant practices.

I am therefore centrally involved in both the natural science and social science aspects of the work (a postdoctoral fellow in biology is financed out of my grant; I am on the committee of a doctoral student on the team). The biological research mainly focuses on determining changes in the absorption of light in retinal photoreceptors, which changes prior to sea migration of anadromous salmonids because of shifts in the visual pigment composition. Because of my graduate training in physics and physical chemistry, the devices (CCD [charge-coupled device] detector) and mathematical techniques (e.g. polynomial curve fitting, Fast Fourier Transform) used for data acquisition and data treatment are very familiar. I familiarized myself with the research by participating in the entire data collection process from the preparation of specimen (sacrificing the fish, excising the eye, isolating photoreceptors) to mounting the specimen in the microscope, and collecting the data. I also participate in the data analyses. Access to the salmon hatchery began when three members of the biology lab (postdoctoral fellow, doctoral student, research assistant) and I presented the project to hatchery personnel. The (personnel and general) managers and fish culturists immediately agreed on all aspects of the proposed collaborative project. As part of my fieldwork, I ask to participate in the different activities of the hatchery, hand-feeding the fish, marking them by removing the adipose fin with surgical scissors, seining for salmon fry in the near-by lake or in the river estuary, and classifying and counting the fish caught in a fish trap in the river.

In this article, I heavily draw on videotaped events, particularly events that involved some form of trouble or breakdown.[2] Normally, classification as process is invisible—as was seen in the examples that opened this article. However, when the normal ways of classifying (as any other practice) break down or when there is an apparent need for new classification, the invisible (ethno-) methods become visible and particularly the practices that make classifications work (Garfinkel 1967).

To prepare the analyses, I normally made coarse fragmentions of the videotapes in an ongoing manner; the fragments contain as much of the audible text as possible and, where necessary for understanding the ongoing conversation, images captured from the tape and imported into the fragmention. During the fragmention, I will already annotate the text and comment on specific features, from which will often emerge first indications of specific themes. Once a theme has been identified, I elaborate the fragmention of several relevant episodes. I first digitize the episodes and then, making use of slow speed features of the video software (Macintosh iMovie), mark overlap, measure pauses to an accuracy of 0.1 seconds, and enter relevant gestures and actions into the fragment synchronized to the ongoing conversation. These fragments then allow me to articulate

[2] All individuals recorded on videotape consented not only to participation but explicitly agreed to being videotaped. As required by the university ethics policy on anonymity and confidentiality, the videotapes are guarded in a locked cabinet. My (and the occasional assistant's) considerable acquaintance with the participants rendered the videotaping unproblematic. The presence of the camera was very quickly forgotten and there was no evidence that it changed the behavior and conversations. All computerized fragments contain pseudonyms and the file linking pseudonyms and participant names are contained in a password-protected file.

the micro-dynamics of social action. The key principle is that in mundane everyday talk-in-interaction, participants are keenly attuned to the verbal, gestural, and bodily cues offered by the respective others, mutually seeking and finding the appropriate moment to begin and end a turn at talk.

I prepared the fragments in the tradition of conversation analysis (originally formulated by Harvey Sacks [1992] and subsequently summarized, for example, by Heritage [1984]), recently articulated in painstaking detail in the pages of this journal (Schegloff 1996). Crucially, though, for the particular sites that I research, I am interested not in the questions of pure conversation analysis but in doing sociologically oriented, applied conversation analysis (ten Have 1999). Applied conversation analysis appears to be particularly suited to the study of everyday "forms-of-life," as the readers of this journal could see from the study of interactional vandalism in Greenwich Village (Duneier and Molotch 1999). Studies of talk-in-interaction requires capturing virtually every aspect of the interaction for subsequent fragmention, including silences, small utterances (umm, oh, em), interruptions, overlaps, gestures, and details of the focal artifacts. Working in everyday settings, not all recorded events can be used because voices are sometimes drowned out by noise, coming from an engine, an air conditioner, or others. Further, sound quality can decrease because the participants, focusing on their work, sometimes orient themselves in particular ways away from the microphones, such as when searching for a flashlight on the floor, turning around to get another tool, etc. Nevertheless, I have large numbers of useable episodes of classification at work. The particular ones featured here were chosen for pragmatic purposes and could be replaced by many similar ones. In particular, I chose three episodes to represent different contexts and thereby to show that the phenomena of interest are pervasive features rather than singular events.[3]

[3] Qualitative work is sometimes accused of focusing on descriptions of single case studies that provide rich detail but lack comparative leverage and explanatory power. In this article, I draw on the data from three

Although my analytic methods are informed by ethnomethodology (Garfinkel 1967, Lynch 1985) and conversation analysis (Heritage 1984, Sacks 1992), I draw particularly on the methods developed by video-based studies of in-situ social interaction (e.g., Heath and Luff 2000, Suchman 1987). I am particularly committed to demonstrate how participants themselves orient to the organization of activities in which they participate, being shaped by and shaping actions. I am committed to describing the sequential and interactional character of social action while preserving an ethnographic respect for the details of the situation (thick description) and the resources that the participants are oriented to and draw upon for making sense of and contributing to the emerging events. This orientation is appropriate because I am not interested in talk as such but in the sociality of interaction, and talk-in-interaction is but one type of resource participants draw on to coordinate the ongoing interaction. The analyses conducted here are closer to applied conversation analysis, because it is concerned with institutional interactions that give rise to particular semantic, syntactic, and turn-taking features not found in normal everyday conversation (e.g. Boden 1994). More specifically, institutional talk is goal-oriented in institutionally relevant ways, often involves characteristic constraints on “allowable” contributions, and is usually associated with institution-specific inferential frameworks and procedures (Devlin and Rosenberg 1996, Drew and Heritage 1992). In the analysis of laboratory talk, it makes sense to consider talk to be of the same order as other forms of actions, for example, manipulations, perceptions, or gestures. In the laboratory, talk is then subject to the activity doing research rather than doing conversation, the structures of which are at the heart of the conversation analysis enterprise.

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different ethnographic projects in the belief that the resulting data would better reveal the mechanisms of transformation. Although conversation analysts suggests that there may be huge payoffs even from the analyses of single episodes (Schegloff 1987), I find it necessary to show the ubiquity and pervasiveness of the phenomena that are at the heart of this article.

CLASSIFICATION AS PRACTICE

Scientists generate data sets relevant to their professions by producing and using coding schemes to transform the world of their interest into categories (events) in terms of which they explain the world (Cicourel, 1964). To understand the transformation of our world, an understanding of the process of categorization has to become an aspect of inquiry. However, the theorization of classification not only differs across disciplines but also has changed considerably over the last few decades within disciplines. Psychologists treat classification as the meeting of two bounded entities: A behavioral invariant (e.g. name) was thought to attach itself to an invariant class of entities in the environment (Epstein 1982). Making classificatory distinctions is not in itself a human prerogative. Animals not only perceive some situations as dangerous, but also emit signals understood by conspecific others as warnings (Sebeok 1986); even plants make classificatory distinctions and show preferences (Krampen 1986).[4] What is specifically human is to use such signals to refer to other situations independent of the context. From a semiotic perspective, classification is described in terms of the relationship between a sign (necessarily social) and a referent. In most general terms, the sign, a segmentation of the material continuum that serves as the sign vehicle, is used to refer to another segmentation of the material continuum (Eco 1984).

In recent years, ethnomethodologists (e.g. Lynch 1992) and anthropologists of science (e.g. Latour 1993) have shown how sign (e.g. language, mathematics) and referent (some “natural” phenomenon) that are taken to be equivalent by natural scientists really come to be correlated in and through the embodied, mundane practices of scientists. Scientific theories are classification systems for the myriad of facts generated by the scientific enterprise; the very nature of theory furnishes a classification system that

4 Pertaining to animals, classification and communication are the subject of zoosemiotics (Sebeok 1986); the differential responses of plants to their environment is the subject of phytosemiotics (Krampen 1986).

enables practitioners to remember what is relevant to their practice (Bowker 1997). In this, we ought to think not of direct mappings between language and the world but of chains of signification where what has been a sign at one stage becomes the referent at the next stage in the transformation process that is at the heart of science (Latour 1993). We then arrive at the following conceptual model of classification (Figure 1). The basic element of sign-related activity (i.e. classification) is a segmentation of the continuum, which is matter of a particular form (Figure 1.a). Any two segmentations that come to stand in a sign-referent relationship are separated by an ontological gap. As Figure 1.b illustrates, through some form of practical activity (e.g. using a Munsell color chart) one segmentation of the continuum (raw piece of soil) is correlated with another (e.g. color code). In the practical politics of classifying, arriving at categories and making perceptual distinctions, uncertainty in either or both processes requires negotiations, organisational processes, and conflict (Bowker and Star 1999). Although matching soil or lizards with color plates may appear a trivial activity, analyses of real-time color coding illustrate the complexity and inherent indeterminacy of the task (Goodwin 1996, Roth and Bowen 1999). Conversely, in everyday practice, we are so familiar with sign and referent that we no longer are aware of their differences so that a spike in a graph “is a clogged pipe” rather than “is a sign of” or “a sign corresponding to” its referent. The classificatory map has become fused with its territory.

In the present study, almost all examples of classification activity involve two segementations. On the one hand there is an often-indeterminate aspect of the environment, a “natural” object, perceptually isolated from everything else—a small fish, rock assemblies, or retinal photoreceptor. On the other hand, there are verbal (chum/sockeye, rock pile/no rock pile, single cone/double cone/rod) or graphical categories (peak, spike in graph) onto which the “natural” objects get mapped and therefore classified; the class name comes to stand for the objects. The classification, especially in situations of breakdown, involves some tool (Figure 1): a Munsell color chart, sets of descriptions and diagrams in a field guide that articulate the characteristics of juvenile salmon (e.g. Figure 2), or an operational definition for distinguishing rock piles from non-rock-piles. In each case, the perceptual aspects of the "natural" object are compared to verbal and visual descriptions embodied by the tool. How such mappings (classifications) come about and especially the social nature of the process and its products is at the heart of this article.

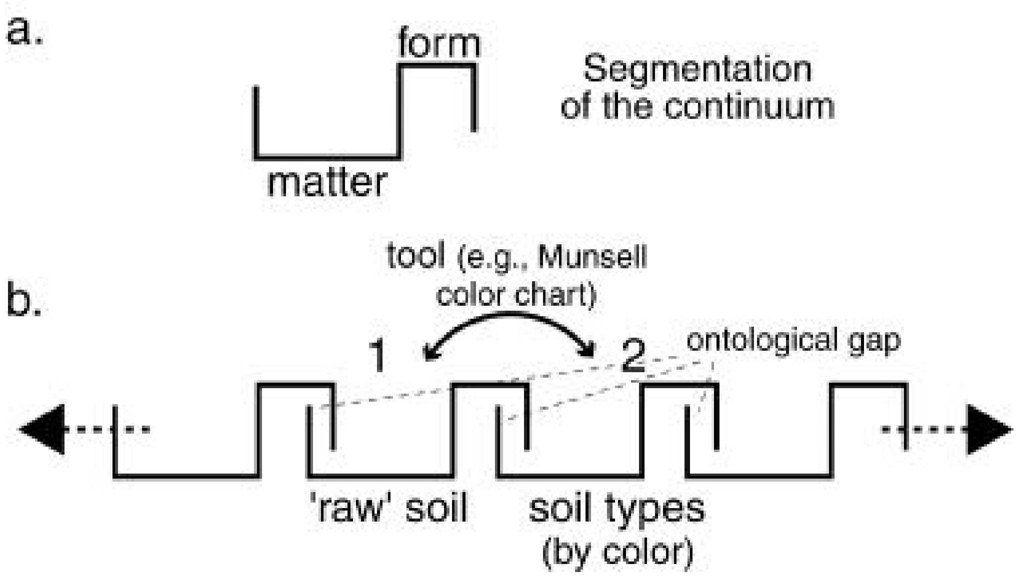

Figure 1. a. From a semiotic perspective, both sign (signifier) and (referent) signified are segmentations of the continuum (matter) that are perceived to take a particular form. b. Scientific activity produces chains of related segmentations separated by ontological gaps. The one on further to the right is used to refer to (classify) the one on the left.

Although classification activities (especially as coding) have been described in general terms (e.g. Cicourel 1964, Lakoff 1987), there is at present a dearth of studies of how our lives are ordered through classification (Bowker and Star 1999), in particular, a dearth of detailed studies of how classification is achieved in and as everyday work practice. In a classic study, sociology graduate students were asked to code hospital records to allow researchers to make inferences about how characteristics of the patient, clinic personnel, and their interactions influenced the patients' trajectories (Garfinkel 1967). The study showed that coding the records required knowledge of the very clinical practices and interactions that the coding was intended to produce descriptions of.

Furthermore, such knowledge was deliberately consulted, regardless of whether or not the records were ambiguous, whenever the graduate students needed to know just what had happened. In terms of the general scheme outlined in Figure 1, the hospital records, already standing in a sign referent relationship to the activities in the hospital, became themselves referents in the coding activities.

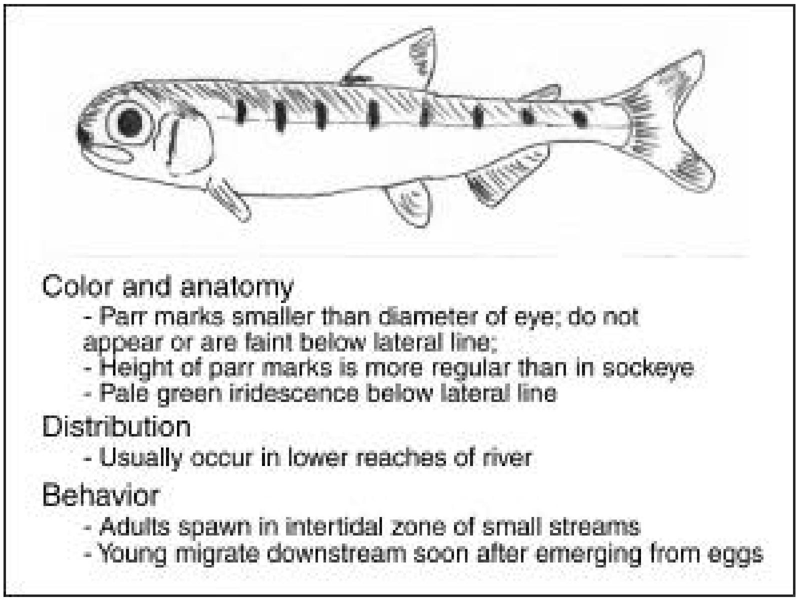

Figure 2. Example for what typical field guide entry might look like, including drawings (sometimes photographs) and text.

A study conducted in the same vein but directly concerned with natural objects concerned the way amateur ornithologists (learn to) classify birds (Law and Lynch 1990) using field guide descriptions not unlike that in Figure 2. The study showed that birdwatchers do not simply see their birds but (a) engage in a reflexive elaboration of the natural object in terms of the iterable organization of the text and images in the field guide and (b) organize their gaze in terms of the sequential order of the field guide contents. The difficulties of organizing perception so that a transformation if the multifaceted complexity of nature into a phenomenal category, and the associated transformation of nature into culture, became apparent in a study of color classification (Goodwin 1996). Collaborative classification involved the intertwining (a process that

Pickering [1993] called “mangle”) of apparently disparate talk, bodies of participants, dirt, and tools (Munsell chart) into a coherent course of action. The study further suggested that the definiteness of category scheme and the categorization achieved erased from subsequent documentation the uncertainties that the participants were struggling with.

All of these studies were concerned with situations where there existed a fixed categorization scheme (Munsell chart, coding instructions, field guide) that served as a frame and resource for classifying, that is, mapping one segmentation of the material world onto another. This leaves open the question what practices we might observe when the parties involved are certain about the perceptual distinctions they make without having a scheme at or having a classificatory scheme (a typical “structure” in the sense of Sewell [1992]) that is uncertain; it also leaves open those situations where the nature of the perceptual object is itself unclear. Finally, in all of the studies, novices (amateur birdwatchers, anthropology undergraduates, sociology graduates) were studied, which leaves open the question what practices and resources individuals draw on who are more experienced in the domain under investigation.

MAKING CLASSIFICATIONS WORK

The seminal studies on classification/categorization asked research participants to judge words, pictures of objects, or sentences (Anderson 1985, Lakoff 1987); the judgments about class membership were always out of the context where they might be normally used. A small number of more recent studies described the classification enacted by novice or amateur scientists (Goodwin 2000, Law and Lynch 1990). In this section, I provide detailed data to show experienced scientists in a situation where the normal classification routines break down. Because the specimen resisted easy classification, they were forced to make available to one another the coherent, consistent, and knowledgeable character underlying normal classification activity.

The episode was recorded as part of my work at a fish hatchery, where regular trips into the nearby estuary are organized for surveying type and number of fish present at strategically chosen sites. The group consisted of five individuals who have extended salmon-related experience. Zeaton and Rod work for the nearby federal fisheries office. Elmer, a postdoctoral fellow who worked for me in the biology laboratory, had done his Ph.D. on imprinting in young salmon (specifically sockeye). Gael, the manager of the salmon hatchery, and Lori, a hatchery employee, rounded out the group. The group had spent all morning capturing and classifying different fish, including coho, sockeye, and stickleback. For the newcomer, even the difference between stickleback and young sockeye is not apparent at first. It took me half the morning of watching the biologists sort and count the different species until I had been able to distinguish between them. However, in my initial attempts to sort the stickleback (which were thrown back into the water) from the salmon, which were measured and weighed.

The work had progressed unproblematically until they had captured a small parr, which they could not easily classify.[5] Over a period of about 10 minutes, the conversation unfolded in which different hypotheses were put forward, discarded, and observations made. Some of these hypotheses (conjectures) contradicted one another, others were supportive of each other. The different themes were not started and ended in one pass, but the participants returned to a theme. Color, size and location of parr marks,

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[5] Parr is the name for a salmon during its initial period of life spent in fresh water (which may, depending on the type of salmon and geographical area, range from a few months to two years.) Immature and pre-spawning sockeye salmon are elongate, fusiform, and somewhat laterally compressed. They are metallic green blue on the back and top of the head, iridescent silver on the sides, and white or silvery on the belly. Some fine black speckling may occur on the back, but large spots are absent. Juveniles, while in fresh water, have the same general coloration as immature sockeye salmon in the ocean, but are less iridescent. Juveniles also have dark, oval parr marks on their sides. These parr marks are short, less than the diameter of the eye-and rarely extend below the lateral line (Figure 2).

size of the fish, location of its capture with respect to spawning grounds and life history parameters of different salmon species.

Transcript 1 Fragment 1 MAY 23 2001 12:13:54 p.m.

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Z:  That’s gotta be a chum. There’s no way a sockeye
    can come out that size
R:  =It’s not a pink.
    (2.2)
R:  °It’s got parr marks on it.°
    (1.5)
Z:  Because a sockeye, I mean
M:  Hm.
Z:  after even it has a full year in the lake (0.7)
    it’s gonna be bigger than that.
R:  Well it, there are zero plus sockeye smolts.
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In this first fragment, which represents only a fraction of the entire classification of one specimen, one can already see some of the themes that are brought out in my analysis of this episode. First, the object is not just classified in and of itself (which is how psychologists and cognitive anthropologists studied classification), but the location where it has been captured does play a crucial part. Where the specimen was captured was as much part of the classification as other characteristics that are ascribed to the fish independent of its location (e.g., the gill size and number of gill rakers). Second, classification, as thinking more generally (Heidegger 1968), is handwork. Scientists actively handle the object, turn it, place it against some neutral background, in order to “get a better look.” In this, the scientists do not just get one look but many different images so that they perceive the object once and for all and in transcendental form, but have many, sometimes differing perspectives. Third, scientists generate observations and hypotheses (“no way a sockeye can come out that size” and “there are zero plus sockeye smolt”). All of these observations and hypotheses constrain one another, and as a whole tend to support one or another classification.

Classification Resources outside the Classified Entity

Salmon undergo physiological changes that adapt them for sea life before moving out from the spawning grounds toward the ocean. Some salmon species move into the ocean during their first year (“zero-plus smolt”), whereas others stay in the creeks and lakes until their second year (“one-plus smolt”). Because the present specimen was so small, the relation between small size and location (estuary with brackish water) rendered the classification problematic.

The following episode began with my question about whether salmon would go out when they are as small as the specimen. Zeaton appeared to hear it as going out into the ocean and suggests that fish this small hang out in the estuary. Rod then elaborated that chum salmon spawn near where we had left the car, still in the brackish water. (This is consistent with the field guide on small salmonids in coastal areas.) So it is not surprising that chum could be found further out in the estuary where we were currently sampling and classifying fish. Elmer added that “they” are always small in small rivers (like in the Big Qualicum River that he knew so well), which constituted an observation positively related to that which Zeaton earlier made, strengthening the possibility that we were dealing with a chum fry. Here, the location of the capture—near the small river that flows into the larger river, in the estuary of which we did our sampling work—crucially entered the tentative classification.

Transcript 1 Fragment 2

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M:  But Is it ready to go out? That small?
R:  Yeah! Well
Z:  They probably hang out here for a bit
R:  Quite often, I mean (0.2) you know where we parked
    [the ] boat or where we put the boats [in?
M:  [Yeah]                                [Yeah
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24   R:  The chum spawn a hundred meters upstream from
25       there,
26       [so it's bra[ckish to start with.
27   M:  [Ah?        [Ah, OK.
28       (3.3)
29   G:  How big are the sockeye?
30   E:  When (.) when they are going out, they are always
31       that size. In the shorter, like Big Qualicum or so
32       where the short river- they are right at the
33       ocean.
34   R:  Yeah, then
35   E:  You have them in the est[uary
36   Z:                          [They probably stay, sticks
37       here
38   E:  Probably stays here in this area, area-
39       (1.4)
40   R:  Yeah [This, these little guys will stay in till
              [((Points to little fish))
41       they get up to [this, but up
                        [((shows about 6
         cm))
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42       to almost [this size
                   [((points then follows
         other fish in container 6 cm
         long))
```

Zeaton and Rod elaborated one reason why chum parr of that "small" size might "hang out" at the particular place where we surveyed. Being familiar with the area and the spawning habits, Rod knows that chum salmon spawns very near, in water that is "brackish to start with," just as was the water around us, the salinity of which we had determined immediately prior. When Gael asked how big sockeye would be, Elmer suggested that they would be "that size," while oriented to the unclassified specimen. As the next-turn repeat suggests Elmer agreed with Zeaton that salmon as small as their unknown specimen would stay in this part of the estuary until it would be of a certain size. Rod specified this size in two ways: visible to all participants he first placed his thumb and index finger the configuration of a vernier caliper and then pointed to a second parr clearly identified as a sockeye parr.

In this situation, the scientists did not just classify the specimen based on perceptual criteria solely attributed to the specimen at hand. Rather, they drew on their familiarity with this and other places, spawning habits, small coastal rivers as spawning grounds, extend of brackish water, and so on to establish the ground on which the unclassified specimen should be evaluated. The specific sizes of salmon at various points in their life history were not explicitly named in discourse, but were made available to one another by means of iconic (thumb-index span) or deictic gestures. The setting, here the two different fish in the container, provided semiotic resources that the scientists explicitly drew on. Although this stretch of the interaction raised the possibility that such a small specimen could be a sockeye, the issue came up again a short time later after Rod reiterated that "it could be a sockeye."

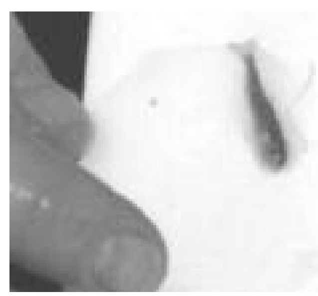
Transcript 1 Fragment 3

78 R: [It could be, it could be a
79 sockeye.
[((Looks at the fish, using
white ruler as a background))

80 E: See as soon-

81 Z: It seems like it's so small for
82 [ ] for to come down

83 R: [I mean]



```
84        we are getting small sockeye
85        like that. But they are not that
86        small. I mean they're
87   Z:   You would think they are grown
88        by the time they get down here
89        in the estuary.
90   M:   These [are
91   G:         [Ah, this doesn't look
92        like a chum I've ever
```

Zeaton was the first to raise doubt about a specimen of that size to be a sockeye, too small "to [have] come down [from the lake]." Rod had earlier suggested that it might be possible to find sockeye that size in the estuary. He first reiterated to have caught "small sockeye like that" (lines 84–85) but immediately followed with a contradictory observation, "but they are not <u>that</u> small," in the second part of the utterance. In the next turn, Zeaton hypothesized ("you would think") that the parr are grown—and therefore larger than the specimen at hand. In these turns, Rod and Zeaton undermined the possibility that the specimen was a sockeye, thereby increasing the likelihood for the specimen to be a chum. Gael invoked his experience, which, as those present know to consist of 20 years in the field of salmon hatchery,[6] to counter a classification as chum. The issue how the specimen could have gotten to this place in the estuary was raised once more. Although Zeaton and Rod had earlier used the relation between size and geographical location to raise doubt about the possibility that the specimen was a sockeye, they now contributed to articulate hypotheses that would support a sockeye classification.

Transcript 1 Fragment 4

```
167   Z:  [Where would that [sockeye ha]ve come from?
168   E:                    [I raised  ]
169   G:  Flushed out of the lake.
170   Z:  It would come
```

[6] Conversational resources that draw on experiences and knowledge previously shared by the participants have been termed "local resources once removed" (Erickson 1982: 48).

```
R:  There is some river-spawning sockeye
Z:  =Yeah
R:  =and all the lake is sure is spawning
G:  And just got wash[ed,
Z:                    [Yeah
G:  washed down in the rain or something.
R:  Well the river is been pretty high. I mean
Z:  It’s coming-
R:  And it was probably not its natural instinct to
    end up down here, but-
    (2.0)
    It’s gotten (flushed?) out.
```

Gael and Rod elaborated a scenario where the specimen, qua sockeye, in addition to those from spawning grounds in the river, could have been flushed out of the lake against “its natural instinct.” The observation that there had been rain (line 176) and that the river has “been pretty high” supported the hypothesis that a sockeye could have been “washed down” into the estuary.

These fragments make it quite clear that in the everyday world of these scientists, an entity is not classified based on properties that it has in itself. In the present situation, how and why a particular specimen would be at this place was an important aspect of the classificatory activity. The possibility of finding a sockeye in this place, at this location in the estuary with brackish water, about 30 kilometers from a lake was invoked. Furthermore, these scientists draw on their memory that it had rained and that the river had been high as resources in their attempt to classify this specimen. Their judgements are based on aspects of the environment rather than the specimen-in-itself. The aspects on the basis of which the scientists classify are distributed, involving weather, geography, and the topography of the area surrounding the location.

Color and Parr Marks: Not Properties in Themselves

In this part of the episode, Zeaton and Rod elaborated the possibility that the fish was a sockeye but from the present year rather than from the previous year as this would be expected under normal circumstances. Rod and Zeaton took turns in listing the properties to be accounted for in the classification—the presence of parr marks, black dots on the side and black on its tail. They also added negative evidence, saying that it did not look like a chum. Neither Zeaton nor Rod seemed to be worried by Shelby's statement that the fish, if it was a sockeye, would have had to come from the lake—no reason was provided why a sockeye should have been present in the estuary.

Transcript 1 Fragment 5

```
R:  It's got black dots on its side.
Z:  Yeah, it's got black on its tail.
R:  But it doesn't look like a chum.
```

```
Z:  If this is a chum (?) (call?) it for-
R:  It doesn't have a black line, but it's definitely got black on its tail.
```

As he described the dots, parr marks, and color of the tail, he took close looks by moving it from the palm of his hand to lie in the depression between two fingers. This allowed the light to fall from different directions onto the specimen: handling the fish, turning it about, literally threw different light onto the fish. This different light allows new observations to emerge, tiny black dots previously invisible now become salient. Movement and the resultant differing light conditions enhance salience so important to the emergence of perceptual gestalts.

In the next excerpt, eye and back color are the topics. Whereas there does not appear to be trouble with the eye color, there are several dimensions to be considered with the body color. Although there are differences between chum and sockeye, the color changes depending on the location in the estuary. In the upper part, chum has a blue sheen whereas sockeye are green; further out in the estuary, the colors are reversed. On the other hand, Gael suggests that the colors on the back of the two fish in front of them are the same. As the larger fish was unproblematically classified as a sockeye, this assessment supports the classification of the unknown as a sockeye rather than as a chum.

Transcript 1 Fragment 6

E: [Chum are usually dark eyed
(find?) ha?

Z: Yeah, they are a lit[tle

E: [They are black [almost

R: [and this has
that, this has the same color on the
[back

Z: [Depends where in the water it is too, right.

R: We'll have

Z: Sometimes I'll use that as the key, like the chum
has a bit of a blue (0.7) she[en] and

E: [Yes]

Z: the sockeye
green

E: Yes.

Z: And you go outside and it flips.

The exact nature of the color then is problematic because it depends on where in the estuary a fry has been caught. Further complicating is the issue that the two alternatives currently considered are involved in the color reversal. The color of the salmon is not just a property, it is a property of the system. Here, the biologists situate the specimen in the local area. They evaluate the system rather than the decontextualized object that one might find in a textbook description. Rod and Zeaton have built up this knowledge through years of working in the area and collecting fish.

(Immediately) Local Resources

When there is breakdown, scientists (and especially those early in their careers, or not clearly in their field of expertise) draw on standard resources such as field guides.[7] Field guides, because they are valid independent of the particular setting and experience, are non-local resources, that is, resources available to anyone or all members of a particular community or society. However, these non-local resources never appear to be enough to bridge the gap between general description of properties, which determine class membership, and the particular, local expression such properties take (Roth and Bowen 1999, 2001). Scientists and scientists in training therefore engage in building (immediately) local resources that have greater specificity in making classification work in and as of ongoing praxis. For example, in one study, we had observed a honors students build a personal library of twigs, leaves, and bark that he could identified without too much uncertainty; he subsequently used these core members of each category as resources in the classification of more ambiguous cases (Roth and Bowen 2001). These can be thought of as immediately local and local resources being shared by the conversational partners (Erickson 1982). Immediately local resources are those shared by the participants in the present context; local resources are those shared by participants but at sometime in the past; nonlocal resources are widely shared within the community. Nevertheless, even with such resources, the identification is not easy—a fact that was reflexively addressed by one of the fisheries biologists:

Transcript 1 Fragment 7

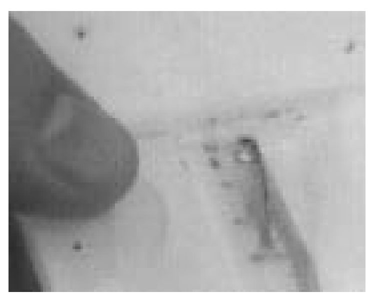
[7] Field guides were also used by the scientists in the next case study, although our focus will be on how these scientists evolved new categories that were not yet available in the field guides listing their (lizard) species.

```
115   Z:  Because it changes back and forth. Just when you
116       think you have the think, just when you think
117       that’s the key.
```

In the present study the scientists also drew on a field guide (non-local resource) to aid in their work, although Zeaton had been especially invited because of his expertise in classifying the local fish. In the following fragment, Lori, Zeaton, and Rod were looking through the field guide, attempting to classify the specimen by drawing on the descriptions in the guide, which are immediately local resources to their interactions. As part of the following section, the conversation splits up producing a second, parallel topic on the relative qualifications of Elmer and Gael. In this situation, Lori, Zeaton, and Rod take the <u>Field Identification of Coastal Juvenile Salmonids</u> as a local resource for making comparisons between the images available in the guide and the specimen. Rod brings in another comparison between the two fish, again pointing out the similarities between corresponding parts of the anatomy.

Transcript 1 Fragment 8

```
183   L:  °Maybe you want a°
184   R:  °A trailing edge (?)°
185   Z:  They don’t have parr marks on them?
186   L:  Look at that one.
187   Z:  I can just barely see them.
188   L:  Yeah, that’s what they look
189       like.
```



```
190   M:  What kind of stuff are you
191       looking at now?
192       (1.3)
193   Z:  N:- just (0.5) the mar- the
194       parr marks and stuff.
195   M:  Hm.
196       (1.3)
```

```
Z:  °It has no black edge.°
    (3.6)
    OK, I looked at that one, the back compared to
    that other sockeye, it’s like (0.4) °the edge°
    where the brain is and where the coloration
    between the eyes- it’s the same but
    (3.2)
E:  Ugh (0.8) I should know. I raised
    [three g e n e r a t I o n s]
L:  [What are you thinking Rod? ]
E:  [o f   t h e m   f o r   m y, m y  w o r k]
R:  [It makes sense it looks a lot like a chum]
Z:  Yeah.
```

In this episode, Zeaton also placed the fish against the ground of board/ruler combination; he thereby created a context where it could be perceived against the whiteness of the ground (an immediately local resource) that also embedded the drawings in the field guide, which itself has become an immediately local resource as it allows the coordination of the interaction between members of the group. Here, we see a characteristic move for decontextualizing an object to be classified to get a better grip on the aspect that they attempt to use as a basis for classification. For example, anthropologists and geologists look at soil samples through the holes in paint blotches on the Munsell Chart, thereby seeing only the soil independent of where it came from (Goodwin 1996). My own ecologists further decontextualized their lizards by using the Munsell chart inside a white-walled box illuminated by a constant light source (Roth and Bowen 1999). But the smolt could not be classified in the same way. Where and the time of year it was caught were crucial elements in the classification. We could also say that the classification is not just that of a smolt but of a different unit altogether, the classification of a smolt-in-context. But the classification also drew on the experiences of <u>this</u> particular scientist in <u>this</u> river system, which had made him the “expert” in the first place. That is, the classification also relied on knowledge that is embodied by this (or these) scientist(s) and could not have been done by others.

In the following fragment, Zeaton and Rod come back to comparing the location of the parr marks with respect to the lateral line with those that they find in the drawings of the field guide.

Transcript 1 Fragment 9

Z: Because the parr marks on this [should be]
E: [Just sockeye?]
Z: [just above the lateral
R: [We saw just sockeye last night
L: They are though, aren't they?
Z: Yeah, like the parr marks on this, which are
barely showing up are above the lateral.
(3.6)
E: Chum then?
(0.8)
R: Based on its size, I wouldn't mind to go with
chum.
Z: But look at-
R: Yeah.
Z: If you follow the parr marks,
it's above the lateral line
R: Yeah.
E: Yeah.
R: I guess.

Field guides are not the only tools used by the scientists to assist in problematic cases of classification. In their collaborative work, scientists who frequently or always work collectively, build a "library" of cases, each of which they have evaluated together and over which they have established some agreement. These cases become immediately local resources, when they are drawn upon again on the same day, and local resources, when the group persists over longer periods of time (such as the scientists in the subsequent two case studies). In such situations, scientists collectively classified samples over periods of days, weeks, or months. They drew on these collective experiences and cases to classify the case at hand, much like a court of law might draw on a legal precedent. In other situations, they have available another exemplar that is more readily classified and therefore can be directly used as a comparison case.

Making direct comparison with specimens that are not contested is another immediately local resource. The specimen that is more easily classified represents a more prototypical member of the class, which, as prototypical members in general are identified more rapidly and with greater ease (Lakoff 1987). Having a prototypical member of one class then becomes a resource for the interacting parties to establish the degree of what Wittgenstein (1958) called the "family resemblance," an additional criterion in the classification of the specimen of interest.

Transcript 1 Fragment 10

```
124   R:   [I am just trying to line them up side by side.
           [((Follows fish in the pan with hand))
125   G:   Oh.
126   M:   This is much more reddish than this one?
127   R:   Yeah. [This one's kw- probably () [this one is
                 [((Points to small fish))   [((points
           again))
128        probably a year younger than [this one.
                                        [((Points to larger
           fish))
```

Transcript 1 Fragment 11

```
147   M:   What do you think?
148        (4.0)
149   Z:   °Still some green.°
150        (3.8)
151   M:   Zeaton?
152        (1.1)
153   Z:   °I don't know°
```

(9.8)

((addressing all)) Like if you look at the (0.6)
pigment in the eye and the brain and all that kind
of stuff that does look like the other one, like
the sockeye.

(1.8)

But I don’t know if that is just-

(0.8)

R: Looks

This episode, too, shows Zeaton handling the fish and closely taking looks and comparing it with the second, clearly identified specimen. Here the second one functioned as an exemplar, a indisputable case from one class against which the unknown member is being compared. In our database, we have repeated instances of individuals building libraries of exemplars. As indicated before, one honors student built collections of exemplar, which allowed him to identify uncertain cases much better than the book, on which the identification of the exemplar was nevertheless placed. The individuals featured in subsequent case studies, too, built a library of (immediately) local resources that they could each refer to when the classification of new cases was difficult and contested. Because of their extended collaborations, Samantha and Melissa and Carl and Ted also “collected” cases but did not keep actually specimen. Immediately local resources, because they are accessible by all participants, are potentially less contestable than other forms of resources. Furthermore, because immediately local resources can also be handled, they directly contribute more directly.

Here, the comparison of eye pigment and brain suggests that the two fish are from the same class, sockeye. But this conflicts with another percept, size. A sockeye of this size should normally not be in the estuary but in the lake 30 kilometers from our position and descend to the estuary only 12 months later. Rod, Gael, and Zeaton then elaborate together a reasonable explanation why a one-plus sockeye might be caught here in the estuary.

Handwork and Distributed Resources

Classification appears to require extensive experience in context and with the entities of interest. One has to have done classification, physically handling the objects, manipulating (Lat. manipulus = handful, manus = hand), moving gaze across, etc. Consistent with Heidegger's contention that thinking is handwork, the present study shows that classifying involves a lot of hand-ling (mani-pulating) of or walking around the entities to be classified. Such movements of and about the objects are required when their perceptual status is at stake. Salience is the operative factor in the identification of perceptual gestalts, and salience is enhanced by motion, either of an object in the hand of the observer or of the observer with respect to the object. The movement, orientation and talk intertwined with the gesture provide the resources through which an object is reflexively and momentarily constituted. Invariant properties of the world are available to an observer only when he or she moves with respect to things (moving themselves or making the object move). We learn how things are by experiencing different ways of how they look.

It has been noted that one of the quandaries that novice birdwatchers experienced in their identification efforts was the fact that they could never get a close look at their specimen (Law and Lynch 1990). The present study shows that although handling specimen assists in getting closer looks at it, this eliminates neither trouble nor effort to produce a classification.

The classic psychological experiment on classification required subjects to indicate class membership of cards imprinted with different objects (circles, squares), in different color, and surrounded by different numbers of borders (e.g. Anderson 1985). These experiments, by definition, could be conducted independent of the laboratory location or of any local context whatsoever. The present episodes show that classification is not just a matter of looking at this entity in a decontextualized fashion but rather occur at a particular place at a particular time and in a set of particular circumstances. What is being classified is not just an entity, but an entity-in-context, with a history sorted by individuals, themselves subject to the contingency of time and place. Classifying in this way undermines any claim to enacting actuarial methods of counting for establishing a fish count in the estuary, because the decisions themselves whether to count an entity as sockeye or chum requires knowledge of the situation irrespective of the quality of the coding instructions (field guide).

MAKING CLASSIFICATIONS AT WORK

In the previous section, I showed that scientists classify an entity according to an existing scheme, the scientists draw on their familiarity with and the circumstances under which the entity was collected. That is, they draw on embodied understandings of the natural world, which they have built up over years of working in this selfsame world. But, someone somewhere had to decide about the minutiae of classifying such things as juvenile salmon. Such decisions may involve difficulties, argument and struggle, and practical politics to institute one classification system over one or more others.[8] In this section, I provide detailed evidence that shows how categories come about in the first place. Here, too, we see that categories emerge from a detailed understanding of the natural world. We are indeed witnessing the work that makes “categorizing as” or “counting as” an unavoidably situated practice that establishes “rock piles” as progressively and discoursably exhibitable rock pile again. “Classifying as” and “counting as” become, in other words, performatively objective.

The purpose of Samantha’s research was to (a) describe their natural history (e.g. body size, habitat preferences, movement patterns); (b) determine basic life history traits

[8] Of course, once the classification system is in place, however, the interactions and practical politics get forgotten (Bowker and Star 1999).

(e.g. life span, survivorship, litter size); and (c) identify the fecundity and survival costs of reproduction. Samantha conducted her research at the northern-most boundary where the particular species was believed to occur. Although southern relatives had been researched by others on occasion before, very little was known about this species. Samantha drew on ideas from other research how to capture life history information, but also thought that there were particular adaptations that this (sub?) species must have undergone to be able to live so far north. Finding out how to represent the lizard and its environment was central to her work. Her task, therefore, was to bring order to lizards and their lifeworld without knowing beforehand what that order might be.

Samantha, however, faced a fundamental double bind that to collect data, that is, to make equivalent observations across sites and animals, she required a coding scheme. Yet she could not establish a coding scheme about a lizard species that was little known (Roth and Bowen 1999). She therefore had to bootstrap her research by developing categories in the process of becoming familiar with the animals and their lifeworld. In the course of her fieldwork, Samantha did considerable classification work, for example, related to the determination of the plants growing in the area where she hunted lizards and the species and type (bush, tree) of plant that is closest to each capture site. Thus, over the course of three field seasons, Samantha evolved many new categories and arrived at ways of deciding what is or is not a “rock,” “rock pile,” “forest edge,” “bush,” and so forth. Here, I provide two examples—the emergence of a new variable (days in captivity) and the emergence and operationalization of “rock pile.” It is only through these means that higher order classification, the relation between classes (correlation, log-linear), can be established. No longer are Sam’s lizards coded in terms of sex (male, female), state (pregnant, non-pregnant females), and speed (fast, slow), but these categories become related—female lizards are faster than male lizards.

In the following episode, Samantha mentions for the first time that there is a problem with the measure of sprint speed. Samantha casts doubt on the issues that they raised so far by stating that when the (female) lizards come to the lab, they are still running; but then suggests that pregnancy itself might be at the origin of not wanting to run.

```
M: They don’t seem to want to run.
S: Well, it’s funny, because like when they first come in
   they are really, they run. That’s why I try to race them
   (1.0) as soon as I bring them in, and then race them when
   I bring them in. But like these girls, it’s kind’a like a
   combination, their pregnant and fat, and they are less ()
   they do sprint less. () Because we’ve been handling them
   a lot, it doesn’t seem to do an awful lot.
```

Eight months later, talking about her statistical analyses, Samantha suggested that she had used “days in captivity” as a variable in her statistical analyses for testing several hypotheses involving “sprint speed” as dependent variable and “sex,” “tail length,” “length of front limbs” etc. as independent variables. Initially, it turned out that the correlations she expected were not born out.

```
S: I just, just from noticing that when I had females in the
   lab, they seem to respond differently, knowing, like
   knowing… I mean, you know you have, it’s probably only a
   few cases where you know how an animal responded when you
   first caught it and within a day of capture and then you
   see its behavior. So particularly, the particular problem
   was for the gravid females, ‘cause when Mike came out we
   were, we got on a run where we were just searching and
   bringing animals back. And we were doing really well
   catching gravid females and so I just didn’t take time off
   searching because we seem to be in a real- Because we
   seemed to be getting animals…
```

In a context where there were no statistically detectable (significant) correlations, Samantha remembered “probably only a few cases” of animals that she had held in captivity for some time (which pertains especially to pregnant females which she kept until after they had given birth) were sluggish and did not “want” to run. As she had noted the date for every entry in her laboratory notebook (in the Julian calendar), she could easily generate a new variable, “days in captivity.” Thus, in the context of non-significant correlations, and from the feeling that keeping the animals (based on a few individuals), emerged the idea of the length of captivity as a variable that mediated sprint speed. That is, length in captivity was not a salient variable in the research for the first two years; the fact that Samantha had the relevant measures was due to the circumstance that she dated all entries into the different field notebooks and tables that she kept. The idea to use the (Julian) dates as information (difference that makes a difference [Bateson 1972]) crept up on her, emerged unpredictably from the surprising lack of correlation between sprint speed and other body measures (leg and tail length).

Distance to the nearest rock as a category has itself emerged from the observations Samantha made while initially out in the field capturing them with an experienced ecologist specializing in reptiles and amphibians. Even the salience of "rock" to the research on lizards is subject to some familiarity with lizards in the field. Samantha had gathered such experience by spending several weeks with her supervisor on various slopes in a mountain valley seeking and capturing these animals. In the process, she made initial observations as to the circumstances when and where she saw and captured these animals. Rocks and rock assemblies (Figure 2) were among the features, though the second ones did not enter the research as a category until the end of Samantha's second year in the field. The following interview excerpt provides an indication as to how rocks and their distance to the capture sites became salient.

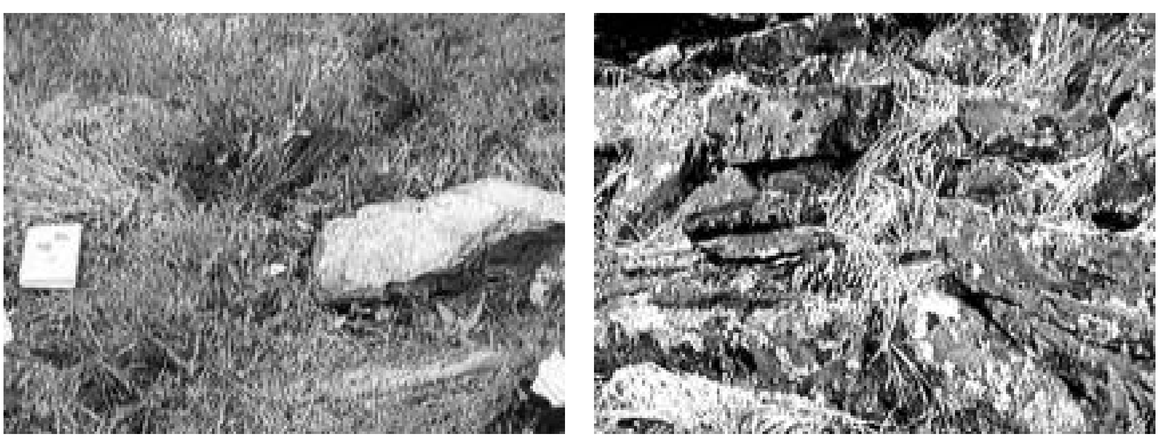


Figure 4. Clear, paradigmatic examples of "rock" (left) and "rock pile" (right). The classifications as rock and rock pile depend on their potential to be relevant to a lizard. Thus, an "it" is a rock only if it provides protection, that is, if it is sufficiently large to allow a lizard to hide.

> I think where they hang out overnight is sort of in more rock piles and burrowed down in. I don’t think they sleep under the rocks. That’s what I’m guessing. I’m totally guessing- I don’t really have any data to support this. Well, when you disturb them they tend to run down into rock crevasses if they can. […] A lot of the animals I find, I do find them under rocks, but they, they’re also, I do find animals sitting on top of rocks, crevices of rocks, and fairly often I do find them some distance away from some potential cover object.

Samantha and Melissa had started the day with a column in the field notebook that had “nearest rock” as a heading, which was to be a measure between the point where a captured lizard had been spotted (basking on a rock, under a rock) to the nearest rock. The “nearest rock” had itself undergone transformation until specified as “nearest rock under which a lizard can hide, about 10 or more centimeters in extension.

Immediately prior to the following fragment, Samantha had asked Melissa what the distance to the nearest rock had been at this site. Melissa said that there were two rocks, but that the trap had not touched either one. Samantha asked whether the two rocks were touching. The fragment picks up at that point. Melissa introduced the idea to specify a measure for distance to the nearest rock pile rather than nearest rock, which would code all of those situations where there are multiple opportunities for hiding. There was a (conversationally) long pause, broken when Samantha accounted for it as thinking about the criterion for the category of “rock pile.” Melissa acknowledged and both gazed again for a long period of time (almost 17 seconds) at the assembly of rocks in front of them, when Samantha suggested that the rock assembly in their focal area does not count as a member of the rock pile category. Melissa agreed and proposed a first operationalization—ten rocks within a half-meter radius. Sam did not respond, which Melissa eventually took as a sign of having caused Samantha problems (line 18). Samantha accounted for what she had done, namely think about (a) how to classify assemblies and (b) the fact that they had already measured numerous sites without the category that they were in the process of discussing (lines 19–23).

Transcript 2 Fragment 1 JUL 23 1997 (early morning)

01 M: I wonder if you could measure distance to a rock
02 pile as opposed to a rock?

03 (15.0)

04 S: I am just, won- (1.4) I wonder what would classify,
05 we need to come up with a criterion for what’s a
06 rock, counts as a rock pile.

07 M: Yeah

08 (16.9)((Both are gazing at a “pile” of rocks in front
09 of them))

10 S: Is that, so [that wouldn’t classify as a rock pile?
11 [((Points to ground, circular gesture
above rocks))

12 M: Yeah, and then there is, like if you said it was like
13 ten rocks or something within a half-meter radius or
14 something.

15 (9.1)

16 Sorry.

17 S: Yeah.

18 M: I am causing you problems?

19 S: No, I am just trying to think of how to classify (.)
20 and then there is the additional problem that I’ve
21 already

22 M: =Counted

23 S: =Measured all of these sites without doing it.

24 M: But it doesn’t matter.

25 S: The intention was that this nearest rock distance
26 would esti- (0.2), would be a measure of that but I
27 am not sure if it necessarily is, because there is
28 cases when there is zero distance but not a rock
29 pile

30 M: Yeah.

31 (2.5)

32 S: Well let’s try it. Maybe develop something or
33 other.

34 Rock pile or no rock pile? So I would say
35 [this is not a rock pile, but I would say

```
            [((circling gesture over rocks at pin #169))
36          [that one is a rock pile.
            [((points into the distance))
37    M:    Which one?
38    S:    [One-sixty-six.
            [((Points and looks into the distance))
39    M:    Oh yeah, OK.
40    S:    So let’s try the, let’s try the greater-than-ten one.
41
```

Samantha then began with two rock assemblies in the vicinity, pointing to one and suggesting that it was a member of the new category, then pointing to the other suggesting that it was not a member. That is, even before they had provided a description of the property that makes something a rock pile (an operationalization or description of a property), they already made perceptual distinctions and classifications. Melissa confirmed and Samantha proposed a membership condition in the “rock pile” category, operationalizing it in terms of a count, which was a number greater than 10. Such a membership condition determines a class in praxis, though it might cause problems for logicians and philosophers (Quine 1995). In this, Samantha began a collection of instances of rock piles and non-rock piles that would be common to her and Melissa; they could draw on these common cases as (immediately) local resources whenever there was a new troublesome case. Every new assembly of rocks will constitute a new case, added either to the member or non-member category.

Samantha and Melissa did not require the definition. Working together on site, rock assembly after rock assembly, they come to know and agree upon which “its” to count as a rock pile and which its did not count as such. Working together, they were able to arrive at making perceptual distinctions (just as the hatchery workers that I observed) without requiring an operational definition to make their classification accountable. Samantha and Melissa worked throughout the day, pointing to entities uttering “this is a rock pile” or “this is not a “rock pile.” What these situations did was aligning the perceptual gestalts of the researchers even in the absence of an operational definition that they will ultimately use to communicate to those not present in the situation how to classify things as rock piles versus non rock piles. This sort of correlating sounds (words, signs) with perceptual portions of the continuum by means of ostension is at the heart of ostensive definition. Before any operationalization existed, the two made available to each other salient features through the most “primitive” form of drawing something to the attention of another. Salience is the key factor in ostensive definition and is enhanced by object motion and iconic (sweeping) or deictic gesturing in the direction of the portion.

However, as scientists their practices are oriented towards others not present in the situation; scientists are through and through social beings oriented to constructing resources that are non-local, useable anywhere by anyone. They are oriented towards all those members of the scientific community that do not have access to the sites and who will require a verbal/written statement that could serve as the basis for doing the same research elsewhere. The language they use to frame is already the language of the other, available to and shared by the other to introduce a new not-yet-shared category to the world.

The two have walked to the next capture site just a few meters away (pin #162). In the meantime, they have discussed and discarded the idea of having a group of junior naturalists collect the now missing data on “distance to the nearest rock piles” from the sites already covered. Here, the first test emerged for their new category. It turned out that something that fit the description of the class property (more than 10 rocks touching) perceptually did not have the aspects of a rock pile.

Transcript 2 Fragment 2

```
42  S:  Well, at the moment, the category stands it’s greater
43      than (0.9)
44  M:  Ten
45  S:  =Ten rocks touching one-
```

```
46  M:  =Like greater than ten (0.8) touching the rock?
47  S:  Touching (0.6) each other.
48  M:  Oh? (1.4) And what about the size of the rocks? Or
49      does that not matter?
50  S:  I don't think that matters? 'Cause you can have big-
51      rock piles and small-rock piles
52  M:  =It's like one two three four five six seven eight
53      nine.
54      (1.6)
55  S:  You see, if I was, if I was eyeballing it, I wouldn't
56      call that a rock pile.
57  M:  OK, because there are like ten rocks in it.
58      (1.2)
59  S:  Are there?
60  M:  Yeah.
61      (1.2)
62  S:  OK, I am going to up that.
63      [(2.8)
        [((Laughs))
64      You don't like your categories, just change them.
65      (1.8) 'Cause what I am thinking in my mind is like, is
66      like real like talus.
67  M:  Yeah, [like the [bi::::g piles of [rock
              [         [((Spreads arms)) [
68  S:        [Is                         [The piles.
69      Yeah, that is what I would- (0.2) Now we could
70      break it down into categories. But I am not sure
71      that (0.7) I really want to rush around counting
72      rocks. I'd rather just say rock pile no rock
73      pile.
74  M:  Yeah. (1.1) But it was just a thought.
75      (1.2)
76  S:  Yeah, no I think that it's a good one.
77      [(4.8)
        [((Flips through notebook))
78      OK, let me. OK, so (1.1) [rock pile.
                                 [((writes "rock pile = 15
        touching" on top of the column))
```

It turns out that they had apparently walked away from the earlier situation with different understandings of the membership condition. As they began to gaze at the next rock assembly (#162), the question evidently being whether to classify the capture location #162, Samantha reiterated the property description. Melissa sought confirmation whether ten-rocks-touching meant touching the target rock (under which the lizard was found), which Samantha elaborated as merely touching one another. Samantha also clarified the next question whether the size of rock mattered. According to Sam, the size of the rock did not matter, so that Melissa began to count the number of rocks in the assembly. But before she finished, Sam suggested that she did not consider this assembly to be a member of the class. Although Melissa acknowledged the assessment but then stated the outcome of her count—there were ten rocks in the assembly, which, according to their operating definition, would make this a member of the rock pile category.

Samantha announced that she would up the count, and then self-depreciatingly and ironically comments on the fact that she was making a change in the property description after having previously defined it. (The fisheries scientists also mocked their efforts as classifying by proposing new categories such as “chock-eye,” “chum-eye”, and “co-chum”) She elaborated that she wanted to make a visual assessment of whether something was a rock pile rather than actually counting.

The rocks, rock piles, and distances to both of them were not abstract entities from a transcendental world that scientific articles often times portray. Rather, when the researchers attempted to catch lizards, they turned over rocks—the lizards (and skinks) that are under some of them never stay still but, with lightening speed, move away to seek cover elsewhere, often other rocks, bushes, or rock assemblies. In their search, the distances between the current rock and the next hiding place were distances that the hunters actually covered and the entities where the lizards disappeared were real things that they turned over or pushed aside.

For all practical purposes, it was sufficient for Samantha and Melissa that their visual assessment whether an assembly of rocks was to be counted as a member of the “rock pile” category (class). At the same time, their first several examples of classifying rock assemblies showed that the initially agreed-upon description was insufficient and needed to be adjusted. In the absence of established criteria/description (property descriptions) that define class membership, scientists resorted to gestural deixis, which allowed them to harmonize impressions of perceptual similarity across the agglomeration (library) of shared cases, the (immediately) local resources that allowed them to continue in their work even though the operationalization, the non-local resource, was not yet established. The present episodes show how these scientists dealt with the bootstrapping problem facing all classification systems. It cannot be known at some outset what makes a relevant difference[9] until there exists a body of knowledge that relies on a classification system; but this classification system cannot be developed without an understanding of what the units of data will be (Bowker 1997).

In this transcript fragment, we see how categories come about and how the members of this group come to decide what <u>is</u> and what <u>is not</u> a rock pile. It is in their joint work of looking at the same piles that they build a practical sense for doing classification into rock piles, and therefore develop an understanding of the different circumstances and knowledge of how classification works that they can appeal. In fact, our interviews show that these researchers draw on their understandings of how <u>this</u> place works prior to how such places work when they are to account for anomalies in data, or when they interpret line graphs (Roth Masciotra and Bowen in press). That is, Samantha and Melissa established an embodied understanding of what kinds of things can actually rather than conceivably happen during the decision making about a particular rock assembly, of what as a matter of fact did happen in connection with the cases they recorded during the field season. This embodied understanding enabled them to arrive at establishing a classification. They contrive ways, then and there, for dealing with any emergent

[9] Bateson (1972) articulated "relevant difference" as a difference that makes a difference in the life of an organism.

difficulties by drawing upon their understandings of what things may possibly be, and what may actually and possibly happen in these situations.

In these episodes, we witness the elaboration of rules for a particular procedure that classifies or measures, and thereby brings into scientific discourse, natural objects in a particular way. In both situations, measurement and classification are not parts of existing practices, at least not in these situations, but only available in a developing way, always (potentially) unfinished and open to further redefining, updating, changing, etc. The rules for doing measuring and doing counting were elaborated and endogenously produced in situated activity, but were always only accounts that described rather than prescribed what was going to happen. The question of whether a light measurement was adequate or whether an unspecified "it" counted as a rock pile was, in each case, a constituent feature of the contingent and historically constituted and evolving practice of measuring and counting as.

In these situations, participants oriented to and addressed the possibility that they would be held accountable for how they have measured and counted as—a process not unlike in forensic science where scientists orient their behavior such that it can be said to have conformed to explicit standards (Jasanoff 1998). In such cases, what they have done tended to be more resistant to skeptical questioning. In my tapes, participants worked on establishing such standards that would hold up to potentially skeptical questioning of the "reviewers" of their work which, in both situations, are constituted by peers. In Samantha's case, the results of her work were to be published in a dissertation and in one or more scientific publications. The nature of the practices, counting as a rock pile, was therefore chained to the local historicity of the day's work. Whatever the outcome of their work such as some fact about the life history of this lizard subspecies, was therefore intimately tied to and intertwined (mangled) with the local practices of measuring and counting as situationally formulated as appropriate or inappropriate and was updated as a matter of course.

The synonyms “aggregate” and “collections” are sometimes substituted for class, drawing on the metaphor of sorting and gathering of objects by bodily displacement (Quine 1995). The present work shows that the synonymous use of these words has something to it. In the present situation, Samantha and Melissa worked together for several weeks. When they began, a classification of “rock pile” did not exist, but emerged in the course of one day’s work. Subsequently, they had many occasions in jointly looking at new specimen and deciding whether to count it as a member of the new class. Each new case became part of a library of cases, some of which were instants, and others that were non-instants of the class “rock pile.” They literally built an aggregate, a collection of cases that served them as reference points for all future classifications.

CLASSIFICATION: CONVERGENCE OF TWO ORDERS

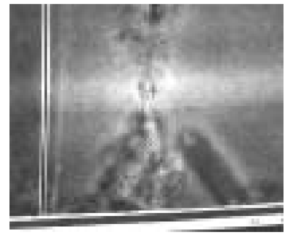
Classifications are particularly uncertain when both the sign (signifier) and the referent (signified) are uncertain. In such cases, the scientists are required to do double work. On the one hand, they have to make a (perceptual) classification of the thing that they are interested in (e.g. Samantha’s rock piles). On the other hand, scientists have to classify the sign (assembly) that they use to refer (and identify) the entity with. This problem becomes particularly evident when they use representations other than words to make such a classification, for the representation also requires classification before it can be said to refer to its corresponding natural object. If both the classification of sign and its corresponding natural object are uncertain, classification becomes a process of convergence and mutual constraint. It is only when the two portions of continuum, the one which is the intended referent and the one which is the intended sign, are consistent and correlated that a classification can be said to be accomplished.

This episode takes us into a biology research laboratory concerned with various aspects of vision in fish. One of the experiments is concerned with the absorption of light in the different cells (rods, cones) that make the retina. Whereas there is only one type of rod, there are four types of cones, distinguished by the color range in which they maximally absorb (red, green, blue, and UV). The maximum absorption of all cells is not constant in the life history of a salmonid but changes. For those that go out into the ocean, a characteristic shift occurs at the time of out migration. Other salmonids also change but then revert back to the freshwater pigment.

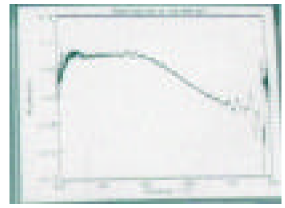
When the vision researchers collect their data, they make two classifications. One involves a perceptual distinction while looking through the microscope or at the infrared monitor, in which the make a perceptual distinction between the type of cell currently of interest (rod, double cone [red, green], single cone [blue, UV]). This might appear simple, but perfect identification involves considerable experience. A broken rod may look like a single cone, and double cones seen from the side look like single cones. Sometimes, the scientists do not get a “signature” (i.e., an unambiguous and useable graph) although they thought they had lined up a cell. At other times, they get signatures that cannot be associated with an entity under the microscope. The second distinction pertains to the other order, a distinction in the “signature,” the graphs that result from a scan. Again, this may appear simple but is, as the following episode shows, an enterprise fraught with problems. The scientists therefore had as their recurrent problem a fundamental double bind: to know what they have under the microscope, they require the graphical sign; but to know what a graph shows, they need to know what they have under the microscope.

In the first part of this episode (lines 01–24), it apparently turns out that the photoreceptor had moved away from under the light beam. This provided a plausible explanation why the sought for consistency between the assessment of a single cone and the signal typical for a signal could not be observed.

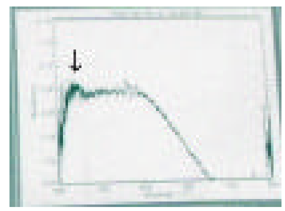
Transcript 3 Fragment 1 JUL 19 2000 2:26:55 p.m.



```
01   C:  Scan
02       [(8.9)
         [((T engages the optics and samples
         the photoreceptor))
03       Now it looks like a single cone.
04       [(3.3)
05       [((T transforms the graph))
```



```
06   T:  It's very wide, that's the first
07       problem.
08       (2.1)
09   C:  What's that little peak up there in
10       the
11       (1.3
```



```
12   T:  [((points with cursor))
13       [This one ri[ght here?
14   C:              [Too short?
15       (1.0)
16   M:  Yeah, it's about three-thir- forty
17       (0.6)
18   C:  Yeah, too short.
19   T:  Yeah, too short, yeah.
20   C:  See where I am here.
21       [(4.4)
         [((Looks through microscope))
22       Off!
23       (0.6)
24   TH: Off, Right.
25       (26.0)
```

Based on his reading of the resultant graph, Ted problematized the assessment that Carl made earlier. However, Carl perceived the graph differently, seeing a “little peak” that could be of interest. Pointing to a feature with the cursor, Ted sought confirmation that the identified peak is in fact the one that Carl wanted to have considered. But even before Ted completed his turn, Carl already raised the possibility that the peak may be at a wavelength that is too short for the signal to be consistent with a single cone. Being too short was confirmed by my own reading of the peak position at about 330 or 340 nanometers, which leads to the succeeding assessments that the wavelength of the “little peak up there” was “too short.” Here, the classification of the peak as “too short” is stabilized through the well-known conversational feature of identical repeat (Schegloff 1996) in lines 18–19.

The classification of the graph as showing a peak that is “too short” occurs over several turns (lines 14–19). Here, the “Yeah, it’s about three-thir forty” does not reiterate an utterance but, after the agreement, stated the actual wavelength at which the peak had its maximum. In this laboratory, the approximate values of curves of interest are known and lie in the range of 380, 430, 520, and 600 nanometers (though there is considerable variation in the actual values). The turn “it’s about three-thir- forty” assessed the current curve in a way that is inconsistent with an expected values.

Now that the classification of “too short” was stabilized, and Ted’s initial reading of it being “too wide” was no longer an issue, there was a problem with the recording. Carl announces that he would take a look and then gazed through the microscope to see whether the photoreceptor still was in the collimator. It was off, which encouraged him to do another scan of the same photoreceptor.[10] Here, too, we see a confirmation by means of an identical repeat, followed by the utterance “right,” which can be heard as a confirmation that it was a reasonable explanation.

In other, similar situations, the assessment of the curve turned out at a wavelength inconsistent with the visual assessment of the photoreceptor, but without the receptor having moved. In such cases, if the peak appeared to indicate a reasonable feature, the visual assessment was revised. This was then a situation in which the visual assessment of the photoreceptor was taking to be problematic (faulty) and where a subsequent reclassification was brought about. For example, there were repeated instances when a “single cone” was changed to a “broken rod” or “double cone on the side,” depending on the graphical signal that was being observed. In other situations, the graphical signal was

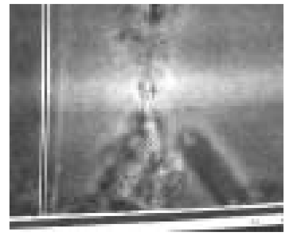
[10] Actually, if he had thought that the photoreceptor was a double cone, he might not have requested another scan, because he knew from experience, that “another look [sampling]” would seldom lead to a good signal. The scientists explained this in terms of the higher sensitivity of these cones to transformation by light, in this case from the recording beam.

highly ambiguous, leading to cases where the scientists used some other problem in the preparation (MEM solution too old, preparation too old, problem with optics, etc.) that did not allow a convergent assessment of the image and the signal.

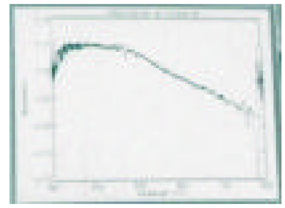
In cases of trouble, the scientists often returned to the microscope (now monitor) again to take another ("closer") look at the image to attempt to discern features that would allow them to make perceptual distinctions. If there is convergence, they do not go back to check the image. That is, when the two types of orders converged rapidly, the scientists took it as a case of an appropriate classification. If the orders did not converge, they tended to "take another look" and attempted to make what they saw accountable to the other. In part because his first assessment was that of a single cone, which were not as easily damaged as the double cones (especially the "red member"), Carl prepared the same photoreceptor for another sampling episode. This second part of the episode began with another affirmation that the receptor was a single cone, which, initially, would not find confirmation in the assessment of the signal (lines 33–37). However, and despite the concurrent assessment of two lab members, the team pursued Carl's hunch that the real peak was hidden elsewhere. Drawing on the tools available for transforming the graph, the team set out to investigate Carl's hunch and ended up, again in a triple confirmation making convergent assessment as to the nature of graph.

Initially, Carl repeats and thereby reaffirms his classification of the photoreceptor as a "single cone" (lines 28–29). In the context of having seen the receptor again, his "definitely" is not simply the same look, but it is a confirmatory second look at the cell. However, both Ted and I, taking first looks at the graph, raised doubts about this assessment. That is, what we perceived in the graph did not converge with Carl's assessment of the receptor as a single cone. Especially Ted's comment that there was a graphical feature around 460 nanometers, more consistent with a green member of a double cone, raised doubts about Carl's classification. "The four-sixty again" indicated that this was the same feature Ted earlier described as "too broad."

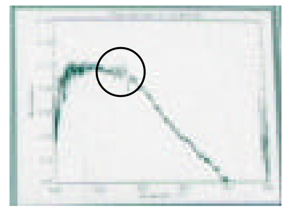
Transcript 3 Fragment 2



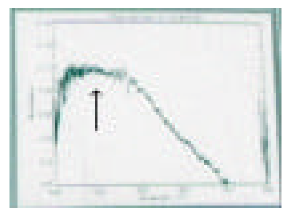
26 C: Scan
27 [(9.8)
[((T engages the optics and samples the photoreceptor))
28 Definitely looks like the single
29 cone.



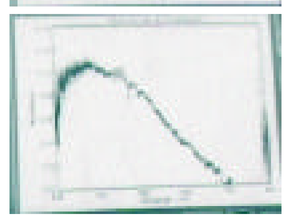
30 (4.9)
31 M: Hmm?
32 (1.1)



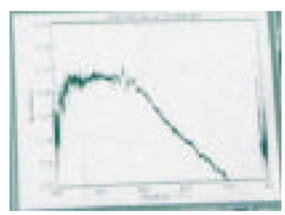
33 T: It’s rather high it’s in the four-
34 sixty again.
35 M: Yeah.
36 (2.2)
37 T: That won’t be it.
38 (2.4)



39 C: Well (0.8) do a pixel shift (0.4) OK
40 because I think [that’s
[((points))
41 [the peak



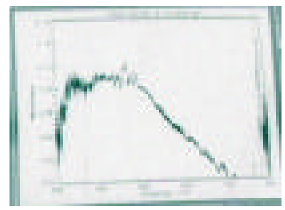
42 M: [‘t’s this one, yeah?
43 C: It’s this one here.
44 [(9.2)
[((T modifies the graph
45 C: Again.
46 (0.8)



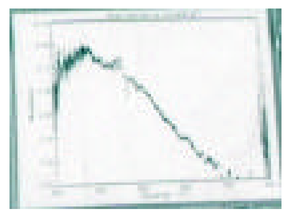
47 T: That doesn’t look like it.
48 [(3.9)
[((T continues to transform graph))

Although I confirmed Ted’s assessment, and another utterance that raised doubts about a converging assessment, Carl suggests to pursued a different feature that he made more salient by pointing to it. Evidently, Ted and I did not see what he was seeing so that he used gestural deixis to increase the salience of the perceptual gestalt evident to him. He asked Ted to “do a pixel shift,” which, after Ted had done a few of these, made salient to me a small peak (line 42). Despite these changes and a double affirmation of something by Carl and myself, Ted suggested that whatever we affirmed could not be it (line 47). Nevertheless, he pursued the transformations, following Carl’s suggestions of the type of transformation to be accomplished.

Transcript 3 Fragment 3



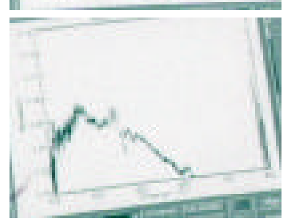
```
49   C:  No, in the other direc[tion
50   T:                         [Yeah
51       (4.5)
```



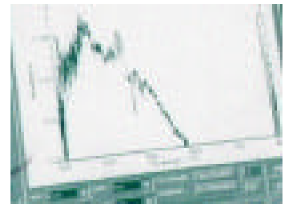
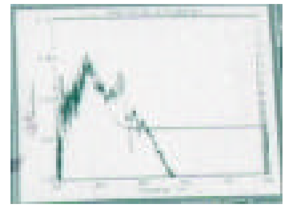
```
52   M:  Yeah (0.8) this one
53       (0.3)
54   C:  May be one more.
55   T:  [((T makes one more change))
         [That?
```

```
56   C:  No, the other way. (1.4) So two that
57       way.
58       (2.5)
59       OK. Now (0.2) ah detrend it.
60       [(17.1)
```

```
61       [((T ‘detrends’ graph))
62   M:  Is this a three-eighty?
63       (1.7)
```



```
64   CH: Yap. (1.5) Keep on detrending.
65       [(14.8)
         [((T ‘keeps on detrending’))
```

```
66        OK, well, this can go on forever.
67        Yeah, put a three-eighty up to see
68        what it looks like.
69   T:   Yep

70        [(33.2)
          [((T works on getting the three-
          eighty)
71        It does fit up to
72        three-ei[ghty.
73   C:           [Here [you  [go
74   M:                 [Yeah [     [Yeah
75   T:                       [Yeah [
76        (0.5)
77   C:   Three-eighty?
78   TH:  Yeah.
```

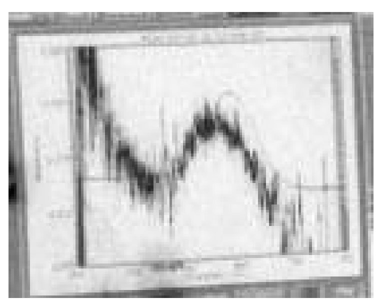
In line 52, I confirmed to see something of interest, Carl suggested one more ("pixel shift") and then, after correcting the direction in which the shift was to occur asked for another type of transformation, to detrend the graph (line 59). At some point, I raised the question whether the peak could be a "three-eighty," which, after several more detrending steps, Carl confirmed. He suggested yet another test to ascertain that the curve we saw at the moment was in fact compatible with the category "three-eighty." Carl asked Ted to "put up a three-eighty," which is a reference curve, a typical member of one of the possible curve classes. "Putting up the three-eighty" then had the same function as lining up the unknown salmon specimen with the other one clearly identifiable as a sockeye. After a long pause during which Ted searched for the software tool that allowed him to put up the "three-eighty" reference, all members of the group contributed to producing agreement that the signal was actually a member of the three-eighty class, which, because it was consistent with a "single cone" classification of the photoreceptor, amounted to a stabilization of both classifications. Again, repeats (lines 72, 77) and affirmations (yeah) were the conversational devices that did the work of stabilizing the classification and agreement.

In this episode we see that quite different assessments of what can be seen and how to classify are possible in the laboratory. Even when two individuals concurred with each other but were contradicted by a third person, this did not mean that the case was settled. Rather, the group persisted in exploring all possibilities. In this case, despite Ted and my assessment of the curve as being inconsistent with the single cone classification of the receptor, we pursued Carl's hunch. It was only after all hunches had been pursued and classified in one way or another that the group as a whole was satisfied. It was only after all possible scenarios had been evaluated that a definitive classification was made or the possibility of it was abandoned.

However, when the reference curve did not provide sufficient overlap, the scientists sometimes decided to keep the classification open and pursue additional routes. This became evident in the following episode recorded near the end of a run, which had begun with Carl's classification of photoreceptor as a single cell. On the basis of the graph, Carl and Ted revised the possible assessments to "it could be a green, a double flipped over" and then "It could be a red." To test whether the curve could correspond to a red cone, Carl asked Ted to "try [a] fife-eighty-eight" standard. Once the standard was plotted (smooth curve in fragment), the following interaction occurred.

Transcript 4 Fragment 1 JUL 18, 2000 2:58:42

```
77  T:  It's slightly lower.
78      (0.5)
79  C:  OK.
80      (6.0)
81  T:  OK.
82      (0.8)
```



```
83      Shall we try red and then bleach?
84      (0.8)
85  C:  Yeah.
```

When Ted finally succeeded in plotting the “five-eighty” standard, it was to the right (more to the red) of the curve before them, a fact described by Ted as “It’s slightly lower.” That is, this comparison is not consistent with a graph that could be counted as a member of the “red” class. Nevertheless, Ted ultimately proposed to “try a red,” that is, he saved the data as a red spectrum and then pursued the investigation by bleaching it. At this point, the status of the cell remained open. If in fact it was a double cone (rather than the earlier announced single cone), there was still a question just how to read the graph. It might turn out to be red, or green, or both. The cell visible under the microscope would, correspondingly be identified with a double cone on the side—which could also mean that the signature has both a red and a green component. How the scientists would ultimately classify both graph and image (sometimes they photograph it) depended on further work in which perceptual and signifying order were stabilized and convergence was reached.

Scientists pursue all possible avenues settling divergent classifications despite the fact that time is at a prime. When coherence between the classifications was not achieved, the scientists did not just move on but frequently searched for possible causes in their apparatus or specimen preparation whether “something could have gone wrong.” For example, the prepared receptors, because they had been excised and subsequently stored in ice, decayed rather quickly and became unusable after about an hour. At the same time, the scientists attempted to get as many cells from each slide because of the amount of preparation that went into sacrificing a fish, excising the eye from its socket, and separating the retina from the hemisected eyeball. Thus, the coherence between the perceptual available cell and its graphical equivalent was not simply achieved locally, involving just these two. The coherence involved the presupposition that everything else is working as it should. Whereas this did not become evident in unproblematic cases, the search for causes of not working turned up many different pieces of equipment and manipulations that did not work or went wrong, respectively.

SUMMARY AND CONCLUSION

My research is centrally concerned with the question how in a world already saturated with natural and social categories and classification schemes new ones emerge from everyday mundane activities of people in a variety of settings. In the past, I had focused almost exclusively on school children learning to see the world in new ways, sometimes consistent with some existing canon (science). However, with school children, developmental aspects confound many issues so that more recently I began to focus on other everyday activities among environmental activists, hatchery workers, and research scientists. Research scientists are particularly rewarding participants because of their involvement in the massive undertaking of generating and reifying new classifications as a central part of their ongoing mundane activities.

Making it "Science": From (Immediately) Local to Non-Local Resources

A classification, then, is the outcome of endogenous, naturally accountable achievements that relate two orders of segmentation of matter. The present study shows that the work of making and using classification systems is richly textured, drawing on many material, embodied and social resources. In all instances that I have illustrated here, perception was socially organized and required the embodied manipulation of the entities (fish, rock pile, graphs and photoreceptors) being scrutinized. In fact, the perceptual gestalts that these entities present constitute a semiotic field that structures the details of language use and the unfolding in time of talk-in-interaction (Goodwin 2000). At the same time, in their concerns to make classifications accountable, the scientists were oriented toward the larger community in which they are members and the rules for accountability that it adheres to. In this, the (macro-) social structures of the community are resources in on-going, embodied, and knowledgeable activity (Sewell 1992).

Through their ongoing interaction, the collaborators built shared “libraries” of cases and classifications. These cases functioned as (immediately) local resources for classifying and coordinating collective work activity. That is, over time, they built a stock of (shared) experiences that came to serve as ground that reflexively elaborated the classifications that ultimately emerged. They did so without the requirement that they have to be able to articulate these classifications in just so many words. There are many situations similar to the one described here between Samantha and Melissa, where the parties involved have a shared sense of how to (perceptually) group the entities under consideration. In the fish hatchery, the workers at the fish marking stations classify smolt into three size classes for marking by one of two machines, or for returning them to be marked by a different method. Although the workers cannot articulate the grounds on which they did their classifications—they could not tell me how to do it—they not only classified the fish but, by putting a “mis-classified” fish into a different bin, communicated this fact to the other individuals present. Perceptual distinctions do become social when collaborators have developed a shared sense even in the absence of a representational (classification) scheme. Perception and its production therefore cannot be separated from public descriptions that the scientists produce and attend to as joint courses of action. In embodied telling, a seeing member of the group brings into being “rock pile,” “single cone,” or a (peak at) “three-eighty.” These emerge in and as temporalized narratives and through the body’s gestures, making the practices highly local and difficult to communicate other than through direct interaction with those who know.

Similarly, in the early parts of the research on the cones and rods in the salmonid retina, carl and Ted often took for “single cones” what turned out to be “double cones on their side” and “broken rods.” Even when they were able to perceptually classify rods and cones with almost perfect accuracy, their descriptions for recognizing them were insufficient for a newcomer to make a distinction—double cones were identified by a “bulginess on the bottom,” broken rods were “more hair-like” and so forth. I learned to distinguish the different types of photoreceptors through massive exposure to many instances, when the researchers pointed to images on the monitor of the infrared microscope.

The tools in the biology laboratory that were used to “transform” the curves in fact make salient features in two ways. First, they appear to become features in their own right, but in the comparison with previous states of a curve, features are salient in comparison to their previous absence. When there were interactional troubles (problems) because members were uncertain about which feature was the topic of talk, participants used pointing (deictic) gestures in the direction more or less close to the object to increase the salience of the intended portion of the continuum.

In all of the episodes, we have seen that scientist come to agreement about the classifications. They do so by building and drawing on (immediately) local resources that, though frequently not communicable in words, are still shared within collectivities—they are social but only within groups. However, local resources in and of themselves do not constitute the activity as science. In fact, these resources cannot count as science unless they are transformed (requiring transformability that is not always possible) in a form that makes them non-local, translocal and therefore transportable into other settings. Science becomes massively social in that scientists are not only interested in (perceptually) classifying objects and processes, but as we have seen with Samantha, seek to “operationalize” the process of classification. That is, whereas Samantha is able to clearly distinguish a rock pile from a non-rock pile on perceptual grounds, the fact that she produces a classification that is accountable in the context of her community (ecologists), requires her to articulate a scheme in a way that others can reproduce it. It is this other-orientation in the production of an accountable scheme that science becomes massively social.

Trouble is noticed, formulated, and brought to the attention of others. Human and technological resources are mobilised to resolve the trouble. The mobilisation of these resources is monitored and assessed for the resolution to occur at any time so that further mobilisation and co-ordination is unnecessary. (Suchman, 1996)

Achieving Closure in the Face of Uncertainty

In the end, we what appears astonishing is that despite the uncertainty involved in various aspects of the classification work, the scientists came to settle each case in one or the other way. After elaborating various observations and possibilities for classifying some specimen, and without requiring any one piece of evidence to be harder than any other, the classification problem resolves and perhaps dissolves. How is classification possible when there are no requirements for single, hard criteria? Although the scientists never actually attempted to get a grip on all the evidence that they had elaborated, constraint satisfaction of multiple hypotheses may be an appropriate model for understanding how classification settles out. Perhaps an analogy may help in understanding how classification is achieved in the face of uncertainty.

Each statement (e.g. an observational description, statement read from the field guide, articulation of embodied understanding) used for making the classification is treated as one hypothesis. , corresponding to a node in a constraint satisfaction network. Each node is normalized to have an activation level between 0 and 1. This activation adds or subtracts from the activation of another node connected to it. It adds if the corresponding hypotheses favor the same classification but it decreases the activation of another node if it supports the other classification. In the present, fish identification is characterized by various observations that the members of the group articulated in the course of the 10-minute episode. The outcome of the classification process can therefore be seen as a solution that arises from the satisfaction of the multiple constraints embodied in multiple hypotheses that are mutually enhancing or conflicting. Unsupported statements (e.g.

"S'my uneducated opinion, it looks like a sockeye" [Elmer, lines 165–166]) do not enter the model.

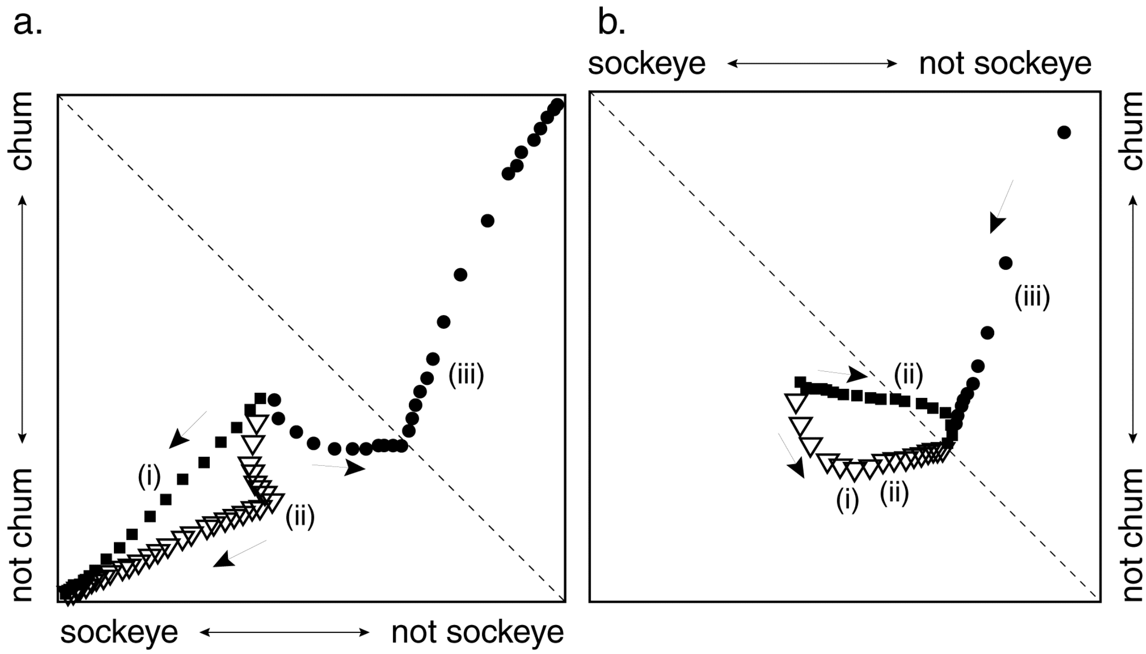


Figure 3. A constraint satisfaction network models classification. A modeling endpoint in the top right corner reflects that the entity has been attributed to chum; the modeling endpoint in the bottom left corner reflects the decision that the entity belongs to sockeye. a. Three different trajectories resulting from the same starting point but with different predilections for particular hypotheses and observations and the strength with which these support or weaken one another. b. Three trajectories with different starting points but all ending with the same solution—at the end, classification is undecided so that the entity may belong to either class 1 or class 2.

Figure 3 shows the outcome of different levels of depressing or enhancing effect of some nodes on others. In Figure 3.a, all classifications start with a preference for a classification of the specimen as sockeye, but only solution 3.a.iii ends with a classification as chum. Trajectories 3.a.i and 3.a.ii differ in that the observational descriptions and other statements in favor of chum undermine more strongly the descriptions and statements in favor of the sockeye. In 3.a.iii, the effect is so pronounced that the outcome is a chum classification despite an initial predilection in favor of sockeye. Figure 3.b shows the outcome of models where the activity does not lead to definitive classification (frequently observed particularly in the vision research laboratory). Despite different predilections at the outset, members conclude that there is not sufficient evidence for one or the other. Although the group had settled for practical purposes on counting the specimen as chum (Gael had suggested that one fish didn't matter), the episode had ended on a much more ambiguous note. Each of the classifications, proposed in jest, invoked the possibility that the specimen could have been both.

Transcript 1 Fragment 12

```
254   E:  A chum-eye
255       (1.6)
256   R:  A ↓chum-eye
257       (0.9)
258   Z:  Maybe it's a hybrid [  [a] sockeye-chum
259   E:                      [ay[:]
260   R:  °hh em a chock-eye
261   Z:  Chock-eye
262       (1.3)
263       co-chum
```

In scientific work, the ambiguity of classification is recognized by many of its practitioners. What may surprise, then, is its presentation as unambiguous in the public media. Further similarly detailed work that articulates the trajectories of emergent classification is required to understand this change.

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