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Following instructions

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To discover some of the implicit and generally unrecognized cognitive tasks which underlie the achievement of coherent or "accountable" cognitive performances we examined videotapes of a series of science experiments in a third grade classroom. These experiments are part of a commercial "multimedia" science program, "Amazing Adventures."[1] This program is comprised of animated film-strips and illustrated storytexts depicting "Cosmos the Incredible" and his young friends performing extraordinary, seemingly magical feats; these turn out to be based on natural scientific principles which are the subject of student science experiments, conducted in accordance with instructions provided by "Activity Sheets" correlated with the film strips.

Our approach to these data is influenced most directly by the recent work of Harold Garfinkel and his students (Garfinkel, in press; Garfinkel, Lynch and Livingston, 1981; Lynch, Livingston and Garfinkel, 1983). Garfinkel is concerned with the practical contingencies, the "lived work," of accomplishing "naturally accountable" activities, such as forming service queues, following map directions, and making scientific discoveries. In our accounts, both as members and as social scientists, of human activities, we tend to ignore the mundane or seemingly insignificant details of how those activities were actually produced within a specific setting. Garfinkel writes of

1. A copyrighted (1979) product of Nystromg, Division of Carnation Company.

> ... "horizonal" properties of naturally available phenomena [such] as their historicity, their detail, their developing intelligibility, their circumstantiality, their contingent occurrence, and their embedded production. Canonical problems of social order are practical methods for theorizing the contents of everyday activities by furnishing grounds for treating the horizonal properties as irrelevant ...
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> The expressions, "unremark-able" and "unnotice-able" are hyphenated in referring to practices of such unquestioned efficacy and banality that no motive ordinarily exists, either in commonplace settings or professional inquiries, to make an issue of their methodic character. In the social scientific search for routine, predictable, standardized, and orderly states of affairs in the society, these practices are overlooked, while at the same time their routine, predictable, standardized, and orderly production of worldly matter of fact and conjecture incessantly "works for" the social science inquiry (Garfinkel, in press).

The indexicality, incompleteness, and ambiguity of rules and instructions, and the status of these properties as necessary and essential rather than incidental or remediable, has been a major topic of ethnomethodology from its early development (Garfinkel, 1967:Ch. 1; Wieder, 1970, 1974; Zimmerman, 1970) until the present. The recent work of Friedrich Schrecker (1981) on the progress of a laboratory experiment is of particular relevance in the present context. "... the sheet of lab instructions used by Schrecker in his lab work required of students that they locate the text's instructions and, accordingly, the answers and practical reasoning conveyed by the text's specifications, by turning away from the text and initiating embodied activities on the distinctive surface of the lab bench" (Lynch, Livingston and Garfinkel, 1983). Schrecker, like the children in our study, had to turn a set of instructions into a concrete course of work and face the practical contingencies created thereby. As we shall see, for children, the translation from instructions to performance is particularly hazardous, engendering diverse, unforeseen, and quaint difficulties. The result is not that the children do not learn, but that they learn something rather different from what the "experiment" is designed to teach them.

It is notable that the instructions provided to the children (examples available upon request from author) are not merely instructions – they are also prospective accounts. That is, if the experiment is "successful," if it achieves its projected outcome, the instructions can serve as an account of "what was done," although in any actual performance a great deal more is necessarily done than can be comprised in the instructions. It is only when things go wrong that the details of the course of work require examination in the search for an account of what happened. This brings up another property of instructions: it is possible to imagine a set of instructions with no particular projected outcome. Perhaps one might even want to argue that such things occur in the realm of moral imperatives. In all other cases, though (at least those which we can bring to mind), either the instructions lead to a specified or generally known outcome, or to an outcome known to the writer of the instructions and to be discovered by the person undertaking to follow the instructions. Instructions have a projected outcome, known to the instructor and possibly the instructed as well. This property is not definitive of instructions, but it is crucial to the process of following them and accounting for "what happened," as we shall see in the data that follows.

Garfinkel has demonstrated and investigated the hidden (or, perhaps we should say, all-too-obvious) structure of ordinary activities by introducing anomalies into them. What happens, for instance, when a son behaves like a polite guest in his own home, when a blind man asks for place directions, or when a person wearing inverting lenses tries to sit down in a chair? In the case of Agnes, the transexual, Garfinkel (1967:Ch. 5) found a naturally occurring resource for his investigations of the structure of ordinary activity. Agnes, having been raised as a male, had to teach herself how to be a competent, "naturally accountable" female. Children, all children, are comparable to Agnes, and a comparable resource for social scientists, in that the child is incompetent in the ordinary, taken-for-granted skills of daily life. There could hardly be a more "perspicuous setting" (Garfinkel's phrase) for discovering the unremark-able and unnotice-able practices involved in instruction-following than a setting in which young children are called on to follow a set of instructions.

Even when intended as a guide to a comparatively simple course of action yielding easily describable results, instructions and related explanations presuppose a range of competencies and conventional understandings, without which even the most detailed instructions are meaningless for organizing practical activities. This is particularly evident in those cases where the third-graders we studied lacked some of these skills or understandings, frequently with the effect of transforming the experiments into something quite different from what was envisioned in the instructions.

Courses of action prescribed by instructions vary considerably with respect to degrees of skill and comprehension required to carry them out, just as instructions themselves vary greatly in terms of clarity and completeness. But some of the competencies and understandings to which we refer, and those we are most interested in here, are of such a general nature, that is, they seem so fundamental to successfully following any set of (adequate) instructions, that they may be regarded as constituting the essential competence which enables one to follow instructions *per se*. Put another way, they define what one does in following instructions in general.

Successfully following instructions can be described as constructing a course of action such that, having done this course of action, the instructions will serve as a descriptive account of what has been done, as well as provide a basis for describing the consequences of such action. However, like instructions, this description leaves undefined the practical skills, the embedded activities, and the background knowledge, in other words, the competence by means of which constructing courses of action in accordance with sets of instructions is accomplished. We suggest that, rather than learning "science," the primary cognitive task confronting our subjects in these experiments was that of developing such competence – a competence which, because of its problematic status, becomes explicit by virtue of being a resource for interpreting the children's behavior.

Perhaps the most important of the cognitive skills required for dealing competently with instructions is the ability to grasp at the outset some of the general relationships and possible connections between a projected outcome and a corresponding course of action on the basis of information given in the instructions, and in the case of the experiments discussed here, in the "Reason" or "Explanation." This despite the fact that in didactic experiments the discovering of such relations is envisioned as a *consequence* of following instructions, rather than as a *condition* for doing so. Yet it is only by inferring some sort of pattern that the necessarily incomplete nature of instructions can be developed into a coherent course of practical activity; that unavoidable ambiguities and unforeseen contingencies can be resolved appropriately; that one can distinguish that which is essential from that which is nonessential in the instructions; and that one can decide whether any particular action among the virtual infinitude *not* specified by the instructions might facilitate, interfere with, or prove totally unrelated to the outcome. As we will see, all of these skills are required for competently following instructions, though as a consequence of the reflexivity of a course of action and its outcome they depend largely upon anticipating relationships between these last two factors.

Consider, for example, the instructions for the experiment called "Keeping Dry Under Water." A napkin is to be pushed down into an eight-ounce plastic tumbler and the tumbler then inverted and plunged straight down into a plastic bowl half filled with water. The tumbler is to be held in the water for a second or two and then lifted straight out. The napkin will remain dry. It will be obvious to a competent adult that these instructions include a number of details that are not essential to the experiment. One could achieve the same result by plunging a 10 1/2-ounce soup can with a rag in the bottom into a bathtub three-quarters full of orange juice and keeping it there for an hour of two. Much of the content of these instructions is therefore determined by practical considerations which are irrelevant to the projected outcome. But one cannot presume that a third-grader would know this. And in fact one of the essential instructions, that the tumbler be lifted straight out of the water, was violated several times, resulting in failures to achieve the projected outcome. The apparent reasons for these departures from the instructions further illustrate the implicit competencies which underlie instruction-following. There is nothing in the instruction sheet that tells (or allows one to deduce) what will happen if the tumbler is tipped while under water. Yet it is precisely this knowledge that is required to correctly understand the meaning of the word "straight" in this context. We would not, for instance, say that a ball did not go straight simply because it revolved in flight. Our understanding of the meaning of "straight" in the instructions is informed by our knowledge of what will happen if the cup is tipped. Rather than saying that several children failed to follow the instruction to lift the tumbler straight out of the water, it would be more accurate to say that they failed to follow the instruction as a competent adult would have interpreted that instruction. This appears to reflect also an unforeseen contingency which arose in the course of the experiment: the napkin often fell out of the tumbler, either before placing the latter in the water or upon lifting it out. Thus some of the children who had successfully gotten the cup and napkin into the water subsequently tipped the cup to ensure that the napkin would not fall out when they raised it. Some of the students met this contingency by suggesting that tape be used to hold the napkin in place, a method adopted by several others; but it is interesting to note that many of the children rejected this solution, preferring the challenge of trying to succeed without such assistance. The latter portion of this science lesson therefore evolved into a competitive social activity, students who succeeded without using tape being rewarded with cheers and applause from their classmates.

This denouement is not inconsistent with what we have been saying about instructions. In making a competitive game out of following instructions which, in a very few years, they will find trivial and so easy to carry out as hardly to require conscious thought, these children are demonstrating that the ability to turn instructions into practical activities that achieve predictable outcomes is not yet an implicit, taken-for-granted competence, but a set of skills which they are in the process of developing. So it was not the problem of "air pressure" so much as the problem of constructing a coherent, "successful" course of action out of the experimental instructions with which they became engaged.

Several incidents we observed illustrate the need for recognizing connections between the projected outcome and the ongoing activity in order to avoid more or less random actions which interfere with the experiment. For example, in the case of "Invisible Writing," where students write with a toothpick dipped in salt water and subsequently produce an image by rubbing carbon paper across the residual salt crystals, we observed several children licking the salt off the toothpick before writing with it. Several others, in rubbing their fingers over the paper in order to feel the dried salt crystals, appear to have wiped the salt away. Not surprisingly, this experiment produced few unambiguously successful outcomes. In the experiment entitled "Making Water Wetter," in which dipping a soap-covered finger into the center of a cup of water sprinkled with pepper causes the pepper to move to the edge of the cup, according to the instructions as a consequence of the soap breaking the surface tension of the water, some students produced this effect simply by bouncing their fingers up and down or stirring them around in the water so vigorously as to create waves which pushed the pepper to the outside.

The pattern which inheres in a coherent set of instructions, and which in turn makes such instructions coherent, not only guides actions, but determines perceptions as well, in that it tells one what to look for, what to regard as relevant observations, and what to ignore. Such a channeling of perceptions is necessary not only in order to regulate the practical course of action but to determine if the projected outcome is in fact achieved. Thus competence in dealing with instructions is at the same time a very situated competence in "viewing the world," or "seeing what is there," according to the account of things embodied in the instructions. Because they had not fully developed such a competence, our subjects frequently ascribed significance to observations which a competent adult would regard as irrelevant, "out of frame," or otiose with respect to a coherent "scientific" account of what was being done.

An example of this may be seen in the "Keeping Dry Under Water" experiment. To expedite carrying out this lesson two similar and functionally equivalent pans of water were placed on a table in the center of the room and the students were called on by pairs to try the exercise. Toward the end, when, as related above, this activity had become particularly competitive, one of the children approached a pan but was urged by classmates to use the other one because it was "luckier." We are not sure how this notion came about, although in a pair of trials closely preceding this comment the student using the "unlucky" pan had failed, while the child using the other one had succeeded. At any rate, the student followed this advice and the experiment was successful. Both of the following two children rushed for the "lucky" pan, though the loser settled for the "unlucky" one (and succeeded nevertheless). In the case of the next pair, the second child waited for the first to finish using the "lucky" pan, and then also used it. The "unlucky" pan remained unused thereafter.

In another experiment, the children were instructed to hold a slip of paper just below their mouths and blow across the top of it. The expected result being that the paper would rise due to the reduced pressure of the air moving over it. One of the students was unable at first to produce this effect and a classmate suggested that she was holding the slip of paper with the wrong hand.

In neither case are such observations *by nature* illogical or irrelevant. If a child were having difficulty learning to, say, bat a ball right-handed it would be appropriate to ascertain, perhaps by experimentation, if he were left-handed; and if one were unable to decide which of two brands of automobile to buy, she might reasonably take into account the good or ill fortune of any acquaintance(s) who had recently bought one or the other. But in these science experiments our understanding of the relationship between the practical course of action and its outcome seems to leave no place for "luck" or handedness. Therefore such factors become "noise"; they are outside of the frame of reference defined by the instructions.

This "framing," by which the complexity of the perceivable world is more or less spontaneously organized, is also evident in the decision as to whether an actual outcome sufficiently resembles the projected outcome described in the instructions that the experiment is to be regarded as a "success" or as a "failure." Phenomena often do not lend themselves unambiguously to such discontinuous classifications, but in these instances, it is necessary to order phenomena so as to yield practical classifications in accordance with criteria given in the instructions. Instructions, furthermore, by their very nature lead us to expect that, assuming we have followed them correctly, the projected outcome will occur. Thus our interpretation of outcomes involves expectations not only concerning *what* should occur, but also *that it should* occur. As the following examples illustrate, competence in this regard requires producing conceptual order put out of phenomenal ambiguity without letting prospective accounts of "what is there" preclude alternative, contingent accounts.

In the case of "Invisible Writing" with salt water, for reasons given above many of the children were unable to make anything even approaching legible writing appear, though by vigorously and persistently rubbing the carbon paper over their papers they did produce irregular blotches and streaks. They often tried to persuade themselves and their classmates that these constituted successful outcomes, attempting to show how certain random marks might be interpreted as particular letters. In the case of "Making Water Wetter," when the first student dipped his finger into the water some of the pepper sank while some went to the sides of the cup. One student immediately exclaimed "success!" while another said, "they're going down to the bottom." When the latter statement was amended by the teacher's observation that some (actually, only a few flakes) went to the bottom and some to the sides, consensus was achieved that the projected outcome, *viz.*, "the pepper will move quickly to the outside of the tumbler," had in fact occurred. The students here achieved a competent, "in frame" interpretation of the results, but only after a certain amount of negotiation. It might be argued that they learned something here about the proper seeing of results produced according to instructions.

One of the other students suggested that the experiment would have the same outcome if small pieces of paper were substituted for the pepper, a prediction which most of the children responded to with disbelief, some even with derision. When this was tried, once again some of the pieces sank while others moved to the outside. In this case the overwhelming consensus was that because some of the paper had sunk, the experiment had failed.

In the initial experiment, the authority of the instructions was decisive in classifying the objectively ambiguous results. "What happened," as far as most of the students were concerned, was that the pepper moved to the sides, as predicted; negative instances were (eventually) discounted as irrelevant. But in the improvised experiment (which was in fact the true "experiment"), lacking such authority and at the same time expecting failure, the children conversely refused to see as overriding those instances where the paper moved to the sides and instead classified the outcome in terms of the paper sinking, i.e., as a failure. (The fact that some of the pepper and paper sank might be seen as a powerful demonstration of the principle of surface tension, but it was not envisioned in the instructions. For the students, concerned with "success" and "failure" rather than with the scientific principles that the experiment was ostensibly teaching, the sinking was unexpected and untoward and consequently a sign of failure at the practical activity of instruction-following.)

Idealized notions of science as an abstract, disembodied enterprise are, as we have seen, a poor representation of the actual work of doing science. In addition, science is also conventionally presented as abstracted from the social setting in which it occurs. But, as *The Double Helix* by James Watson vividly documents, science is through and through a social enterprise, penetrated with social considerations, and this is at least equally true for scientific "experiments" done in classroom settings. It is not simply a matter of doing something and seeing the results. The results are classified as "success" and "failure" and thus are laden with social implications. The doing of the experiment and the interpretation of the results come to involve social support, competition, gain and loss of face. The nature of the results is a matter not merely for observation but for negotiation. Although we will not go further into these considerations here, any discussion of the socially defined outcomes of the pepper and paper experiments described above would have to take the social contexts of these experiments into account.

In many instances, as we have seen, there were failures to achieve outcomes predicted in the instructions. In virtually none of these cases was such a failure allowed to pass without at least one of the children offering an explanation. This would seem to reflect a common, if implicit, acceptance of instructions as prospective accounts of how projected outcomes are brought about; the correctness of these accounts remained unquestioned, though their completeness, in the sense of providing all relevant details, was often in doubt. A failure, therefore, might bring into question the completeness but never the correctness of the instructions. The "experiments" did not test the validity of a scientific principle, only the competence of the students at carrying out the instructions. The children were also provided with the occasion to practice a useful social skill – accounting for discrepant outcomes within a framework of unquestioned authority.

In this sense, and unlike in the case of hypothetical experiments, it may be said that rather than learning how to use evidence to reason from controlled conditions, the students were learning the practical skills and imagination involved in rationalizing such evidence, that is, in *ad hoc* speculation concerning violations of or incompleteness in instructions. For example, in an experiment involving the use of liquid dish soap to blow bubbles through plastic straws, a few of the students who were unable to blow bubbles as large as those expected on the basis of the instructions took this as indicating that the brand of soap employed was inferior. The failure to produce a legible message in "Invisible Writing" was said by some to be due to using the wrong kind of paper.

A common feature of the failures to accomplish expected outcomes which we observed was their lack of any real theoretic interest; they were rationalizable in terms of retrospective accounts of practical courses of action, rather than explainable in terms of general principles. The result, as suggested earlier, is not that the children fail to learn, but that they learn something different from what the experiment is intended to teach them. What they learn are, most importantly, the practical and creative skills needed to successfully turn a set of instructions into an accountable course of action, or, if necessary, to account for failure without discrediting the instructions.

We have suggested that dealing competently with the instructions requires not just the apprehension of bare imperatives, but an understanding of general relationships and possible connections between a projected outcome and a corresponding course of action, of which the instructions are indexical. This indicates the reflexivity, or the mutually determinative nature of the course of action and its outcome, in which is grounded the meaningfulness and coherence of a set of instructions. The course of action is determinative of the outcome not only in a physical sense but in that the course of action, as it comes to be formulated in subsequent accounts, makes certain aspects of the outcome noticeable, relevant, and mentionable. The perceived outcome, on the other hand, informs one's perception and account of what the course of action was. The same course of action may be differently described in accordance with what outcome it appears to have produced. This is especially the case when the projected outcome does not materialize and one has to examine one's course of action to see if and how it was consistent with the instructions. In such cases, previously insignificant and irrelevant details may become crucial in an account of the course of action. There is another aspect, though, to this reflexivity: One's sense of the course of action prescribed by the instructions is informed by one's knowledge of the projected outcome, just as one's sense of what will serve to constitute and be essential in such an outcome is informed by the prescribed course of action. It is in this way that the meaningfulness and coherence of instructions is grounded in the perceived relationship between course of action and projected outcome.

As our observations of these third-graders indicate, it is largely by means of achieving competence with respect to the indexical and the reflexive nature of instructions that one becomes able to recognize the essential and unessential features of the accounts embodied in instructions; to fill in the gaps in these accounts, both conceptually and through practical activities; to determine the relevance of particular acts; and to reduce ambiguity by means of practical classifications of phenomena. Although our subjects were in many respects less than competent in these skills, they seemed clearly to possess well-developed senses of "accountability" as an organizing and interpretive principle of practical activities (and their outcomes). By virtue of this sense of accountability as the form according to which meaning is ascribed to actions, and actions are constructed out of meanings, the cognitive skills tapped and developed by elementary science experiments were far less of a "theoretical" (in the usual sense) than of a practical nature.

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