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ABSTRACT

This report on the Adult Math Skills Project includes sections on theory, empirical studies, and their implications. Section 1 presents an overview, noting that activity and setting are seen as mutually creating, sustaining, and changing the nature of problem solving. The empirical studies involved: (1) arithmetic practices among grocery shoppers; (2) the acquisition of arithmetic skills by new members of a dieting group; (3) the management of money-flow through households; and (4) an exploration of the backgrounds and customary procedures of participants in the first two studies. Section 2 introduces the theoretical perspective of the project, using the money management study and other data for illustrations. In section 3, the various arithmetic tasks designed and carried out with 35 participating adults are described, followed by an analysis of the character of links between school-learned and everyday arithmetic Section 4 analyzes the grocery shopping activity. Finally, section 5 discusses the implications of the studies for educational policy in the United States. An appendix contains the tests and tasks administered. (MNS)

FINAL REPORT

The Mature Practice of Arithmetic Problem Solving in the Daily Lives of Americans

NIE-G-78-0194

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Table of Contents

I. Introduction

II. From Universal Standard to Situation Specific Devices: The Dilemma of General Knowledge and the Specificity of Use

- A) The Management of Money
- B) Measurement and Calculational Devices

III. School Math Links with Other Situations in which Arithmetic is Used

- A) The Sample and other Constructs
- B) Substantive Links: Descriptions of School-Like Arithmetic, Mediating Situations and Tasks, and Arithmetic Practice in an Everyday Situation.
- C) Substantive Links: Statistical Analysis

IV. The Analysis of Arithmetic Practice in Context: Grocery Shopping Arithmetic

- A) Introduction
- B) Setting
- C) Activity
- D) The Supermarket and Grocery Shopping: Arena, Setting and Activity
- E) Problem Solving in Grocery Shopping Activity
- F) Dialectically Constituted Problem Solving Processes
- G) Conclusions

V. The Educational Implications of Situation-Specific, Dialectically Constituted Arithmetic Practice

VI. Appendix 1: Arithmetic Tests and Tasks

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Jennifer Fullmer managed the project with enormous intelligence and energy, taking on, as a matter of course, all those grey areas of management that usually are the responsibility of the director but which fared much better in their hands. The School of Social Sciences at UC Irvine has provided very strong support for the project. Kathy Girvin patiently taught us how to manage a grant budget; George Ferrington did all of the technical management of the grant. Their exceptionally sound advice and their kindness is greatly appreciated.

Final Report

The Mature Practice of Arithmetic Problem Solving

in the Daily Lives of Americans

I. Introduction

There are several parts to a full report on the Adult Math Skills Project (AMSP): theory, specific empirical studies, and their implications for educational policy in the U.S. During the course of the project a critique of existing efforts to develop a pyschology-in-context has gradually matured into a new theoretical position, a dialectical one, in which activity and setting are seen as mutually creating, sustaining and changing the nature of problem solving. It is one which emphasizes the situational specificity of problem solving activities. This approach creates dilemmas, both theoretical and practical. On the one hand there are difficulties in encompassing the generality of systems of knowledge in relation to the specificity of its use. On the other hand, formal education and the use of knowledge thus acquired in the multitude of particular everyday settings, also seem too far apart to bring into a single theoretical framework. This seems especially true given the aded factor that we live in a world peopled by alumni of schooling, whose relationship with their formal educational experience is, for most of their lives, that of alumni. The empirical studies fall into four parts: (1) a study of arithmetic practices among grocery shoppers in Orange County supermarkets; (2) a study of the acquisition of arthmetic skills by new members of the Weight Watchers dieting organization; (3) a study of the management of money-flow through households; and (4) an exploration of the biographies, educational history, history of arithmetic involvement, and customary arithmetic procedures of the participants in the first two studies.

The studies are interrelated, sharing a common set of assumptions. First, to understand everyday cognition requires the investigation of cognitive activity in context. This is not a matter of interviewing or of laboratory experimentation, nor of reconstructing familiar environments into cognitive obstacle courses, as quasi-experimental situations. Context and activity mutually bring each other into being; a radical change contrived for either produces radical change in both. Methodologically this translates into observing people-doing-in-context.

Second, analysis doesn't stop with problem solving activity, but focuses in detail on broader scope activities and the settings in which they take place. Together these create the context for specific problem solving activity. The act of bringing problem solving under close observation in experimental contexts has, in the past, distorted its relations with ongoing activities. Problem-solving has been magnified into an end-in-itself for the problem solver, in the course of becoming an end in itself for "scientific" purposes. It is partly in reaction to this tradition that it seems important to ask what role problem solving activities, such as arithmetic ones, play in the ongoing flow of daily life.

Third, the role of specific cognitive activities (arithmetic problem solving _is_ partly cognitive) varies from situation to situation. What constitutes a problem, a solution and the procedures for solving a problem, vary with the encompassing activity and context which generate problem solving activity in the first place. Thus while the focus of the studies is arithmetic problem solving, each specific study depends inextricably on an analysis of the context and activity within which arithmetic occurs. (For one example, see Section IV, The Analysis of Arithmetic Practice in Context: Grocery Shopping Arithmetic.)

Fourth, what occurs in one setting is structually related to other activities in other settings. Each of the studies reported here contrasts arithmetic practice in unrelated settings (math testing and everyday activity) and explores transformations of arithmetic practice across deeply interconnected settings (the preparation and serving of meals in the Weight Watchers study; the preparations for shopping, shopping, putting away the groceries and use of groceries in meal preparation in the grocery shopping study.)

The studies also differ. In particular, we began with the intention of contrasting situations in which arithmetic might vary in its priority within the ongoing activity. Arithmetic calculation appears in grocery shopping as a discrete series of mini-episodes, of rather minor significance to the larger activity ongoing in the supermarket. For cooks (including Weight Watcher cooks), the importance of quantitative, often numerical, transformations of meal ingredients, the timing of food preparation and food portion control have crucial impact on the end product, the meal--more than in grocery shopping. And in balancing a checkbook, calculation is an explicit, major, structure-giving activity in which numerical accuracy is valued.

A second dimension of variation across studies concerns the malleability of the setting in relation to the activity taking place in it: The contrast here is primarily between grocery shopping and Weight Watchers' activities in the kitchen. The supermarket is a public arena, organized by store personnel with goals of their own, for huge numbers of shoppers. Rearrangement to accommodate an individual's pattern of grocery shopping is therefore out of the question. Not so in the kitchen, where the environment is in many ways arrangeable at the pleasure of the cook.

Another dimension of variation between studies focusses on school learning. The situations and tasks which we asked our informants to take part in were designed to vary in their relations with the learning and use of arithmetic in school. We observed arithmetic problem solving in paper-and-pencil testing situations, similar to school test situations. We also attempted to simulate problem-solving conditions in the supermarket. And we made intensive observational studies of arithmetic in supermarkets. Finally, the last dimension on which the studies vary is one of degree of skill and experience. The Weight Watchers' study focuses on novices in the dieting program, while the supermarket study involves grocery shopping pros.

All of these dimensions deserve careful analysis. They presuppose first order analysis of the individual cases and we have but one in detailed form to present at the moment: arithmetic practice in the supermarket (Section IV of the report). We are not yet ready, therefore to take on the public/private setting contrast or that between pros and novices, though we intend to address them in the future. But questions concerning (1) the relative priority of arithmetic problem-solving across situations, and (2) the relations of everyday situations and tasks to the practice of arithmetic in schools will both be explored here. The latter is the central focus of the present report.

In comparing the research project in its current state, to the project as originally proposed to NIE, there are both correspondences and divergences. An atlas of problem-solving circumstances is not forthcoming from our work--though we tried. We spent two full days with each of several pilot informants, observing their preparations for a major grocery shop, a shopping expedition, putting the groceries away, cooking and serving a meal, carrying out Saturday chores and so on. We experimented with lengthy open ended interviews intended to elicit detailed schedules of work, domestic chores, recreation and rest; we collected anecdotes on the problematic aspects of routine activities--being late or early, being out of cash or carrying too much, and many others. Some of the difficulties with this broad-scope approach were practical. Partly in response to these practical difficulties we curtailed the scope of the individual studies. But gradually, also, our increasingly strong theoretical position recommended intensive analysis of settings and their interrelated activities. This sealed our committment to abandon the exhaustive atlas for a small number of carefully analyzed situations.

The practical difficulties included long hours of observation that were irritating to informants; no two weekly routines looked easily classifiable as "the same" type; arithmetic events seemed concentrated in certain areas of activity--cooking, grocery shopping and money management being of central importance. But long periods of unquantified action took place as well. Theoretical concerns led us to question whether "daily life" was the appropriate unit of analysis. The (arithmetic) curricula of everyday life seemed more various, and more closely the outgrowth of specific activities, than were captured in the very broad and general units of analysis with which we initally approached the project.

In the proposal we declared our intention to study the everyday practice of small-scale problem-solving, especially arithmetic, in a variety of settings. We proposed, and have carried out, a mixed research strategy involving participant observation, interviewing and experimentation and a large variety of analytic approaches to the data. The proposal is skeptical about whether we can get beyond identifying instances of arithmetic problem solving activity and outcomes (correct or not) to the more fundamental questions concerning the processes of problem solving. We have in fact been much more successful than expected, collecting process data in the course of school-like tasks, the best buy calculation test session and in both supermarket and kitchens. Our analysis of the problem solving processes involved in supermarket arithmetic are presented in detail (section IV of the report). We have not yet analyzed the rest of the process data, but hope to complete it in the near future. Finally, we started with an "environmental demand" model to account for variation in problem solving processes in different situations; we ended up with a dialectical theory focussed on the inextricable interrelations and mutually generative character of human activity and the settings in which it takes place.

Our publication plans have likewise undergone modification, more in time scale rather than scope. Two Ph.D. dissertations will reach completion during 1983 (Murtaugh: A Hierarchical Model of Decision-making in the Grocery Store, and de la Rocha: The Use of Arithmetic in the Context of Dieting: A Study of Practical Problem Solving). In 1982 an Introduction and a chapter were prepared for Rogoff and Lave, Everyday Cognition: Its Development in Social Context to appear, Harvard University Press, 1983. The Introduction is a critique of existing theory and includes a programmatic sketch of the dialectical theory employed in the analytic work of the project. The other chapter (included in this report as Section IV) is a detailed analysis of grocery shopping arithmetic in the supermarket setting. Together these two papers provide a skeletal version of the full book on the Adult Math Skills Project which we plan to write collaboratively as soon as the two dissertations are completed.

The remainder of this report is divided into four sections. Section II introduces the theoretical perspective of the project, using the money management study and other data for purposes of illustration. In Section III there is a description of the various arithmetic tasks we designed and carried out with our informants, followed by an analysis of the evidence concerning the character of links between school-learned arithmetic and the practice of arithmetic in everyday situations by adults. Section IV is an analysis of grocery shopping activity, the supermarket as arena and setting for grocery shopping, and the impact of grocery shopping activity in the supermarket setting on the forms of arithmetic problem solving which occur there. This section is being published separately, but is included here because it exemplifies better than any other of our written accounts to date, our approach to the understanding of everyday problem solving. The final section of the report (V.), discussed the implications of our studies for educational policy. Appendix I contains the math tests and tasks administered to all informants.

II. From Universal Standard to Situation-Specific Devices: The Dilemma of General Knowledge and the Specificity of Use

The introduction began with the proposition that there are parallel problems raised by the work reported here. One has to do with relations between the cultural fund of general arithmetic knowledge and what we call the practice of arithmetic in the contexts of our lives. The other has to do with relations between a social institution, school and other situations in our daily lives. In school the teaching and learning of arithmetic is organized in relation to the culturally structured knowledge domain, arithmetic, while generally in everyday contexts, arithmetic takes its structure in large part from the activities and settings in which it occurs. In theoretical terms the first problem is a difficult, old and central one in the social sciences (see Sahlins, 1981 and Comaroff and Roberts 1981 for recent attempts to reconceptulize it). It appears in various guises--structure versus process; competence versus perfomance; norm versus its instantiations; collective knowledge and belief versus individual knowledge and belief conceived of as a refraction or partial version of that collective wisdom. For present purposes our position may be stated in crude form. 1) Arithmetic practice is an active, generative process growing from the mutual shaping of the actor's activity and the setting in which it takes place. But what is generated also bears the stamp of culturally shared general knowledge. After all, the same number system, arithmetic operations, written numerals, weights and measures and monetary units are <u>common</u>

stock, to mention just one small item of evidence. 2) At the same time arithmetic activities are not simply acquired universal knowledge or procedural algorithms. Indeed practical arithmetic skills are not primarily specific algorithmic tools transmitted through universal schooling in this culture. Nor are they applicable, in the precise form in which they were learned, for insertion (like a subroutine in a complex computer program) into any or all situations where arithmetic is called for. 3) The cultural fund of arithmetic knowledge is ordered and taught primarily on the basis of internal arithmetic relations within the knowledge domain. This kind of ordering of arithmetic knowledge stands in complicated, contradictory tension with the richly structured activities of life experience which in their turn give order and structure to arithmetic as practiced. 4) Like Sahlins recently (1981) and Comaroff and Roberts (1981), we see these two orders of arithmetic knowledge as in dialectical relationship, mutually producing, reproducing and transforming each other. Like Comaroff, we view actors as taking normative arithmetic principles and algorithms as resources to be applied generatively in particular situations, rather than as rules to be obeyed or not. The difference between these two views of norms grows, of course, out of dialectical and functional views respectively, of the relations between norms and practice. Thus our work starts from somewhat different theoretical assumptions than most existing research on cognition. 5) Essentially all cognitive psychology, including cognitive developmental psychology, begins with functional assumptions about the one way transmission of general cultural knowledge. Further, they sustain the view that that which is learned, remains unchanged when in use. The notion that knowledge changes every time it is used, infused with and infusing whatever else is "going on" at the time, is foreign to this position. Thus we are arguing a notable more complex relation between internally structured bodies of knowledge and knowledge in use, than is conventially espoused in this field; similarly we advocate committment to the integral nature of activity-in-context, in contrast to the position that there exists high separation between knowledge in the head (even in use) and the activities in which it comes into play.

The second problem alluded to in the opening paragraph is that of relations between school, in which arithmetic is taught and learned, and the contexts in which school "alumni" use arithmetic. The same contrasts may be made here as for the theoretical problem. Thus, the traditional goals of school instruction are to teach powerful general procedures for solving arithmetic problems of all varieties. The varieties are defined in terms of the internal categories and relations internal to the domain of arithmetic knowledge. The term "general" in the phrase "powerful, general procedures" is intended to connote the value placed on the context-free elucidation of arithmetic principles. Indeed, in school, children are taught numerical arithmetic per se. They also encounter what are called "word problems" but which convey a miniature lesson, that content is relevant only as something to be peeled away so as to apply universal algorithms to numerical relations. The term "powerful" in the same phrase is used in at least two senses; to indicate the efficiency, vis a vis some implicit baseline consisting of counting procedures, of arabic place holding arithmetic algorithms--especially with large numbers. The term "powerful" also seems appropriate to indicate the foolproof character of well-learned algorithms, such that if the procedure is correctly, automatically executed, the answer must be correct.

Both generality and power are impeccably valuable goals, shared very widely, perhaps universally in this society. And until recently, the organization of school curricula and the strategy of teaching algorithmic general arithmetic met not only these goals, but lay at the junction of several of the many goals of formal education as a whole. First, they satisfied functional psychological theory about how to produce powerful knowledge in maximally useful, e.g. most general, form. This has long been viewed as a key to the transferability of knowledge acquired in the school setting to the highest possible number of situations outside of school. Learning transfer theory has, indeed, mainly focussed on the acquisition of general principles, in as context free manner as possible (e.g. Bruner, 1966). This has been coupled with the assumption that the more general the individual's grasp of principles the more often and readily she can recognize appropriate occasions for their application. Second, the knowledge domain arithmetic, as part of formal systems of higher mathematics, contains highly valued information. It is a treasured part of the cultural heritage. Part of being a cultured human being is to be mathematically literate. To some extent, therefore, mathematical knowledge is a goal in and of itself without regard for its uses. And it follows from this perspective that it is appropriate to employ the structure of the knowledge domain itself as the motiviating, organizing principle for its teaching and learning. Third, public schooling is the first step in the education of a small but crucially valued elite whose function is to creatively increase the cultural fund of knowledge. This, too, is compatible with the other goals for the teaching, learning and anticipated subsequent uses of arithmetic.

But once a goal of practical utility, adult competence, or survival skills for the everyday world is added to those above, it creates contradictions with the other goals, and especially with the focus on the internal structures of arithmetic as the basis for organizing learning experiences which will translate into useable procedural knowledge in other settings. All aspects of the investigations reported here converge on the proposition that everyday life is NOT like a tossed salad, in which arithmetic is one ingredient, which like all the others, keeps its separate identity and integrity, making co-appearances with other vegetables in the salad bowl. It is much more like a good bowl of chili, where each of the ingredients is transformed by association with the others--in the end barely recognizable, and tasting different.

We don't intend to recommend our position merely by asserting it, either in its immediate metaphorical guise or in its more serious development in the last few pages. Instead, this report is intended to lay out the analyses which catalyzed our move towards this position. We will try to recreate the kinds of experiences which have gradually drawn us away from an orthodox view of schooling, cognition and the practice of arithmetic in everyday life.

This brings us back to the parallel nature of the theoretical and practical problems. How is it that we find parallel dilemmas arising over the generally shared and uniquely situation-specific aspects of knowledge on the one hand and our conceptualization of relations between scholing and everyday life on the other. The commonality is not accidental, and perhaps a major argument to support this assertion comes from simultaneous shifts in current views as to the importance of contextualized understanding of the nature of human activity. Our theoretical position is one instance among a growing body of criticism of positivistic, functional theory in the social sciences. There is increasing interest in dialectical theoretical positions which emphasize the integral interrelations beween activity and the contexts in which it occurs. In developmental psychlogy there is much more concern for problems of ecological validity and the relevance of experimental findings for activities in the everyday world. It is but a small step to make relations between the teaching/learning experiences of schooling and the uses of knowledge in everyday settings an object of inquiry rather than an implicitly assumed "fact" in this society. Indeed, schooling may be thought of as, among other things, the institutional embodiment of the same curents in Western thought that have produced our psychological theories. Not incidentally, those same theories are under more serious attack today than at perhaps any time since the inception of psychology as a scholarly discipline at the end of the 19th century. The appropriate nature of schooling is likewise in serious question.

We have so far argued that goals for schooling which place value on its relevance to everyday life activities stand in contradiction to several other major goals informing the educational system. To take a position emphasizing the situational specificity and generative nature of arithmetic activity in everyday settings is to underline the contradiction. Let us first proceed to the evidence that compells us to do so. In the last section of the report we will then consider the question of what implications the work may have for educational policy.

A. Money Management

The pilot work on family money management, conducted by Katherine Faust, provides a vivid introduction to the dilemmas of integrating general.knowledge with everyday practices. For our system of money provides a universal standard of value and a universal medium of exchange. At the same time, money is involved ubiquitously in everyday activities. Faust's study was carried through to the end of pilot interviews and the development of a conceptual scheme for pursuing the subject. Therefore the lessons to be learned from it are mainly general ones. It will be useful to have on record in as much detail as we can muster, the preliminary findings. It looks very promising for further research in the future.

First of all, the anthropological literature is full of contrasts between the special purpose monies of "primitive" cultures, where beads may be exchanged for pigs and iron bars for women, but not the reverse; and they are not, as standards of value, translatable between systems of exchange. In contrast, Western cultures are noted for having a single medium of exchange, money, providing also a universal standard of value.

Yet money passes through families, and according to Faust's work, we can capture the major cyclical flow of money in terms of income(s), stashes--various compartmentalized modes for the holding of money temporarily--and expenditures. There are different media of exchange, including cash, checks, and credit cards (special and general purpose). Incomes, stashes and media, in many combinations are used to create in effect, special purpose monies. In particular, they are used to create categories of monies that may not be treated as equivalent; these prohibitions having the same moral character as those surrounding special purpose monies in other societies as well. One gets the impression that a universal standard of value and medium of exchange is not viewed as an advantage by our informants, and that enormous effort goes into creating paths and flows of money which both produce and reflect the particular character of different value-expressing activities of daily life.

The anthropologist Mary Douglas has promoted this view of money use in Western societies. She has noted the parallels between special purpose monies in other societies, and strategies used by individuals in Britain, "to reduce liquidity by blocking, earmarking, and funding it (money) in various ways." (Douglas, 1967:119, in a paper entitled Primitive Rationing," in Raymond Firth, Themes in Economic Anthropology). There are many examples of the use of special purpose monies in the money management systems of the people in our sample. For example, one elderly couple maintained two separate sets of checking and savings accounts, one set for bills and day to day expenses, the other set for larger expenses, gifts and taxes. The wife was responsible for the bills accounts, and the husband was responsible for the tax related accounts. She states:

> I have a checking account I pay my bills out of. And then we keep a small checking account out of that other money. But we don't write checks on it unless, like, for example, little E--little E--six foot six--needs something or god sons need something, it comes out (of) that money....(Later): Now taxes, anything on that, that's E's (her husband). Anything big, like when we ran into this thing like the surgery. That just, of course wouldn't fit my figures at all. All that came out of his money. Eighteen thousand dollars . . . ..

In addition, she has a separate cash fund which she refers to as "mad money."

> Faust: Do you have a sense of how much cash you have on hand?
>
> Informant: Every bit. I'll tell you that's a joke especially around here . . . I keep about one hundred dollars in mad money in the back of my wallet and E'll say, honey could I have twenty dollars out of your mad money. Or--he'll say, C., I'm out of money, can I have ten dollars out of your mad money. See, I keep about one hundred dollars that don't count. That's mad money. But they all pay me back.
>
> Faust: What kinds of things do you buy out of mad money?
>
> Informant: Things you want to buy. I love to do ceramics. They're foolish because you know I have no place to put all the things, that--
>
> Faust: Is that separate from the cash you might use if you're going out to lunch or something?
>
> Informant: Really you shouldn't spend it on lunches. Nobody else probably thinks the way I do about some things.
>
> Faust: Why do you say that?

> Informant: Well, everybody, all the women, all the ladies I know they put their money in their purse, just dump it in their purse, and they just spend it the way they want to spend it. I don't do that. If I don't have it to spend, if I want to buy something that I feel isn't necessary, I always can take it out of my grocery money. If I didn't have any mad money, I just wouldn't buy it. I wouldn't even charge it. I wouldn't charge anything that I felt was foolish. Because I don't think that's a necessary evil.

Other examples of compartmentalized distinctions among stashes of money include Christmas Club accounts, separate checking accounts for bills versus personal expenses, or a separate account for vacation expenses.

The second aspect of this work had to do with the organization of the family and the expression and creation of those relations in monetary terms. There are contradictory relations between money, utilitarian exchange, adversary relations between buyer and seller on the one hand and altruistic exchange, solidarity and collective well-being, ideals associated with the family. This presents the family with dilemmas about how to negotiate the entry, internal circulation, and expenditure of money. In her interviews, Faust found the problem beginning with pay checks. A pay check is inextricably "owned" by a family member, yet ideally once money is associated with the family, its source should not be attributable to any individual--it must be transformed into collective property. Thus, in the twenty-five interviews conducted by Faust, there was only one case of regular direct transfer of cash from one spouse to the other. This was couched as an even split between the two spouses, although it was the husband's salary money. (The explicit description of what was going on "division of the spare cash" was more acceptable to the spouse supplying the money than to the other, who was keenly aware of the contradictory, other conditions present on these occasions.) Such transfers are too close to payments, which would change the meaning of women's work with household and children in a capitalized economy.

There are several common strategies for bringing about the transformation of money from individual income to collective resource. Informants deposit money into a checking account for which both spouses have check-writing privileges; very often the spouse who draws most heavily on the account for family expenditures is not the one who has made the major deposit. In two-job families, both checks may be deposited into a single family account, thus erasing the specific association of particular dollars with a particular individual. A third method of "laundering" away the individualistic connotations of particular sums of money is to allocate one pay check to certain specific expenses for the family, so that in effect, it becomes redefined in terms of its uses instead of in terms of its source. Thus women will say that they work part time in order to earn the family vacation, or extras of various kinds. And sometimes cash is deposited, often in equal amounts by spouses regardless of income, into a "teapot"-equivalent, for specific everyday expenses (the laundry, gas money, busfares, children's lunches, parking meters, etc.). It has been remarked in the anthropological literature that the characteristics of paper money--its impersonality, and interchangeability and easy concealment, compared with cattle, has affected the institution of bride price. For it is impossible to tell whose contribution to a money stash is specifically being spent on any given occasion. Yet if contributions to bride price are in cattle, it is clear what each cattle owner has contributed. In the interests of emphasizing the collective nature of the family in this culture, the various means of handling money are designed to mask its individual sources within the collective family unit.

In terms of expenditures, the problem of collectivity is relatively less difficult than that of individuality. Family members are at one and the same time part of a collective social unit and they are individuals, most of whom spend much of their time in activities with peers/coworkers, etc., outside the family, so that in both practical terms and in symbolic terms, there are conflicts between the collective definition of family and the independence of family members as individuals. This dilemma comes out clearly in at least two ways: first, the family as collective stands in contrast with the organization of many families in this society which are composed of two previously constituted partial families from previous marriages. The pattern of allocation of pay checks, and of responsibility for family routine expenses looks quite different beween the two kinds of families, and as one might expect, expenditures are kept far more clearly labelled separately within the families formed of two individuals and their children from previous marriages. Much of this has to do with differential expenses for children, which involve former spouses not present in the household as well as household members. It involves the coming together of two spouses who very often have each been sole providers for their households and who merge families not when there are two people, young, small incomes, no dependents, no history of independent family management, but at a time when mechanisms are already in place for the independent management of complex family arrangements. And finally, the clearer separation of expenditures may reflect reactions to the painful financial disentanglement process of divorce, if the earlier collectivity had strongly emphasized the collective nature of income, stashes and expenditures.

Figures 1 and 2 illustrate two quite different systems of money management. Figure 1 illustrates the flow of money for a young couple without children. Both husband and wife have incomes which they pool in joint checking and savings accounts. Most expenses are viewed as communal, and are paid for from the joint checking account, as are their individual expenses, such as clothing, etc. Figure 2 illustrates a family in which each spouse has been previously married. Her children are living with them, and his children are living with his first wife. In contrast to the first example, this couple keeps their finances essentially separated. They have no joint accounts, and in paying for household bills each one writes a separate check for half of the total from thir own checking account. The only direct transfer of money between them is a set amount of money which the husband gives the wife each month to cover one quarter of the food bill, which she pays for from her own account.

The second dilemma associated with individuation within the collectivity, has to do with what amounts, and in what media shall spouses, and for that matter, children, have monies for which they are not accountable to the family. Accountability can start with the

Figure 1. Young Family with Joint Accounts

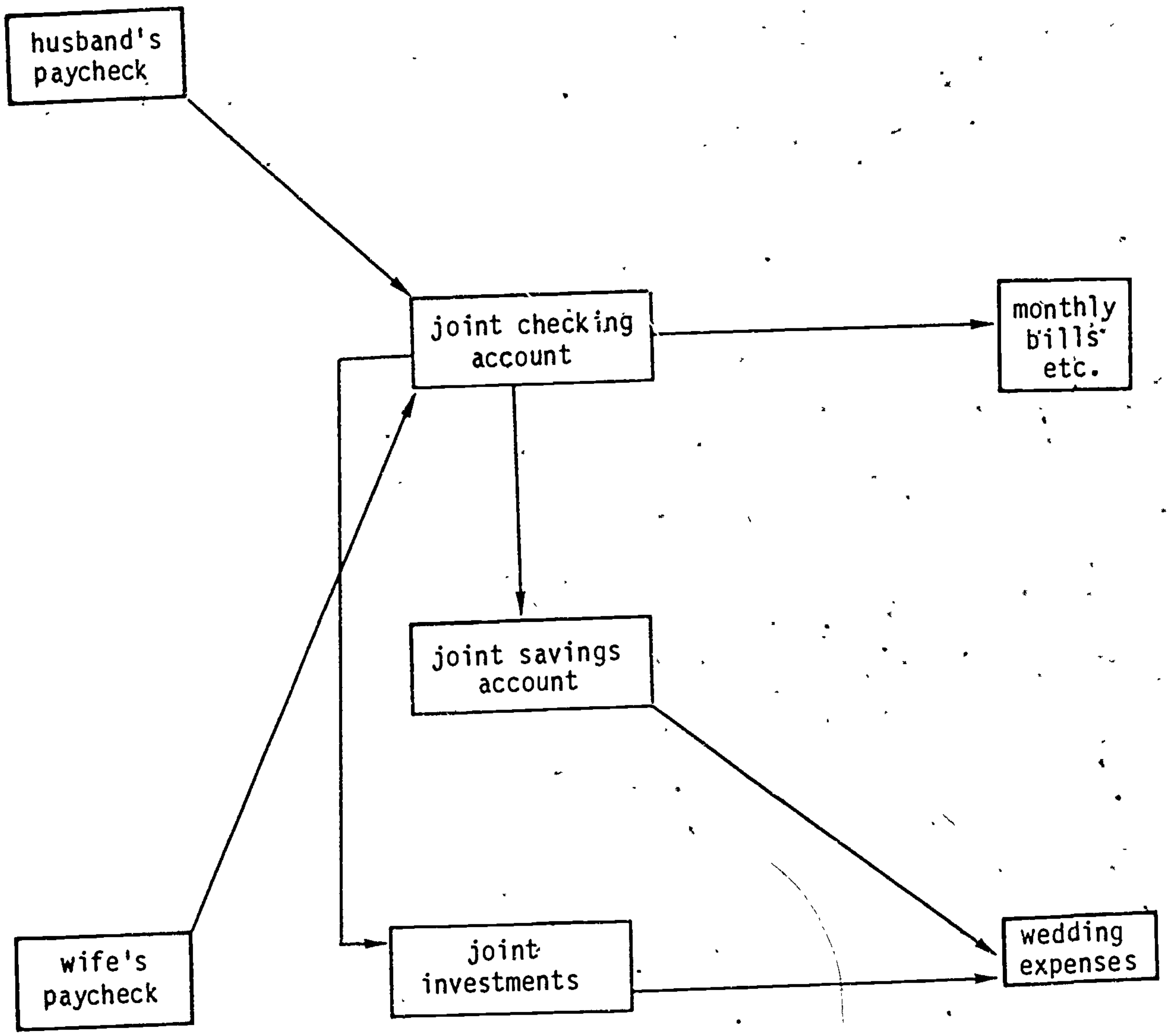
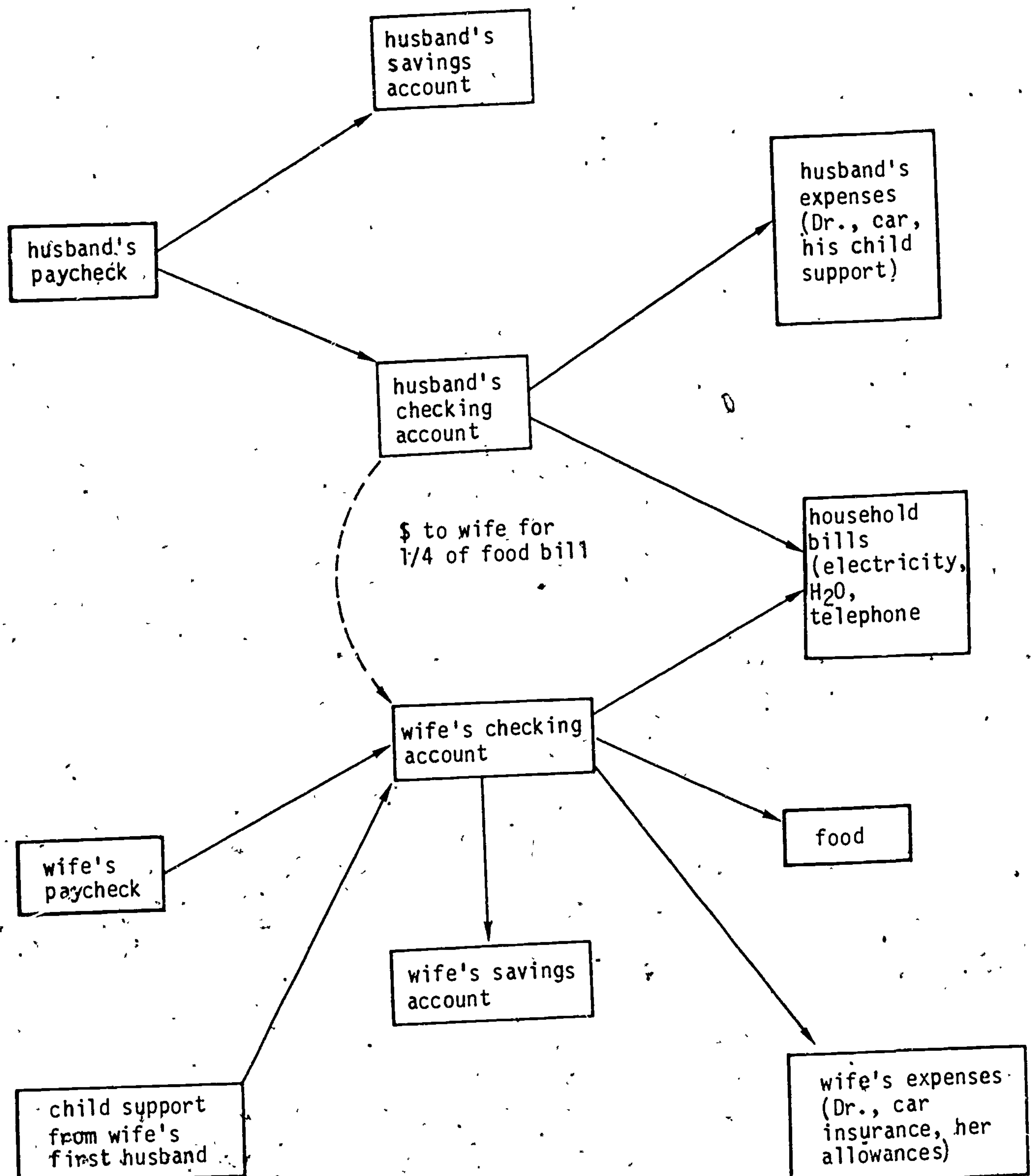


Figure 2. Reconstituted Family with Separate Accounts



question of how much income is being generated by the individual; and go on to kinds of stashes it is assembled in and what it is spent for. Here there may be variation growing from the changing division of labor within the household. Older women have what they call "mad money." (The description quoted above is typical.) Significantly, it comes from monies established as collective in their uses--household expense money. Mad money is the reward of frugality and good family management, set aside when there is money left over after the payment of routine family expenses. As the quoted example suggests, it is to be spent frivolously and may not be used for family expenses. It is not that it never is used for family expenses, but the incommensurateness of the mad money and collective funds is indicated in Faust's interviews by explanations that it may be borrowed--but must be replaced, not simply used for other purposes. The description of its uses emphasizes the gender-specific and specifically non-utilitarian character of appropriate mad money. The message is one of individuality in action, but defined in relation to other members of the collectivity. (Its frivolity probably defines it in relation to children's needs as well as the spouse.) There are male versions of mad money, spent according to the same principles, but in this case on beer, bowling and cigars. The man's individual fund of money for which he is not accountable tends not to be so stressed in interviews, for the man has direct access to personal funds out of income, unless he turns over his income to his wife, and receives spending money back from her, which is sometimes part of the laundering process to produce collective monies. This stands in contrast to women's personal funds, which are obtained through a series of complex transformations, from spouses' income, to collective funds for collective expenditures, to skillfully saved surplus, and finally to individual pocket money.

Families in which spouses have significantly different incomes, the wife working part time and/or for very low pay, appear similar to families in which the wife does not work for pay at all. However, families with both spouses employed for incomes that would at least marginally suffice for a whole household, tend to find the individuaton of some (in all cases minor) portion of funds for private use less contradictory and less difficult. They tend to have three bank accounts--his, hers and theirs. Each contributes substantially to the joint account, saving a small portion in private accounts. Thus, the small portions simply aren't put through the transformation into collective funds.

The picture is incomplete without including children's uses of money and the interrelations between parents and children concerning the transfer, transformation and control of children's monetary moves. But at this point in time we have no data to report. Also, we have concentrated here on complex family situations rather than on single person or single parent household, for the dilemmas are attenuated in the latter circumstances.

One level of complexity not addressed in this report is the complicated nature of negotiations about money, given that all parties understand the contradictions involved. They know, in some sense, that transformations in the meaning and compartmentalization of money in the family context violate the public scheme of Western values and practices concerning money, power, control, the individuation of relations, etc. They know that the management of money within a social institution based on collective solidarity is a contradiction in terms. Thus, money management must have as much to do with managing the contradictions as it does with the transfer of dollars and cents from income to stash, or from stash to expenditure. Any analysis of arithmetic activities associated with the management of money must take these factors into account.

I have said very little so far about the media of exchange and their variable use, and their relations with stashes. Most bills are paid by check; but whose check, from what account, provides multiple possibilities for differentiation among special purpose stash/expenditure combinations. Checks have some security against theft if sent off into the public domain; they act as record keeping devices at the same time that they are expenditure devices--records being desirable by the system of taxation, among other things; checks also provide automatic receipts for expenditures. Most regular bills--mortgage or rent, utilities, and credit card bills are paid by check, then. Cash, like checks, has customary uses--sometimes by size ("under $10, I pay cash"), sometimes by category of expenditure--"I always pay cash for gas" and/or groceries, etc. People create various cash stashes; generally one in the billfold of each adult, a "petty cash" fund in a teapot-equivalent; piggy banks; a dish of change for parking meters or laundry or telephone, etc. Stashes of cash, like checking accounts, are designated for special uses, and their use is circumscribed by special restrictions on ease of access and transformation of purpose. They are also circumscribed by conditions under which they may/must be replaced, and by devices for replenishing them consistent with their customary rate of use. Hence, on a smaller scale than checking accounts and credit cards, where devices for keeping track of rates of flow are also essential, the expenditure of cash may be modified to fit flow rates within a pattern of routine cash acquisition activity. To use cash, or not, for a particular expenditure, is a multifactor decision which involves knowledge of the state of the stash vis a vis typical cycles of cash in- and out-flow.

A very interesting question then, in relation to all the various stashes and flows, is how people maintain a sense of "where they are" in money cycles. I don't know the answer. But if there is convergence, as I suspect, between this question, the question (for which we do have data) on how people estimate what their grocery basket will cost them before its rung up, and the management of time in preparing a meal, we can make a tentative beginning. Keeping track of quantitative rates and flows involves a clear knowledge of what is hardcore routine and non-negotiable. This may involve assumptions about which grocery items are fixtures: e.g., milk and bread; or which monthly bills are fixtures: e.g., the mortgage and telephone bill. It may involve similar assumptions at a higher level, about fixed categories of items--purchase four dinners, each with meat, a vegetable, a starch, beverage and dessert, with no expensive cuts of meat except Sunday dinner; or medical and clothing expenses, on average per month. Next, it requires a sense of the unusual, the unexpected, appended to, or subtracted from that basic ballpark figure.

Credit cards are especially interesting in this regard. Here is a medium, which might be described also as a "negative stash," otherwise known as credit. Some credit cards stipulate their own special purpose stash nature (gas credit cards are the major examples). Others provide general purpose stash capabilities, but no one uses them that way. Either they are defined in contrast to other media--use credit card if over $10, instead of cash (relations with checking are more complex), or in terms of expenditure categories--restaurant meals, travel expenses, prescription drugs, gifts, etc.

We wondered about the difficulties involved in using credit cards. Faust's queries about how people keep track of the amount they spend on credit cards revealed two strategies. 1) One involved keeping receipts, though almost no one admitted to adding these up at any time other than when paying the monthly credit card bill. 2) The other strategy involved keeping track mentally. Three strategies for keeping track mentally are typical. First, some informants keep a rough running total. For example, one woman stated,

> I do have a sense in my head of what I've done so that I know that I spent, for instance, about fifty dollars the other night at the Broadway and I think I have about a twenty five dollar balance on there so that would make seventy-five dollars . . ..

Another woman stated that for her gas card she filled her tank each week and it was about twenty dollars each time. This is similar to a second strategy by which people assume their total will be close to what it usually has been in the past. That is, they rely on the regularity of their expenditures. A third strategy for keeping track involves monitoring individual purchases. One woman states,

> As long as it's not over thirty to fifty dollars, I figure it will fit somewhere.

Keeping track of credit cards is one instance of the more general problem of managing the flow of money through the family, that is, budgeting. Faust has found that budgeting activities are best described as a strategy through which people use their knowledge and experience with the regularities and synchronization of inflows and outflows of money to plan for and meet routine household expenses. This contrasts with common normative and prescriptive notions that budgeting is a matter of planning how money should be properly allocated to the different categories of expenditures.

We can examine the concept of budgeting further by focusing on another small part of a money management system: strategies for bill paying. As with other types of money allocation, bill paying requires expectations of future expenses. People's expectations are based on their routine experience with the regularity of income and expenses across some loosely specifiable and regular period, for example, a month or a pay cycle. On a monthly basis people rarely write down figures corresponding to the amounts they intend to spend for various categories of expenses. That is they do not keep normative prescriptive budgets.

People do, however, pay bills which arrive on a month to month basis, and receive income which is often viewed in a monthly frame.

One common strategy for bill paying is to meet the absolute necessities which must be paid in full to avoid severe consequences (house payment, utilities, loans) and then pay variable amounts on credit card bills and other contractable bills (doctors, dentists, etc.) subject to the qualification that "enough" be left over to meet the day to day operating expenses.

It is clear that since this strategy depends on expectations of routine expenses across a monthly (specifiable) period, any major non-routine expense such as insurance or taxes which is large and occurs on a cycle longer than a month will be problematic. That is, it can knock the props from underneath this sort of plan or budget. As indicated by the woman quoted above, these expenses will be particularly troublesome for a low income household where the money allocated for day to day expenses is very close to the amount absolutely needed. A strategy of paying variable amounts on bills can require considerable calculation on a day to day basis, but for some households such a strategy is unavoidable.

A major step toward resolving the paradox in how people talk about budgeting is therefore to recognize tht the word "budgeting" is used to refer both to long run planning and to the day to day performance of household money management. The routineness of income and expenses provides the basis for expectations about the usual level of expenditures, and a strategy of allocation which makes it possible to coordinate multiple expenses without a normative budget. The problems of how people keep track of credit card expenditures, pay bills, and indeed manage whole budgeting strategies, is especially interesting because they address typical problems of flow management in circumstances in which conflicting goals, multiple media, and complex timing of in- and out-flows, all contribute to the circumstances in which the calculations to be made involve complex quantitative relations.

We have so far presented our analysis of the context of arithmetic problem solving within the complex activity of money management. Had it reached completion, it would have involved detailed analysis of arithmetic activity in the context delineated above. There are instructive results of the project, even so. First, Faust has developed subtle methodology, that is capable of organizing money flow data--unlike most descriptive studies and all normative ones. Her work develops both theoretical (family organization, money as symbolism with different meanings in the family context and market place) and specific (analysis of flow, stashes, accounts, etc.) reasons for describing the process as one of differentiating, transforming, masking, moving and tracking monetary flows. It is not a matter of making overlapping cycles of income and expenditure concrete--a teapot full of cash is described as "having no money" if the plumber must be paid. Instead, it is a matter of making such cycles specific--trackable within the parameters of available sums of money. "Specific" in this context implies that some segment of activity is integrally structured in relation to the ongoing activity-in-setting of which it is a part. Structured in this way, it may be general and/or specific with respect to the structuring of knowledge domains, of course. It brings into question the role of arithmetic in producing specificity, for the complex structuring of money in practice seems to take place at more inclusive levels, in the creation and maintenance of distinctions among stashes and media rather than at the levels at which arithmetic is practiced. This conclusion fits with the results of the supermarket arithmetic study. As we shall see, the latter argues that the role of arithmetic is not as financial management instrument, but as rationale for difficult discriminations when qualitative selection criteria do not produce a specific choice of grocery item. Like the other studies, this one suggests that the crafting of specific structures for money management, in intimate relations with the structuring of life activities and the settings for these activities, creates enormous monitoring potential for keeping it all straight without making "keeping it all straight" a major activity in and of itself.

B. Measurement and Calculational Devices

The lessons of the money management study resonate very strongly with one of the findings of the Weight Watchers study. de la Rocha reports that Weight Watchers go through a process, first adopting careful measurement principles using measuring instruments, then abandoning them for personal measures--pinches, bites and the baby's old cup. They use specific, familiar containers with which they can approximate ingredient-measurements perceptually with very high accuracy. Salad dressing is very often made this way, in an old mayonnaise jar or some such. Here, as elsewhere, the construction of activity-specific jigs for getting the job done aptly describes these everyday activities.

The lessons of the money management study also resonate strongly with the results of another small study which we carried out very much as a sideline. This we call a "Device Inventory." In a pioneering work on the cross-cultural study of arithmetic, Gay and Cole (The New Mathematics and an Old Culture, 1967) reiterate a contrast which parallels the standard "primitive/civilized" sterotype about presumed differences in the nature of money: that measuring devices in primitive cultures are fragmented, specialized devices for doing a single job, not universal standardized units of measure, translatable in large degree between related scales (e.g., the metric system is touted on these grounds as preferable to the British system of measurement). However, we believe Gay and Cole have recognized properties of measurement systems-in-use which are true for our society as well. We conceive of most quantitative predicaments as ones of flow and cycle, like money, and most calculations and measurements to be first and foremost checking devices on perceptual or other customary estimation procedures. We also take the money management findings seriously. From these considerations we conclude that it is the multiple, rich connections between the structure of the quantitative dimension of activity, and the structure of that activity in its setting, which provide the most powerful monitoring potential for individuals who must "keep track." It should not be surprising, then to find special-purposes "stashes" (to borrow a metaphor) of numerical information lying about the environment, and such is indeed the case. A survey of the local ten cent store produced a list of 80 separate measuring and calculating devices intended for home use. We began keeping a list of measuring and calculating devices. We had two goals in mind. The first was to inquire which of the devices our informants had in their homes and which they used. For those which, like money and universal measuring devices such as tape measures, are supposed to be available for a wide range of tasks, we asked people what they used them for. And finally, if an informant didn't have a particular measuring or calculating device, she was asked how she managed when in need. Thermometers provide a good example of the high degree of variety and specificity we have discovered. There are indoor and outdoor air-temperature measuring devices; oven thermometers, temperature regulators in refrigerators, candy thermometers, and fever thermometers (two kinds). The uses of each are quite specialized; the scales are limited in range, rarely adaptable to more than one use even if someone, atypically, was so inclined. Further, most are designed so as to be specially marked at points that allow easy assignment of qualitative meaning to points or regions on scales--98.6° on the fever thermometer, "soft-ball" stage on the candy thermometer, "rare," "medium," and "well-done" on the meat thermometer. With repeated use it is not the degrees but their substantive significance which governs use. They become transformed in use into effective jigs for everyday operations.

At this point in the argument two cautions may be useful. First, there is a tendency within the social sciences, perhaps especially within psychology, to treat evidence for the situational specificity of cognitive activity as a defeat for the development of general theory. But there is no need for this conclusion. Instead, it is more useful to take as the object of study the rich, intricately structured specificity of peoples' activities in the recurring settings of their lives, and theorize about that. Second, there are two ways to interpret the very general characteristics of everyday activities so far laid out. Again, the caution is focused on more traditional theoretical positions. There have been some attempts to characterize everyday life--in toto, and in the most abstract terms--as simpler in its cognitive demands on the individual than the demands of the experimental laboratory. Only very recently (e.g., Latour 1981), has this assumed contrast been subjected to close empirical investigation. The results emphatically wash out the distinction.

The characterizations of mind in action proposed here are therefore based on a different set of assumptions than the conventions which take cognitive processes to be universal across situations and assume that these processes are brought to bear to different degrees in response to variations in a single abstract dimension which could be glossed as "the stringency of situational demand." In contrast, we take it that in any situation people bring to bear a relatively constant fund of energy and attention; if asked to solve math problems in a test setting they will devote energy and attention to that task, skillfully doing the social management work necessary to minimize other demands on energy and attention; in the grocery store the same energy and attention go into grocery shopping; arithmetic gets a proportioned share of it, in general quite small. The complexity of cognitive activity on the face of it seems likely to be much greater in the grocery store. The contradictions in this setting between the need for math accuracy, but minimal math effort, would seem to create cognitive demands not found in experimental situations. But let us adopt for the moment the more conservative position that all situations are equally complex, cognitively. Then arithmetic may be shaped by quite different considerations in different settings, including differences in appropriate effort and attention, but situations per se probably do not vary much in these very general attributes. In short, we have adopted the information processing constraint model of cognitive psychology, but applied it to situations rather than to specific cognitive tasks.

To reiterate, then, we begin the exploration of arithmetic data in everyday settings with a conviction that the procedures encountered are relatively specific to situations and variable across them that this is the proper object of theorizing; and that general theory is the main goal of the project. And we also take it that the variance in performance across situations will be interpretable in qualitative terms, in relation to the rich structuring of activity and setting, and not in terms of variations in individuals' energy and concentration on arithmetic, nor in terms of the specific demands of individual tasks of the kind most common in cognitive experiments.

III. School Math Links with Other Situations in Which Arithmetic is Used

We have just argued that new understanding will be found through the analysis of (1) activity and setting, (2) the role of particular cognitive tasks in that activity-in-setting, and (3) cross-situational comparisons based on descriptions of problem solving processes rather than on indices of pe-formance. There is, nonetheless, preliminary work to be accomplished by exploring relations beteen performances in one setting and performances in others. They will serve us on the one hand to establish the claim that people do act differently in different settings. On the other hand, they make it possible to address a number of existing theoretical speculations about the nature of small-scale problem solving (everyday or otherwise), and learning transfer.

Perhaps the first point to be made about the enterprise of tracing links between school math and the uses of arithmetic in everyday life, is that it is impossible, except by crude approximations. The truth of this proposition could be established on many different grounds, of which two will be discussed here. First, if we are to assume that math used in everyday circumstances was learned in school, we must assume that school is the only place people learn arithmetic. Second, if indeed people learn arithmetic in other places as well, we could only establish its origins in schooling if the arithmetic learned in school is different from the arithmetic learned elsewhere. The first is indefensible (see especially Herb Ginsburg's work on children's arithmetic). The second offers us limited possibilities, for there are characteristic pencil and paper, place holding algorithms, especially some in which the spatial layout of the developing calculation has been rigidly taught, that probably are not learned for the first time anywhere except in school.

But it would be a mistake to consider the problem to be one of natural history--one that will give way to the equivalent of magnifying glass and butterfly net. If it were, it would be more than anything else a matter of identifying and classifying specimens of arithmetic activity, perhaps paper and pencil algorithms, in various habitats. And such an approach would almsot certainly end in a quick conclusion that school arithmetic is rarely found in other situtations, and this might be a too hasty dismissal. Instead, the question is a theoretical one, and depends, as has been stressed in the first two sections of this report on what relations are assumed between general knowledge and its uses; between activity and its settings.

One specific research question, for which different assumptions would lead to different expectations about empirical phenomena, would be the following. If schooling expands the generality of understanding of arithmetic principles, they will transfer to more situations. An alternative is that the better memorized specific pieces of arithmetic knowledge and the more well-drilled the routines of problem solving, the more they will be incorporated into other activities. We have attempted to gather evidence concerning both.

Another specific research question has to do with the variablity of procedures across settings. This variability is overwhelmingly supported by our investigations. But it might be the case that components of school learned math are incorporated into otherwise varying procedures.

There appears to be some litte evidence for the learning and use of basic integer arithmetic, though not for paper and pencil algorithms in general, in all settings in our lives, including school. But there are many other arithmetic procedures employed in other settings that are not taught in school. And we find little evidence that efficacy at formal arithmetic problem-solving is related to efficacy in arithmetic problem-solving in other situations; or that control of relatively more arithmetic "facts" affects frequency of calculation.

Another specific research question asks whether there is variation in performance levels across situations as well as in arithmetic techniques. A positive finding would bring into question the relations of schooling and other kinds of situations (regardless of which ones were associated with better performances) with each other. In particular, variation across situations in performances by the same individual raises the question of what it means to be alumni of a concentrated exposure to arithmetic, over increasing time spans. If individual performances vary across situations, we may also inquire into the extent to which schools or test performances provide adequate baseline evidence of "best-performance" capability. Our data suggest that they may well stand as just one among a varied collection of performances.

So far we have addressed the problem of tracing links between school math and the uses of arithmetic in everyday life in terms of arithmetic practices themselves. But how and when people choose to calculate is partly a matter of the culturally assigned meaning of arithmetic. School arithmetic stands in the same relationship with arithmetic practice in daily life as money and general systems of measurement do with their respective uses. They are valued cultural resources; all of them express and are symbols of rationality, science, objectivity and utility. But especially since these are valued norms, it follows that much of the everyday practice of arithmetic is either not recognized to be arithmetic, or is uncomfortably discounted as not "real math." We will come back to this in sections IV and V. Indeed, it is in part the very characteristics which make universal standards of value, systems of units, and procedural algorithms universal that makes them unserviceable in everyday practice. For their structure stands in conflict with the structure of specific activities, yet their role in these activities is too peripheral to motivate complex interface development. Instead they are transformed and thereby take on rich new and useful structure within on-going activity as we shall see especially in section IV.

If the problem of characterizing links between school math and daily practice is theoretical in the first instance and effectively impossible in the second, how do we propose to proceed. The answer must surely include the proposition that the proceedings will be crude approximations, and the results tentative. We begin in part (A) by describing the activities and sample of informants with whom the data were collected. Part (B) of this section discusses the arithmetic procedures and performances encountered in various settings and their implications for school links to other settings. In part (C) we will present the statistical analysis of relations between school arithmetic and arithmetic practice elsewhere.

A. The Sample and Other Constructs

We chose to work with a relatively small number of people--thirty five in all--but very intensively. About forty hours were spent with each, and this represents an even greater investment of time on the part of the field researchers (de la Rocha, Faust, Murtaugh and Migalski), for they planned their appearances to coincide with ongoing activities in the lives of the informants, while all activities took place in the personal settings of informants, so that no economies of scheduling or centralizing field activities were possible. Each study invloved extensive background interviewing and math testing, one or more core participant/observations sessions in grocery stores and kitchens, (for which transcriptions of tape recordings have been combined with observer notes and descriptions of the activities and settings and their relations), and multiple special interviews and discussions concerning what happened during the observation sessions. The goal was to try several methods obtaining data that might converge on the same theoretical problem, helping eliminate the artefactual basis of some one-method studies, without descending into diffuse eclecticism. Convergence would also suggest a certain robustness to the findings.

Taking the option of doing intensive work with a small number of informants led us to another decision as well. With thirty-five people randomly chosen we could technically hope to generalize from our sample to some appropriate population, but just barely. Also, given the amount of time demanded from informants and our intrusion into the informants' homes and customary routines, we could not recruit people through the usual random sampling techniques. For the supermarket study, we therefore decided on a network sample, using peripheral personal connections in our own lives as intermediaries who could vouch for us to peripheral acquaintances of theirs as a means of recruiting our first informants; subsequently we both pursued other peripheral two-step links of the same kind, and also asked informants to vouch for us to peripheral acquaintances of theirs.

For the Weight Watchers study an advertisement was place in local weekly advertising circulars, in several communities with varying class/income characteristics. All informants recruited by this means had to be planning to join a dieting organization in the immediate future, but not to be currently members. In both studies care was taken not to introduce our interest in arithmetic into the negotiations, for we were afraid of biasing the acceptance pattern toward those who were expectionally at ease with math, or possible uneasily but obsessed with it, but in any event away from the diversity of views and attitudes which we were seeking.

Before beginning data collection we established a small number of criteria that all informants should meet, and quotas for criteria that we wished to vary. In general, we did not try to maximize the goal of recruiting "typical" informants, but rather, figured we would learn more about everyday arithmetic practice by systematically exploring high variance in the practice of arithmetic problem solving. In essence, we decided to sample many instances of problem solving, across situations whose characteristics we had theoretical reasons for thinking might lead to differences in math practice; and across individuals whose demographic characteristics might theoretically affect variation in arithmetic practice. Yet in a way this is too simple a description; for ultimately we want to build an integral account of arithmetic practice growing out of relations between people-acting and the contexts of this activity.

The characteristics of informants that we set out to vary included amount of schooling, age, time since schooling was completed, and income. In addition, for the supermarket study (n=25) all had to be expert grocery shoppers and major grocery shoppers for their households. For the diet organization study (n=10) all had to be novices with respect to Weight Watchers. All thirty-five informants spoke english as their first language, and attended U.S. Public schools. We imposed this homogeneity on the sample because spoken and written number systems affect the salience of simple arithmetic operations, and customary linguistic forms for expressing arithmetic operations have similar effects. Also, arithmetic algorithms differ from country to country. We made no attempt, however, to control for historical change in U.S. public school approaches to the teaching of arithmetic, or to regional differences. The following table lays out a demographic profile for the sample.

Table 1: Informant Characteristics

	mean	range
age	43 years	21-80 years
schooling	13 years	6-23 years
time since schooling completed	22 years	0-66 years
family income	$27,000	$8,000-$100,000
Number of children in household	1.5 children	0-7
Number of persons shopped for regularly	3.2	1-9
sex	--	3 males, 32 females
Use of math on job	8.0	0-20

The variance in age and family income is undoubtedly large. Yet, though the highest income was $100,000/year for a family of two and the lowest was $8,000/year for a family of four, we do not believe we were successful in expanding our sample beyond the middle class. The $8,000 family was in a temporary state of low income. The wealthiest couple had earned their current state of affluence themselves and in a relatively few years. One other modified success was the attempt to separate, through sampling procedures, age and time since schooling was completed. It seemed quite useful to separate these two effects if possible, because they address questions concerning the nature of changing arithmetic performances across the life-span. The correlation between these variables in our sample is almost certainly lower than in the population at large, but they are not completely independent. The sex ratio in the sample is quite uneven, preponderately female. Expert and novice statuses for the grocery shoppers and Weight Watchers, respectively, took precedence over sex as a criterion for choosing informants. Our estimate of arithmetic involvement on the job is a relative one, useful only as a crude means of depicting the contrasting experiences of the imformants. It is simply the number of kinds of job math on a list we supplied that informants say they do regularly at work. It is included primarily to check for interconnections between this crucial educational (as well as work) arena and school, best buy session, and supermarket arithmetic interrelations.

In sampling the informants' activities, the most important construct was that of "school-like" activities. Since all were adult alumni of the public school system, there is no way around the need to accept a "stand-in" for school if we wish to compare the performance levels or substantive procedures for arithmetic between school and other situations. (Perhaps there is comfort to be taken from an argument intended by its author to support the position that investigating problem-solving in schools is sufficiently like experimental conditions to obtain rigorous results. Here we turn it around, to argue that experimentally designed problem-solving tasks are sufficiently like school to provider relevance. Thus Kvale, 1977:186 comments: "Discarding the laboratory studies of list learning in favor of remembering in natural environments need not imply a reliance on subjective impressions and anecdotes. It is precisely the well-controlled (school) examination situation, where the natural world has become adapted to the experimental laboratory . . . that should secure experimental rigor.")

Table 2: Arithmetic Tasks Carried Out by Informants

School-like tasks	Mediating situations or tasks	Everyday Activities-in-setting
1. paper and pencil arithmetic test	1. solving arithmetic problems mentally	1. grocery shopping arithmetic in the supermarket
2. standarized multiple choice test on arithmetic	2. recall of arithmetic number facts	2. serving portion control among novice Weight Watchers
	3. recall of measuring system facts	
	4. best buy arithmetic problems in a supermarket simulation	
	5. solving arithmetic problems with a hand-held electronic calculator	

We have divided the various math tasks which we observed, or asked our informants to carry out, into three parts. In order to explain in detail how we have pursued an understanding of relations between school arithmetic and arithmetic practice elsewhere, let us examine the tasks one by one.

B. Substantive Links: Descriptions of School-Like Arithmetic, Mediating Situations and Tasks, and Arithmetic Practice in an Everyday Situation

School-Like Tasks

The Math Test included fifty-four problems of various kinds. (This, and each of the other tests and tasks described in the following pages, is reproduced in Appendix I.) These include integer, decimal and fraction problems, each category including addition, subtraction, multiplication and division. (This portion of the test was borrowed practically in toto from the Torque Project at MIT. We take this opportunity to express our gratitude to them.) Additional problems were developed according to two criteria. The first was to explore arithmetic operations a little more broadly than the Torque Test. Hence there are also some negative-number problems and a few which required a knowledge of associative and commutative laws to solve. The second was to allow us to pursue in a testing situation problem solving activities parallel to those we had discovered in grocery shopping arithmetic during pilot work. Thus a number of problems demanded a comparison of two fractions to decide which is the larger. For example, problem 51 says, "circle the larger fraction: 6/3 or 5/4." A final cluster of problems combined a decimal and a fraction (using each of the arithmetic operations). We were interested to know whether there were preferences among the problem-solvers when one numerical expression must be transformed into the same terms as the other. Both kinds of problems reflect our observations that ratios and conversion from fractions to decimals and vice versa are far more common than might be supposed from our stereotypes of everyday arithmetic. This is due, we believe, to the ubiquity with which activity-settings are linked in sequences and cycles such that very often things taken from one setting into another play sufficiently different roles in the two contexts that the quantitative characterization of an item in one setting must be transformed into a different characterization in the next. (Think of buying a 32 ounce sack of rice but cooking X-number of cups of rice.) Fractional compares and transformations from one measurement system to another have not attracted sufficient attention, in our opinion, given their importance in everyday practice.

We thought people might find certain arithmetic operations easier than others. But in fact there are no signficant differences in success with one operation or another. (The highest mean score, for addition problems, was 68%, the lowest, for division problems 55%.) As expected, division appears to be treated as reverse multiplication, just as subtraction is often treated as reverse addition (90-30=60 is assimilated to 30+what=90). Far more interesting are the difference in performance levels for different types of arithmetic. Informants are notably more agile at integer arithmetic than other kinds, while fractions are by far the most difficult. We will explore this question further as the analysis proceeds. Table 3 summarizes the mean scores of 34 informants for each category of arithmetic.

Table 3:

Mean Scores, by Type of Arithmetic and Operation

Type of Arithmetic	Mean Score (in %)
Integers	84%
Decimals	67%
Fractions	48%
Ratio Comparisons	57%
All addition problems	68%
All subtraction probs.	65%
All multiplication	55%
All division problems	55%

Before beginning the analysis of test data, let us introduce the second school-like math task, a set of multiple choice questions from a standardized test. This includes translations between numerals and written numbers; comparison of fractions to decide which is larger; conversion from fractions to decimals, and vice versa; rounding and estimation; taking a simple average; and a few questions about metrics. This selection of questions from a much larger test reflects our particular interests, previously discussed in relation to the math test. Building strong overlaps between different means for inquiring about a single kind of knowledge or skill is typical of our procedures in general. Rather than break the test down here for detailed comparison with the math test, we will utilize only the total score on multiple choice questions. A copy of the multiple choice test may be found in Appendix I.

Mediating Situations and Tasks

The first of these is a set of four mental math problems. We are primarily interested in the procedures employed in solving these problems. But this analysis has not yet been performed. (In this report we have been able to present most of our planned analyses, down to the level of dissecting process data on actual problem solving procedures. This is available only for the supermarket problem solving episodes. We expect to pursue it in the future.) Here we will include only performance scores on the mental arithmetic problems, for purposes of analyzing patterns of performance on different kinds of tasks. A quick inspection of the problems will probably be more useful at this point than further exposition.

A major reason for treating the mental arithmetic problems as possible mediating tasks between school-like tasks on the one hand and everyday situations on the other hand comes from its execution in the head rather than with paper and pencil. We think the techniques for solving problems in everyday situations approximate mental math problem-solving circumstances more closely than pencil and paper math. Further, we have already suggested that paper and pencil algorithms may be the major identifiable approach to arithmetic which may be uniquely identified with schooling. Mental arithmetic also might serve to differentiate between more and less school-like strategies for problem-solving. That is, it is possible to approach mental math problems by visualizing them as if written on paper, and using place holding algorithms beginning at the right and proceeding leftward through the problem as if on paper. Alternatively, the problem solver can apply a host of techniques for decomposing and simplifying mental math problems, so that arithmetic operations are applied to numbers treated as units, rather than to base-10 columns, as on paper. Our future analysis of individual strategies may allow us to differentiate between the individual problem solvers; we expect, however, that the overwhelming majority will use decomposition, simplification and recomposition techniques. This expectation is, of course, implied by our broad finding concerning the situational specificity of arithmetic procedures.

The mental arithmetic facts, and measurement facts tasks were meant to test the hypothesis that specific, rather than general, knowledge is the major legacy of schooling. Very shortly we will look at relations between math fact knowledge and the frequency with which shoppers calculate in the supermarket. But the unusual format of this exercise deserves comment. We thought that perhaps people would be more inclined to calculate in every setting if they commanded a ready fund of arithmetic facts. We therefore asked informants to respond to verbally presented problems with an instant answer, if they had it memorized, or to tell us that they would need to figure it out in order to obtain an answer. Migalski in fact produced a more sensitive scheme, involving pause length between question and response, to measure how accessible the math facts were for each individual.

We did not leave the matter here, however, and developed two indices of mental factual knowledge, one a measure of quickness of access to math and measurement facts, built from the pause data; the other a measure of accuracy as a function of speed. The first is presumed to reflect the confidence of the problem solver, the second the efficacy of the problem-solver at retrieving arithmetic facts. The relations of these variables with others will be discussed shortly. The absence of relations between specific math facts and other arithmetic performances suggests that the nature of arithmetic procedures may differ across settings in ways more radical than previously suspected. This suspicion is born out by the analysis of supermarket math in section IV.

Best Buy Problems in a Supermarket Simulation

The mediating nature of this task is to be found in its relations with grocery shopping arithmetic, thought it also is related to the fraction comparison problems on the math test and multiple choice tests as well. We designed these problems (and also the fraction comparison problems on the math test) to test hypotheses about the procedures used in solving a particular kind of problem observed in pilot work with grocery shoppers in the supermarket. Now and then they wished to figure out which of two or three items was the better buy--would give the most for the money. People sometimes utilized unit price shelf labels in making purchase decisions. But invariably, if constructing their own calculations of superior price/quantity ratios, they compared the two prices and the two quantities, but did not form ratios composed of unlike units.

We can speculate about why they proceeded in this fashion. First of all, they may perceive best buy calculations as an extension of the far more common practice of simply comparing prices for two items of equivalent weight or volume, which would, of course, lead to a comparision of like units. Second, the comparison of like units circumvents the problem of deciding what units the quotient would be expressed in for a unit price calculation. Third, and perhaps most convincing, price/price, quantity/quantity comparisons require two calculations only--the second being a comparison to a target ratio established by the first calculation. Unit price calculations involve two independent calculations, the results of the first being stored while working on the second. Only after the second calculation is the comparison undertaken, as a third step. In short, unit price calculations are more cumbersome than best buy calculations. Unit prices take their utility as public, durable calculational results precisely from their self-contained character, for such a calculation presupposes no particular comparison item--unlike best buy calculations. It may be noted that best buy calculations do not occur at the level of decision making at which the shopper might stare at an entire grocery display and ask, which, among many products, would be the very best buy? Instead, like essentially all price arithmetic in the supermarket (see section IV of this report), best buy calculations occur when the decision process for choosing a particular item has reduced the alternatives to no more than three and almost always to two. Under these circumstances, the specific comparison is a more efficient calculational technique than the unit price.

Twelve best buy problems were presented to each informant, in their home, in a session with the math tester. Some were presented on cards, others involved actual bottles, jars, packages and cans from the supermarket. The quantities and prices on these items were major criteria in choosing them. Each pair of items had to satisfy both the criterion that they required no doctoring of either price or quantity and that they could fill a place in a systematic scheme for varying the ratios involved in price and quantity compares. The informants were asked to figure out which is the better buy for each problem, doing the problems without paper and pencil. After each problem they were interviewed about the process they went through in arriving at an answer.

The principles we had in mind were the following: (1) Neither price nor quantity should be routinely chosen as the place to start in solving these problems, rather, it is more likely that the problem solver would inspect both pairs of prices and quantities, seeking the "easiest" ratio as the place to begin. An "easy" ratio is one which is simple and also precise. Simple ratios include first and foremost 2/1, but also 3/1,4/1,5/1 and 10/1. Precise ratios would include two prices, $5 and $1, or 50¢/25¢, or 48oz./24 oz. Next easiest would be ratios easily simplified to simple ratios: $1.79/.59, an example from our grocery shopping data, is representative. Difficult, but still manageable, ratios would include $3.10/.99. (2) In general, best buy problems are carried out by simplifying the first ratio, "that's twice as much as this," then examining the second pair of numbers to see if their ratio is greater than or less than that of the first pair. (3) Not all problems are best buy problem, and they fall into a simple typology: If A is smaller and more expensive than B, no calculation is required--B is a bargain. If A and B are the same size but different prices, a simple comparison of prices will reveal the better buy. If A and B are different sizes and difference prices, one item smaller and the other more expensive, a best buy calculation is required. The twelve problems include these three types. The bargains, simple comparisons, and best buy calculations could be arranged in order by complexity of the calculation demanded. But differences in complexity don't tax informants it appears, since they were very successful regardless of problem complexity. (4) The data confirm our hypotheses that easy ratios are the major factor in shaping the sequence of calculations involved in best buy problem-solving. People prefer to compare like units to unlike ones, but we purposefully made two problems so that one unit price ratio was the most attractive of the four possible ratios, and in this special circumstance it was the overwhelming choice for the problem-solvers.

Calculator Problems

Very much in the spirit of a small hobby, we have been curious as to whether hand held calculators were in frequent use in everyday situations, and also to what extent people were habitual users. We asked informants how frequently they used calculators, what they used them for, and we also asked them to solve two fairly complicated arithmetic problems on a hand held calculator. Most of them had a calculator. We supplied one for those who did not. But their limited use by informants made this a relatively unilluminating exercise. Twenty of the thirty-five informants reported using a calculator no more than once a month. Only six reported daily use--at work rather than in domestic contexts. The only use reported by the majority (23/30) of informants was in balancing checkbooks. In fact there was very little familiarity displayed with the use of calculators. Many did not know how to set up the problems, even if they had a calculator. They often used pencil and paper to carry the brunt of the problem solving activity, using the calculator only as a simple adding machine. It is also the case that we almost never saw, in casual observation, or among our meticulously observed informants, the use of a calculator in the supermarket. Even one person who announced that she had one with her, and "used it often" in fact used it only once, and that on the last grocery item she purchased, possibly in the interests of verisimilitude. Like paper and pencil, it appears that calculators are too unweildy for convenient use in the supermarket. They require too much hand work to be feasible when it takes two hands to push a cart, another to get groceries off the shelf, one to hold a grocery list, one to hold a pocketbook and several more for children. The major use we shall make of the calculator problems here is in the discussion of ideological links between school and everyday arithmetic practice. In the present section we shall simply include the calculator problem score among the other math task scores for correlational analysis.

Arithmetic Practice in an Everyday Situation

The analysis of arithmetic practice in the course of grocery shopping is the subject of such detailed analysis in section IV. that not much needs to be said about it here. For purposes of the analysis to follow, we have developed three variables, one, the frequency of calculation in the store, per item purchased; another the percentage of times the calculation led to an arithmetically correct solution. In addition, there is a variable reporting how nearly shoppers estimated the cost of the groceries in their cart, standing in the checkout line before reaching the checker. The most erroneous answer differed from the actual grocery bill by 35% but this was the exception to a truly impressive set of estimates, half of which were within 10%. This is especially startling considering the number of items purchased and the size of the bill. It is characteristic of everyday arithmetic to find none of the wildly wrong problem solutions which are found in school.

At this point the means by which we composed the sample, and the various tasks and situations informants took part in, have been described in sufficient detail that we can begin the analysis of relations among them. The central questions guiding the whole enterprise are whether, and how, school learning of arithmetic can be demonstrated to have links with the practice of arithmetic in other settings. It is to these questions that we now turn.

C) Substantive Links: Statistical Analysis

Although we have explored the data extensively using regression analysis, in the end we have relied primarily on simple percentages and correlation coefficients. We often have used them in sets, placing interpretive emphasis on the level of patterns of relations among variables, rather than on individual statistical indices. Table 4 lists the different arithmetic tests and tasks and their associated mean scores.

Table 4 : Mean Scores, All Math Tasks

Math Task	Mean Score (in %)
Multiple Choice	82%
Math Test	59%
Math Test Ratio Probs.	57%
Mental Math	75%
Number Facts	85%
Basic Measure Facts	66%
Best Buy	92%
Grocery Shopping	99%

From this background table it appears that the paper and pencil math problems are the most difficult of the school-like tasks, multiple choice the easiest. Scores on the mental arithmetic problems are slightly better than those on the math test. Informants had an impressive command of arithmetic facts. Measurement facts required no calculation, but it appears that people don't know a whole lot of them. By contrast, the best buy problems did require calculation but were startlingly well done. If we ignore for the moment the two tasks that did not require calculation (one school-like task, the multiple choice problems, and one mediating task, the measurement fact problems), it appears more difficult to do school-like tasks than it is to do best buy problems. But this is no simple function of differences in problem difficulty: it is easier to do ratio comparisons in the best buy problem context (92% correct) than in the math test context (57% correct). This is a really surprising finding especially because the ratio problems on the math test were designed to correspond with best buy calculations, according to the ratios used, their difficulty, and so on. The real news in this table is, however, the extraordinary success rate for supermarket problem solving. This will be a major focus of analysis in section IV.

The apparent variation in success at dealing with ratio problems in test and best buy situations suggests that it might be worthwhile to inspect the correlations between performances on different math tasks (Table 5).

Table 5 :Intercorrelations of Math Task Performances

	Multiple Choice	Math Test	Mental Math	Number Facts	Measure Facts
Mult.Choice	XXX	.86 (.001)	.24 (.05)	.34 (.03)	.34 (.03)
Math Test		XXX	NS	.33 (.03)	NS
Mental Math			XXX	NS	NS
Number Facts				XXX	.44 (.005)
Measure Facts					XXX

Performance success on school-like tasks are intercorrelated. Performance on the mental math problems is not related to pencil and paper math test performance. Knowledge of measurement facts is correlated with knowledge of number facts and with the multiple choice test (on which there are a number of measurement questions), but not with pencil and paper problem solving, as we might expect. On the other hand, total number facts shows a marginal relationship with the school-like tasks (correlations about .33, at .03), though not with the best buy problems or with supermarket math. Most important, (see Table 6, below) the best buy performances are not correlated with performance on any other math task. This contributes to a picture of situation-specific arithmetic procedures and performances, further born out by the absence of correlation between any of the math tasks and the frequency of calculation in the supermarket. (There is one exception--measurement facts. Among the measurement facts, weight and volume facts help to account for variance in frequency of calculation in the supermarket, but not length, as one would expect.) We cannot emphasize too strongly a major finding of this research: that problem solving in the supermarket is virtually error free. In carefully and precisely detailed observations of several hundred calculational episodes in the supermarket, there were only three instances of errors in the ultimate outcome of price arithmetic, all by a single individual. Among other things, this has led us to construct a variable to reflect differences in arithmetic activity in the supermarket. We chose frequency of calculation as the best substitute we could think for performance success.

Table 6: Correlations of Math Tasks with Best Buys and Grocery Arithmetic

Math Tasks	Best Buys	Grocery Math Freq.
Multiple Choice	NS	NS
Math Test	NS	NS
Mental Math	NS	NS
Number Facts	NS	NS
Measure Facts	NS	.39 (.03)

The results so far do not support the proposition that agility at pencil and paper algorithmic arithmetic is a good predictor of efficacy in other problem solving situations. Yet it may be that more subtle relations are masked by treating the math test as a unit, when in fact it may represent several kinds of problems. Even a breakdown between integer, decimal and fraction arithmetic may not reflect the most salient divisions between math most likely to be employed in everyday settings and "the rest." With this argument in mind, we decided to separate basic integer arithmetic from the rest of the math test, and also to single out the ratio (fraction comparison) problems as another subset that might be related to arithmetic in other settings. In the analyses that follow, BASIC math, RATIOS and NEWMATH(the rest of the arithmetic test) are substituted for the math test as a whole. The three are strongly correlated with each other. Thus, the BASIC, NEWMATH correlation is .43 (.001); the BASIC, RATIOS correlation is .37 (.005); and the correlation between NEWMATH and RATIOS is .55 (.001).

Table 7: Correlation of Sub-Tasks on Math Test with other Tasks

Math Tasks	BASIC	NEW	RATIO
Multiple Choice	.45(.001)	.86(.001)	.55(.001)
Math Test	.42(.001)	.97(.001)	.65(.001
Mental Math	NS	.22(.052)	NS
Number Facts	.27(.020)	.34(.023)	.24(.035)
Measure Facts	NS	NS	NS
Best Buy	NS	NS	NS
Grocery Freq.	NS	NS	NS

The greater diversity of correlation levels in this table reflects a greater performance distinction than we have seen before. While ratio problems receive scores similar to the math test as a whole (57% and 59% respectively), BASIC integer math shows a considerably higher mean score (84%). Table 7 provides the information that basic interger arithmetic scores are less highly correlated with other school-like arithmetic tasks than the rest of the scool-like tasks are with each other. Let us inscribe this distinction in the terminology employed hereafter, as that between basic and doodad math. The latter term will take on greater meaning as we proceed.

One way to describe the phenomenon is to say that people seem to know the most basic arithmetic procedures better than we might have expected, given the mean time elapsed since schooling was completed for these informants (22 years); at the same time, it may likewise be surprising how little informants remember about other parts of the domain of arithmetic, given that from the perspective of either the educational system or the discipline of mathematics arithmetic looks like a very small, systematically structured unified body of knowledge. Thus scores on doodad math seem surprisingly low. The terms "basic" and "doodad" are intended to convey the <u>informants</u> probable views on the matter: there is a certain, small amount of arithmetic that is ubiquitously useful in life, and a bunch of mathematical rituals whose only useful context was school, many years ago. (Kathy Larkin's work illuminates the processes by which doodad math is generated by adults in situations like the arithmetic test. She calls the partially remembered algorithms "knowledge islands," and shows how people reconstruct bridges between them, and also reconstruct useful information.)

We must not be hasty about our conclusions, however. It is possible that integer arithmetic is learned in the supermarket and other scenes of daily life rather than in school. In fact, what seems most plausible is that it is learned, honed, refreshened, and used in many different settings including school. Certainly, we know from Herb Ginsburg's work that children arrive in first grade with considerable knowledge of integer arithmetic. What we can add to the picture is the continuation of this phenomenon throughout life.

If such a distinction appears in the arithmetic test, perhaps it will be found elsewhere. Math and measurement facts conform to this same pattern, with an abrupt drop in the number of knowledgable informants when the problems are (literally?) out of the ordinary.

Another way to approach the problem of links between schooling and math practice in other situations is to examine relations between the math task performances and demographic characteristics of the informants But first let us inspect the pattern of correlations among the demographic variables themselves (Table 8).

Table 8 : Relations Among Informant Characteristics

	Sex	Age	School	Time Since	Kids	Job Math	Income	Calculator
Sex	XX	NS	NS	NS	NS	NS	NS	-.33(.02)
Age		XX	NS	.87(.001)	NS	-.30(.05)	NS	NS
School			XX	NS	NS	.37(.02)	.37(.02)	NS
Time Since				XX	NS	-.34(.03)	NS	NS
Kids					XX	NS	.33(.03)	NS
Job Math						XX	NS	.34(.03)
Income							XX	.34(.03)
Calculator Freq.								XX

Sex of informant is significantly correlated (at .02) with reported frequency of calculator use, (more often by men than women). Age and time since last schooling are far more highly correlated than we had hoped. Amount of schooling, income, and the use of math on the job are related, but of course, the causal relationships between these variables is a matter of ongoing debate. As reported earlier, calculator use seems more a matter of use in work settings than domestic ones, which helps to account for correlations between both job math and income and reported calculator uses. We explored this set of variables a little further: Job math is more highly correlated with experience in higher math courses than with the more general variable, "years of school." Whether providing credentials, teaching enabling skills for technical jobs, or both, it is impossible to say here. This constellation of variables is related to performance on the non-basic part of the arithmetic test, though not to basic math, nor to best buy calculations and grocery shopping math. It appears that use of math on the job may provide a lifelong curriculum for the learning and practice of some doodad arithmetic.

Let us look more closely at patterns of relations between math tasks and the informants' age, years of schooling, and years since schooling was completed.

Table 9 :Age, Schooling and Task Performance

	age	Since school	yrs school
multcho	-.52	-.56	.44
%math test	-.45	-.53	.47
% new test	-.46	-.53	.48
% ratios	-.24	-.30	.21
%basic	-.11	-.14	.08
%#fact	.24	.12	.20
%measure	.13	.21	.33
bestbuy	-.08	-.16	.002
mental	-.32	-.30	.13

First of all (Box 1 in Table 9), the older the problem solver and the further from last schooling, the worse the performance on school-like problems. The exception is basic integer math, and here age and time since last schooling do not affect performance (Box 2). Nor are number and measurement facts and best buy calculations affected by age and time since last schooling. It suggests that they are a function of lifelong education through use, rather than a relatively unique product of schooling. (The negative sign associated with the corelations for both age and time since schooling are to be read as, "the older or further from school, the lower the score.) There is a high, and highly significant correlation between years of schooling and performance scores on school-like tasks, and nearly significant correlations with the number facts, measurement facts and basic math score(Box 3 in Table 9). Because these were ambiguous, we ran regression equations, holding age constant to check on the affect of schooling on these variables and it drops to insignificance. (This contrasts with what happens when age is held constant and schooling allowed to vary in relation to the school-like tasks--schooling stays significant in this case.). The relations of Best Buy performance to the age and schooling variables is a bit different than the others. Like the frequency of arithmetic in shopping variable, there is no significant relationship between the bestbuys and age, time since last schooling, and amount of schooling. The mental math problem performance score is the only one which shows a different pattern of relations with the demographic variables. Thus, its relations with age and time since last schooling are like the school-like tasks, but it appears more like the BASIC and facts variables in relation to schooling. It may well reflect, in terms of favored problem solving procedures a swing point between school-like procedures and everyday ones, but this must remain speculation until we can complete the procedural analysis.

These data support our general position very strongly. Those tasks we hypothesized to be representative of school arithmetic show close dependence on schooling--the more of it one has, and the closer to it in time, the better the problem solving score. But on tasks which were designed to replicate the everyday problem solving activities we observed in the supermarket, and in the latter activity itself, arithmetic performances bear no relationship with schooling, time since schooling or age either. The generalization is as true for the specific math and measurement facts as it is for the general arithmetic principles tapped in the math test. There is no evidence that those facts, and basic integer arithmetic are not learned in school. Was does appear to be the case is that they are also learned in use, throughout life. The portion of the school curriculum which also appears in lifelong lessons is stringently limited, though adult problem solvers are not without the resources and ingenuity to reconstruct some of that substantial portion of the school arithmetic curriculum that takes on the role of esoterica from their perspective as school alumni. We suggested in the beginning that the theoretical approach taken here could not but highlight the contradictions between the various goals for schooling. It should now be clear that the empirical findings of the project present the same message.

IV. The Analysis of Arithmetic Practice in Context: Grocery Shopping Arithmetic

There is a serious problem with the analysis in the previous section for it was based on the premise that both tasks and performances can be "lifted" from their contexts and explored as if their reality were a matter of fact. This approach is directly contrary to the theoretical stance of the project. The previous section must stand as a memorial to our own early attempts to conceptualize the important theoretical questions concerning math practice; certainly it was these questions that we built into our plans for carrying out the project. There is a more forward-looking rationale for the analysis in section III as well. By presenting statistical evidence for the situational specificity of arithmetic performances as a conventionally argued case, we hope to have established, for the broadest possible audience, reasons for considering the theoretical framework as well. But we have yet to present a full-blown example of this theory in practice. The paper presented in this section consistently takes the position that arithmetic practice is shaped by the actor's activity in dialectically generative relations with the setting in which that activity takes place. And it analyzes the processes of arithmetic problem solving that we observed our informants practicing in the supermarket. Following this analysis the report will conclude with a consideration of the educational implications of the work described in the report as a whole.

(Jean Lave, Michael Murtaugh and Olivia de la Rocha. To be published as "The Dialectical Constitution of Arithmetic Practice," in B. Rogoff and J. Lave (eds.), Everyday Cognition: Its Development in Social Context. Harvard University Press, 1983.)

A) Introduction

The ubiquity and unremarkable character of routine activities such as grocery shopping qualify them as apt targets for the study of thought in its customary haunts. For the same reasons, such activities are difficult to analyze. We think such an enterprise depends on an integrated approach to everyday activities in their usual contexts. In this chapter we address the general problem at a fairly specific level, analyzing a recently gathered body of data. This example involves a familiar social institution, the supermarket, an environment highly structured in relation to a clearly defined activity in that setting, grocery shopping.

The Adult Math Skills project has as its goal the exploration of arithmetic practices in daily life. Michael Murtaugh has carried out one branch of the project, developing both theory and method for analyzing decision-making processes during grocery shopping, including the role of arithmetic in these processes. This has involved extensive interviewing, observation and experimental work with twenty-five adult, expert grocery shoppers in Orange County, California. Detailed transcribed observations of shopping preparation, a major shopping trip, storage and use of the purchased foodstuffs over a period of weeks, compose one dimension of the work. A comparative dimension, involving a sampling of arithmetic practices in several settings by these same individuals, will be discussed below. The Orange County residents vary in age from 21 to 80, in income from $8,000 per family to $100,000, and in education from 8th grade to an M.A. degree. Twenty-two are female, all are native speakers of English, whose schooling took place in U.S. public schools.

In recent years there has been increasing concern about the ecological validity of experimental research within cognitive and developmental psychology (e.g. Bronfenbrenner and Mahoney, 1975; Neisser, 1976; Cole, Hood and McDermott, 1978; Bronfenbrenner, 1979). These, and other, researchers have speculated that the circumstances that govern the role of most problem solving activities, in situations which are not prefabricated and minimally negotiable, are different from those which can be examined in experimental situations. The questions raised by these speculations are fundamental and demand more radical changes in the nature and scope of theory and empirical research than has, perhaps, been generally recognized (see the Introduction, this volume). Because we are trying to develop a new perspective from which to consider cognition in context we initiate the enterprise here as simply as possible, with a series of commonsense propositions about the contextualized nature of human activity. These will provide guidelines for the empirical study which in turn may suggest more strongly the outlines of a systematic theoretical position.

1) Let us assume that "arithmetic activity" has formal properties which make it identifiable in the flow of experience in many different situations. 2) Arithmetic problem solving is smaller in scope than the units of activity in which people organize and think about their activities as wholes, and in relationship to which settings are specifically organized. The enormous productivity of script theory, on the one hand, and the organization of environments in relation to 'scripted' activities, e.g., "the drugstore," "fourth grade classroom," suggest that human organization of activity gives primacy to segments on the order of 10 minutes to 2 hours. 3) If this is so, solving an arithmetic problem must be experienced by actors as a small segment of the flow of activity. 4) It follows from (2) and (3) that the character, form, outcome and meaning of arithmetic activity should be strongly shaped by the broader scope of activity and setting within which it occurs. 5) It will also be shaped by the past experience and beliefs of the problem solver about what the individual believes herself to be doing, what should happen in the course of it, and the individual's personal version of the setting in which she acts. 6) And finally, an "integrated" approach to activity in context has two meanings: the integral nature of activity in relation with its contexts; and the mutual entailment of mental and physical activity. Both meanings of "integration" imply a prescription for research methodology: that relevant data is to be acquired as directly as possible about people-doing-in-context.

These propositions do not constitute a theory of activity in setting, for they do not specify relations between activity and setting, or between the individual and the social order within which the world is actively experienced. In their present form, however, they suggest a series of analytic steps, and it is around these that the remainder of the chapter is organized. Grocery shopping is an activity which occurs in a setting specialized to support it--the supermarket. "Grocery shopping" is what we asked our informants to do, during which we paid special attention to arithmetic segments of activity in context, and within the flow of activity. The analysis begins at that level, then, with the supermarket as arena for grocery shopping activity.[1] The analysis of setting and activity is focussed on the question, wh-t is it about grocery shopping in supermarkets that might create the effective context for what is construed by shoppers as "problem solving activity." What, then, are the general characteristics of problem solving, when something happens in the course of shopping that appears problematic to the shopper? And finally, how does the character of problem solving activity within grocery shopping specifically affect the nature of arithmetic problem solving? To answer these questions, we begin by taking apart the unit of analysis, that is, activity-in-setting.

B) Setting

Our current view, that the relation between activity and setting is a dialectical one, conflicts with Barker's position which assumes a unidirectional, setting-driven, relation between activity and setting.

Nonetheless our conceptualization of setting derived initially from the work of Barker and his colleagues (e.g. 1963, 1968). He states his position thus (p. 4),

> The view is not uncommon among psychologists that the environment of behavior is a relatively unstructured, passive, probabilistic arena of objects and events upon which man behaves in accordance with the programming he carries about within himself . . .. But research at the Midwest Field Station and elsewhere indicates that when we look at the environment of behavior as a phenomenon worthy of investigation for itself, and not as an instrument for unraveling the behavior-relevant programming within persons, the situation is quite different. From this viewpoint the environment is seen to consist of highly structured, improbable arrangements of objects and events which coerce behavior in accordance with their own dynamic patterning.

For Barker (1968), a segment of the environment is sufficiently internally coherent and independent of external activity flow to be identified as a behavior setting, if little of the behavior found in the setting extends into another setting; if there is sufficient but not too much sharing of inhabitants and leaders of the activity in that setting; if behaviors in the setting are closer to each other in time and space than to behaviors outside the setting; and if there is sharing of behavior objects and modes of behavior in subparts of the behavior setting but little such sharing between this setting and adjacent ones. Barker and his colleagues operationalize these criteria in complex ways, and undertake the monumental feat of describing all of the behavior settings of a year's behavior in a small town in Kansas (Barker and Wright, 1954). The goal of this effort is not to produce an ecological description of a town, but to establish a basis that accounts for the behavior of its inhabitants. They argue that for each setting there is a standing pattern of behavior (it can be thought of as a set of norms prescribing appropriate behavior; they often refer to "rules of the game" literally, in describing favorite behavior settings, such as baseball games). Further, the setting and the patterned sequence of behavior taking place in the setting, are similar in structure, or "synomorphic."

Barker's conceptualization of setting as a peopled, furnished, space-time locus, is an interestingly complex one, particularly in his insistence that varied relations among the multiple elements (people, behavior, furnishings, space and time) of setting contribute in different degrees to the establishment of boundaries for different settings. Although he maintains that settings are objective entities, independent of observer and participant alike, it is a short step, for the theoretically insouciant, to the view that changing relations of space, time, people, furnishings, etc., that create settings for activity are the constructions of participants. (Indeed, this is not far from the position taken by Cole and the Laboratory of Comparative Human Cognition, 1981). But care is required here, for if setting is not an objective phenomenon, how do we account for Barker's extremely elaborate and often convincing enumeration of behavior settings, in practice? We will return to this question in a moment.

On the other hand, there are difficulties with Barker's objectivist approach. Especially, his emphasis on the setting-driven nature of behavior makes the parallel analysis of the internal organization of activity uninteresting, indeed, impossible--it remains a passive response to the setting. It also precludes analysis of the relation between behavior and setting, beyond the simple principles just mentioned, because only one of the two poles of this relation is available for analysis in its own right. Nor does its unidirectional nature keep Barker from recognizing the existence of a more complicated state of affairs than his model will encompass. Thus, he says in passing,

> a great amount of behavior in Midwest is concerned with creating new milieu arrangements to support new standing patterns of behavior, or altering old milieu features to conform to changes in old patterns of behavior. (1968, p.).

But their model has no mechanism in it that would account for these possibilities.

The simultaneous existence of a theory with which we disagree, and impressive empirical data in its support that calls effectively into question the constructivist alternative, poses a dilemma. We propose a time honored solution: that both views are partially correct, though neither complete. Thus, certain aspects of behavior settings have durable and public properties, as Barker's data suggest. The supermarket, a behavior setting in Barker's terms, is such a durable entity; a physically, economically, politically and socially organized space-in-time. In this aspect it may be called an arena within which activity takes place. The supermarket as arena is the product of patterns of capital formation and political economy. It is not negotiable directly by the individual. It is outside of, yet encompasses, the individual, providing a higher-order institutional framework within which setting is constituted. At the same time, the supermarket is a repeatedly experienced, and hence codified, personally and interpersonally ordered and edited version of the arena, for individual shoppers. In this aspect it may be termed a setting for activity. Some aisles in the supermarket do not exist for a given shopper as part of his setting, while other aisles are multifeatured areas to the shopper, who routinely seeks a particular familiar product.

The relationship between arena and setting is reflected in the ordinary use of the term "context." What appear to be contradictory features of meaning may be accounted for by recognizing that the term applies to a relationship rather than to a single entity. For on the one hand, 'context' connotes an identifiable, durable framework for activity, with properties which clearly transcend the experience of individuals, exist prior to them, and are entirely beyond their control. On the other hand, it is clearly experienced differently by different individuals. In the course of the analysis we shall try to distinguish between the imposed constraints of the supermarket as arena, and the constructable, malleable nature of the setting in relation with the activity of particular shoppers. Because a social order and the experience of it mutually entail one another, there are, of course, limits on both the obdurate and malleable aspects of every context.

C) Activity

In developing a set of assumptions about activity, we begin with the active individual in action and interaction with her context. But there is more to it than the mode of relation by which the individual is engaged with the context of activity. Here we have drawn on the concept of activity as it has been developed in Soviet psychology, particularly in the work of Leontiev. Activity theory, in contrast with Barker's, setting-dominated view of the interaction, is able to address the order intrinsic to activity. Activity, "is not a reaction or aggregate of reactions, but a system with its own structure, its own internal transformations and its own development." (Wertsch, 1981, p. 255; quoting Leontiev). It may be characterized, in Leontiev's terms, at three levels of analysis.[2] The highest level is that of activity, e.g. play, work, formal instruction, which occurs, according to activity theory, in relation to motive, or energizing force. As Wertsch explains, "Leontiev often uses hunger as an example of a motive. This provides the energizing force behind an organism's activity, but at this level of abstraction nothing is said about the goals or ends toward which the organism is directed." (Wertsch, 1979, p. 86). This level appears abstract enough that it is difficult to tell if it would meet the criteria proposed here, in which the highest order unit of analysis is person-doing-in-context. The distinction would become a point of disagreement to the extent that "work" or "play" refer to cultural categories of activity rather than specific activities in context. The remaining levels in the theory of activity fit more easily with the units of analysis proposed here. Thus, the second level is that at which an action is defined by its goal, e.g. solving an arithmetic problem or finding the shelf in the supermarket with olives on it. "An action is a segment of human functioning directed toward a conscious goal." (Wertsch, 1979, p. 86). The third level is that of operations, which contrasts with that of action by not involving conscious goals. Instead, "certain conditions in the environment influence the way an action is carried out without giving rise to consciously recognized goals or subgoals." (Wertsch, 1979, p. 87). Examples would include shifting gears in the car (for an expert driver), or putting a can of olives in the grocery cart.

It is not our intention here to map a multi-level system of our own onto Leontiev's, and draw lessons from the similarities and differences; difficulties of translation and comparison suggest that the moral should be a more general one: principally, a strong commitment to the wholistic nature of activity in context. This may be made clearer by providing one example of interlevel relations. Leontiev places strong emphasis on the derivation of meaning, by actors, from the multilevel activity context. He locates it in relations between the levels of activity and action, on the one hand, and action and operation, on the other. The distinction he makes, between "sense" and "meaning," parallels those we have suggested in distinguishing the concept of arena from that of setting. For Leontiev, "sense" designates personal intent, as opposed to "meaning" which is public, explicit, and literal. "Sense" derives from the relations of actions and goals to motivated (higher order) activities of which they are a particular realization. Furthermore, "the goal of one and the same action can be consciously realized in different ways, depending on the connections it has with the motive of the activity." (Wertsch, 1981, pp. 264-265). This same relational emphasis operates "downward", in the system of activity as well, at the action/operation interface. Zinchenko's work (cited in Wertsch, 1981) provides an apt example. In his research, tasks were designed so that the "same" arithmetic problems were to be treated as conscious actions in one experimental session, and as operations in the course of inventing math problems, in another. The arithmetic stayed the same, in formal mathematical terms, while its role in the subject's activity changed. This change had clear affects on the subjects' memory of the arithmetic, according to Zinchenko:

> Material that is the immediate goal of an action is remembered concretely, accurately, more effectively, more durably. When related to the means of an action (to operations) the same material is remembered in a generalized way, schematically, less effectively, and less durably. (Wertsch, 1981, p. 272).

These results support our conviction that to comprehend the nature of arithmetic activity as a whole, requires a contextualized understanding of its role within that activity. Indeed, the work of Zinchenko and Leontiev and their colleagues provides a strong argument for the necessity of analyzing any segment of activity in relation to the flow of activity of which it is a part.

One could construe the argument so far as follows: take Barker's theory of behavior settings and tinker with it, then adapt Leontiev's theory of activity, and finally, combine them. If this summed up our intentions, the major difference between our analysis and theirs would be only its scope. But neither Soviet psychology nor Barker's functionalist brand of setting-determinism (see the Introduction, this volume) make it possible to address the nature of the articulation between activity and setting. A few words on this subject must precede the ethnographic analysis towards which we are moving.

We have distinguished between a supermarket as an arena, a non-negotiable, concrete realization of a political economy in place, and the setting of grocery shopping activity, which we take to be the individual, routine version of that arena which is both generated out of grocery shopping activity and at the same time generates that activity. In short, activity is conceived of as dialectically constituted in relation with the setting. For example, suppose a shopper pauses for the first time in front of the generic products section of the market, noting both the peculiarly plain appearance of the products, divested of brand and other information to which the shopper is accustomed, and the relatively low prices of these products. This information may be added to an existing repertoire of money-saving strategies. In fact it provides a potential new category of money-saving strategies, if the shopper incorporates the new category. This in turn leads the shopper to attend to the generic products on subsequent shopping trips. The setting for these future trips, within the supermarket as arena, is thereby transformed. And the activity of grocery shopping is transformed by change in the setting within the arena. A fuller account of activity-setting relations in dialectical terms may be found elsewhere (e.g. the Introduction, this volume). The point to be made here is that neither setting nor activity exist in realized form, except in relation with each other; this principle is general, applying to all levels of activity-setting relations. The nature of dialectical relations will become clearer in the course of more extensive ethnograhpic analysis.

D) The Supermarket and Grocery Shopping: Arena, Setting and Activity

The arena of grocery shopping is the supermarket, an institution at the interface between consumers and suppliers of grocery commodities. Many of these commodities are characterized in consumer ideology as basic necessities, and the supermarket as the only avenue routinely open for acquiring them. Typical supermarkets keep a constant stock of about seven thousand items. The arena is arranged so that grocery items remain stationary, assigned locations by suppliers and store management, while shoppers move through the store, pushing a cart, searching for the fifty or so items he or she buys on a weekly basis. The arena may be conceived of as an icon of the ultimate grocery list: it is filled with partially ordered sequences of independently obtainable objects, laid out so that a physical progression through the entire store would bring the shopper past all seven thousand items.

A shopper's progress through the arena, however, never takes this form. The supermarket as "list" and the shopper's list are of such different orders of magnitude that the fashioning of a particular route through the market is inevitable. Part of what makes personal navigation of the arena feasible is the ordered arrangement of items in the market, and the structured nature of purchase-intentions of the shopper. The setting of grocery shopping activity is one way of conceptualizing relations between these two kinds of structure. It may be thought of as the locus of articulation between the structured arena and the structured activity; it is the relation between them, the "synomorphy" of Barker's theory.

For example, the arrangement of the arena shapes the setting, in that the order in which items are put in the cart reflects their location in the supermarket rather than their location in any of the activities from which shoppers routinely generate their lists. On the other hand, the setting is also shaped by the activity of the shopper: without babies and dogs, he may routinely bypass the aisles where diapers and dogfood are located; expectations that the chore ought not take more than an hour shape the amount of time the shopper allocates to each item, and hence the degree of effort and structure to her search. This in turn has articulatory implications for the arena: it is created in response to the character of individual search structures, for example, in packaging design and display of products.

The character of the resulting synomorphy is part of what is meant by "setting." It is particularly important to stress the articulatory nature of setting, not because setting is unique in this respect, but because it would be easy to misunderstand the concept as simply a mental map, in the mind of the shopper. Instead, it has simultaneously an independent, physical character, and embodies a potential for realization only in relation to shoppers' activity. All of this together constitutes its quintessential character. The mutual relations between setting and activity, such that each creates the other, both coming into being at the same time, is not so difficult to observe, though difficult to convey in the medium of print. But a transcribed incident may help to illustrate the phenomenon.[3]

A shopper and the anthropologist walk toward the frozen enchilada case. Until the shopper arrives in front of the enchilada display it is as if she were not just at a physical, but a cognitive distance from the enchiladas. In contrast, she and the enchiladas, in each other's presence, bring into being an entirely different quality to the activity.

Shopper: . . . Now these enchiladas, they're around 55 cents. They were the last time I bought them, but now every time I come . . . a higher price.

Observer: Is there a particular kind of enchilada you like?

Shopper: [speaking hesitantly, eyes searching the shelves to find the enchiladas]: Well they come in a, I don't know, I don't remember who puts them out. they move things around too. I don't know.

Observer: What is the kind you're looking for?

Shopper: Well, I don't know what brand it is. they're just enchiladas. They're put out by, I don't know.

She discovers the display of frozen Mexican dinners, at this moment.

Here they are! [spoken vigorously and firmly]: They were 65 the last time I bought them. Now they're 69. Isn't that awful?

This difference--between activity in setting, on the one hand, and activity and setting caught in transit, not in any particular synchrony (or synmorphy), on the other hand--is ubiquitous in our data. It confirms the integral and specific character of particular activities in particular settings.

Grocery shopping activity is made up of relatively discrete segments, such as this enchilada purchase. The shopper stops in front of one display after another and goes through a process of deciding which item to transfer from shelf to cart. In most cases it is possible to face the display and locate and take it from the shelf without moving more than a foot or two out of the original place. Within an item display area, size and brand are taken into account, in that order, in making decisions, while price and quantity are considered at the end of decision processes.[4] But the complexity of the search process varies a great deal across items. Many selections are made without apparent consideration, as part of the routine of replenishing supplies. More often than not, however, shoppers will produce an account for why they routinely purchase a particular item rather than an available alternative. We call this using "old results." It suggests that part of the move from novice to expert grocery shopper involves complex decision processes, a few at a time, across many trips through the market.

Much of the decision making which takes place as shoppers place themselves in physical relation with one display after another, is of a qualitative nature--particular foodstuffs for particular meals, brands which have particular characteristics, e.g., spicy or mild, and so on. Shoppers care about the taste, nutritional value, dietary implications and aesthetics of particular groceries. In relation to this qualitative decision making, commodity suppliers and store management respond with large amounts of persuasive information about products, much of it adhering to the item itself. Shoppers face overwhelming amounts of information, only a small part of which they treat as relevant. Even this information is brought into play only when a shopper establishes a new choice or updates an old result. In general, through time, the experienced shopper transforms an information-rich arena into an information-specific setting. It appears that cognitive transformations of past experience, and presence in the appropriate setting, form an integrated whole which becomes the basis of what appear to be habitual, mechanical-looking procedures for collecting items purchased regularly.

The integration of activity-in-setting is not limited to repeated purchases. Nor is setting merely a stage within which action occurs. Both of these points may be illustrated by calling attention to the fact that the setting imposes shape on potential solution procedures, in cases of new search or problem solving. Indeed, the setting often serves as a calculating device. One shopper, for example, found an unusually high priced package of cheese in a bin. He suspected that there had been an error. To solve the problem he searched throug, the bin for a package weighing the same amount, and inferred from the discrepancy between prices, that one was in error. His initial comparison to other packages had already established which was the errant package. Had he not transferred the calculation to the environment, he would have had to divide weight into price, mentally, and compare the result with the price per pound printed on the label, a much more effortful and less reliable procedure. Calculation of weight/price relations devolved on the structured relations between packages of cheese (their weight varied, but within a rather small range; weight, price per pound, and price were printed on each package but not the steps in the calculation of price pe. pound) and the activity of the shopper (who searched among them for an instructive comparison). In another case a shopper exploited the fact that chicken thighs come in packages of six. She compared package prices and chose a cheap one to insure small size, a moderate priced package when she wanted larger serving portions. In this case, also, weight/price relations were enacted in the setting.

Shoppers describe themselves as engaged in a routine chore, making habitual purchases. But the description must be addressed as data, not analysis. Rather than treating "habit" and "routine" as empirical descriptions of repeated episodes of the same activity in the same setting, we prefer to treat them as statements of an ideological order. For the arena and the general intentions of the shopper--"doing weekly chores," or "grocery shopping, again"--come into juxtaposition repeatedly in such a way as to make it both customary and useful for the shopper to claim that it is "the same" from one occasion to the next.

The similarity is not a matter of mechanical reproduction, however. The truth of this is first and foremost one of definition--it is part of the set of assumptions with which we began. But there is more to be said, for it is a complex problem at several levels. For one thing, shoppers shop in routinely generative ways, for grocery lists almost always include categories such as "treats" for children. Second, the setting generates activity as well: consider the experience of walking past a display and having a delayed reaction which leads to a backtrack and consideration of a needed but forgotten item. And third, relations between activity and setting are so highly structured in so many ways that salient aspects of the process such as the sequence of choices (alternatively, the path through the arena) are not all that heavily constrained: what one learns from past experience is not a fixed path through the setting but the numerous short run structuring devices which can be played end to end, to produce one path this time, a different but structurally related path another.

For instance, shoppers do not generally order their physical activity to conform to the order of their private grocery lists. This would involve much greater physical effort than ordering activity to conform to the market layout. This is explicitly confirmed by shoppers:

> Well, let's see if I've got anything over in this . . .: I usually [look] and see if I've got anything in these, yeah, I need some potatoes . . . I usually shop . . . in the department that I happen to be in. I check my list to see if I have anything on the list, to save me from running all over the store.[5]

Saving physical effort is a useful rationale for using setting to organize the sequence of shopping activity. But there is a more general--and generative--principle at work. Personal grocery lists contain items whose interrelations are often not relevant to the organization of the arena. When ordered in anticipation of their location in the market, they tend to appear as discrete items. Within grocery shopping, as we have already remarked, segments of activity are relatively independent and hence one segment rarely is a sequentially ordered condition for another one. Almost by default, it is the structure in the setting that shoppers utilize to order their activity. It gives the appearance of a choice between mental and physical effort, when it is in fact a choice between a more, and a less, compellingly structured component of the whole activity-in-setting, any structure being available for use in sequencing the activity. If, or rather, when, the structure of shoppers' lists involves item-interdependence (e.g. buy eggs only if the ham looks good), then the source of sequencing might just as well be the list instead of the market layout, or some mix of the two.

In sum, we have tried to suggest the complex, generative nature of an activity-in-setting labelled by its practitioners as a routine chore; and on the other hand to suggest that descriptions such as "habitual" and "routine" are ideological in nature, and lead shoppers to interpret their own activity as repetitive and highly similar across episodes, rather than to treat as normative its non-mechanical, generative variability (as we normatively characterize "education" and "research"). This set of considerations must surely affect the manner in which shoppers come to see certain parts of activity-in-setting as smooth repetitions and others as problematic.

E) Problem Solving in Grocery Shopping Activity

Problem solving in grocery shopping takes its character from the routine nature of the activity-in-setting, from the overdetermined nature of choice and from the dialectical relations between activity and setting. We shall consider each in turn.

Grocery shopping shares with some, but not all, other activities-in-setting its routine character. Frequent, regular visits to a public arena with the intention of carrying out a repeated activity, leads to actors' interpretation of activity in that setting as "routine." Furthermore, the ideology makes repetitive activity and repeated use of the same arena look sensible. This gives character to the particular dialectical relation between chores such as grocery shopping and settings such as those in supermarkets. This relation is one in which repeated interactions have produced smooth "fit" between activity and setting, a streamlining of each in relation to the other. (Turning an information-rich arena into an information-specific setting is an example of what is intended here.)

The routine character of chores such as grocery shopping is generated in a larger context, which contributes to its stability. For grocery shopping is part of a set of interrelated activities involved in the management of food for the domestic context. There is a relatively constant relationship betwee: the scope of the activity "weekly grocery shopping," and that of activities in other settings such as meal planning and cooking, including a consistent division of food processing effort among them. The sameness of grocery shopping over repeated episodes helps to maintain the routineness of these related activities as well. Thus, there is a connection between habitual grocery purchases and regularly prepared, "standard" family meals. In each example here the shopper is looking for an ingredient for such a standard meal.

Observer: So now you're looking at the cheese?

Shopper: Yes. I make that goulash stuff I was telling you about. And I use mozzarella.

Another shopper remarks:

> Oh, and I'll have to get corn bread now, because I forgot to put that on my list. We like corn bread with chicken.

And another:

> We're out of hot sauce, so I have to buy hot sauce for the burritos.

An ideology of routineness embodies expectations about how activity will proceed; that a "routine" episode will unfold unproblematically, effortlessly--rather as if the whole enterprise ideally had the status of an operation, in activity-theory terms. It is in relation to this expectation that a snag or an interruption is a problem. It follows that where both expectations and practice lead to relatively unproblematic activity, snags and interruptions will be recognized, or invented or viewed, as properly limited in scope--as small scale relative to the activity as a whole. And like grocery shopping activity-in-setting, the segments of which it is composed, including problem solving segments, are generated, rather than mechanically reproduced, over a series of occasions.

A second determinant of the character of problem solving in grocery shopping is the nature of the choices to be made by the shopper. The supermarket is thought of by consumers as a locus of abundant choices, for which the stock of thousands of items constitutes apparent evidence. But in contradiction to this view, there stands a different order of circumstance: the shopper cannot provide food for the family if he leaves the supermarket, trip after trip, empty-handed, due to repeated attacks of indecision. That is, the shopper, faced with abundant alternatives, nonetheless cannot avoid making choices. Conversely, because the making of choices cannot be avoided, it is possible for decision criteria to proliferate in the shopping setting; any small set is sufficient as a basis for choosing one item rather than another. This contributes to the shopper's experience of abundant choices, and helps to maintain the contradiction.

The contradictory quality of routine grocery choice is a crucial point in understanding what has been described as the rationalizing character of everyday thought, of which arithmetic calculation in the supermarket provides a typical case. The term "rationalization" is used in common parlance to refer to after-the-fact justification of an action or opinion. It has been proposed as a hallmark of everyday decision-making (e.g., Bartlett, 1958). The term contrasts sharply with folk characterizations of rational decision making, in which evidence should provide logical motivation for a conclusion. Without the contradiction, we shall argue, the production of a rational account of choices would not be construed by the observer as "rationalization." Activity-in-setting is complex enough that a description of the activty as "marshalling the evidence after the fact" does not take into account contradictory, multiple relations between evidence and conclusions. For in decision processes such as those in grocery shopping, it is impossible to specify whether a rational account of choice is constructed before or after the fact. It occurs both before and after different orders of fact; before a unique item is chosen but after the determination that a choice must be made. The "rationalizing" relation of evidence to conclusion is not, then, a matter of "everyday thinking" or "unscientific use of evidence," but an unavoidable characteristic of the activity of grocery shopping. The relations between evidence and conclusion are an inevitable outcome of the organization of the activity-in-setting, rather than the mode of operation of the everyday mind.

Arithmetic problem solving plays various roles in grocery shopping, not all of which will be discussed in this chapter. We will concentrate on price-comparison arithmetic, because it constitutes the preponderance of cases in our data, and because this kind of calculation serves in the "rationalizing" capacity just described. It occurs at the end of decision making processes which smoothly reduce numerous possibilities on the shelf to single items in the cart, mainly on the basis of their qualitative characteristics. A snag occurs when elimination of alternatives comes to a halt before a choice has been made. Arithmetic problem solving is both an expression of, and a medium for dealing with, stalled decision processes. It is, among other things, a move outside the qualitative characteristics of a product, to its characterization in terms of a standard of value, money.

That arithmetic is a prevalent medium of problem solving among shoppers, and elsewhere, is itself an interesting problem. Certainly it justifies choice in terms that are symbolically powerful in this society, being both mathematical, i.e. "objective," and monetary. In the supermarket, calculation may be the most immediate means of rational account construction in response to interruption because of its condensed symbolic connections to both mathematics and money, that is, its position in folk theory about the meaning of rationality. Indeed, a good case can be made that shoppers' ideological commitment to rational decision making is evidenced by their justificatory calculations and explanations, for the alternative is to declare selection, at that point, a nonchoice. Only rarely in the transcripts do shoppers recognize the unavoidable, and hence in some sense arbitrary, nature of choice. One shopper, referring to a TV commercial in which an animated package of margarine gets in an argument at the dinner table, selects this brand and comments ironically:

> Shopper: I'll get the one that talks back.
>
> Observer: Why?
>
> Shopper: Others would have been more trouble.

Support for our interpretation of price arithmetic as rational accounting (in both sense of that term) comes from Murtaugh's (1983) research on the decision processes used by shoppers in choosing grocery items. He shows that if arithmetic is utilized, it is employed near the end of the process, when the number of choices still under consideration is not greater than three and rarely greater than two. Thirteen shoppers purchased 450 grocery items. Of these items, 185 involved problem solving of some variety and 79 of these latter items utilized arithmetic. There were 162 episodes of calculating, approximately two calculations per item on which calculation occurred. Of these calculations, 122 (73%) involved price-comparison arithmetic; 104 compared prices for equal quantities of some grocery item and the remaining 18 both price and quantity comparisons. It would be difficult to picture arithmetic procedures, in the light of these data, as major motivations 'driving' shopping activity. Justifying choices, just before and after the fact, is a more appropriate description of its common role. Demographic data provide indirect support for the argument that most grocery arithmetic serves as a medium for building a rational account for overdetermined choices. The incomes of the shoppers varied enormously, but this variation does not account for differences in calculating frequency by the shoppers (Spearman r = -.0879, n.s.). Decisions that affect a family food budget tend to be made elsewhere than in the supermarket. These decisions include which supermarket to frequent, and how much to spend on particular meals, how often.

So far, we have argued that a "problem" in routine activity-in-setting is an interruption or snag in that routine, and that arithmetic is often used in a rational accounting capacity to overcome snags. A third critical feature of problem solving follows from the charcter of activity-setting relations as a whole. We have taken the dialetical relation between activity and setting as an assumption; (arithmetic) problem solving is part of activity-in-setting and thus must conform to the same dialectical principle, by which it is brought into being, reproduced, and transformed. If activity-in-setting as a whole is crucial in shaping problem solving segments of activity-in-setting, the character of problem solving activity should vary from setting to setting. Barker and his colleagues supply much supporting data for consistent variation in behavior across settings (e.g. 1954, 1963). Our own comparative data support the view that activity varies strongly in relation with setting.

Thus, we contrived a second activity-in-setting in which the shoppers took an extensive paper-and-pencil arithmetic test, covering integer, decimal, and fraction arithmetic, using addition, subtraction, multiplication and division operations (based on a test from the Torque Project, MIT). The sample of shoppers was constructed so as to vary in amount of schooling and in time since schooling was completed. Problem-solving success averaged 59% on the arithmetic test, compared with a startling 98%--virtually error free--arithmetic in the supermarket.[6] Subtest scores on the arithmetic test are highly correlated with each other, but not with frequency of arithmetic problem solving in the supermarket. (We turned to this dependent variable after finding no variance in the problem solving success variable.) Number of years of schooling is highly correlated with performance on the arithmetic test but not with frequency of calculation in the supermarket [add more corr lation coefficients?] Years since schooling was completed, likewise, is significantly correlated with arithmetic test performance (Spearman $r = -.58$, $p < .001$) but not with grocery shopping arithmetic (Spearman $r = .12$, n.s.). In short, to the extent that correlational evidence provides clues, it appears that arithmetic problem solving by given individuals in test and grocery shopping situations is quite different; at least it bears different relations with shoppers' demographic characteristics. An analysis of the specific procedures utilized in "doing arithmetic" in the supermarket lends substance to this conclusion. Moreover, such an analysis, to which we now turn, illustrates the dialectical form of arithmetic problem solving.

F) Dialectically Constituted Problem Solving Process

A successful account of problem solving procedures in the supermarket will explain two puzzles uncovered in preliminary analysis of the grocery shopping data. The first is the virtually error-free arithmetic performance by shoppers who made frequent errors in parallel problems in the formal testing situation. The other is the frequent occurrence of more than one attempt to calculate in the course of buying a single item. Further, while the error-free character of ultimate problem-solutions is a remarkably clear finding, such is not the case for earlier calculations in a sequence, where more than one occurs. It would be useful to account for this as well.

First, it is useful to make explicit what is dialectical about the process of problem solving. The routine nature of grocery shopping activity and the location of price arithmetic at the end of decision making processes, suggest that the shopper must already assign rich content and shape to a problem solution at the time arithmetic becomes an obvious next step. Problem solving, under these circumstances, is an iterative process. On the one hand, it involves what the shopper knows and the setting holds that might help, and on the other hand, what the solution looks like. The latter deserves clarification: we take as axiomatic that the activity of finding something problematic subsumes a good deal of knowledge about what would constitute a solution. In the course of grocery shopping many of a problem-solution's parameters are marshalled into place as part of the process of deciding, up to a point, what to purchase. (Consider the shopper who knew which cheese package was inconsistent with others before he established whether there was really an inconsistency or not.) The dialectical process is one of gap closing[7] between strongly specified solution characteristics and information and procedural possibilities for solving the problem.

Thus a change in either solution shape or resources of information leads to a reconstitution of the other: the solution shape is generated out of the decision process up to an interruption or snag. But the act of identifying a "problem" changes the salience of setting characteristics. These in turn suggest, more powerfully than before, procedures for generating a specific solution; information and procedural knowledge accessed by eye, hand, and/or mental transformations thereof, make possible a move towards the solution, or suggest a change in the solution shape that will draw it closer to the information at hand.

The example that follows, drawn from a transcribed segment of a grocery shopping expedition, is fuller than those given previously. Let us make clear immediately what is general about it, and what are its limitations as a generalizable sequence of data. First, it successfully illustrates the dialectical nature of gap-closing arithmetic problem solving processes, and, more specifically, makes it possible to typify some of the parts of such processes. But the example is not generalizable with respect to all aspects of the argument developed in this chapter. In particular, a word of caution is appropriate about its relevance to the interpretation of price arithmetic as rational account-production activity. Interaction between the shopper and the observer in the transcribed example gives a special character to the activity segment,[8] perhaps not a difference of kind so much as one of degree (though our argument does not rest on this distinction). The shopper may well think of the observer as the embodiment and arbiter of normative shopping practices; and from his point of view, his role is to investigate empirically the appropriateness of normative models of rational problem solving (about which he is sceptical). We argue that the combined effect of the assumptions each has about the observer's role is to intensify the focus on rational accounting, in terms common to folk ideology and much of consumer economics; this, at the expense of the qualitative character of decision making which, in fact, leads to most purchase selections in the supermarket--even in our data (i.e. only seventy-nine items out of four hundred and fifty involved arithmetic).

At the same time, our argument about the account-production role of price arithmetic does not rest on the detailed description of such activity in this, or other, transcripts. Instead, we have argued that rational account-production derives from the location of arithmetic activity, almost always at the end of processes of decision making, under the conditions of constrained choice found in supermarkets. It is on this analysis, supported by numerical data on the location of arithmetic in decision processes, rather than on the transcript analysis, that the argument about rational accounting stands or falls. But, further, the following example in no way undermines that argument; rather, it provides (only) a specialized illustration of it.

In the shopping transcript, a forty-three year old woman with four children discusses the price of noodles. She takes a few steps towards the noodle display:

Shopper: Let me show you something, if I can find it. I mean talk about price [1].[9] Last week they had that on sale I think for 59 cents.

Observer: Spaghetti?

Shopper: [with the vagueness associated with imminent arrival-- see the enchilada example, p. 15] Yeah, or 40--I can't remember . . . That's not the one.

She then puts an old result into practice, taking a package of elbow noodles from the shelf and putting it in her cart. It is a 32 ounce package of Perfection brand noodles, costing $1.12. This decision prefigures and shapes the course of the conversation, and calculations, which follow. The latter are best buy problems, comparing price per unit of weight for pairs of packages. The other three packages weigh 24 ounces, 48 ounces and 64 ounces. The difference in price per unit is not a linear function of size. That is, in order by weight:

American Beauty noodles,	24 oz. for $1.02	68¢/lb
Perfection noodles,	32 oz. for $1.12	56¢/lb
American Beauty noodles,	48 oz. for $1.79	59 1/2¢/lb
American Beauty noodles,	64 oz. for $1.98	49 1/4¢/lb

The 64 ounce package is, of course, the best buy.

Observer: [acknowledging her choice] [1] Perfection. [The brand name.]

Shopper: Yeah. This is what I usually buy. Its less expensive than--is that American Beauty [2]?

Observer: Yeah.

Shopper: That, what I need right now is the elbow macaroni [noodles]. And I always buy it in two pound [3] . . . . [packages]. I'm out of this.

The first underlined segment is the choice which establishes the point of reference for comparative calculations. The second, establishes an initial solution shape, and the third provides evidence both that the choice is an old result and that numerical simplification work has occurred, since the weight on the package is expressed as "32 ounces" rather than as "2 pounds." She expands on the qualitative choice criteria which have shaped her purchase in the past:

Observer: This seems like a big package of elbow noodles and you add these to the macaroni?

Shopper: I add some, I just take a handful and add it to the rest, to the other packaged macaroni. 'cause I add macaroni to it. Plus I use that for my goulash [1].

Observer: For the goulash. O.K. And you . . . like these particular kind? Are there other alternatives here?

Shopper: Yeah. There's large elbow. This is really the too-large economy bag [1]. I don't know if I, probably take me about six months to use this one. And I just, I don't have the storage room for that kind of stuff [1]. I guess if I rearranged my cupboards maybe I could, but it's a hassle [1] . . . . I don't know, I just never bought that huge size like that [1]. I never checked the price though on it. But being American Beauty it probably costs more even in that large size [2].

Her comments reinforce the expected direction of American Beauty/ Perfection noodle price comparisons [2]. (While this judgment is correct for 24 and 48 ounce packages, it is incorrect for the 64 ounce size. But the matter does not rest here.)

More important, the nature of the decision-making problem is here shown in integral relation with the particulars of interaction between the shopper and the observer. For qualitative reasons (use in standard meals, storage capacity, etc. (1)) she has previously avoided purchase of the large size. But she is caught in a public situation in a discussion for which we shall see evidence that she would like to display her shrewdness as a shopper. And best buy purchases are the best evidence of rational frugality in this setting (even though qualitative criteria take precedence for her, as for most shoppers, most of the time).

The next interchange starts a process of simplification of the arithmetic comparison. She transforms large numbers of ounces into a small number of pounds.

Observer: That's what, that's 6 . . . [64 ounces?]

Shopper: It's 4 pounds and what did I buy, 2? <u>Oh, there is a big savings</u> [1]. Hmmm. <u>I might think about that next time</u> [1], figure out where I can keep it. <u>I actually try to look for better prices</u> [2]. I used, I guess I used to and I was such in the habit of it that some of the products I'm buying now are leftovers <u>from when I was cutting costs</u> [3]. And I usually look. If they have something on sale, you know, a larger package of macaroni or spaghetti or something, I'll buy it.

If the preemptive character of financial evidence as a means of demonstrating utilitarian rationality requires illustration, this segment provides it. The shopper's clearly stated earlier decision to reject the large size package on the basis of kitchen storage capacity is not sufficient to override the opposite choice on monetary criteria, when challenged [1]. She places a general value on price as a criterion for choice [2] and correspondingly emphasizes that current financial state does not require such choices [3]. This has the effect of emphasizing the absolute nature of the value. It produces a half commitment to future action [1] which does not seem likely to occur once the pressure of observer demand on the production of rational "accounting" is removed. We think there is also a strategy of "if I can't be right, at least I can demonstrate my objectivity," both by admitting she is wrong and by accepting quantitative (symbolically objective) criteria as overridingly legitimate.

Meanwhile she has made a calculation, at the beginning of the segment, correctly, that four pounds of American Beauty noodles would be cheaper than two pounds of Perfection noodles. It is not possible to infer what calculation took place, only that she arrived at a correct solution.

The next example follows almost immediately in the transcript. She sees what appears to be a comparison of packages which offer a counter-example to the previous conclusion that the large size is a best buy. If correct, it would soften the impression that she had violated a general principle ("bigger is cheaper") in her shopping strategy.

Shopper: But this one, you don't save a thing [1]. Here's 3 pounds for a dollar 79, and there's 1 pound for 59.

She is comparing two packages of American Beauty spaghetti noodles. But what she believes to be a one pound bag weighs only twelve ounces. She very quickly notices the weight printed on the package and corrects herself in the following manner:

Shopper: No, I'm sorry, that's 12 ounces [2]. No, it's a savings.

This pair of statements ([1] and [2]) involve two calculations. In some form (there are alternative adequate representations among which we cannot distinguish) the first was probably 1 x 60 = 60 and 3 x 60 = 180, and therefore there is no difference between them in price per pound. If the weight of the smaller bag is less than one pound, then the equations are no longer equivalent, and the three pound bag is the better buy. Only a "less than" relation would be required to arrive at this conclusion.

The pattern of problem solving procedures used by J. is something like this: She starts with a probable solution, but inspection of evidence and comparison with the expected conclusion cause her to reject it. ("No, I'm sorry" is her acknowledgement that the initial problem solution is in error.) Pulled up short by the weight information from the package, she recalculates and obtains a new conclusion. This pattern is an example of gap-closing, dialectical movement between the expected shape of the solution and the information and calculation devices at hand, all in pursuit of a solution that will be germane to the activity which gave it shape in the first place.

The penultimate paragraph closed with a comment that "only" a less-than relation was required to complete the second round of calculation. However, the "only" is deceptive, as is the conciseness of her statements, if they convey the impression that the arithmetic is simple in the terms in which it would be represented in paper-and-pencil conventions: $1.79/3 \stackrel{?}{=} .59$. It requires an active process of simplification to transform it into the form suggested above.

Once J. has concluded that the large bag of noodles is a better buy than the small one, she comments:

Shopper: They had some on sale there one day and the large package was like 69 for 2 pounds and it was 59 for 1 pound. And it was just such a difference, I, you know, it was almost an insult to the shopper to have the two on the same shelf side by side.

She concludes with another two-round calculation in gap-closing form. This episode is initiated by the observer who addresses the monetary but not the size difference, and emphasizes its magnitude. The observer may be trying to acknowledge her amended views, for he repeats her previous conclusion:

Observer: Well, you seem to think this was a real big difference, then, this 4 pounds of --

Shopper: Yeah, that is. That's 2 dollars for 4 pounds [1] [the American Beauty elbow noodles], this is a dollar [2] [referring to the Perfection elbow noddles in her cart], that's 50 cents a pound [3] and I just bought 2 pounds for a dollar twelve [4], which is sixty. So there is a difference.

She begins by simplifying \$1.98 to two [1] dollars and \$1.12 to one dollar [2]. But the calculation leads to the conclusion that both are 50 cents per pound. This conclusion, however, does not fit the established solution shape, "a big difference" between the smaller and larger bags of noodles. The current problem as simplified, produces an intermediate solution, that 4 pounds of noodles for two dollars is fifty cents per pound [3]. This move serves two purposes: as a means to recheck information simplified from that printed on the package; and as the first item in the next round of calculation. The second round is a similar price comparison, but with a "more than" relation: \$1.12 is more than one dollar [4]. It would be consistent with a desire to appear objective and to meet the norms of the observer, that she would round up from 56¢/pound to 60¢. She thereby reiterates the earlier conclusion about the direction of difference in price.

One characteristic of the preceding account has been the need to assign multiple functions to individual moves in gap-closing arithmetic procedures. Dialectically ordered problem solving processes do pose problems when we try to describe them. Perhaps we must give up the goal of assigning arithmetic problems to unique locations--in the head or on the shelf--or labelling one element in a problem solving process as a "calculation procedure," another as a "checking procedure." It may be difficult, even, to distinguish the problem from its solution.

Another example may help to clarify these speculations. In her research on the acquisition of arithmetic skills by new members of Weight Watchers, de la Rocha (in preparation) posed a problem of food portion control: "Suppose your remaining allotment of cottage cheese for the week is three-quarters of the two-thirds cup the program allows?" The problem solver in this example began the task muttering that he'd had calculus in college, and then, after a long pause, suddenly announced he'd "got it!" From then on he appeared certain he was correct, even before carrying out the procedure. He filled a measuring cup two-thirds full of cottage cheese, dumped it out on a cutting board, patted it into a circle and marked a cross on it, scooped away one quadrant and ate the rest. Thus, "take three-quarters of two-thirds of a cup of cottage cheese" is not just the problem statement, but also the solution to the problem and the procedure for solving it. Since the environment was used as a calculating device, the solution is simply the problem-statement, enacted. At no time did the Weight Watcher check his procedure against a paper and pencil algorithm which would have produced 3/4 cup x 2/3 cup = 1/2 cup. Instead, the coincidence of problem, procedure, and enactment is the means by which checking takes place. One implication of this is that there is a strong monitoring potential in gap-closing procedures. It simply falls out of the nature of the activity when various aspects of problem solving are juxtaposed.

We have suggested that the calculations made by J. were possible because of her active construction of simplified versions of them. In order to do the complex work of simplifying problems, she needed a clear grasp of "what she was doing." "Knowing what one is doing" means having generated a process (e.g. decision making in the supermarket) oneself, in context. Faced with a snag, then, one has already produced a partial form of the solution.

Checking procedures, in this analysis of gap-closing arithmetic, consist of an ongoing process of comparing the current state of knowledge of the problem and the current definition of the solution. The intention is to check the plausibility of both procedure and solution in relation to previously recognized constraints on answer-characteristics rather than comparison of two linear problem solving procedures without reference to such constraints (the convention in pencil and paper arithmetic checking procedures).

In supermarket arithmetic, an alternative to arithmetic problem solving is abandonment of the arithmetic and resolution of snags through exercise of other options. A last example shows abandonment of a calculation when it becomes too complicated for solution, within grocery shopping activity in the supermarket setting. Abandonment, like a high level of success at calculation, supports our view that the juxtaposition of various aspects of problem solving makes monitoring of the process exceptionally productive. In the example, a forty-five year old mother of five children and her fifteen year-old daughter are shopping, together with the observer. The mother is interested in ketchup, but turns to the barbecue sauce, next to the ketchup, when her daughter calls attention to it.

Daughter: Do you want some Chris and Pits barbecue sauce? We're almost out.

Shopper: [to the observer]. Heinz has a special [on ketchup]. I have a coupon in here for that. And I was going to make spareribs one night this week, which I didn't mention to you, but that was in my mind now that she mentions the sauce. [shopper examines her coupons.] I want to see if their price on their barbecue sauce is going to be as--we usually buy Chris and Pits . . . Now see this is the one that I was telling you about. [She has noticed a Heinz ketchup coupon.] . . . But they don't have the 44 ounce ketchup here. [B. continues searching through the coupons until she finds the one for the barbecue sauce.] Okay, 25 cents off any size flavor of Kraft Barbecue Sauce including the new Sweet and Sour, which I would like to try because I'm going to have spareribs. But if you notice they don't have it. Oh, here they do. Hickory.

Observer: Kraft Hickory Smoked.

Shopper: Yeah, but they don't have the Sweet and Sour. [to her daughter] You see it, D? Nope. Okay, see now in a situation like this it's difficult to figure out which is the better buy. Because this is--I don't have my glasses on, how many ounces is that, D?

Daughter: 18.

Shopper: 18 ounces for 89 [refers to Kraft Hickory Smoked] and this is--

Daughter: 1 pound, 7 ounces--

Shopper: 23 ounces for a dollar 17. [referring to Chris and Pits.] [Then speaks ironically] That's when I whip out my calculator and see which is the better buy.

The comparison to be made has been simplified by putting both equations into the same units. But it requires a comparison which is difficult to simplify further: eighteen ounces for eighty-nine cents must be compared with twenty-three ounces for a dollar and seventeen cents. The comment about using a calculator could be interpreted, solely on the basis of its tone, as a move to abandon the calculation. But more convincing evidence is available. The shopper has a calculator in her purse, and has previously told the observer that she uses it rather frequently in the supermarket, yet on this occasion (as in all but one case) she makes no effort to get it out and suit action to words. She makes one more attempt to solve the problem, and then abandons it even more definitively.

Observer: So what are you going to do in this case?

Shopper: In this case what have we got here? I'll try to do it quickly in my head . . . They don't have the large um--,

Daughter: Kraft Barbecue Sauce?

Shopper: Yeah, so what I'm going to do is, I'm going to wait, and go to another store, when I'm at one of the other stores, because I'd like to try this.

One choice open to shoppers is to abandon a calculation, in the course of which they choose an option to calculation as a basis for completing the decision process. Supermarket settings and grocery shopping activity are rich in options to calculate, and this circumstance aods support to what already appears to be a low penalty level for abandoning calculation in favor of some other criterion of choice. This contrasts with activity-in-setting in which problem generation, and hence constraints on problem solution, are furnished to the problem solver, in an asymmetrically structured sequence of interaction in which the problem solver has little to say about the terms. In these circumstances the only "option" other than success is failure, for example, on school tests and in many problem solving experiments.

In discussing problem solving in dialectical terms we have, among other things, been developing an explanation of the multiple-calculation (ultimately) error-free arithmetic practiced in the supermarket setting. Multiple calculations cannot be easily accounted for in the linear progression models assumed in conventional algorithm-based arithmetic procedures. But our theory of gap-closing, dialectically constituted, arithmetic procedures predicts that calculating will occur in multiple "rounds." We hope to have demonstrated this in practice as well. Multiple rounds are possible because of the initial conditions by which something becomes problematic in the course of activity-in-setting. The problem solver generates problem and solution shape at the same time; each entails the other. Procedures which operate on both problem and solution-shape stand in juxtaposition to one another. Errors, which are frequent in early rounds, can therefore be recognized and instruct. Why is the end product of supermarket calculation so accurate? First, dialectical processes of problem solving make possible powerful monitoring because of the juxtaposition of problem, solution and checking activity. When, in addition, properties of the setting join in as calculating devices, this adds another factor to those already juxtaposed: the enactment of problem solving. Second, any circumstance that makes abandonment of a calculation a feasible alternative, leads to fewer completed calculations, but more correct ones, than if options were not available. One main circumstance has been mentioned previously: if the process of problem generation is under the control of the problem solver, the solution shape is generated at the same time; alternatively, the problem solver may exercise options other than calculation.

In closing, we raise the question of how arithmetic practice might change over time within grocery shopping activity-in-setting, though we can do little more than indicate our interest in the problem. The effortful process of snag repair leads to a choice--to the moving of an item from shelf to shopping cart and the resumption of the rhythm of routine activity. The snag has been transformed into a rationally-accountable choice. The latter replaces both problem and solution effort in future grocery shopping episodes. But such a choice creates the terms for the occurrence of new snags, either as the choice becomes a baseline for new comparisons, or as the criteria invoked in a rational account are violated (e.g. by rising prices, changes in relations of price and quantity, changes in family composition or food preferences).

As a whole, grocery shopping activity changes over time, in a changing arena, in relation to changing activities-in-other-settings, and as a result of the activity taking place across repeated episodes. Shoppers marshal ideological efficiencies partially to domesticate this variability; but if they are to shape activity effectively, there must be scope within it for investigating, checking, updating and reflecting changes occurring in this setting and elsewhere. To be effective over time requires smooth routines partly because this enables shopper-setting interaction focussed about instructive novelties.

We have concentrated on snag repair but are now in a position to contrast this with a routine choice, when it becomes (for the moment) an activity-setting relation at its simplest. Think of the shopper's daughter in the last example as part of the setting. The daughter points out the barbecue sauce. The shopper does not go through a choice process, initially. Instead, she and the setting bring a choice into being. She reflects this in her comment: "that was in my mind, now that she mentions the sauce." The relevant aspect of the setting need not be a person: replace the daughter with a bottle of sauce on the shelf, and an equivalent event would be the shopper who does a double take as he passes this display, and backtracks slightly to transfer the "forgotten" item from shelf to cart. Each may be thought of as a moment in the dialectical constitution of activity and setting.

G) Conclusions

We have argued that the defining characteristics of arithmetic problem solving in supermarkets must be sought in the dialectical constitution of grocery-shopping activity in the supermarket setting. Thus, in relation to the routine character assigned grocery shopping activity, problems impinge on the consciousness of shoppers as small snags to be repaired. Given this ideology of routine and the complex structure of choice in the supermarket setting, arithmetic is used to produce rational accounts of choice. Procedures for solving problems are dialectically constituted, in that setting and activity mutually create and change each other; in the process "problems" are generated and resolved. These characteristics emerged from analysis of arena, setting and activity. Had we taken as our template school ideology concerning linear algorithms for problem solving, or the structured knowledge domain "arithmetic," we would not have been in a position to analyze the arithmetic practices. We hope, then, to have demonstrated the value, indeed the necessity, of analysis of both the context of activity and activity in context.

This last principle led us to account for price arithmetic in dialectical terms, as a process of gap-closing. This process draws problems and solution shapes closer together, through operations whose juxtaposition gives them multiple functions and creates circumstances for powerful monitoring of the solution process. This, in turn, provides an explanation for the extraordinarily high level of successful problem solving observed in the supermarket. There are specific ways in which the supermarket setting stores and displays information, offers means for structuring sequences of activity, acts as a calculating device, and shapes the way in which "problem solving" is construed by shoppers. These characteristics are not confined to supermarkets. Most, if not all, settings store information, offer calculating potential and means of structuring sequences of activity. These pr.nciples concerning the nature of settings are general ones. Likewise, gap-closing arithmetic--the simultaneous generation of problem and solution shape and the process of bringing them into coincidence--the production of rational accounts in complex choice situations, along with the abandonment and use of options to calculation, are at work in other settings; they form a general class of arithmetic procedures, with implications which extend far beyond the supermarket.

The analysis of gap-closing arithmetic--indeed, the very conceptualization of practical arithmetic as a gap-closing process--has implications for theories of cognitive processing as well. "Problem solving" is a term often used in free variation--or worse, synonymously--with "cognition," to describe (but not to contextualize) such activities as arithmetic practices. The assignment of unwarranted theoretical centrality to problem solving reflects a failure to comprehend these activities as practices sui generis. This conventional theoretical framework views a problem as "given," the generic "independent variable" in the situation. The effort, the solving of the problem, is correspondingly characterized as disembodied mental activity. But the reduction of cognition to problem solving per se simply cannot grasp the generative nature of arithmetic practice as cognitive activity. In the dialectical terms proposed here, people and settings together generate problems. Moreover, they generate problems and solution shapes simultaneously. Very often a process of solution occurs in the setting, with the enactment of the problem, and may transform the problem for the solver. Indeed, the most general lesson of our analysis is the integral, generative and, finally, dialectical nature of activity-setting relations. The lesson applies to grocery shopping and to experience-generating segments thereof; it may be usefully applied to other, and more inclusive, systems of activity as well.

Footnotes

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[1] We have pointed out that it is difficult to analyze familiar situations, not only for grocery shopping, but for laboratory experiments as well. A program of multilevel analysis such as we propose here requires analysis of the institutional arena within which activity comes under scrutiny. The greater the remove of the activity and setting under analysis from the activities of the observer qua social scientist, the

less severe the requirement for reflexive analysis of one's own ambience. Thus, laboratory experimentation poses far tougher analytic problems than grocery shopping, in our view. (The difference is only a matter of degree, however.)

[2]According to Wertsch, on whose translation and interpretation we rely here.

[3]A few simple conventions were followed in recording the shopping transcripts. Numbers are written in words whenever numerals create ambiguity in wording (e.g., '12¢' is unambiguous but '$1.12' is not). Dashes are used to terminate a statement whenever one speaker is interrupted by another. Three dots indicate either missing material, reflecting a lack of clarity on the tape, or a pause in the speaker's comment. It is often difficult to distinguish between these two cases. Other punctuation, including commas and periods, were inserted solely to improve the intelligibility of the text.

[4]This generalization is the product of Murtaugh's analysis of the selection process for nearly a thousand grocery items (see Murtaugh, 1983).

[5]Underlining, and sometimes bracketed numbers are used to mark transcript passages which are later referred to in the text.

[6]Since data were recorded on the prices and quantities of each grocery item mentioned by a shopper, it was possible to test objectively the shopper's claim that one item was less expensive than another. In only three of the 125 cases where arithmetic problem solving was used did the shopper judge the lowest unit price incorrectly. All three errors were made by the same shopper.

[7]The term "gap closing" is Bartlett's (1958). Our adoption of his terminology acknowledges the acuteness of his description of, and speculation about, the forms of certain problem solving processes. It is important to try to account for the phenomena he describes under that rubric, but as will become clearer in the text, a dialectical model of problem solving conflicts with his interpretation. For Bartlett, gap closing is a mental activity; for us a series of relations between activity and setting, each of which changes the other at every step.

[8]There is a contradiction inherent in the enterprise of observing the ordinary. It might be useful to indicate, therefore, the ways in which we have coped with it, if not transcended it. Before entering the supermarket shoppers strapped a tape recorded over their shoulder and were asked to "think out loud" while proceding through the store. Shoppers were told that the two researchers accompanying them were interested in learning about their shopping procedures, whatever they might be.

As a shopper walked through the store, one researcher maintained a running conversation with the shopper. This approach grew out of pilot work in which both more and less active methods were tried. We found that shoppers felt more comfortable describing their behavior as part of a conversation than simply as a monologue. Second, it was necessary to clarify many of the shoppers' comments and other aspects of the shopping environment which would otherwise not be clear in a taped recording. Third, the researchers sought information about influences on the shoppers' decisions which the shoppers might not volunteer. Once an item was selected, the shopper was asked about other items present which had not been mentioned. These questions generated much additional information. In all cases, the researcher was careful not to interpret the situation for the shopper, but rather to clarify the shopper's behavior for the record. Our attempt to exercise high ethnographic standards could not, of course, eliminate the interaction between actor and observer. Rather than ignore it we have tried to take it into account in our analysis.

[9]The topic of conversation [1] is established in a way strongly reminiscent of topic establishment in Mehan's transcripts of class-placement meetings (this volume p.).

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V. The Educational Implications of Situation-Specific, Dialectically Constituted Arithmetic Practice

In this section we'll start with a reexamination of some numerical findings, but intend to end up with some general ideas. First of all it cannot be too strongly emphasized that our findings conflict with the common wisdom. The data collected in the course of the project paint a picture of enormous efficacy in adult uses of arithmetic in everyday settings, and in contrast, rather severe difficulties with school-like arithmetic. These characteristics are not, however, limited to adults. There seems good reason to believe that school may be uniquely designed to produce arithmetic incompetence and its attendant anxieties. We shall pursue this further in a moment.

In addition to the discontinuous pattern of test scores across situations--with school-like problem solving at the low end--there is the surprising finding that performance on best buy problems in circumstances where a minimal attempt was made to simulate supermarket problem solving conditions, leads to performances very similar to those in the store. This is surprising, not so much because it violates common knowledge but because it doesn't fit with two ongoing attempts to simulate "real world" problem solving. One of these occurs in schools as they try to enrich math curricula with "real world" problems like those children might encounter in their everyday lives. The second is experiments on math learning which have the same goals. One hears most about the consistent failure of these attempts, at least as these are measured by performance levels and errors made in the simulated circumstances. James Herndon provides an extraordinarily vivid example of the phenomenon (How to Survive in your Native Land, 1971:93-95):

> For a while I would drop in on the Tierra Firma bowling alley, ... One day I ran into the dumbest kid in the dumb class . . .. In the end, of course, I asked him what he was doing around there. He was getting ready to go to work, he told me. Fooling around until five, when he started. What did he do? I keep score, he told me. For the leagues. He kept score for two teams at once. He made fifteen bucks for a couple of hours. He thought it was a great job, making fifteen bucks for something he liked to do anyway, perhaps would have done for nothing, just to be able to do it.
>
> He was keeping score. Two teams, four people on each, eight bowling scores at once. Adding quickly, not making any mistakes (for no one was going to put up with errors), following the rather complicated process of scoring in the game of bowling. Get a spare, score ten plus whatever you get on the next ball, score a strike, then ten plus whatever you get on the next two balls; imagine the man gets three strikes in a row and two spares and you are the scorer, plus you are dealing with seven other guys all striking or sparing or neither one....I figured I had this particular dumb kid now. Back in eighth period I lectured him on how smart he was to be a league scorer in bowling. I pried admissions from the other boys, about how they had paper routes and made change. I made the girls confess that when they went to buy stuff they didn't have any difficulty deciding if those shoes cost $10.95 or whether it meant $109.50 or whether it meant $1.09 or how much change they'd get back from a twenty. Naturally I then handed out bowling-score problems and paper-route change-making problems and buying-shoes problems, and naturally everyone could choose which ones they wanted to solve, and naturally the result was that all the dumb kids immediately rushed me yelling Is this right? I don't know how to do it! What's the answer? This ain't right, is it? and What's my grade? The girls who bought shoes for $10.95 with a $20 bill came up with $400.15 for change and wanted to know if that was right? The brilliant league scorer couldn't decide whether two strikes and a third frame of eight amounted to eighteen or twenty-eight or whether it was one hundred eight and one half.

There are some reasonable speculations to be made about why people performed so well on the best buy simulations of grocery shopping arithmetic--it was untest like in that the problems were underspecified, the data were gleaned from the environment, no pencil and paper was required so school algorithms weren't encouraged. No specific problem was stated, other than "which is the best buy?" for the actual bottles-and-jars problems, and even the format of the problems on cards was not conventionally linear. Many of these are just like Herndon's tactics, which, however, led in that case to failure. The one difference that takes on serious significance from our theoretical perspective is that laid out in the previous section: The informants here, unlike kids in Herndon's class, engaged in problem construction, and with it the creation of solution shapes which made gap-closing procedures feasible. They were not members of the social category "dumb class," so eloquently described by Herndon.

But in raising the problem posed by the best buy problems, the inte[illegible] was to focus on the other, more important, problem of why attempts like Herndon's are not successful. It should be clear that the problem is broader than the failure of pedagogues and researchers to replicate the essential dimensions of every day problem solving. That failure is visited on children, who experience anguish and anxiety about it during their school years, who, as adults, apologize for their jerry-rigged procedures in the supermarket which, they say, aren't "real math." Not a single one of our informants realized that they were arithmetically efficacious in that setting. And failure at arithmetic is visited differentially on children of different races and ethnic groups. We refer here to evidence from Ginsburg and others that white and black children from lower and middle class families enter first grade with undifferentiatable arithmetic skills and that the disparities begin, and increase, in school. Our data suggest that school may be the only routine everyday setting in our lives for which this pattern of failure at arithmetic--socially differentiated--is to be found.

While we have been trying to map links between school arithmetic and the practice of arithmetic in daily life, experimenters have approached the same problem primarily by trying to simulate in the laboratory what they consider to be the crucial features of problem solving situations in other settings. Educators might be similarly described as expressing their increasing concern for the practical relevance of schooling by adding simulations of real world problems or situations to arithmetic curricula. Why have attempts to create verisimilitudinous arithmetic problems,to teach practical math, more often than not been disappointing? To take the teaching of practical arithmetic seriously would require the reorganization of math curriculum to reflect the organization of everyday activities rather than the internal organization of arithmetic principles. At present, the act of transforming "daily life problems" into arithmetic assignments destroys their mundane characteristics: the problem is given to the problem solver rather than generated by the problem solver. The only resources for solving the problem acceptably for teacher or experimenter are algorithmic place holding ones, usually done with paper and pencil. Many of the everyday strategies for efficaciously solving problems--using the environment as a calculating device, changing the problem, asking someone else, etc. wouldn't be recognized as acceptable solution procedures in school or experiment.

A second major reason that simulation attempts have generally failed comes from the diverse multidimensional nature of arithmetic activities. Both our theory and our data stand in conflict with constancy models of arithmetic performance across a lifetime (you are either born with math ability or you aren't). They are likewise incompatible with views that arithmetic is learned (only) in school, and that you leave the door with a fixed repertoire of arithmetic skills. (It follows from such a model that the last/best performances in school should be accurate prognosticators for future arithmetic performances, while we find no relationship between performances across situations.) The work reported here does not even support a simple unilinear decay model of arithmetic learning. It is true that age and time-since-schooling-was-completed are negatively related to performance on school-like tasks, so that the older and more distant from schooling, the poorer the performance. But BASIC arithmetic is not correlated with age or time-since-schooling-was-completed; nor are number and measurement facts, best buy calculations, or frequency of success of calculation in the supermarket. The picture drawn in the previous section of gap-closing procedures for solving problems adds to this picture substantial evidence of discontinuity in strategies, tactics and use of situational resources, between arithmetic practice in school and elsewhere. The very circumstances of our lives, then, point to the variety and complexity of what is all too often reduced to "native ability," or "basic competence," or "learning the fundamentals."

The picture is supported still further when standard difficulties in solving problems, are compared between, say, school-like arithmetic and problem solving in the supermarket. In section IV. it was argued that supermarket arithmetic is abandoned at times when particular numbers are unmalleable--difficult to manipulate in ways that won't distort relations among them in such a way as to negate the purpose of the calculation. Were further evidence for this difficulty needed, strategies used by supermarkets for pricing goods in odd pennies and packaging goods in prime-number weights, should suffice. Yet in an extensive fine-grained analysis of problem by problem patterns of success and difficulty on the math test by Katherine Faust (using multi-dimensionsal scaling, quadratic assignment analysis and factor analysis), it appears that the only constant division among the problems has nothing to do with the properties of the numbers, but instead, lies between problems that are directly solvable and those that must be transformed before solving. Why should reformulating problems be so easy in the supermarket and difficult in school-like situations? We have discussed the supermarket data in section IV. In relation to the school-like test, it is plausible, though not compelling, to argue that the demand for changing the problem violates those school norms which characterize problems as "givens" and problem-solving procedures as "discovery procedures," rather than as procedures for transforming problems. Secondly, it may be that many of the transformative procedures (for example, in setting up division-of-fractions problems) are learned as meaningless protocols (algorithms may not always promote understanding of deep arithmetic relations, and for the ordinary arithmetic user may remain unmotivated in relation to the structure of the arithmetic itself, and hence easily forgotten. Certainly the division of fractions data would suggest this). Whether our speculations are substantially correct or not, it should at least be clear that the differences in standard difficulties in different contexts provides data as convincing as, perhaps more convincing than, the arithmetic procedural differences between tests and supermarket.

It has been suggested that two major conditions contributing to the failure of attempts to link school to everyday life through simulating everyday problem solving have been the organization of curricula, and too many one-dimensional views of a multidimensional arithmetic universe of practice. There is a third condition inimical to the goal of bringing life's problems into the classroom. It is perhaps the most crucial of all. What we have referred to as "multidimensional" arithmetic practice is more precisely called "multisituational." For, the powerful effectiveness of everyday arithmetic practice comes from its integral relation with the substance of what is going on around it. That is true in school as everywhere else. And the character of arithmetic in these settings correspondingly varies. The trouble with most simulations is that they are in fact translations rather than simulations, translations from one context into another, with the attendant difficulties already described. They are not simulations of the activities and settings within which people actively generate problems and problem solutions, and change both problem and solution, and engage with the setting in the process. Those simulations conform with a venerable tradition in the social sciences, but so long as school continues to provide first and foremost an institutional embodiment of this tradition, it is not likely that cross-situational integrative goals will be achieved.

Had we in section III. done a complete analysis (in the terms proposed here), we would have presented analyses of the testing situation and the best buy problem solving session in character and detail comparable to that presented in section IV. for grocery shopping in the supermarket. Far more important, evidence will soon be available from the Weight Watchers project, which specifically addresses the processes by which arithmetic is so efficaciously acquired in everyday settings. It is not possible to rectify the omission now. But at the very least, it can be noted that the math testing situation was one in which the solving of a sequence of problems was a major structure-giving shared understanding about the activity in progress. It seems plausible to assume that more effort and attention went into the arithmetic in this setting than in the supermarket. Even this crude observation on situational difference makes the contrast in performances between the two settings more startling than before. School-like arithmetic tasks do not seem to provide a priviledged occasion for diagnosis of arithmetic competence in other settings. There are instead a variety of performances, but given the situational specificity of arithmetic practices there is no obvious rationale for selecting any one of them as a baseline, or for that matter, peak, performance indicator. Competency exams, by this analysis, are a contradiction in terms. It may be that examination makes us all incompetent--precisely Herndon's point in the passage quoted above. This is not intended as an idle remark. For being dumb may be as much as anything a matter of being acted upon, silenced, kept from generating one's own problems--and solutions.

Success is an admirable form for equality to take. In the supermarket age, gender, income and amount of schooling do not seem to matter. We presume that race and ethnic affiliation are similarly irrelevant. Could the same situation be achieved in school? In terms of arithmetic knowledge, it would be possible to emphasize mental arithmetic skills. Drawing on existing everyday mental math skills might help as well. The latter might be useful in changing the role of school arithmetic as the normative, universal standard for proper math practice, into a more relative scheme of valuation of a multiplicity of arithmetic strategies. Our informants report more math anxiety in relation to the school years of their lives than at any other time. Increased awareness of the variety of arithmetic strategies in different situations might reduce to some degree the anguish, if based on respect for the efficacy of everyday arithmetic strategies.

But basically, it is not feasible to modify the teaching and learning of arithmetic in school without changing fundamentally the situation in which it is learned. And, if our analysis is correct, to make such modifications requires coming down on one side or the other of the existing dilemmas concerning the school's role in the transmission of culturally valued knowledge. It may be just as well that explorations of everyday arithmetic in context provide such an optimistic picture of widespread efficacy.

Appendix 1:

Math Tests and Tasks

Math Test

Multiple Choice Test

Mental Math

Number Facts

Measure Facts

Best Buy Problems

Calculator Problems

Device Inventory

Arithmetic Problems

*Instructions: Read the following introduction:

"Now, we have some arithmetic problems that we would like you to work out. This is not a test in the usual sensxe, since we are not particularly interested in how many questions you get right and wrong, but rather how you do the problems and what kind of mistakes you make, not how many. There is no time limit for working these problems and you will not be timed so work at the pace which is most comfortable for you. Feel free to skip any problem and return to it later but please at least try to work out all of the problems. If you want to change something that you have written, please cross it out neatly, using only one or two lines, so that it is still readable. After you have finished all of the problems, we will go over some of them and talk about how you got your answer."

Have the person work the problems in ink. When the person is finished, changxe the pen that they are using so that a different color ink will be used if they write on the test during the following discussion.

While the person is doing the problems, notes should be taken on the observable procedurexes. For example, things such as pauses (and a rough indication of their lengths), when persons resort to scribbling and figuring off to the margin, the direction of work (left to right or rightx to left), when people put in decimal points, and when people skip problems or return to them should be noted. In general, notes should be taken on the the order of activities observed, since this is difficxult or impossible to obtain from and examinxaxtion of the test papers.

People may ask certain proceedural questions purposely not covered in the introduction read to them; the most common (with answxers) are:
asking if they can rewrite problems--yes
asking if the may check their work--yes
any question involving "should" or specific problem solving methods should be left to the d scretion of the person, ie. "Its up to you" (this applies to questions concerning the form oxr length of remainders as well).

ADD

1) $\begin{array}{r} 36 \\ +\underline{98} \end{array}$

2) $\begin{array}{r} 975 \\ 987 \\ +\underline{956} \end{array}$

SUBTRACT

3) $\begin{array}{r} 703 \\ -\underline{476} \end{array}$

4) $\begin{array}{r} 547 \\ -\underline{233} \end{array}$

5) $\begin{array}{r} 34 \\ -\underline{58} \end{array}$

6) $\begin{array}{r} 82 \\ -\underline{69} \end{array}$

MULTIPLY

7) $\begin{array}{r} 38 \\ \underline{\times 26} \end{array}$

8) $\begin{array}{r} 437 \\ \underline{\times 305} \end{array}$

DIVIDE

9) $24 \overline{)984}$

10) $8 \overline{)124}$

11) $26 \overline{)100}$

ADD

12) $\frac{1}{2} + \frac{5}{6} =$

13) $\frac{1}{5} + \frac{2}{3} =$

14) $5\frac{1}{3} + 4\frac{3}{4} =$

SUBTRACT

15) $\frac{3}{5} - \frac{1}{10} =$

16) $\frac{3}{4} - \frac{2}{3} =$

17) $3\frac{1}{3} - \frac{1}{2} =$

MULTIPLY

18) $\frac{4}{5} \times \frac{3}{4} =$

19) $\frac{2}{3} \times \frac{5}{7} =$

20) $16 \times \frac{1}{2} =$

DIVIDE

21) $\frac{2}{3} \div \frac{4}{5} =$

22) $\frac{3}{2} \div \frac{1}{4} =$

23) $8 \div \frac{1}{2} =$

ADD

24) .4 3 + .1 8 =

25) 6.4 + .7 =

26) .5 6 + 2.0 7 =

SUBTRACT

27) .8 1 - .0 5 =

28) 6 - .2 5 =

29) 3.7 5 - .8 =

MULTIPLY

30)
$$\begin{array}{r} 3.5 \\ \underline{\times\ .6} \end{array}$$

31)
$$\begin{array}{r} .4\,2 \\ \underline{\times .0\,8} \end{array}$$

DIVIDE

32) $5 \overline{)3.5\ 5}$

33) $.7 \overline{)1.4\ 7}$

34) $.6 \overline{)2\ 4}$

ADD

35) $\frac{6}{4} + .8 =$

36) $.6\ 3 + \frac{4}{5} =$

SUBTRACT

37) $1.79 - \frac{1}{2} =$

38) $\frac{3}{4} - .2 =$

MULTIPLY

39) $.24 \times \frac{1}{4} =$

40) $\frac{2}{5} \times .75 =$

41) $.59 \times \frac{1}{2} =$

42) $10 - 25 =$

43) $-48 + 37 =$

44) $-5 + 24 =$

45)
$$\begin{array}{r} -795 \\ 253 \\ -309 \\ +\ 166 \\ \hline \end{array}$$

46)
$$\begin{array}{r} 46 \\ -\ 75 \\ \hline \end{array}$$

47) $3 \times 6 + 3 \times 4 =$

48) $2 \times 7 \times 8 \times 5 =$

49) $-3 \times 4 \times -5 \times -6 =$

50) $4 \times 2 \times -7 =$

CIRCLE THE LARGER FRACTION

51) $\frac{6}{3}$ OR $\frac{5}{4}$

52) $\frac{20}{35}$ OR $\frac{12}{18}$

53) $\frac{8}{10}$ OR $\frac{66}{60}$

54) $\frac{8}{13}$ OR $\frac{4}{7}$

Multiple Choice Questions

*Instructions: Read the following introduction.

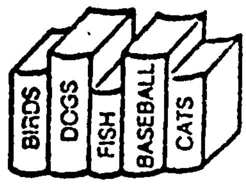
"We have some multiple choice questions that we would like you to answer. Each question has one and only one correct answer. Please circle the number of the answer which you feel is correct. If you get stuck on a question, feel free to skip it and return to it later, but please try to answer all of the questions. There is no time limit on these questions and you will not be timed so feel free to work at your own pace."

Have the people use a pen when working the problems and they can use the margins or scrap paper to do calculations (but be sure to keep any paper used for this). If a person has absolutely no idea of the correct answer and asks about it, they may skip the problem or just guess, but note any pure guesses either in the notes or on the test form itself (this is most likely to come up in the two metric system questions). If the persons asks for clarification of a question be as helpful as possible but do not define terms or suggest any particular techniques. Feel free to point out that there are no "trick" questions and it may be helpful to suggest that the person may be trying to read too much into the problem.

While the test is being taken, notes should be taken on the pen movements and pauses or hesitations. Some persons may use the pen to follow along while they read the question or consider th answers. It will be quite difficult to record all of these movements but it shold be attempted. A shorthand helps. Pauses shoxuld be noted along with approximate length (short vs. long) and when they occur in the problem solving process. Any questions, comments, or mumbles by the person should also be noted. Hesitations are when a person appears to begin to circle a particular answer (note which one) but then stops as if reconsidering. Any questions answered particularly quickly should also be noted.

1. What is another way of writing 83?
   1) 80 + 3 3) 8 + 3
   2) 8 + 30 4) 80 + 30

2. What is a name for the number of books shown below?
   1) 1
   2) 4
   3) 5
   4) 6



3. How would you read 21?
   1) Two ones
   2) Twenty tens and one
   3) Two and one
   4) Twenty-one

4. How would you write 5 tens and 6 ones?
   1) 561 3) 65
   2) 506 4) 56

5. What is another name for two hundred thirteen?
   1) 20,013 3) 2,130
   2) 2,310 4) 213

5. Which numeral tells how many tens there are in seventy?
   1) 5 3) 50
   2) 7 4) 70

7. Which of these is a way to find one-half of eight?
   1) $8 \div 2$ 3) $8 + 2$
   2) 8×2 4) $8 - 2$

8. Which numeral is nearest in value to 9000?
   1) 8998 3) 8008
   2) 9998 4) 9119

9. What is the meaning of 206?
   1) 2 hundreds and 6 ones
   2) 2 tens and 6 ones
   3) 20 hundreds and 6 ones
   4) 26 tens

10. What is another name for one thousand sixty?
   1) 100060 3) 1060
   2) 1600 4) 1006

11. What is another name for 30,000 + 300 + 6?
   1) 300,003,006 3) 30,306
   2) 33,006 4) 3,306

12. What is another name for twenty thousand three hundred six?
   1) 2,306 3) 23,006
   2) 20,360 4) 20,306

13. Which of the following numerals has the greatest value?
   1) $\frac{3}{2}$ 3) $\frac{9}{8}$
   2) $\frac{5}{4}$ 4) $\frac{6}{6}$

14. What should replace the □ in the number sentence.
   35,247 = 30,000 + 5000 + □ + 40 + 7?
   1) 2 3) 200
   2) 20 4) 2000

15. Which numeral below represents the greatest value?
   1) 1.9234 3) 10.1
   2) 10.09 4) 9.99

16. In which of the following exercises are the numerals correctly arranged for addition?

1)
```
4.1
.05
.9
```

3)
```
 4.1
  .05
  .9
```

2)
```
  4.1
.05
 .9
```

4)
```
4.1
 .05
 .9
```

17. How would you read 3.009?
1) 3 point 9
2) 3 and 9 tenths
3) 3 and 9 hundredths
4) 3 and 9 thousandths

18. Which of the following is not another name for $2\frac{4}{10}$?

1) 2.4   2) $\frac{24}{10}$ 3) $2\frac{2}{5}$ 4) 2.410

19. Which of the following is not another name for four and two-ninths?

1) $4 + \frac{2}{9}$ 2) $\frac{38}{9}$ 3) $4\frac{2}{9}$ 4) $\frac{4 \times 2}{9}$

20. The income of a business in a recent year was \$4,325,829. Which of these is the closest approximate expression for this amount of money?

1) \$$4\frac{1}{2}$ million   3) \$$4\frac{1}{4}$ million
2) \$$4\frac{1}{3}$ million   4) \$$4\frac{1}{6}$ million

21. Which of the following is the greatest distance?
1) 5 kilometers
2) 5 centimeters
3) 5 millimeters
4) 5 meters

22. Which of the following measures would give the best estimate of the height of the doorway in your classroom?
1) 6 centimeters   3) 2 meters
2) 6 meters   4) 2 kilometers

23. Which group of numbers below has an average of 4?
1) 2, 4, 6, 8
2) 2, 3, 4
3) 4, 6, 8
4) 3, 4, 5

24. Which of the following would give the best estimate of 363 × 192?
1) 200 × 350   3) 100 × 400
2) 200 × 300   4) 100 × 350

25. Which of the following is the best estimate of 5.09 × 8.91?
1) 5 × 9   3) 6 × 8
2) 5 × 8   4) 6 × 9

26. Which of the following is closest in value to 398 × 100?

1) 30,000   3) 3000
2) 40,000   4) 4000

27. In which case is 235,739 rounded to the nearest thousand?
1) 240,000   3) 235,700
2) 236,000   4) 235,000

28. The numeral 46.537 was rounded to 46.5. How was the rounding done?
1) To the nearest whole number
2) To the nearest tenth
3) To the nearest hundredth
4) To the nearest thousandth

29. Which numeral below is equivalent to 5%?

1) .5   2) $\frac{1}{2}$ 3) $\frac{1}{20}$ 4) $\frac{1}{5}$

30. Which has the same value as 8 × 3?
1) 3 × 8   3) 8 + 3
2) 3 + 8   4) 3 × 5 × 3

31. How would omitting the decimal point in 1.20 change the value of the number?

1) It would not change the value.

2) It would make it $\frac{1}{10}$ as great.

3) It would make it 10 times greater.

4) It would make it 100 times greater.

32. There are 3 feet in 1 yard. Which of these is a way to find the number of inches in 1 yard?
1) 12 × 3   3) 12 + 3
2) 12 ÷ 3   4) 10 × 3

Mental Math

Present each of the problems orally. Have the person do the problem mentally (no paper and pencil or calculator) and record their answer. Then have them describe the process they used to solve the problem. In particular check to see if they used any mental images when solving the problem; i.e., "Did you picture the problem as if it were written on a piece of paper?" If so, have them describe the image, was it horizontal, vertical, etc. Have them talk through the steps they went through to solve the problem, noting particularly how they handle carries, borrows, etc. Go on to the next problem.

(1) 26 + 37 (2) 139 - 20 (3) 246 X 2 (4) 120/30

Math Facts

Read the person the instructions given on the interview forms. Record the answer they give or an "F" if they say that they would have to figure the problem, along with the length of time it takes them to respond: none (almost immediate response), short pause, pause. Also note any obvious rising intonation by using a small question mark and note whether the person repeats the problem before responding. **Note, there are two possible responses to the Math Facts, a number or "F". There are three possible answers to the Measures: a number, "Figure", or "don't know," used when the person has no knowledge of one or both of the measures in question.

Some arithmetic we just carry around in our heads--it is memorized. For example, if someone says, "What's 2 + 2?", I just say "4" without having to stop and think about it. On the other hand, there are lots of problems we can figure out the answers to, but the answers aren't just at the tip of our tongue; for instance, 35 + 7.

On this set of problems I'm interested in knowing which ones you've got memorized, not how you would figure the other ones out. So if you know the answer without stopping to figure, tell me what it is. If you don't know it right off, let me know it's one you would ordinarily do figuring in order to get the answer. We won't bother to stop and do the figuring, though.

We'll start with some addition problems.

Addition

2 + 3 =

57 + 114 =

4 + 5 =

7 + 9 =

46 + 16 =

300 + 120 =

11 + 8 =

24 + 12 =

8 + 6 =

12 + 9 =

6 + 7 =

10 + 5 =

38 + 12 =

9 + 3 =

40 + 60 =

4 + 7 =

8-4=

62-40=

31-11=

17-9=

10-6=

65-9=

80-20=

5-3=

19-5=

20-6=

350-50=

9-6=

15-10=

18-6=

Multiplication

5 x 7 =

10 x 11 =

7 x 3 =

6 x 9 =

12 x 8 =

9 x 7 =

4 x 10 =

3 x 5 =

7 x 8 =

9 x 9 =

7 x 12 =

6 x 8 =

11 x 8 =

5 x 9 =

8 x 8 =

12 x 3 =

4 x 6 =

9 x 8 =

3 x 11 =

10 x 8 =

8 x 4 =

2 x 3 =

Division

$\frac{18}{3} =$

$\frac{20}{5} =$

$\frac{12}{6} =$

$\frac{72}{9} =$

$\frac{100}{2} =$

$\frac{24}{3} =$

$\frac{80}{8} =$

$\frac{84}{7} =$

9 / [illegible] =

$\frac{22}{11} =$

$\frac{8}{2} =$

$\frac{12}{3} =$

$\frac{54}{9} =$

$\frac{36}{6} =$

$\frac{60}{5} =$

$\frac{56}{8} =$

$\frac{24}{4} =$

$\frac{60}{10} =$

$\frac{36}{4} =$

$\frac{110}{11} =$

$\frac{6}{3} =$

Measurement Facts:

I want to do the same sort of thing we've been doing with addition, multiplication and so on with some weights and measures. Again, some of the have memorized and others we have to stop and figure, and we're interested i which ones you have memorized and which you have to figure. Some measures have been included which you may not be familiar with, if so just answer don't know to those questions.

Have you learned the metric system?

If so, what parts of the metric system do you know about?

How many inches are in a foot? (12)

milimeters in an inch (254)

feet in a yard (3)

yards in a rod (5.5)

feet in a mile (5,280)

miles in a league (2.42-4.6)

rods in a furlong (40)

ches in a yard (36)

How many teaspoons are in a tablespoon? (3)

tablespoons in a quarter cup (4)

ounces in a pound (16)

quarts in a gallon (4)

cups in a quart (4)

cups in a gallon (16)

gills in a pint (4)

ounces in a quart (32)

pints in a quart (2)

quarts in a peck (8)

pecks in a bushel (4)

tablespoons in a stick of butter (8)

How much does a stick of butter weigh? (1/4 pound)

Best Buy Calculations

*Instructions: First ask the person

"When you go shopping, do you ever find yourself comparing two items in order to find out which one gives you the most for your money?"

If no, probe a little deeper to make sure. If yes, ask:

"About how often do you think you do this?" On the order of once/shop, twice/shop, one a week, etc.

"XX How do you usually do this? In your head or do you use paper and pencil or a calculator?"

"Have you ever run into a situation where you couldn't figure this out using _____________(fill in usual method)? If so, what did you do?"

After getting the above information say:

"Now I have some problems of this type x for you to do. Each problem will have two or three items, either the actual items or written on notecards, and I want you to tell me which one gives you the most for your money. Assume that the quality of each items is the same and that you have no other preference except for getting the most for your money. Please talk through the problem while you are figuring it out, so that I can follow the steps you are going through in making your decision."

The first try on all of these should be mentally (no pencil and paper or whatever), but if the person says that they cannot decide or the problem is too hard, allow them to use whatever they would if they were doing this in a store, which should have been discovered in the initial questions. If no alternative was given, you then play the role of a calculator. Ask:

"What information would you need to answer theis question? Tell me exactly what needs to be done to help you decide and I will use this calculator to get any intermediate steps done.""

Then do just that.

After each problem clarify any parts of the procedure which were not clear from the subject's discription.

1. Potato chips

Bag A $1.09 $7\frac{1}{2}$ oz.

Bag B $1.09 8 oz.

Bag C $ .83 8 oz.

Best buy? ______

2: Worcestershire Sauce

Bottle A	77¢	$5\frac{1}{2}$ oz.
Bottle B	71¢	10 oz.

best buy? _____

3. Olives

Can A	30¢	4 oz
Can B.	60¢	$5\frac{1}{2}$ oz.

best buy? _____

4. Q-tips

Box A	\$1.49	350
Box B	\$ .99	200

best buy? ______

5. Soy Sauce

Bottle A	47¢	5 oz
Bottle B	83¢	10 oz.

best buy? ______

6. Applesauce

Jar A	65¢	20 oz.
Jar B	49¢	15 oz.

best buy? ______

7. Barbecue Sauce

Jar A	79¢	18 oz.
Jar B	81¢	14 oz.

best buy? ______

8. Sunflower Seeds

Jar A	\$1.25	16 oz.
Jar B	\$.50	6 oz.

best buy? ______

9. Sandwich Bags

Box A	78¢	155 bags
Box B	47¢	80 bags

best buy? ______

10. Salad Dressing

Bottle A	94¢	17 oz.
Bottle B	47¢	7 oz.

best buy? ________

Calculator Problems

Read the first two problems. Feel free to ~~supply~~ repeat any numbers that the person asks for. If the person requests it, allow them to write down intermediate results or you may act as memory. Show the person the third problem, as this is ambiguous if read. For each problem record the order of entries and operations and when and what the person writes down or asks you to remember.

1) Find the price of an appliance which lists at $27.60, but has a 30% discount, and the sales tax is 6%.

2) Find the gas mileage for ~~x~~ your car, if you fill up your tank and the odometer reads 55738 and after a trip you again fill up your tank, which takes 12.8 gallons, and this time your odometer reads 56052.

3) Find the result of 345 plus 289 divided by the result of 42 plus 37 squared.

$$\frac{(345+289)}{42+37^2}$$

Device Inventory

Here is a list of measuring devices, tables, etc., some of which you may have in your home. If you are not familiar with a term, or are not sure what the device is used for, please ask about it. Please check the answers which seem most correct.

3 MEASURING CUP

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

4 MEASURING SPOONS

I have a set I'm not sure I have any. I don't have any.

I use them a lot; they are indispensible. I use them quite a lot. I use them some. I don't use them.

alternatives used in place of them? If I had one I'd use them.

6 RECIPE FILE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

7 BLENDER JAR OR CONTAINER WITH QUANTITY MARKED

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensable.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

8 OVEN TIMER (to delay start and stop of oven)

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensable.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

9 WINDUP TIMER (60 minute)

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensable.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

10 DIET SCALE

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensable.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

11 OVEN THERMOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

12 MEAT THERMOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

13 CANDY THERMOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

14 REFRIGERATOR THERMOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

15 EGG TIMER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

16 SHOT GLASS

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

DO YOU HAVE A CAR? [ ] yes [ ] no
If yes, please do the following 8 questions:

20 SPEEDOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it; it's broken.

alternatives used in place of it to reckon car speed?

21 GAS GUAGE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it; it's broken.

alternatives used in place of it to keep track of gas?

26 OIL PRESSURE GUAGE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

27 ROAD MAPS

I have more than 5. I have 3 or 4. I have 2 or 3. I have one. I'm not sure I have one. I don't have any.

I use them a lot; they are indispensible. I use them quite a lot. I use them some. I don't use them.

alternatives used in place of them. If I had some I'd use them.

29 BATHROOM SCALE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

30 FEVER THERMOMETER

I have one. I'm not sure I have one. I don't have one.

When someone is sick I use it a lot; it is indispensible. I use it quite a lot when someone is sick. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

31 EYE DROPPER

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

32 BABY SCALE

I have one. (or once had) | I'm not sure I have or had one. | I never had one.

I use or used it a lot; indispensible. | I used it quite a lot. | I used it some. | I did not use it.

alternative method used in place of it? | If I had one I'd use it.

33 BLOOD PRESSURE GUAGE

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

35 RULER

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

36 TAPE MEASURE (cloth)

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

37 YARDSTICK

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

38 CALENDAR

I have at least one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

39 DATEBOOK

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

40 PHONEBOOK SUPPLIED BY PHONE COMPANY

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

41 PERSONAL PHONE AND ADDRESS BOOK

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

42 CHECKBOOK

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

43 SAVINGS RECORD

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

44 CONVERSION AND EQUIVALENCE TABLES (measures, metric, etc.)

I have at least one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

45 CALCULATOR

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

46 STOPWATCH

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

47 STEEL TAPE MEASURE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

48 LIGHT METER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

50 POSTAL SCALE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

51 DARKROOM THERMOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

52 FISH TANK THERMOMETER

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

53 POOL THERMOMETER

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensible.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

54 METRONOME

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensible.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

55 CALIPERS

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensible.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

56 WIND GUAGE

I have one.

I'm not sure I have one.

I don't have one.

I use it a lot; it is indispensible.

I use it quite a lot.

I use it some.

I don't use it.

alternatives used in place of it?

If I had one I'd use it.

57 COIN ROLLS

I have or had some. | I'm not sure I had some. | I never had any.

I use them a lot; they are indispensible. | I use them quite a lot. | I use them some. | I don't use them.

alternatives used in place of them? | If I had some I'd use them.

58 DIRECTIONAL COMPASS

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

59 AIR PRESSURE GUAGE (inflation pressure)

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

60 VOLT METER

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

61 AMPMETER (ammeter)

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

62 ALTIMETER

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

63 BAROMETER

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

64 KNITTING NEEDLE GUAGE

I have one. | I'm not sure I have one. | I don't have one.

I use it a lot; it is indispensible. | I use it quite a lot. | I use it some. | I don't use it.

alternatives used in place of it? | If I had one I'd use it.

65 PROTRACTOR

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

66 drawing COMPASS

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

67 T RULE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

68 L RULE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

69 LEVEL

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

70 PLUMB LINE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

71 ZIP CODE DIRECTORY

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

72 ADDING MACHINE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

73 LOG TABLE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

74 SLIDE RULE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

Did you used to use a slide rule?

Why did you stop?

75 ABACUS

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.

76 TAX TABLE

I have one. I'm not sure I have one. I don't have one.

I use it a lot; it is indispensible. I use it quite a lot. I use it some. I don't use it.

alternatives used in place of it? If I had one I'd use it.