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Introduction from the Editorial Group

This issue of the Newsletter spans topics from the history and philosophy of science to classroom achievement and computer use. Age old questions about normative science, representation and a cultural (ideal) vs. cultural (materialist) split are pertinent for promoting reflection on the articles.

The first two articles present different views on the historical context of the development of socio-cultural-historical approaches to cognition. The first article, by Lucy, compares the ideas of Whorf and Vygotsky in the context of the dichotomy between cultural and material approaches to social phenomena. Long time *Newsletter* readers will find many familiar topics here, including various strategies for understanding the relationship between language and thought, and the impact of schooling on cognitive development (see articles by Cole and D'Andrade, 1982, *4*(2), and by Carraher & Carraher, 1981, *3*(4), among others).

The second article, by Van der Veer, applies the ideas of Lakatos to the development of scientific research programs, with Vygotskian socio-cultural-historical theory as a case in point. Among the interesting links to Lucy's article is Van der Veer's discussion of the change in socio-cultural-historical psychology in the years following Vygotsky's death. When Van der Veer contrasts his hypothetical Vygotskian position ("Internalization is to be understood as the transformation of symbolic tools and social relations") with the hypothetical Leont'ev view ("Internalization is to be understood as the transformation of practical, external interactions") he picks out just the cultural vs. material split that was worrying Lucy.

Significantly, it is precisely conflicting claims about the "symbolic tool vs. external action" split that have been the center of controversies within contemporary Soviet psychologists concerned with the concept of "activity" (see Wertsch, 1981). While Vygotsky could be accused of entrapment into idealism, Leont'ev could be accused of entrapment into "vulgar" materialism, or behaviorism.

In their article, Schneider, Hyland and Gallimore make clear their reliance on Vygotskian theoretical constructs; as is not uncommon in work done in the United States, Leont'ev's position is refracted only through secondary sources. Yet, one cannot doubt that they are focussing on "practical external interactions" as well as "symbolic tools and social relations." In a brave move, Hyland became the teacher/researcher for Junior High children to contrast the aspects of responsive teaching and student performance that appear when the "student bodies" differ greatly in their independently assessed performance. We suggest that readers first read the transcripts and "feel" the differences between the Period 3 class exchange and the Period 6 class exchange. Although Schneider and her colleagues provide an interesting account of the similarities and differences of the processes involved with the two groups, the less-mediated impact of the transcripts provide a frame not only for evaluating their perspective but also for apprehending the need for rich and deep exploration of theoretical constructs and practical activity to approach the often painful reality of modern schooling.

Two articles concern children and computers; they involve more standard experimental methods than much of the other work on computers that we have included in past issues. Lancy and his colleagues used computer games to study

the cognitive consequences of play. Two treatments were compared; the pre-post test measures are not at all conclusive, but that is not the story of this article. Like other articles involving computers (Michaels, 1985, 7[3]; the issue guest-edited by Levin & Souviney, [1983, 5[3]; and the Fifth Dimension reported in July, 1982, 4[3]), the details of the social situation that embed the two "treatments" become more interesting than the particular contrast between pieces of software. The report gives a great deal of information about the joint activity and cooperation that were involved in the treatment; we have come to expect a hubbub of activity in studies of computer use by children and we sympathize with the attendant problems such a situation brings for research that is still restricted to individual outcome measures. As in Michaels' case, one of these groups developed a special vocabulary relevant to the task; in contrast to Michaels' groups, girls were the "stars" of one of the groups studied here. A paradox is raised in the article that needs to be attended to: these computers and their razzle-dazzle games really do appear to be "intrinsically motivating" if anything can be said to be, and Lancy and his colleagues make this point; yet the experimenters found absenteeism in one group and found great effects from the introduction of ice-cream cones as extrinsic rewards in both groups! How are we to understand "intrinsic" in the hubbub of cooperating children and what happens to it in the course of time in a setting unconstrained by the institution of schooling such that the children all scream for ice-cream? The Vygotsky/Leont'ev perspective could be fruitfully applied here.

The Cunningham and Paris piece is complementary to the one by Lancy and his colleagues in two respects. First, the Lancy article notes the impetus for reading that a computer game can provide, while Cunningham and Paris investigate how reading skill effects learning a computer task. Second, while Lancy and his colleagues were interested in "two C's" (cognitive consequences), Cunningham and Paris investigate cognitive components, completing the "three C's" important in standard psychological paradigms. Cunningham and Paris note the interrelations among reading and writing and computer literacy, focussing on common components: recognition, memory, and manipulation of symbol strings and sets of symbols. They report on children in pre-school and kindergarten learning to locate items on the keyboard. Children in the treatment group improved with practice over five weeks. In accord with a socio-cultural interpretation of the results, Cunningham and Paris found that learning differences could be related to whether the children had a name for the item (as for letters and numbers but not for semi-colons) and to the material arrangement of items on the keyboard (i.e., the numerical order is used for the numbers but the alphabet recieves no such support). Although the measure of reading skill with such young subjects is quite limited, reading skill makes a difference, not just on initial performance but also on the advantage that can be taken of practice sessions. The comparison with a control group that did not practice the task is slightly marred by an all too familiar problem of work with children and computers -- a scarcity of resources. The control children practiced on an unrelated computer task, but they worked in groups of two and three, watching for half or two-thirds of the time and actually contacting the computer for less time than the treatment group.

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In describing the history of his botanical studies, and particularly his reaction to the comparatively fixed categories of Linnaean classification, Goethe offered the following account of what we might now call the ethnographic instinct:

I must confess that after Shakespeare and Spinoza, Linnaeus had the greatest influence upon me -- and through the reaction he provoked in me. That I may be clear about those circumstances, think of me as a born poet, seeking to mold his words and his expressions immediately on the objects before him at any time, in order to do them some measure of justice. Such a poet was now to learn by heart a ready-made terminology, to have a certain number of words and selection he should know how to apply and order them into an appropriate description. Such a treatment always seemed to me like a mosaic, in which you put one finished piece next to another, in order finally to produce out of a thousand individual pieces the semblance of a picture; and so in this sense I always found the demand to some extent repugnant.

Goethe

The Historical Relativity of the Linguistic Relativity Hypothesis

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Introduction

Social science research in the twentieth century has become increasingly concerned with semiotic phenomena in general and language in particular. One important problem has been the evaluation of the nature and significance of linguistic diversity, especially the possibility that diverse languages give rise to diverse forms of thought--a problem generally referred to as the linguistic relativity hypothesis or the Sapir-Whorf hypothesis. At first glance, this topic and the issues involved in it seem at some remove from the debate over competing claims of the material and the cultural accounts of social phenomena. In fact, however, there are both formal parallels and substantive linkages between the two areas, parallels and linkages which, when examined, can illuminate the nature of the traditional antinomies governing research in both areas. This paper outlines some of the ways in which the linguistic relativity hypothesis itself is historically specific and suggests, by analogy, that the traditional antinomy of cultural and material accounts of social life may be historically specific too.

In its broadest terms, the linguistic relativity hypothesis suggests that our thought is in some way shaped by the specific language we speak. Many variants of the hypothesis can be differentiated, either by reference to the aspects of language and the understanding of thought which are presupposed in the research or by reference to the strength of the proposed causal relation (Fishman, 1960). Perhaps the most venerable and controversial version of the hypothesis claims that the overall structure of each language embodies a world view which shapes the overall image of reality held by a speaker. (Various more narrowly conceived versions exist which focus on specific portions of the overall structure.) This ***structural relativity*** has been of recurrent concern, although from quite different perspectives, since the 18th century. A second view focuses on differences in the *use* of language in thought, arguing that a distinctive pattern of use is also associated with each specific language and governs, or frames, any possible structural influences. At present, only the foundations of an approach to this *functional relativity* have emerged, largely within the last quarter century. The present paper attempts to indicate how these two forms of the linguistic relativity hypothesis intersect historically with implications for broader theoretical concerns.[1]

Structural relativity

Although one can find arguments that appear similar to the linguistic relativity hypothesis throughout the Western philosophical tradition, there is some consensus that explicit concern originates in 18th century Germany with the work of Machaelis, Hamann, and Herder.[2] The debate formed part of the larger movement in Germany in the direction of an understanding of social phenomena in secular and evolutionary terms. This was an era of intense speculation about the origins and significance of the differences among the languages of the peoples of Europe. There was, for example, debate over the natural versus divine origin of language, concern with tracing the development of languages from primitive (or ancient) to more advanced (or modern) forms and concern with whether the word of God in the Bible could be adequately rendered by the European vernaculars. Works taking up these issues proliferate in the 19th century, again, particularly in Germany. There are strong connections between this tradition, especially the works of Mueller, William von Humboldt, and Steinthal with the later approaches of 20th century American anthropological linguists working in the Boasian tradition.[3]

But the resurgence of interest in the problem in America in this century took a distinctive direction and incorporated important new elements which have frequently been overlooked. Extensive first hand contact with radically different New World languages produced fresh appreciation of, and solid detail about, the actual range of structural differences among so-called "primitive languages." It also further prompted skepticism about universal evolutionary sequences for social phenomena such as language, and promoted more detailed ideas about the actual operation of

linguistic influences on thought. The most important figures in this American reconceptualization were Edward Sapir and Benjamin Lee Whorf.

Whorf's work is typical of the contemporary approach to relativity at the structural level.[4] In his view, each language must be able to refer to an infinite variety of experiences with a finite number of formal devices. To accomplish this, languages select from, and condense, experience, implicitly classifying together as "the same" (for the purposes of speech) things which are in many ways quite different. Speakers make the error of assuming that elements of experience which are classed together on one criterion are similar on other dimensions as well. The configuration of categories and their suggestive implications *together* represent a ready-made classification of experience which may be used as a guide for thought.

These linguistic classifications vary considerably across languages. Languages differ not only in the basic distinctions they recognize but also in the assemblage of these categories into a coherent system of reference and hence in the pattern of implied secondary meanings as well. Thus, the system of categories which each language provides its speakers is not a common, universal system, but one peculiar to the individual language. Nonetheless, speakers tend to assume that the categories and distinctions of their language are entirely natural--in fact · not really a part of language at all, but part of external reality--and they regard the obvious differences among languages as superficial.

The crux of Whorf's argument is that these linguistic categories are in fact used as guides in habitual thought. A speaker attempting to interpret an experience by applying a category available in his language automatically involves the other meanings suggested by the overall configuration of the language. Consequently, a situation is created whereby the speaker can unwittingly come to regard these other meanings as being intrinsic to the original experience. Thus, the point of Whorf's argument is not that the language category blinds the speaker to some obvious reality, but rather that it suggests to him associations which are not *necessarily* entailed by experience. Further, because of the transparent, background nature of language, speakers do not understand that the associations they "see" are from language, but rather assume that they are "in" the external situation and patently obvious to all. A central point of Whorf's argument is that these very broad analogical suggestions from language have great power and force both for individuals and for the culture at large precisely because they are both so pervasive and so transparent to speakers. In the absence of another language (natural or artificial) with which to talk about their experience, they will not be able to recognize the conventional nature of their linguistically-based understandings.

The possible "relativity" of this formulation is entailed in the hypothesis itself since the understanding of language and thought may be shaped by the language of the investigator. For example, Whorf (1956, pp. 134-59) describes in some detail a set of grammatical relationships in English which, he argues, encourages speakers of English to conceive of entities (both tangible and intangible) as composed of a "form" plus a "substance."[5] Taking for granted, for the moment, the validity of the argument, what would be the implication of such a claim for Whorf's own work? It becomes clear, upon examination, that Whorf has conceived of experienced reality as unstructured until given "form" by thought, and that thought, itself, in turn is given "form" by a language; in other words, the universal substance of thought is given a variable form by each language.[6] It should be clear that the view of language and of thought which underlie this hypothesis is a very specific one.

To suggest that the idea of linguistic relativity might itself be a product of the form/substance dichotomy latent *in English* produces an apparent paradox. It would be true that Whorf's idea was shaped by *his* language (English) *only* if the hypothesis were in fact true; if it were true, then in what sense could the claim itself be seen as derivative of, or specific to, the grammar of English?

One resolution of the paradox centers on the fact that Whorf was claiming an influence for language on habitual patterns of thought, not on the absolute potential for thought of a certain type. Thus, one language's structure might more readily lead to the recognition of a general truth which, once recognized, others speaking other

languages would acknowledge.[7] This resolution of the paradox suffices at one level, although, as will become clear shortly, there is a much larger problem involved here.[8,9]

Functional Relativity

The second form of the linguistic relativity hypothesis, that of functional relativity, derives from work on the ethnography of speaking which tries to move beyond grammar as the sole unit of analysis and focus on, for example, the social functions of speech (Hymes, 1974, and references therein). Hymes (1966), in particular, argues that there is a potential level of linguistic relativity prior to the structural level which he terms the relativity of use. Only when two languages are used, or function, in a similar fashion can one reasonably ask whether the grammatical structures themselves have specific independent effects.[10] According to this sort of argument, any claim for relativity at the structural level must rest on the prior demonstration of a commonality (or universality) of use - either social use or individual cognitive use. In terms of social functionality, arguments can be made for the universal centrality of the referential function of language (Hymes, 1974; Jakobson, 1960; Lyons, 1968; Silverstein, 1976); in fact, the general success of contrastive linguistics depends heavily on such universality. But a general argument for, and demonstration of, a universal pattern of use of linguistic structures in *thought* has not, to my knowledge, yet been made, although there are many--including Whorf--who presuppose such a relationship. Only if individual thought can be shown to be dependent on linguistic structures to a similar degree and in similar ways will there be an equivalent basis for the assessment of structural effects.

One theory, that of Soviet psychologist L. S. Vygotsky (1962; 1978; [in preparation]), posits just the opposite, namely that language can be differentially used in thought, both ontogenetically and socio-historically. Vygotsky was engaged in the task of building a Marxist psychology, that is, one which emphasized the *social* origins of consciousness and the importance of *mediational means* in developmental process-- whether the development be historical, phylogenetic, or ontogenetic. Vygotsky's approach emphasized the importance of language in the development of the higher mental functions such as reasoning, voluntary attention, and logical memory. Especially important in the later stages of this process both developmentally and historically is the emergence of scientific or "true" concepts through the systematic elaboration of verbal meaning during formal schooling.

In Vygotsky's approach, cultures without formal schooling, or some functionally equivalent form of discourse, would not develop scientific concepts of the familiar sort.[11] The specific forms of language usage required by schooling are *the* critical factors and not the structural properties of particular languages *per se*. Thus, for Vygotsky, peasant societies represent an historically earlier form of social organization, one that exhibits less developed forms of thinking, that is, forms which do not fully exploit the conceptual potential of the linguistic resources. Similar arguments underlie most theories concerned with the importance of schooling, literacy, and the like. The important difference of this approach from that of Hymes is that whereas Hymes points to the importance of functional differences, he does not hierarchize them as more or less advanced; Vygotsky does this, attributing a large-scale historical significance to the differences.[12]

If Vygotsky is correct, and there are important problems with his approach, it would suggest that the peculiar emphasis on abstract, decontextualized thought characteristic of our society, reinforced by specialized forms of discourse such as formal schooling, has significant structural connections with the broader set of developments we associate with modern capitalist societies. The linguistic relativity hypothesis may be more than culturally relative in a synchronic sense. It may be specific to the historically significant development of a qualitatively different form of social organization on a par with those divisions that anthropologists often use to distinguish large groups of societies, for example those with or without agriculture or those with or without an organized state. Although many social scientists including anthropologists (e.g., Boas, 1911; Redfield, 1953) have articulated a vision of a progression or cumulation of knowledge in human societies over time, there is considerable ambivalence about *evaluating* this progression or seeing significant differences at the level of individual actors. Nonetheless, this is the implication of Vygotsky's approach.

Quite aside from these hierarchical and evaluative views, however, Vygotsky's framework suggests a heightened significance for relativity at the functional level in the evaluation of the linguistic relativity hypothesis. The structural relativity outlined in the first section can *only* operate when language is used as a guide for thought and it will operate most pervasively and most powerfully precisely to the extent that language is taken as *the* primary guide for thought, supplanting or overriding other organizational possibilities. In this sense, a society like our own, in which, as Vygotsky suggests, the dependence of thinking on language has reached extraordinary proportions, is presumably especially susceptible to such structural influences. In short, the significance of the structural relativity proposed by Whorf is socially contingent and may reach its highest degree precisely in our own society. His theory and others like it which have been developed in the modern era may be inspired by, and particularly appropriate to, our own cultural experience. Its significance may be considerably less in those forms of social organization which have predominated throughout most of human history. It is in this sense that Whorf would indeed have been influenced by the grammar of English, and yet his hypothesis need not be generally true in the form in which he proposed it.

Implications

Most "materialistic" accounts of social life trace their origins to the writings of Karl Marx. Yet, in his mature writings Marx (1977) recognized that the classical theories of political economy were products of the social forms of thought characteristic of modern capitalism. And, at a deeper level, he recognized that the very activity of theory construction of that sort, that is, the doing of political economy, was also a product of the same social forms of thought (Lukacs, 1971). Thus, the theories were derivative of, and particularly appropriate to, the society within which they arose, and their extension to other societies and other epochs was problematic. But those who have not understood his arguments have used those theories of political economy uncritically to account for other societies--giving rise to the so-called "material" accounts of social life with their characteristic transhistorical and transcultural assumptions.

If the form or the force of the linguistic relativity hypothesis is itself historically relative, that is, a product of our own social institutions and forms of thought, then we are also led to question the bases of those "cultural" accounts of social phenomena which typically take language as their paradigm of things cultural and which speak in parallel fashion of a *cultural* relativity. The uncritical extension of our own conceptualizations of language in particular or of culture in general to other societies is problematic. The concepts of a linguistic form shaping a cognitive substance, or of a cultural form shaping a material substance, are no more universally applicable than the inverse notions of a cognitive form shaping a linguistic substance or of a material form shaping a cultural substance. In the end what we must question is the very separation of form and substance, of language and thought, and of the cultural and the material in the first place, for it is these antinomies so natural to our own way of thinking, which most need to be grounded.

Notes

Presented at the symposium "Social Mediation: Beyond the Antinomy of the Material and the Cultural" at the 107th Annual Meeting of the American Ethnological Society, Toronto, Canada, 11 May 1985.

[1]The approach here will focus on analytic and conceptual issues rather than detailed chronology. No adequate history yet exists which integrates specifically linguistic, general intellectual, and broader social materials into a unified account. For partial accounts, see references in Notes 2 and 3.

[2]See Brown (1967), Koerner (1977), Penn (1972), and Stam (1980) for discussions of the history of the hypothesis.

[3]See Haugen (1967), Hymes (1963), Stam (1980), and Stocking (1974) for discussions of these connections.

[4]For a more detailed account of Whorf's theory and its connection with other contemporary work see Lucy (in preparation).

[5]See Whorf's original essay for numerous subtleties which must be omitted here; fuller commentary is available in Lucy (1985).

[6]See Lucy (1974) for a more complete argument.

[7]For example, in my own research on the significance of the form-substance opposition in languages, I have been able to show both the common underlying salience of various types of form-substance distinctions and the specific cognitive salience of one or another linguistic encoding of them (Lucy, in preparation).

[8]Notice that this argument is *not* the usual one that the hypothesis is intrinsically circular because, if we are prisoners of our own language, then the analyst can never know the languages or thoughts of other groups sufficiently well to even construct let alone prove the relativity assertion. It is rather a claim about the historically specific or relative nature of creating the *hypothesis* itself, and not a claim about the logic of its proof or disproof.

[9]It would be important in this regard to have studies of the relation, if any, of the course of philosophical understanding in the West in terms of possible relations to the language of the philosophers (e.g., Greek, Latin, German, English). Although there are some isolated case studies (e.g., Benveniste, 1971 on Greek) none is historically comparative. It would also be interesting to compare how other diverse language groups formulate or account for the phenomenon and significance of language variation itself. Although there are interesting case studies about attitudes toward language, particularly by sociolinguists, they are not oriented to this specific problem.

[10]I encountered a concrete example of such a functional difference in a study of the relationship between the linguistic encoding of colors and recognition memory for colors in three language groups: English, Spanish and Yucatec Maya. The latter two groups exhibited a number of differences between men and women speakers which were not found with English speakers (Lucy, 1981). The differences between the men and women could not be accounted for on structural grounds, but only in terms of the differential *use* of language in cognition by men and by women in these two groups. In comparing these two groups with English, it it necessary to recognize that the differential use, that is, the presence or absence of a sex difference, is as important if not more important that any structural differences.

[11]In fact, cross-cultural psychological research consistently reveals that the single most important variable in studies of intellectual skills is the existence of school experience (Scribner and Cole, 1973).

[12]For a contrast of Vygotsky's approach with that of Whorf, see Lucy & Wertsch (in press).

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It is only in a social context that subjectivism and objectivism, spiritualism and materialism, activity and passivity cease to be antinomies, and thus cease to exist as such antinomies. The resolution of the theoretical *contradictions is possible* only *through practical means, only through the* practical *energy of man.*

Karl Marx.

The Cultural-Historical Approach in Psychology: A Research Program?

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Introduction

Most philosophers of science have been rather reluctant to consider psychology a "real," mature science. Examples of this attitude can be found in the work of prominent philosophers such as Popper, Kuhn, and Lakatos. The implicit or explicit assumption in their writings seems to be that standard examples of rational scientific development are mostly to be found in the natural sciences. Time and again we meet the worn-out cases of Galileo's new mechanics, Newton's gravitational theory and Bohr's theory of the atom. Psychology and the humanities seem to fall short of standards of rationality taken from these periods of history in the natural sciences. Therefore, psychology is considered to be an immature, unscientific or "preparadigmatic" science.

One could, of course, criticize this harsh judgement by maintaining that it is not necessarily or conceptually true that psychology should be measured by the same standards as the natural sciences. This is not the approach we will follow, however. Instead we will accept the standards of rationality of one philosopher of science, notably Lakatos (1978), and show that at least one approach in psychology can live up to his requirements.

The purpose of this paper will be, then, twofold: 1) to show the applicability of Lakatos' theory to an important approach in contemporary psychology, namely the cultural-historical theory, and to argue that this approach satisfies the demands Lakatos formulates for fruitful research programs. I believe that the same could be done for other psychological theories, e.g., Piaget's and Kohlberg's theories of cognitive and moral development. There seem to be no grounds to restrict the applicability of Lakatos' theory to the natural sciences; 2) to show that the application of Lakatos' theory in any science will meet with some difficulties. First, there is the problem of formulating what is considered to be the hard core of a research program. The choice of hard core items will inevitably depend on some debat-

able judgements. Second, one has to decide which time period should be used to formulate the hard core. Third, as an encore, the question will be raised whether Lakatos' concept of the hard core doesn't necessarily imply some sort of essentialism.

Vygotsky's Cultural-Historical Theory

The popularity of Vygotsky's cultural-historical theory (Vygotsky, 1962; 1978) is growing and several books offer a more or less complete description of its content and development (e.g., Kozulin, 1984; Van IJzendoorn & Van der Veer, 1984; Wertsch, 1981). Therefore, we will confine ourselves to the bare outlines of the theory and the history of its development.

In the late 1920's the Russian psychologist Lev S. Vygotsky (1896-1934) started to develop a theory of cognitive development. Together with his colleagues, Luria and Leont'ev, he formulated the so-called cultural-historical theory, which was meant to incorporate some of the basic concepts of Hegelian Marxist thought while at the same time doing justice to the results obtained by important researchers such as Bühler, Külpe, James, Piaget and others (Vygotsky, 1934 [1962]; 1978). One of the characteristic features of Vygotsky's theory was the distinction he made between "lower" and "higher" psychological processes. The latter were supposed to be typically human and based on the acquisition of cultural tools or instuments. Lower, "natural" psychological processes were supposed to be hereditary. They formed the raw material out of which the higher processes were formed. To give an example, some basic memory mechanisms are hereditary and common to both animals and human beings, e.g., the ability to recognize an object seen before. This, then, constitutes a lower psychological function. Typically human, however, is the use of mnemotechnic devices and language in remembering. These Vygotsky considered to be cultural instruments used to transform lower natural memory processes into a higher, "cultural" memory. The lower processes continue to play a role but become subordinated to higher goals. They are, in the words of one of Vygotsky's favorite philosophers, G.W.F. Hegel, "superseded" (aufgehoben). The cultural tools themselves also have a history. They have been developed by earlier generations and this history can be investigated by doing cross-cultural and archeological research.

Vygotsky's research plan was as simple as it was comprehensive: to study the acquisition of cultural tools and the transformation of lower psychological functions into higher ones; to study the historical development of cultural tools, and finally to study the most complex psychological tool, language, with respect to its formative role for human thought (Kozulin, 1984, p. 106).

It is clear for those acquainted with the philosophical and psychological issues of the 1920's that Vygotsky had a thorough knowledge of the research that had been done in this period. To give but a few examples: the distinction between lower and higher psychological processes had already been made by Wundt; the general anti-reductionistic trend in Vygotsky's writings and his emphasis on typically human vs. animal processes can be traced back to Engels' writings; the distinction between two types of memory is implicit in Janet's work; etc.

In retrospect we can say that Vygotsky's theory was a quite original attempt to tackle one of the oldest and most respectable problems of Western thought: the nature-nurture issue. After his death, his work was continued by his colleagues and pupils. Among his most influential followers were undoubtedly A. R. Luria, who contributed much to the development of neuropsychology, and A. N. Leont'ev who was to become well-known as the originator of the so-called activity theory (see Wertsch, 1981).

The hard core. After this short introduction to the cultural-historical theory it should be possible to formulate its Lakatosian "hard core". Careful reading of Vygotsky's writings suggests the following, mutually connected, statements.

a) It is necessary to distinguish between lower psychological processes, which have evolved in biological evolution and higher psychological processes, which are connected to cultural theory;

b) Child development is the acquisition of cultural instruments, which transform the lower processes into higher ones;

c) All higher psychological processes have a social origin, because the cultural instruments are acquired in a person-to- person interaction and

because the instruments themselves embody social, cultural experience.

d) Cognitive development is not a process of gradual accumulation of knowledge, skills, etc., but a "dialectical" process of sudden transformations.

It seems unlikely that a hard core formulated in this way could be attributed to some other theory of cognitive development, e.g., Piaget's theory. It thus seems to be successful in characterizing the cultural-historical theory as distinct from other psychological theories. But this is not enough of course. The hard core should be a set of assumptions, presuppositions, and beliefs shared by all participants in the research program. To answer the question of whether our description of the hard core of the cultural-historical theory is acceptable to all researchers involved, we will again dip into the history of this school of thought.

Vygotsky very much emphasized language as the most important cultural tool. Speech, in his opinion, transforms the mental functions of the child and therefore, ultimately, the child's consciousness. The acquisition of verbal concepts and symbols takes place during adult-child interaction. It is therefore understandable that Vygotsky was highly "interested in the internalization of symbolic tools and social relations," as writes Kozulin (1984, p. 107).

The tragedy of Vygotsky was that this point of view was quite unacceptable in the social climate of the 1930's. Vygotsky's point of view seemed to imply that children's consciousness is wholly determined by the consciousness of their parents. If our consciousness is determined by verbal concepts and these concepts are learned from more experienced members of a culture, then the danger of "idealism" looms large. It was not clear to critics where the material praxis came in, a praxis which had to play an important role in the formation of consciousness according to the standard dialectical-materialist doctrine. Although it clearly was possible to defend Vygotsky's point of view (see Kozulin, 1984, pp. 117-118; Van der Veer, 1985a), this was not what happened.

Shortly after the death of his colleague and teacher, Leont'ev dissociated himself from Vygotsky's ideas (Leont'ev, 1983). He accepted the criticisms of "idealism" and emphasized that one had to study the child's practical, material activity. Internalization was to be understood not as the transformation of symbolic tools and social relations into mental functions (Vygotsky), but as the transformation of external actions. Clear examples of this approach can be found in the work of Leont'ev's colleague P. Y. Gal'perin. Leont'ev's article meant the starting-point of the so-called Kharkov school (see Van der Veer & Van IJzendoorn, 1985; Wertsch, 1984) which would eventually lead to the above mentioned activity theory. It also meant the starting point of a controversy within the cultural-historical school which continues to this day (see Kovalev & Radzichovsky, 1985). From the theoretical point of view, we think that the switch from a Vygotskian emphasis on symbolic tools and social interaction to Leont'ev's emphasis on practical activity can be understood as a switch from Hegelian dialectical thought to Engels' more materialist writings (Van der Veer, 1985b).

The switch from Vygotsky to Leont'ev had important consequences for both empirical and theoretical investigations within the cultural-historical tradition. Does this imply that Leont'ev started a new research program? Do we have to formulate a new hard core? We do not think this is necessary if we stick to the description of the hard core as given above. But we could of course have supplemented this description by the typical Vygotskian statement.

e - Internalization is to be understood as the transformation of symbolic tools and social relations into psychological functions.

This would then be in clear contradiction to Leont'ev's statement that

e' - Internalization is to be understood as the transformation of practical, external actions into mental functions.

It is not clear how this problem can be solved. The solution partly depends on the time period one takes into consideration. If one considers a period from 1930 until now, then one will arrive at something as formulated above (the statements a-d). These are probably the assumptions shared by all researchers from this period. If, however, one concentrates on Vygotsky's period (until 1934) one could add statement e, which would then in a later period have to be replaced by e' (assuming for the sake of argument that they cannot be reconciled). The choice of statements pertaining to the hard core of a research program thus seems to depend partly on the time period taken into consideration.

Quite apart from these difficulties any attempts to formulate the hard core of a research program will always depend on some decisions which can be questioned. We would not be very surprised, for instance, if some cultural-historical researcher turned out to be not very attached to statement d. Some might deny that this rather "empty" statement is indispensable. Another illustration can be found in Wertsch (1981): In his description of Leont'ev's theory, he does not explicitly mention our statement a.

These, then, are some of the difficulties one meets in describing the hard core of the cultural theory. They do not seem, however, to be specific to the cultural-historical theory or to psychology in general. They are difficulties the philosopher of science has to face in any science; be it chemistry or psychology, physics or sociology.

Positive and Negative Heuristics: Assessment of a Research Program

Having formulated the hard core of the cultural-historical theory we can proceed with the description of the so-called positive and negative heuristics. The negative heuristic of a program is the demand that during the development of the program the hard core is to remain unmodified and intact. Any scientist who modifies the hard core has opted out of that particular research program. Lakatos (1978, p. 48):

> The negative heuristic of the program forbids us to direct the *modus tollens* at this 'hard core.' Instead, we must use our ingenuity to articulate or even invent 'auxiliary hypothesis' which form a *protective belt* around this core, and we must redirect the *modus tollens* to *these*.

The positive heuristic of a research program indicates to the scientist how the hard core is to be supplemented in order for it to be capable of explaining and predicting real phenomena. It consists of a set of suggestions, hints and guidelines on how to modify or sophisticate the protective belt. Lakatos states that the principles expressing the positive heuristic are of a flexible, metaphysical nature (Lakatos, 1978, p. 51).

Clear examples of positive and negative heuristics can be found in the history of the cultural-historical school. Statement c from the hard core, for example, clearly implies some suggestions and hints for empirical research. The assumption that "all higher psychological processes have a social origin, because cultural instruments are acquired in person-to-person interaction" implies that schooling (teaching), being a particular form of social interaction, can play a role in the development of higher psychological processes. This means that participants in a cultural-historical research program will try to develop curricula to promote cognitive development. The work of Davydov and Gal'perin testifies to this attitude (cf. Davydov, 1972; Gal'perin, 1980). The tenacity of these researchers in developing curricula and their optimism in the face of setbacks can be explained in view of the fact that this type of research is intimately connected with, and implied by, the hard core of their research program. It is part of the positive heuristic. On the other hand, if a child performs badly on a task requiring cognitive functioning, the cultural-historical researcher should not, at first, look for hereditary and/or physiological factors (such as minimal brain damage). Such a strategy would clash with the hard core assumptions as described above. First and foremost one should look for earlier social interaction patterns to explain the child's inferior performance. It is rational to do so as long as the research program bears fruit.

> We may rationally decide not to allow 'refutations' to transmit falsity to the hard core as long as the corroborated empirical content of the protecting belt of auxiliary hypotheses increases (Lakatos, 1978, p. 49).

Chalmers (1982, p. 84) mentions two ways in which the merit of a research program is to be assessed. Firstly, a program should possess a degree of coherence that enables the mapping out of a definite program for future research. Secondly, a research program should lead to the

discovery of novel phenomena at least occasionally. It does not seem difficult for the cultural-historical theory to satisfy these demands. The high degree of coherence of the theory can be shown in a few words. The hard core, to begin with, consists of a set of intertwined assumptions. Statements b and c presuppose statement a, statement d is connected with b, etc. In the above we have shown how the positive and negative heuristics are implied by, and connected to, the hard core of the program. Hard core and heuristics taken together lead to a program for future research, which we described in Van IJzendoorn and Van der Veer (1984, pp. 96-98). The second demand, that the program should, at least occasionally, lead to the discovery of novel phenomena, has also been met repeatedly. As examples of research leading to the discovery of novel facts we would suggest, for example, the research into literacy (see Scribner & Cole, 1981) and Luria's neuropsychological research (see Luria, 1973).

To summarize, we have shown that it is possible to formulate the hard core of cultural-historical theory as well as the positive and negative heuristics. We have further suggested that the theory can satisfy Chalmers' additional demands of coherence and fruitfulness. This implies that the cultural-historical theory can be considered a Lakatosian research program. At the same time it has been shown that the application of Lakatos' ideas is not without problems. The formulation of the hard core and the choice of the historical period taken into consideration will rest on certain debatable grounds.

Discussion

The main purpose of this paper was to show the applicability of Lakatos' theory to one of the most important approaches in contemporary psychology. Our demonstration has of course been rather brief and we understand that a really convincing case requires a detailed description of all the ins and outs of the historical development of the cultural-historical research program. A first approximation of such a description can be found in Van der Veer (1985b). We believe, however, that we have given some arguments in favor of the thesis that the cultural-historical approach should be considered a Lakatosian research proram. It seems likely that other important theories in psychology can also meet Lakatos' conditions. As a first candidate we would suggest the Genevian school of cognitive psychology, developed by Piaget. Like the cultural-historical theory, this approach has a respectable history and it led to a wealth of novel facts.

Another purpose of this paper was to show some difficulties connected with the application of Lakatos' theory in any science, be it psychology or physics. They do not seem to invalidate Lakatos' approach, but show that any philosophical-historical analysis of scientific developments presupposes a point of view, which influences the results. One can of course question Lakatos' approach itself. The conception of a "hard core" as a set of immutable assumptions and beliefs, for example, is not without difficulties. It rests on the assumptions that the resemblance of theory variants T1, T2,...Tn is based on some common set of statements. This is not necessarily true, as Wittgenstein showed with his notion of "family concepts." One could, in other words, see the development of a research program as a process of organic growth, in which the last theoretical product does not necessarily resemble the first, and which theoretical products are not necessarily compatible with some shared set of assumptions. This would mean that one avoids essentialism and allows for some modification of hard core assumptions without immediately drawing the conclusion that the researcher has totally opted for a different research program. Perhaps such a point of view would be able to handle more examples of theoretical traditions than a "rigid" Lakatosian approach. This is only an afterthought, however, and we leave it as a suggestion to the reader. In this paper we accepted Lakatos' point of view and showed its applicability to cultural-historical theory and some of its problems.

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Man lives with things mainly, even exclusively-- since sentiment and action in him depend upon his mental representations--as they are conveyed to him by language. Through the same act by which he spins language out of himself he weaves himself into it, and every language draws a circle around the people to which it belongs, a circle that can only be transcended in so far as one at the same time enters another one.

Wilhelm von Humboldt

The Zone of Proximal Development in Eighth Grade Social Studies

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Since 1910, study after study has described recitation as the dominant pattern of teacher-class interaction (Hoetker & Ahlbrand, 1969). Recitation may test students' existing knowledge but it does not teach. It is rapid paced, with as many as five questions per minute. Students are commonly given only a brief time to answer before a question is repeated or re-directed to another pupil. The emphasis is on lower-level facts and ideas, literal detail, and the already known. Teachers often do not use follow-up questions; they do not engage in Socratic give and take to assist students to understand at a higher level, or to express their ideas in a more complete form. There is little attention to comprehension at the level of cause-effect reasoning, interpretation, or inference, nor is the tentative and problematic nature of understanding a given text acknowledged. Teachers act as if students should understand and apply ideas on their own. Vygotsky's (1978) ideal of teaching as assisted performance in the zone of proximal development (ZPD) is rarely achieved.

Such restricted patterns of teacher-class interaction were observed in a junior high school serving an urban, Latino community. Hyland (1984) spent many months in this particular school conducting an observational study of eighth grade social studies instruction. Among other findings, he reported that recitation was the dominant form of teacher-class interactions. For example, teaching of the U.S. Constitution in all achievement groups consisted of an emphasis on simple facts about the document and its authors. Virtually no attempts were made to foster, through teacher-guided discussion, students' understanding of the principles of American democracy or the application of these principles to his-

torical or contemporary problems. This school is by no means unique. Recitation dominates interaction in most U.S. classrooms--in schools attended by middle class Anglo students (Durkin, 1978-1979) and retarded children (Levine, Zeitlin, and Langness, 1980).

If asked, teachers have a ready explanation for the emphasis on recitation, factual details, and lower level mental activity. To paraphrase many with whom we have worked: "You have to stick to textbook facts because that is all they can handle. Anything else goes over their heads."

If teachers are correct in their assessment of their students' ability to participate in more complex interactions, then in fact recitation would be the most appropriate teaching style. Alternatively, if it were shown that students can be assisted to higher levels of comprehension, then there would be no reason to persist in lower-level activities through recitation. Are teachers' perceptions accurate here? Are students really unable to participate in higher-level activities when assisted by the teacher? What would happen if a teacher tried another style of interaction, a style that incorporated the Vygotskian notion of the zone of proximal development?

To explore these questions, we gained access to two eighth grade social studies classes in the junior high school that Hyland had observed. The students in Period 3 were described as remedial, with a reading level of. 4 to 5 grade levels below the norm for their age group. Period 6 was described as a gifted group, many of whom were college-bound and reading well above grade level. Approximately ninety per cent of the students in both classes were Latino.

For two successive Fridays in each period, one of us (JH) taught a 50 minute lesson. Both classes read and discussed part of an account of a Supreme Court decision in the case of Minersville School District v. Gobitis (Starr, 1978). The case involved a flag salute controversy, in which two children whose religious beliefs prohibited them from pledging allegiance were expelled from public school and forced to enroll in and pay fees to a private school.

Recitation questioning was kept to a minimum. The emphasis was on the teaching style adapted from the responsive teaching practices developed at KEEP (Kamehameha Early Education Project) for early reading instruction (Gallimore, Dalton, & Tharp, in press; Tharp et al., 1984). In responsive teaching, the teacher assists as well as assesses students' performance. A principle vehicle for assisting performance is contingent questioning, which is similar in some ways to the adult-child dialogues observed in problem-solving tasks (Wertsch, 1985). In both instances, adults adjust help based on a continuing assessment of the child's performance level. In responsive teaching, these adjustments support student thinking and expression of ideas. Questions are not asked to test what the students already know as in recitation. Responsive questions lead to a level of performance that could not be achieved without the teacher's guidance (Gallimore & Tharp, 1983; Gallimore, Dalton, & Tharp, in press; Tharp et al., 1984). Thus, responsive teaching operates within the zone of students' proximal development. The use of responsive questioning raises two associated but distinct questions: How far can the students go? and How far can the teacher go?

How Far Can the Students Go?

The level of unassisted comprehension on the part of the students in Period 3 is much lower than that of the students in Period 6. This was observed not only in their performance during class but also in standardized measures of the students' independent level of development. Students in Period 3 demonstrate difficulties with vocabulary, literal comprehension (grasping the main idea and details), interpretive comprehension (classifying, sequencing, recognizing cause/effect relationships, drawing conclusions, separating fact from opinion), and critical comprehension (inferring, comparing and contrasting, distinguishing relevant from irrelevant details).

What is not revealed by standardized test results or classroom recitation is the potential level of comprehension that the students in Period 3 might someday achieve. According to the Vygotskian framework, the level of achievement with assistance, such as in the examples to be presented, *is* the potential development; over time, such achievement-through-assistance leads to a new level of *independent* functioning. If the dominant recitation pattern of instruction were different from that which students presently experience, and have very likely experienced for a number of years, it is conceivable that their level of independent achievement might rise signifi-

cantly. How far can these students go in their level of understanding with assistance? A microgenetic analysis of our brief exploratory lessons offers some clues.

If we begin our analysis at the outcome of our lessons, we see that both classes accomplished essentially the same task in the excerpts presented here: each jointly produced a connected narrative account of the Flag Salute case. A consideration of the *processes* involved in these productions, however, reveals differences in terms of individual student and teacher contributions--i.e., in the relative responsibility assumed by the students vs. by the teacher.

One striking difference between the two narrations is the number of turns (i.e. student and teacher contributions): Period 6 takes 17 turns to produce the details of the story, while Period 3 takes 92. What is the reason for this large discrepancy in number of turns? We might inquire whether Period 3 produced more details; in fact, despite the shorter narration, Period 6's account included one issue (the family's financial hardship) not mentioned in Period 3's discussion until much later (when introduced by the teacher).

In addition to number of turns, the length of each turn differed in the two periods as well. In Period 6, several students contributed to the narration, each generally adding information to the previous student's contribution (especially in 12, 13, and 17). The number of words in each student turn ranges from 4-65, the average being about 24 words. In contrast, most of the students in Period 3 are called upon to contribute at last once to the construction of the narration, but the length of turns is shorter, ranging from 1-21 words and averaging less than 6 words per turn, and are more frequently incomplete sentences than was the case in Period 6.

Thus, when considering student contributions, two striking differences are number of turns and length of individual contributions. However, if we wish to go beyond these superficial characteristics and understand why they exist, we need to look at the interaction between the students and the teacher -- specifically, at how the responsibility for structuring the narrative is divided between students and teacher.

Period 6

1	**T:**	Now, you've read the story and real quickly let's tell me something about the story. What's it about? Who's it about? And so forth.
2	**R:**	It's about students who didn't want to salute the flag and got expelled ...
3	**T:**	Okay. Tell me some more about the story. Somebody else? Yes?
4	**J:**	Well they -- the Minersville school district they wanted to take them to court because they didn't think it was right that they shouldn't be saluting the flag. But so the Gob ... what's their name?
5	**T:**	Gobitis?
6	**J:**	Gobitis -- uh, they went to court, and they ... the judge said he was going to (inaudible word) religious beliefs and so like it was better for his (inaudible) ... politics, or something like that ... (inaudible phrase)
7	**T:**	Okay. Er., what's the story about?
8	**Er:**	It's about um, (the flag salute)?
9	**T:**	What about the flag salute?
10	**Er:**	It's that ... (Gobitis) ... should salute the flag?
11	**T:**	Somebody else -- let's get out here what this story is all about.
12	**El:**	It's about having the freedom of saying the pledge of allegiance or not, whether they want to say it or not?
13	**I:**	I think it was because their religion said that they should not salute the flag or something like that, and they had to go along with their religion. So when they didn't want to say it, they got expelled from school, and their parents put 'em, well were gonna put 'em in a public school -- I mean a private school, so they wouldn't have to say the pledge of allegiance, and took them to court.
14	**T:**	What's the problem? Yes?
15	**B:**	It was against their religion to say the pledge of allegiance.
16	**T:**	Yes?
17	**G:**	The only reason they did not put them in a private school was because it would have been a financial hardship, so therefore they didn't want to put them in a private school. And then they were expelled, because their religion stated they should not worship a flag or praise it.

Period 3

18 **T:** So ... who can. what is this story about? What is this story about? V?

19 **V:** People from another religion didn't do the flag salute.

20 **T:** Okay. (pause) Tell me something about the story ... You said "people." Tell us some --

21 **V:** Students from the school.

22 **T:** Students from school? What's their names?

23 **V:** Lillian Gobitis ... and the brother William.

24 **T:** P, tell us something else about this story.

25 **P:** (pause) (laughs) They got expelled for not -- not saying the flag salute.

26 **T:** Okay ... A. how many people got expelled? We're just trying to get the details out here, class. How many people are we talking about?

27 **A:** Two.

28 **T:** Two? Who can tell me something else about the story? (pause) S?

29 **S:** They were Jehovah's Witnesses.

30 **T:** Okay. And what does that mean?

31 **S:** They can't participate in some things ... or ...

32 **T:** They can't participate in some things? Like what? What's the obvious thing they can't participate in?

33 **S:** Doing the flag salute.

34 **T:** The flag salute. Okay. Something else about the story. (pause) For example ... G, why is it that they wouldn't be able to do the flag salute? What's that all about?

35 **G:** Cause they're from a different religion.

36 **T:** Uh huh. Okay, but there's lots of different religions. Why is it that they wouldn't be able to do the flag salute? What's involved here?

37 **G:** I don't know.

38 **T:** Anybody? Why is it they can't do the flag salute? According to the story ... (pause)

39 **J:** Because they broke the law.

40 **T:** How's that?

41 **J:** (shrugs) (pause) (Don't know.)

42 **T:** J says they broke the law. Did they break a law?

43 **A:** Yes.

44 **J:** How's that?

45 **A:** Cause everybody is supposed to do the flag salute, and they didn't do it.

46 **T:** So according to the story, what happened to them in the story?

47 **J:** They had to go to a private school.

[48-61: Teacher elicits literal details by sending students to text.]

62 **T:** Here we have these two kids. Lillian and William ... why is it that they did not do the flag salute? We need to get that out. According to the story, what does it tell us in the story? Why didn't they do the flag salute?

63 **G:** (shrugs) Don't know.

64 **T:** What does it say?

65 **G:** Can I read it? (starts to read first line of article)

66 **T:** Wait a second, G. I don't want you to read the whole thing. I want you to help us to get out in the open here why they wouldn't do the flag salute. L?

67 **L:** It's against the law of their religion

68 **T:** It's against the law of their religion. Tell me more about that. What does that mean? I think you're on the right track there ...

69 **L:** They can't do it.

70 **T:** D, why couldn't they do it? Why would that be the situation for them? According to the story ... what does it tell us in the story?

71 **D:** (pause) They're from another religion. They can't ... say the ... flag salute.

72 **T:** Alright. You got it. But why? You got to go a little step farther here in this story. Both L and D I think are on the right track for us. But the question is *why*?

73 **D:** Because they're from another religion.

74 **T:** Okay. (long pause) Let me give an example --

75 **A:** They'll break the law from the -- from the church.

[76-81: Teacher tries unsuccessfully to elicit clarification of the main character's motives.]

82 **T:** I want you to look in there in the paragraph where it talks about Lillian.

83 **A:** It says right here that you have to have respect for the flag. And they ... they didn't do the flag salute.

84 **T:** They had to have respect for the flag, and they what ... ?

85 **A:** And they didn't do it.

86 **T:** Okay. And what's that have to do with it? You're right. I'm with you 100%, A. But what does that mean?

87 **A:** It says right here. I don't know, it says it right here.

[88-97: Teacher directs students to text to clarify motivation].

98 **T:** You guys have read a story, right? I'm asking what is this story about? So far, I know it's about two kids. I know these two kids didn't do what?

99 (**Chorus:**) The flag salute.

100 **C:** Religious people.

101 **T:** About religious people. Okay. Right? Is everybody with me? Now my question to you is what's the problem?

102 **A:** That -- the problem is they didn't do the flag salute.

103 **T:** But what's the problem with that? Lots of people don't do the flag salute.

104 **A:** Because there was a law in school.

105 **T:** OHHHH! RIGHT! You got a law in the school. And where else do you have a law?

106 **A:** In the church.

107 **T:** A law in the church. Thank you, A. You're pushing us forward here. So we got two laws here. What does that mean? What's the problem?

108 **P:** They don't know which one ...

109 **T:** What?

110 **P:** They don't know which one to um ... (pause)

111 **T:** P, you have to finish your sentence. I know you're saying something. I'm not sure ...

112 **P:** Uh, they don't know which one to obey.

In both classes, the teacher's contributions carry out similar functions: he moderates (calls on students, etc.), asks for clarification, requests additional information and so forth. What is different about his behavior in the two classes is what we shall call the "tailoring" of his contributions to the level most useful to the students at a particular point in the discussion. In studies of adult-child dyadic interaction, this adjustment of assistance to the less experienced interactional partner's level has been termed "assisted performance" (Gallimore, 1985), "semiotic mediation" (Wertsch, 1985), and "controlled complexity" (McNamee, 1979) by other authors.

In this process, the adult provides assistance at a level from which the partner can benefit at a particular point in their joint activity. When the junior partner is successful, the adult provides what we might call "broad" assistance, which provides minimal direction and leaves maximal responsibility to the junior partner for that portion of the activity. When such assistance is not responded to appropriately, the adult typically switches to "narrow" help which provides more specific direction; the adult is thereby assuming a greater share of the responsibility for the overall activity. When narrow assistance is successful, the adult typically switches to broad assistance once again. Thus, gradually, the junior partner learns how to carry out activities independently, by learning both the steps necessary to carry them out and the fact that activities are made up of a series of steps.

In Period 6, the teacher's questions are primarily broad ones. In 1, he asks for a summary of the story and gets what we might call a "first draft" in 2; in 3 he asks nonspecifically for more information and gets another, more detailed draft, in the midst of which (in 5) he provides specific information at the students' request. He asks another broad question in 7, switching to a slightly narrower one in 9 after the vague response in 8. Eleven and 14 are also broad; 16 consists solely of calling on a student. After 17, a student begins discussing the issue of freedom, thus ending the narration. Thus in this class, tailoring at the broad end of the continuum was sufficient to elicit the details of the story in a small number of turns.

In Period 3, a quite different pattern is evident. Once again, the teacher also begins with a broad question ("What is this story about?"); unlike the beginning of Period 6, however, he gets a rather vague response (the reference to "*another* religion;" no mention of the context of school). The teacher's next turn begins with another broad question and then narrows down to a request for clarification ("...You say 'people'..."). The response in 21 is to add the information that they were "students from the school." The teacher tailors his assistance even more narrowly to a request for names. He continues to tailor by alternating between broad and narrow questions for a number of exchanges. Note that each student contribution furthers the narrative very little, generally only by the addition of a single detail.

In 34, after beginning with a broad question, the teacher moves toward a more *coherent* narrative by asking a *why* question. Note that in Period 6, students had provided their own explicitly marked cause-effect sequences, as in the following examples.

> 4. J: [...] They wanted to take them to court *because* they didn't think it was right...*But so* the [Gobitis family] (6) went to court...

13.I: I think it was *because* their religion said...*So* when they didn't want to say it, they got expelled...

17. G: The only reason they did not put them in private school was *because* it would have been a financial hardship, *so therefore* they didn't want to put them in a private school...

In contrast, the cause-effect sequences in the Period 3 discourse are almost exclusively *across turns*, with the teacher providing narrow questions to elicit them. Thus the cause-effect sequences are assembled from many separate turns, by the agency of the teacher's comments. We can see such sequences in 33-35, 45-47, and 62-75. The class appears to be having difficulty in making explicit the major conflict in the story -- i.e., that the students' religion had required them not to pledge alliegance while the school had demanded that they do. Finally, in 101-110, there is a particularly successful cause-effect sequence, beginning with the teacher's broad question, "What's the problem?" A student responds by repeating what was just said in 98-99, that the Gobitis children had not done the flag salute. The teacher replies with a repetition of the same broad question, which signals that he wants a different answer this time; he adds the challenging comment that "Lots of people don't do the flag salute." In 104, the same students gives a reason; this detail had been brought up before, but now in 105 the teacher uses it in an important way: after acknowledging it, he requests a specific detail while providing an important link between the two facts ("*And where else* do you have a law?"). The student provides the detail, and teacher again links the two details in 107 ("So we got two laws here") and asks another broad question ("What does that mean? What's the problem?"). A student begins a promising sentence in 108, and the teacher encourages her to finish it, rather than providing more narrow assistance at this point. Finally the student explicitly states the notion of conflict: "They don't know which one to obey."

Thus through the teacher's provision of contributions at the appropriate level (broad to narrow) at the right time in the interaction, these students were able to express the essence of the story in a connected narrative. Since it did not emerge with only broad questions as it did in Period 6, it apparently was beyond their ability without such assistance. Yet it was not beyond their readiness to deal with such complex ideas with assistance in the ZPD.

How Far Can the Teacher Go?

Learning the technique of responsive questioning is a dynamic process in which the teacher also develops. The level of discourse (especially during training) is constrained not only by the students' development but by the teacher's as well. Whatever the level of development, the teacher's authoritative role in the classroom means that during responsive questioning the teacher's behavior greatly affects the amount of learning that takes place. Thus in Period 6 the students repeatedly demonstrated their ability to comprehend the text independently; however, they were rarely engaged by the teacher in their ZPD -- i.e, they were rarely pushed toward more advanced levels of text comprehension.

At later points in the Period 6 discussion, we observed domains that seemed to be beyond the students' level of independent functioning. For example, at one point the teacher recognized students' inability to express a general principle; he tried to assist their efforts by using a hypothetical case involving students whose religion required them to carry a dagger at all times. Period 6 students were able to give reasons why daggers should or should not be allowed at school, just as they were able to discuss whether the Jehovah's Witness children should or should not be required to salute the flag. However, they did not formulate general principles for determining what are and are not tolerable forms of religious observance in a plural society. Possibly, this was beyond the limits of their independent cognitive functioning.

The teacher had also reached a limit. He subsequently reported not knowing how to respond when Period 6 "topped out." He did not know how to use the comparison of the flag salute case and the hypothetical example to assist the students to form more general conclusions. As a result, the discussion lost focus just as the students may have been ready to understand the text at a higher level.

In such cases the teacher failed to anticipate students' responses to the text. Greater experience with responsive teaching, as well as discussion and interaction with others more experienced

with this teaching style. would help him to respond to unanticipated responses in a more effective manner.

Conclusions

We can use Vygotsky's ideas to redefine recitation as a teaching style in which teachers aim at students' independent level of development -- i.e., teachers elicit responses of which the students were already capable without any assistance. So what is the teacher's role in instruction through recitation? He or she apparently serves the function of forcing students to display what they already know; by relying on recitation, teachers do *not* directly induce development to a higher level of functioning. Is this the only role that teachers can play? We think not. We have demonstrated here that teachers can do more: they can assist students through responsive teaching to perform at higher levels than they are otherwise capable of. Thus recitation is neither the only possible nor the most desirable method available for teachers.

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Using the Joystick as a Tool to Promote Intellectual Growth and Social Interaction

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Introduction

The study we will describe here was motivated by a series of events and episodes in the life of the senior author. In 1966 a debate on the cognitive impact of children's play appeared in *Psychological Review.* The protagonists were Jean Piaget and Brian Sutton-Smith. Piaget's position (1966) was that play serves mainly to practice emerging intellectual skills while Sutton-Smith has consistently argued (1980, 1983) that play serves a much more complex and creative role in cognitive

development. In 1974, when Lancy undertook a series of tests of these rival hypotheses in a remote Liberian village, Sutton-Smith's views appeared to be ascendant. However, the Liberian results (Lancy, 1974) provided only lukewarm support and he went on to study other topics in other places (e.g., Lancy 1983).[1] In 1983 Lancy was introduced to the computer by several of his present co-authors. In particular, Evans convinced him to purchase the Atari 800 model, including the "entertainment package." Several significant events followed this purchase. Lancy's 6 and 8-year-old daughters beat him hollow on "Pac-Man" which had been included in the entertainment package and, like Greenfield (1983) under similar circumstances, his research instincts were aroused.

A second game cartridge, "Star Raiders," was set aside for a time but when he finally got around to playing it, Lancy was completely overwhelmed -- it seemed so incredibly complicated. It is a simulation of some elements from the recently popular space films. The player pilots a Starship and tries to destroy the entire Zylon Fleet before they surround and destroy his Starbases. At one level you just aim and shoot so the game has much in common with many other video games. However, you can alter speed, direction, sector, etc. You can also refer to several distinct information screens including the Galactic Chart, the Long Range Sector Scan and the Attack Computer Display which shows the status of the ship's vital functions, its location, the location of enemy ships, and so forth. Furthermore, there is a great deal of arithmetical estimation involved. Just reading and understanding the manual took me several hours. Despite many complications and the lengthy training period, "Star Raiders" is one of the most highly acclaimed and popular computer (as opposed to VCs or arcade) video games. Thus, it was likely that the game was being played by thousands of average American children. It was at this point that the present team was constituted to investigate the potential impact on children of "Star Raiders" and similar games.

Initially we enumerated the general features of video games that suggested something new might be happening in the lives of American children. First, as we have noted, video and computer games represent a very high degree of complexity -- they would top just about anyone's game hierarchy (e.g., Sutton-Smith, 1976). Mastery for even the most rudimentary games may take hundreds of hours (Surrey, 1982; Sudnow, 1982). Second, most video games can be played at several levels of difficulty. In the game "Miner 2049er" for example, there are 10 levels and the player must complete them in exact order of increasing difficulty. The kinds of sensorimotor skills required are relatively constant throughout the game even though the amount of skill required increases. Strategic or problem-solving features of the game increase *dramatically* from level to level, however. At Level 1 there are really only about 3 things to "figure out," at Level 2 at least three new "twists" are added and so forth. The "rules of the game" are simple at first but get increasingly demanding as one progresses. This means that a player can be fairly inadept and yet gain entree' to the game and begin practicing *and* improving.

A third, closely related point is that, like traditional games, one can learn to play by reading a guide, observing games being played or, by being taught. However, unlike traditional games, one can also learn to play many video games by *trial and error*. Trial and error may not be very efficient but any parent who has been rebuffed by the words "I can do it myself!" knows that it is the preferred learning tactic of young children.

Fourth, video games incorporate built-in opponents, score keepers, timers, playing props, and, in many cases, coaches. In short, most of the major impediments that might prevent a child from enjoying the benefits, if any, of an intellectually challenging game have been removed in the video game. Take chess, for example, a game which has been used to represent the epitome of cognitive skill (Simon & Chase, 1973). To play chess, you need to know *all* the rules. You can't move the knight at whim until you've learned what all its moves are. You need a board, chess pieces and an opponent. We would no sooner expect an eight-year-old to learn to play chess by "messing around" with the board and pieces than we would expect a chimpanzee to write *The Carpetbaggers* while pecking away at a typewriter.

It is also important to point out some other characteristics that video games *share* with traditional games. Unlike other kinds of play, games provide constraints which keep the player "on-task." Unlike other activities which require concentration, learning and persistence to master,

games are fun, playful, and *intrinsically motivating* (Loftus & Loftus, 1983). Thus, and not surprisingly, students spend 50% more time with a fraction exercise when it is presented in a video game format compared to a computer drill format (Malone & Lepper, in press).

To summarize the arguments, we have said that while video games are intellectually very demanding, they are also extraordinarily seductive. The net effect of this combination may well be to accelerate the cognitive development of children who have access to them. Let's see.

The Study[2]

We advertised for volunteers for after-school "computer clubs" in the sixth grades of an elementary school in a Phoenix suburb. The school serves a lower-middle to middle-class population. Half of the 24 volunteers (age range 10 years, 8 months to 12 years, 6 months) were randomly assigned to the "Missile Commanders" and half to the "Star Raiders" Clubs. Missile Command is also a computer video game but is more strictly of the aim and shoot variety. That is, while we might expect it to have some impact on hand-eye coordination (e.g., Donchin, 1983; Lowery & Knirk, 1982-83) unlike Star Raiders, we could not expect it to tax the children's reasoning abilities. Each club met for two afternoons a week from 3:30 to 5:00 for 6 weeks. Three students were assigned to each of four computers and were required to take turns. During the fourth session, students were permitted to regroup into triads of their own choice. During the first of the twelve sessions children were pretested with the Hidden Figures Test (Wilson, Cahen & Begle, 1968) and the Ankney and Joyce Reasoning Test (Stefanich, Unruh & Perry, 1983). This is a 30 item pencil and paper test which measures operational functioning and includes items reflecting conservation of length, area, and liquid; seriation, class inclusion and so on. During the second session we held a Pac-Man tournament. The purpose of the tournament was to establish each student's high Pac-Man score as a proxy measure for degree of prior involvement with video games. In the 3rd through the 10th sessions the children played their respective games. In the 12th and last session we post-tested each child with the Hidden Figures and Reasoning Tests.

The quantitative results were disappointing. We calculated gain scores for each student on both tests (the tests were correlated: r=.41). For Star Raiders the average gain on the Reasoning Test was 1.17 (SD=3.51), on Hidden Figures .08 (SD=2.47) compared to 1.00 (SD=2.28) and 2.00 (SD=4.38) for Missile Command Club. There was enormous variability on each test *within* each group and none of these were statistically reliable. On the Reasoning pre-test, for example, scores ranged from 8 to 26. Similarly, on Hidden Figures the range was from 1 to 16. Pac-Man high scores ranged from 3,000 to 56,000. Several of the high Pac-Man scorers also did well on the club game, however, several of the *low* Pac-Man scorers showed steady improvement over the period and ended among the high scorers in their respective clubs.

Every session was attended by two or more participant observers -- university faculty members and doctoral candidates. Hence, we have a great deal of qualitative data which yielded some tentative, but very interesting, insights (Lancy, Evans, & Levine, 1984). Unlike most video games, you cannot turn on Star Raiders and start to play. You must first read the manual. The manual is 10 pages long and it must introduce nearly 30 new concepts to the student (e.g., hyperspace, sector, warp energy, centon, etc.). Consequently, the third session was actually taken up with reading and discussing the manual. Early in the fourth session however, a couple of the more able players were experimenting with the game while still keeping one eye on the manual. These players were more than willing to model and discuss the correct way to play. When they were not playing, they circulated freely among the four stations coaching the students who were playing. In fact there was a very high level of cooperation throughout in terms of two players jointly managing a game (e.g., one pilot guides the ship while the other keeps track of the vital functions and the ships location), and in terms of the sharing of information between computer stations. Whenever someone discovered how to do something or discovered how some part of the game functioned or what some symbol meant, they shouted it out to the group as a whole. This air of cooperation and interaction is also characteristic of LOGO programming classes (Hawkins, Sheingold, Gearhart & Berger, 1982).

Once a few students learned to play, the manuals were no longer used to any great degree because the children preferred to learn from each other. When players got in trouble or when something strange happened, they consulted the manual only if no one in the room knew what to do. This happened, for example, when one player's "on-board computer" was destroyed -- a rare event. The students reached a plateau after three "play" sessions -- they would destroy some enemy ships but would run out of energy before completing the game and end up with low scores (expressed humorously as ratings like "Garbage Scow Captain" or "Galactic Cook Class IV"). So we announced a contest such that all who successfully docked (a pilot must dock at his starbase to take on fuel) would get a coupon for a free ice cream cone. This galvanized the group into action -- and we saw a complete reprise of their behavior at the onset. That is, everyone buried his nose in a manual again. A few figured it out pretty quickly and then taught the others. In fact they were so cooperative that the better players helped weaker players by taking over the joystick at the appropriate moment and docking for them. Everyone's scores improved but again there was a plateau as the students seemed to be stuck at the simplest level of the game. They were unable to coordinate the many variables to maximize their scores -- hence no one advanced beyond the "novice" level. We believe that two of the boys might have done so had they been permitted to play indefinitely. The rest of the students were tiring of the game and would not have continued playing it. It should be pointed out, however, that it is much harder to keep track of your performance and to compare yourself with other players in Star Raiders than in Missile Command. The main motivating force in Missile Command is competition with the machine and with other players, in Star Raiders it is the chance to participate in a very well simulated microworld (Lawler, 1982). The Star Raiders were far more likely to use appropriate vocabulary than the Missile Commanders who would, for example, talk about "that little white thing" rather than "that ABM" or "Shoot" rather than "fire", "plane" rather than "strategic bomber" and so on. In fact, the Missile Commanders did not seem to be aware of the essential theme of the game thereby vitiating the concern that it trivializes nuclear warfare (Rogers, 1982).

In the eleventh session the two clubs swapped games so they could see what the other group had been up to. Despite the fact that the Star Raiders group had needed to rely to a great extent on the manual to get them into the game, they did not even glance at the Missile Command manuals before beginning play. Their attitude was, in effect, "Let's see if I can figure this out without the manual." Thus there appears to be several clues as to why the Star Raiders group showed no signs of any important change in their cognitive repertoire. First, they invested as little intellectual effort in the game as they could get away with. Second, there was a great deal of absenteeism and, with the turn taking, each student probably logged no more than four hours on the game in total -- a very short "treatment".

Although no differences emerged between the two groups in terms of the test results, the social dynamics engendered by the two games were strikingly different. First, it was interesting to observe the effect of switching from Pac-Man to Missile Command between sessions two and three. Many of the top scorers in the Pac-Man tournament performed poorly on Missile Command and their pride was badly damaged. Two of the boys said things like -- "This wouldn't be happening if I had my own joystick" or "Are you sure there's nothing wrong with this computer?" During the Pac-Man round-robin players acted as individuals and the "pecking order" was quickly established; hence, there was a great deal of free discussion about strategy and tactics. It took several sessions for this ordering to occur in Missile Command. Scores were very unstable at first, and every fifteen minutes a new champion would be crowned or someone would get bumped from third. The girls were irate at being grouped with boys in the triad: "No fair, girls should play against girls and boys should play against boys." They were not overly inhibited (contrary to findings of Weisfeld, Weisfeld, & Callaghan, 1982), however, and the girls rather consistently scored higher than the boys. Although the top ranking player in the end was male, the other two males ended up ninth and tenth. One especially proficient lady was awe struck by this state of affairs: "God, I beat Richie by a mile." These girls were so accustomed to losing in one-on-one contests with boys that they couldn't believe their success, especially (in this case) given the very "macho" nature of Missile Command (see Kiesler, Sproull &

Eccles, 1983). In both clubs there was a tendency for boys to compare their scores with those of other players, whereas girls tended to compare their current scores to *their own* highest scores.

Unlike the Star Raiders the members of the Missile Command Club continued to improve with each session. They were, in fact, getting 3-4 turns to play at each session and the game has far fewer strategic elements, so steady improvement is to be expected. Nevertheless, interest did seem to wax and wane. In the fifth and sixth sessions players invested a fair amount of time in investigating the instruction manuals (finally). Interestingly, no one ever got very far into the manual; in particular, no one made it to the "Helpful Hints" on the last page. Had they done so they could have increased their scores substantially.

In the eighth session we introduced a contest to try and stimulate interest and to encourage cooperation. Whichever triad had the player with the "most improved score" during the session would win ice-cream coupons. We reasoned that to win, the group would take its weakest player and coach him/her, forego turns, etc. The subtlety went over their heads, however, and the only aspect of the rules they understood was that improvement in one's score, rather than high score, would determine the winner. Hence, everyone went at it with a vengeance and the scores did jump dramatically in this and the next few sessions (we continued with the contest). Normally, of course, extrinsic reward reduces motivation to perform an intrinsically rewarding task, however, recent research suggests that the nature of the task can reverse this tendency (Morgan, 1984).

How much learning occurred then, as children played Missile Command and Star Raiders? Like Pac-Man (Sykora & Birkner, 1982), and Break-Out (Sudnow, 1982), Missile Command is easy to learn but difficult to master. There are many, many subtleties to these games that are crucial to mastery but are only revealed after much *intelligent* practice. It is not enough to merely play the game repeatedly; one must test hypotheses, search for patterns, and discover relationships. One must discuss the game with other outstanding players, read the guide books and so on. Although we saw occasional glimpses of this kind of intelligent practice, it was not the dominant mode of play. Choosing older children might have made a difference and undoubtedly our club setting encouraged interaction with other children as much as interaction with the game. In an arcade or at home, there isn't as much social pressure to get a high score each time and players can sacrifice a high score in order to explore alternative strategies that may or may not work.

With Star Raiders we saw a great deal *more* learning going on, however, only as a means to an end. Once players were able to do a reasonable job of completing their missions, interest in learning more about the game waned. As we have seen, even the best players barely scratched the surface of the game's complexity.[3] No doubt older students and students playing alone would have gone into greater depth. Indeed, this was the case with a "visitor," a ninth grade boy who stopped by to play Star Raiders on a couple of occasions while waiting for his younger brother. Command was appealing to virtually everyone, this was not the case with Star Raiders. Thus we can imagine that, under different circumstances, while some players might have gotten more involved with the game, the majority would be turned off immediately and never even learn the rudiments of play. Our work with Star Raiders did suggest, however, that students will read, discuss, question the teacher -- do whatever is necessary -- in order to gain entree to a difficult game.

Issues for the Future

The possibility suggested above, that students will do some sort of academic "work" in order to proceed with the game has served as the major impetus for subsequent research by Lancy and his colleagues (e.g., Forsyth, 1985; Hayes, Lancy, & Evans, in press; Lancy, 1985; Thomas, 1985). That is, there has been an increasing emphasis on harnessing the enormous motivating power of the video game and its offspring (like fantasy adventures, interactive fiction, and simulations) to teach school-like subjects. These attempts are indeed bearing fruit, suggesting that Sutton-Smith may turn out to have won the debate after all.

Interestingly, however, we found that video and computer games are much easier to study within a Vygotskian (e.g., 1978) as opposed to a Piagetian framework. The "Zone of Proximal Development" in this case is quite apparent. For example, virtually all the games we have worked

with (about 30 to date) can be played at several "levels" of difficulty -- in many games the level is automatically adjusted upward or downward as a function of the child's success rate. Many of the newer (e.g., post-Star Raiders) games offer on-screen instructions and "demo games" to relieve the child, who is unwilling or unable, of the necessity of reading the manual or "documentation". Other "props" which now are regularly packaged with games include maps, clue cards and hint books. In addition, in a great variety of game environments which we have investigated over the last two years, the level of cooperation among the players has always been extraordinarily high. Thus novice players can usually count on a great deal of coaching, or help from their peers, in figuring out how to get around nasty obstacles like giant rats. In closing, we note that Vygotsky would no doubt be delighted to see "development" turned on its head in the lab as, on several occasions, we have brought together novice teachers with expert kids wherein the teachers became almost pathetically dependent for guidance and encouragement on their junior tutors.

Notes

Mannell and LaFave (1979) once accused play researchers of taking their topic too seriously. Our title reflects a sincere attempt to ward off any such accusation. This paper is excerpted from Lancy (1985a).

[1]Subsequent research by others has not substantially altered this situation, see for example, Simon and Smith (1983), Christie and Johnsen (1983) & Krasnor and Pepter (1980).

[2]We are grateful to Merrill Harlan and his staff at Bicentennial School in Glendale, Arizona and to Atari, Inc. for their support of this project.

[3]Another piece of software that we were very interested in at the time was Bill Budge's *Pinball Construction Set.* Nancy Levine conducted an in-depth study (five 45 minute sessions) with a single sixth grade player. Although this program permits creativity and "mind-stretching" comparable to the finest pre-computer construction kits (e.g., Fisher-Technik; Advanced LEGO; Heathkits), Nancy's subject treated it like a pile of blocks. That is, he never set out to systematically build anything -- he stayed at the trial and error, *pure assimilation* level. In another recent study Jeanne Hoover (1985), a master's candidate in Family Life at Utah State University, observed the play behavior of pre-school children in several centers including the manipulative play center, a sociodramatic play center and the computer center. While she did indeed observe a greater degree of higher-order play (following Smilansky's [1968] model) at the computer center, what is interesting was that she also observed quite a bit of lower-level "dramatic" play around the computer as well.

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The Origins of Computer Literacy

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Today's personal computer rapidly presents a multitude of information in rich visual and auditory modes. Furthermore, a computer is capable of providing immediate feedback to a learner. The implications of such a system and the impact computers may have on our method of education remain unclear. Computers are already affecting children's education in mathematics (Abelson & diSessa, 1981) and science (Gorman & Bourne, 1983; Papert, 1980). More recently, computers are beginning to change the teaching of reading and writing (Collins, 1983).

The use of computers requires many of the cognitive functions that are involved in reading and writing. For example, reading, writing and computer use all involve remembering symbol strings and all require the ability to manipulate sets of symbols for communicative purposes. In

addition, all three are embedded in other activities of literacy. Reading for example, is embedded in writing literacy: writers revise drafts by rereading previous entries. Likewise, computing skills require reading and writing even during elementary keyboard learning. Thus, computer use becomes enmeshed in the acquisition of literacy.

One of the critical skills involved in literacy is the manipulation of symbols. While young children may have the ability to recognize and *form* symbols, this process can be so laborious when performed manually that children often lose track of a word or thought they are attempting to express (Bereiter & Scardamalia, 1982). A more efficient connection between a thought and written expression might be made by providing children with a tool that circumvents this initial problem of forming each symbol. One such tool is the computer keyboard which can compensate for children's physical and attentional limitations. Another issue involved in children's writing is legibility. When the computer is employed, writing becomes legible (Levin, Boruta, & Vasconcellos, 1983). Fewer motor-control problems may promote less concern with errors, and a higher frequency of revisions (Daiute, 1982).

Significant improvements may be observed in children's writing skills through the use of computerized programs designed to elicit ideas via a series of prompts (Scardamalia & Bereiter, 1983). When children are provided direct assistance with the oganization of their ideas, writing skills are enhanced. The *quality* of children's writing, therefore, may be facilitated directly when limitations such as motor, attentional, and planning strategies are attenuated.

Although computers are introduced to young children at home and school at progressively earlier ages, it is not clear how children confront and master the fundamental mechanics of using a keyboard. A prerequisite to using the computer for learning new skills may be facility with the computer and its keyboard. The computer keyboard has many symbols that must be organized in spatial memory. Interacting with computers also requires complex perceptual and motor operations. If the task demands of learning how to use the computer *and* learning a new skill prove too difficult, children will not be receiving optimal learning experiences with the computer. Although adults routinely receive instruction in keyboard use, children are not traditionally taught the mechanics of a keyboard. While earlier machines (e.g., the Typing Tutor) attempted to provide learning experiences for children in a systematic manner, their capabilities were limited and educators argued that the initial difficulty in learning the keyboard offset the advantages of using the machine (West, 1969). Because the literature on children's learning of the keyboard is, however, largely anecdotal, empirical studies are needed to examine individual and developmental differences in acquiring the skills necessary to use a computer to facilitate learning. Because these prerequisite skills are the beginning of computer literacy, it is necessary to determine the optimal age at which children can successfully manipulate symbols and recall their location on the computer keyboard.

One of the research questions that can be addressed is whether letter knowledge is a prerequisite to skilled keyboard use. Can children successfully match stimuli on a physical basis alone, or is the ability to name the stimuli essential? Also, the *rate* of progress in learning the keyboard must be determined for children of different ages. For example, will kindergarten children acquire these skills faster than preschoolers? Little empirical data exist on these issues.

The purpose of the present study was to assess how children learn to use a computer keyboard from their very first exposure. Learning rates relative to age, practice, and early reading abilities were examined to determine how preschoolers acquire the fundamental skills of computer literacy. Subjects were required to match numbers, letters, and symbols on the keyboard to a model presented on the monitor. Data on response times and error rates were collected. Measures of reading ability were compared to determine if early reading ability is related to children's understanding, memory, and manipulation of the keyboard.

Method

Subjects. Thirty-two subjects (11 males and 21 females) were recruited from four classrooms in a predominantly middle-class university preschool/kindergarten. The mean age of this group in October was 5.0 years; all subjects were between the ages of 4.5 and 5.5 years. All testing was done between late September and early December. A second group of subjects was tested

the following January. Twenty-eight subjects (14 males and 14 females) were recruited from three preschool classrooms in the same university school. The mean age of this group in January was 4.0 years; all subjects were between the ages of 3.5 and 4.5 years. Testing was completed between mid-January and mid-March. The children were administered the Reading Subtest Level I of the Wide Range Achievement Test. The first section of the WRAT assesses letter knowledge. Subjects were also tested on their ability to recite and recognize numbers (0-9), the letters of the alphabet, and their name.

Stimuli and Apparatus. The stimuli for the test sessions were numbers (0 thru 9), symbols: (/ ; ' = -), uppercase letters (H, S, B, A, T, U, R, Y, I, X), the uppercase words (GO, CAT, STOP, and BLACK), along with each child's name in uppercase letters. The stimuli for the practice trials were the numbers, the symbols, the 26 uppercase letters of the alphabet, the words UP, RED, BLUE, and HOUSE, along with each child's name. All of the numbers, symbols, letters, and words were displayed on an Apple III monitor by an Apple IIe computer. Subjects sat approximately 60 cm from the screen. A five letter word subtended a visual angle of approximately 1.88 degrees. Target onset and timing were controlled by the experimenter pressing the space bar which, in turn, caused the target to be displayed and simultaneously started a Mountain Hardware clock that was connected to the microcomputer. When the subject located and pressed a key, the clock stopped. If the subject pressed an incorrect key, it was coded as an error.

Procedure. Subjects were assigned randomly to practice and control groups. The practice group received periods of testing and practice each week over five weeks. The control group was also tested on the first and fifth week, and exposed to unrelated computer activity in the interim weeks.

The subjects were tested individually in sessions that lasted approximately 15 minutes. Subjects were told to look at the monitor screen where a symbol would appear following a short presentation of a prompt in the shape of a cross. The subjects were told that as soon as they saw the symbol they were to look at the keyboard, locate that same symbol, and press the key it was on as quickly as possible. Subjects were asked initially to attend to the keyboard and to locate an example of a number, symbol, and letter. When the children were successful at this, and the experimenter felt sure the child understood the nature of the task, the experimental trials began. Each subject received the same ordering of numbers, symbols, letters, words, and their own name. This same procedure was followed for all subjects (practice and control) for both testing periods.

During the second, third, and fourth weeks, the practice group received further exposure to the keyboard program. The procedure was identical to the testing situation except that feedback was given when incorrect keys were pressed and children were given second opportunities to locate correct keys. These sessions occured once each week, and lasted approximately 30 minutes.

The control group was exposed to the computer in the second, third, and fourth weeks also, but they workd with a simple discrimination task. The subjects manipulated two *colored* keys to indicate whether two complex shapes were either same or different. The control group received exposure to the computer in groups of 2-3 children. Each child played the game once individually and watched others play the game. These sessions occurred once a week and lasted approximately 30 minutes.

Total computer exposure for both groups in weeks 2 through 4 was approximately 90 minutes. During the 90 minutes, the experimental subjects worked alone while the control subjects shared the time with one or two other children.

Results

Mean reaction times were calculated for each subject in each condition for all correct trials. Trials on which the subject did not know the stimulus or hit an incorrect key were scored as errors. Although infrequent, response times that were extreme outliers (greater than 20 seconds or more than three standard deviations above the mean for that subject) were also scored as subject errors.

Table 1 displays the means for all variables as a function of age. A 2 (Age) x 2 (Time of Testing) x 2 (Group) x 3 (Condition) analysis of variance on the reaction times indicated that the effects of Time, F (1,29)=9.37 and Condition, F (2,58)=27.52 were significant at the .001 level, while the main effects of Age and Group were not significant ($Fs < 1$). Thus, we observed that with exposure to the keyboard, children of *both* ages became increasingly faster for some conditions. The interaction of Time x Condition x Group, F (2,58)=4.38 was significant ($p < .05$), and indicates that over time, the practice group's advantage (i.e., reduction in RT) was greater for some conditions than for others. Symbols displayed the greatest experimental effect, followed by numbers. The difference between the two groups for letters however, was negligible.

Similar patterns were observed in the error data, along with a main effect of treatment. The effects of Time, F (1,56)=36.58 Group, F (1,56)=8.13, Condition, F (2,112)=66.95 and Age, F (1,56)=3.49 were significant at the .001 level. Error rates decreased over time; the practice group made fewer errors; errors varied by condition, and 3- to 4-year-olds were less accurate. Furthermore, we observed that over time, the practice group became increasingly more accurate (Time x Group F (1,56)=14.39 $p < .05$). Of the three conditions, symbols displayed the greatest decrease in error rate, followed by letters (Time x Condition F (2,112)=3.82, $p < .01$).

Symbols are highly unfamiliar to the children and their organization on the keyboard is not apparent initially. Given these two factors, one would expect significant changes with exposure.

Table 1

Age, Condition, Time of Testing, & Treatment
Mean Response Times & Mean Number of Errors
(errors in parentheses)

Age (yrs.)	Condition	Time 1			Time 2		
		Symbols	Numbers	Letters	Symbols	Numbers	Letters
3.5-4.5	Control	6991 (4.07)	4388 (1.93)	5624 (3.43)	6211 (3.93)	3977 (1.71)	4976 (3.07)
	Practice	7500 (4.07)	4037 (1.21)	5527 (3.29)	4182 (2.64)	2331 (0.50)	4613 (1.43)
4.5-5.5	Control	6669 (3.94)	3654 (1.31)	6564 (2.44)	5364 (3.63)	3201 (1.19)	5289 (2.00)
	Practice	7825 (3.69)	3740 (0.75)	6589 (2.25)	4528 (1.94)	2722 (0.63)	4966 (1.19)

Note: 5 symbols, 10 numbers, and 10 letters were presented to each subject.

While many children could name and recognize the letters of the alphabet, the organization of letters on the QWERTY keyboard has no obvious structure to young children, thus their response times do not exhibit the dramatic decrease that symbols did with practice. It is not surprising that numbers exhibited the fastest response times, a smaller decrease over time, but a larger experimental effect than letters. Numbers are both highly familiar and sequentially organized on a single row on the keyboard and, therefore, may reasonably lead to larger practice effects. Although there was no difference for response times between the two groups, we did observe an effect for error rate.

A median split of the 4- to 5-year-old subjects was performed on the basis of their reading ability in order to compare performance of skilled and less-skilled readers. The mean raw score of the 16 skilled readers (M=28.9, SD 9.05, grade equivalent=1.4) was significantly higher than that of the 16 less-skilled readers (M=23.4, SD 7.81 grade equivalent=1.1), t (30)=3.61, $p < .01$. Table 2 displays their mean response times and error rates.

Among 4- to 5-year-olds, early reading ability interacts with learning rate on the keyboard. This relation appears to be particularly strong given that the groups of skilled and less-skilled readers were formed on the basis of a median split of the classrooms, rather than having been chosen from the extremes of reading skill. Thus, the mean differences are not inflated due to the use of extreme groups. The significant interaction of Time x Condition x Ability x Group,

Table 2

Reading Skill. Condition, Time of Testing, & Treatment
Mean Response Times & Mean Number of Errors
(errors in parentheses)

Reading Skill	Condition	Time 1			Time 2		
		Symbols	Numbers	Letters	Symbols	Numbers	Letters
Skilled	Control	6102 (3.38)	2602 (0.63)	5663 (1.38)	5579 (3.38)	3031 (0.50)	5608 (0.75)
	Practice	9250 (3.75)	2975 (0.88)	5325 (1.88)	4374 (2.38)	2455 (0.63)	4352 (0.63)
Less-skill	Control	7882 (4.50)	3429 (2.00)	6263 (3.50)	4536 (3.88)	3036 (1.88)	5611 (3.33)
	Practice	6163 (3.63)	4252 (0.63)	7438 (2.63)	4041 (1.50)	2923 (0.63)	5590 (1.75)

Note: Data are shown for the 32 subjects who were at least 4 years-old.

($F(2,36)=3.53$, $p< .05$) for response time, demonstrates that with practice, reaction time decreases significantly, particularly for skilled readers on symbols and letters. While practice facilitates response times for *both* skilled and less-skilled readers, it is the skilled readers who derive the *greatest* benefit from practice on the keyboard.

Reading ability was also a significant factor for error rate; skilled readers responded more accurately than less-skilled readers, (Group, $F(1,28)=8.26$, $p < .01$). Skilled readers derived greater benefit from keyboard practice than less-skilled readers (Ability x Group, $F(1,28)=6.25$, $p < .05$). The significant interaction of Ability by Condition, ($F(2,56)=5.12$, $p < .01$) suggests that prior knowledge may facilitate keyboard learning. Planned comparisons demonstrated that reading ability was a factor for familiar stimuli: skilled readers displayed greater accuracy than less-skilled readers for numbers and letters ($p < .01$). Ability was not a factor, however, for unknown stimuli; the practice effect for skilled and less-skilled readers for symbols did not differ. One implication of these findings is that a child's acquisition rate for typing skills is dependent upon the prior recognition of the symbols. The ability to name the stimulus provides a definite advantage in the beginning of computer literacy. If children possess these prerequisite recognition skills, their subsequent learning of the keyboard may be facilitated.

Discussion

The results of this study demonstrate that children who have had no prior experience with a keyboard can understand the order and structure of the board, and can respond differentially after relatively brief practice. We deliberately did not provide modeling and instruction so that we could examine consequences of exposure and practice, conditions that are likely to exist in the initial interactions of young children with microcomputers.

Previous research suggested that the keyboard may be too difficult for young children to learn and it was probably not worth expending instructional effort at such an early age. However, the findings of the present study argue against this conjecture. The practice group received no direct instruction regarding the location of various symbols. Yet these young children were capable of organizing an initially haphazard set of symbols, as revealed by their decreased response times and error rates between time 1 and time 2, and in their varying response times to the conditions of numbers, symbols, and letters.

Suprisingly, there were no age differences for response times; 3- to 4-year-old children responded as quickly as 4- to 5-year-olds. The significant interaction of Time x Condition x Group for respone time demonstrates the facilitating effects of simple exposure to the keyboard. Over time, both age groups benefitted from additional practice on the keyboard.

As predicted, children's performance varied in each condition. Symbols are the most abstract condition to young children, and as a result, their initial response times were particularly long and error rates quite high. However, with exposure, not only did they become more familiar, but the structure of symbols on the keyboard became more apparent. Thus, symbols exhibited a larger practice effect than either numbers or letters. Although letters have an advantage of being more familiar than symbols, their structure on the keyboard appears equally random. Numbers have the decided advantage. The majority of children could name them and perceive their structure on the keyboard readily. Thus, while numbers displayed the fastest response times and lowest error rate of the three conditions, the practice effect for numbers was larger than for letters. One would expect that even greater efficiency could be attained with training and, therefore, it appears worthwhile to introduce the basic components of the keyboard and computer literacy, to children as young as 3 or 4 years of age.

An interesting finding of this study was how prior knowledge interacts with keyboard learning. Keyboard acquisition *is* facilitated when children can verbally represent the stimuli. When comparing the performance of skilled and less-skilled readers, skilled readers displayed significantly faster response times and lower error rates for numbers and letters, symbols whose names they knew. No difference, however, was observed between the two groups for the unknown stimuli, the symbols. Thus, it appears that performance is significantly enhanced when children possess not only a physical representation, but are able to represent verbally the names of each key as well.

In summary, this study revealed that 3- to 5-year-olds can learn to identify and match symbols on a computer keyboard with relatively brief amounts of unstructured practice. Error rates decreased significantly for older children and for those receiving practice. As might be expected, children who had better reading skills, that is, greater knowledge of letters, words, and decoding skills, displayed faster response times and lower error rates than less-skilled readers. The greatest changes were observed on familiar stimuli (numbers and letters), and the smallest differences on the other symbols. Thus, we see that even skills useful for beginning keyboard manipulation are embedded in children's development of skills related to literacy.

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Computer Networks and Education

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This is a brief report of a meeting of the Interactive Technology Laboratory (UCSD). Margaret Riel, who has a long history of research with computers and networks (e.g. Riel, 1985), opened the discussion. The focal question was: How can networks help accomplish educational goals? The successful use of networks depends on the design of a functional 'learning' environment (c.f. Newman, 1985). Such environments fulfill the need to coordinate the various participants in the same activity voluntarily, while requiring them to attend to the features that map onto educational goals. A review of various networking projects provided background for the current "activity approach" of the Inter-Cultural Learning Network.

The other speaker, Ezequiel Garber, is a Latin American student in the Communication Department (UCSD), examining on-going computer networks involving Latin America. Garber, too, is interested in the properties of networking activity that are essential if it is to provide a real advantage to the users. His points display the similarity between his interests and Riel's: (1) Once a connection is established, people need an activity that engages their continuing common interest. (2) There must be people who are committed to learn on both ends of the system. Each site needs someone learning both about the technical matters (how to set up a network and operate it) and about the varying cultural conditions (what people on the other end are experiencing in their own context). (3) The computer should be understood as a *different* vehicle for human interaction; indeed, its characteristics should be interesting to study. (4) Practical issues concerning priorities of access to the networking facilities and priorities of use need to be considered. For example, it may not be immediately obvious how networking would be advantageous in schools for younger people in some countries in Latin America. It could be that access will begin with university students.

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