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Psychosociological Processes, Operatory Level and The Acquisition of Knowledge*)

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INTRODUCTION

The following text can be considered as a preliminary version of a research in progress. The aim here is to demonstrate that the child's cognitive development takes place within situations where one or more individuals are in interaction. It follows that the cognitive competences of a subject can be neither described nor evaluated without considering the social context which elicits their actualization. The learner is not a passive reciever of knowledge and social norms, rather he is actively implicated in the development of his instruments of understanding and engaged in the activity of the appropriation of knowledge within a dynamic which could be described in terms of construction and interaction.

In order to support these hypotheses, the authors examine the contribution of recent researches permitting an articulation between different levels of psycho-sociological analysis with particular attention to the specific problem of diagnosing an operatory level in Piagetian stage theory. They then consider the application and interest of these results to the understanding of educative situations, especially didactic situations in mathematics.

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I. COGNITIVE AND PSYCHOSOCIOLOGICAL PROCESSES: DIFFICULTIES OF THEIR ISOLATION

In psychological debates, the field is often divided by a border between what is deemed as "internal" and "external". This division risks simplifying certain questions of research by placing researchers who have demonstrated the existence of individual processes (considered as "unique to the subject") against those who have evidenced social processes (so-called "external determinants"). In order to situate the gist of this debate as well as our object of study, permit us to sketch this dilemna.

For some, the individual is the primary object of study. He[1] is considered as having his proper identity, abstract from its social context. He is the source of all his elaborations (especially cognitive), and the determinants of his behaviours are found in their biological origins and in the individual's own experience. While foreseeing a possible incidence of social factors, this perspective considers them only with the status of supplementary variables susceptible to affect individual behaviours yet not constitutive.

For others, the individual is but an element of a larger phenomenon: the social group. It is the group which gives meaning to the individual behaviour of its members by the collective representations, norms, roles, and structuration it imposes. While admitting inter-individual differences, the adherents of this perspective tend to consider them as only being the result of statistical fluctuations or as part of the variance which remains to be explained by the other social processes. The individual is the actor of "external" determinants.

This sketch is perhaps caricatural but admittedly the individual is rarely considered simultaneously as being engaged in a psychological activity of construction of meanings and as a member of a social group which conveys sollicitations and models of comprehension.

In the domain of cognitive psychology, the subject's behaviour is most often examined in individual terms, despite the fact that the experimental paradigms used always stage[2] particular social and relational situations with pre-determined social agents. Yet these elements are not considered as such in most of the theoretical conceptualisations refered to in cognitive psychology.

> *But, in fact, several studies have shown the importance of these relational contexts. For example, Katz (1970, 1973) and Labov (1972) have both demonstrated that social characteristics of the interlocutor play an important role in the determination of the modalities and*

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1) For the sake of simplicity, we will consider the pronoun "he" as generic.

2) In using this term, we refer to Goffman's The Presentation of Self in Everyday Life (1958).

quality of the subject's performance. Katz (1970, 1973) reports differences in the productions of subjetcs tested by examiners of differing ethnic origins. Labov (1972) has similarly demonstrated that utterances of children from disadvantaged backgrounds are more elaborated when they are addressed to a person with whom the child can identify, such as someone of the same social origin.

McGarrigle and Donaldson (1974) have studied performances in tests of conservation of number by young children divided into two contrasting experimental conditions: in one, the deformation of the line of objects to be counted is due to the direct and explicit action of the experimenter; while in the other, it is caused by the accidental interruption of a clumsy teddy bear. This 'staging' produces a threefold increase in conserving behaviours by subjects in the latter group as compared to the former.

Light, Buckingham and Robbins (1979) have also presented data illustrating similar context dependancy of performances. These studies all evidence the dependance of the evaluation of the subject's competences on the characteristics of the testing situation.

Examining the effect of adult counter-suggestions made to the child during Piagetian clinical interviews, several experiments have shown that the simple fact of presenting an opposing point of view to the child is susceptible to induce progress on operational tests (Mugny, Doise and Perret-Clermont 1975-76, Mugny, Lévy and Doise 1978, Lévy, 1981).

Researches concentrating on clinical descriptions of cognitive processes have sometimes described incidentally analogous phenomena: Comiti et al. (1980) report a series of observations of children during tests of conservation of number whose incidental interpretation is pertinent to our exposé. They describe the reactions of the child Naïma who was asked to make two equal collections of matches and tokens. Naïma started collecting the matches and declared "There're more matches.". The experimenter asked her how she knew this: "I don't know." But this question probably led Naïma to seek an objective method of making a correct decision, as she started to count the two collections and announced, more suve of herself this time: "There're more matches.". In the same study, the child Frederic is observed learning a task. It appears that the child does not apprehend the task independently from the person who has demanded it of him. Indeed the authors note that "Frederic, while

saying "I have to put down more tokens", adds one, then two, then three tokens, all the while on the watch for an approving glance from the experimenter.".[1])

Similarly Schaffer (1979) in his studies of mother-infant relations, has shown the extreme interpedendance between the child's first interest in objects and the reactions of his mother in a given situation.

We have chosen these examples to call attention to the impossibility of describing and evaluating the cognitive competences of a subject without considering the social context which elicits their actualization. The failure to consider the social and the microsocial context of data collection leads to the construction of a social abstraction of the individual which attributes perceived differences in behaviours to individual characteristics and consequently neglects their social significance.

For those who are interested in education (in all of its complexity) it is useful to keep in mind that cognitive behaviours can not be reduced to individual autonomous psychological processes. The individual does not develop in isolation but is nourished by a culture and an education conveyed to him by the various special groups with which he identifies and must remain in communication. The subject is constantly solicited in his cognitive and emotional life by particular social demands inherent in the co-existence with others: conversations, interactions, exchanges, negociations, etc.

However it does not suffice to simply state that the individual is inserted in a field of social relations. The mechanism and processes of these subject-environment exchanges must be specified. Studies whose methodology has been inspired by ethnology have evidenced the interplay between the structuration of the subject and the specific social and cultural demands of the context.

The observation of cognitive exchanges between dyads has shown that the development of communication and thinking obeys certain cultural rules which structure conversation (Cook-Gumperz and Gumperz, 1980). Only by grasping the presiding cultural rules of these exchanges can the researcher understand their meaning.

Erving-Tripp (1980) has studied the evolution of strategies of comprehension of others in situations which allow her to put into play "... a context of action and of persons with social properties so that it is possible to find how the social factors affect the understanding and judgement". (p. 3) She has observed that the implicit or declared intentions of others do

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1) Our underlining.

not play a large role in the child's understanding of the situation: "In many children, even of school age, estimation of consequences of various outcomes and the learning of effectiveness of different strategies, especially towards others unlike themselves, may not depend on imputing purposes. What takes on much greater importance is the child's understanding of patterns of events." And this comprehension can only be explained by reference to the social experience that the individual has acquired in his specific environment.

When psychology establishes developmental scales (or hierarchies of stages) for subjects of different social and cultural backgrounds without taking into account these rules which regulate social relations (including tester-testee relations), it inevitably unconsciously biases the evaluation of the behaviours of others[1]). One could well wonder if these biases are not always socio-centric, that is to say, biased in favour of the researcher or of his own membership group.

We now know that it is impossible to render a test "culture-free". The performances of the partners in this situation cannot be understood independantly of their social significance (Donaldson, 1978). But it is likewise evident that an analysis uniquely in terms of social marking is not sufficient for an exhaustive explanation of individual performances. It is the interplay of these social processes with psychological ones which interests us.

We are therefore going to examine the contributions of recent studies which permit an articulation between these different levels of psychological and sociological analyses. We will first center our attention on the social conditions of the subject's elaboration of a particular type of competence, namely, operatory notions (as Piaget defines them). We will then turn to educative situations: can the psychosocial processes described to explain the acquisition of operatory competence in laboratory-type settings aid in the understanding of the socio-cognitive dynamic of school teaching setting? For example: can it explain, by analogy, in which condition culturally constructed knowledge such as mathematics can be successfully transmitted to the individual?

The comprehension of the dynamic of situations which are at the origin of cognitive developments of the participating subjects necessitates theoretical references besides those of the psychology of intelligence. We wish to link the necessary description of

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1) The existence of close correlations between cognitive performances and social or cultural origin has often been reported (see for example, among others: Bruner et al. (1966), Haroche et Pêcheux (1972), Coll et al. (1974), Siches et al. (1974), Villasonda et al. (1974), Perret-Clermont (1976, 1980), Mugny et Doise (1978, 1981), Mackie (1980), Dasen (in press) Perret-Clermont et Schubauer-Leoni (1981). But some of the studies mentioned also report that the cognitive hierarchies observed are liable to change when the characteristics of the testing and/or educative situations are changed.

the processes of thinking to the relational processes which elicit them. This requires, beyond cognitive psychology, contributions from other disciplines (social psychology, ethnology, sociology). It is therefore a question of finding the theoretical and experimental means to integrate the study of the "internal" cognitive dynamic of the individual with that of the "external" factors (social environment, task, etc.) which affect it, keeping in mind that the individual always interprets these "external" factors, giving them particular "internal" meaning.

Our object of study is learning. But we postulate that learning does not take place in a social vacuum nor does it happen in a cultural desert where all has to be re-invented by each individual. The context of cognitive development is marked institutionally, culturally, historically.

We are interested in learning as a signifying activity, not only for the researcher or teacher observing the pupil, but also for the learner himself in his search for mastery of comprehension. The different partners of the experimental or didactic situations are susceptible to attribute different meanings to these situations: the study of these misunderstandings between partners is an intrinsic part of our study. Rather than considering them as artefacts, we will examine by what "art" shared social meanings are constructed.

However, the activity which the subject displays in the learning situation is not necessarily the direct reflection of the properties of this situation. It is thereby interesting to describe the progressive evolution of the strategies and procedures adopted by the subject within the constraints of the task. The pedagogue can vary these constraints and attempt to relate them to the representations of the situation actively formulated by the subject. In doing so, he also has the means to apprehend the repercussions of his own interventions and of the task's constraints. The teacher is engaging in social interaction with the pupil. Under which circumstances is this interaction the source of progress for the child? The causality is never direct. It depends on previous learning and experience of the child, his interpretation of the situation and its demands, his abilities to draw correct analogies between previously acquired mathematical knowledge and present task requirements, as well as his awareness of the success or failure of the problem solving strategies and generalizations that he develops. But in themselves, all these activities are likely to be largely affected by social circumstances in ways that remain to be studied.

On this subject, see, for example Brousseau (1978) who examines how the circumstances create opportunities for the subject to reconstruct prerequired knowledge or to transform his understanding of a notion. Balacheff (1981) has observed how peer group interactions between secondary school pupils working together on mathematical problems affect their produc-

tion of proofs. A suggested mathematical procedure is not always immediately adopted by the child and is likely to appear only much later in his responses. It seems as if the meaning of this procedure is only slowly reconstructed by the pupil via a multiplicity of experiences. The question remains as to the circumstances in which pupils percieve a problem as belonging to the field of mathematics and hence as deserving a "mathematical solution", rather than, for instance, as a social issue deserving a "social compromise" (Cavicchi-Broquet & Florimond 1980).

The didactic situations presented to pupils are culturally marked and will be understood by them in function of their previous school and social experience. Mathematics has particularly powerful social connotations, especially in the school context: it holds an important place in education today as indicated by the load and duration of its instruction. Moreover, it often plays a primary role in the processes of streaming. For a valid applicability, psychology of education must also take these discussions into account.

II. PSYCHOLOGICAL AND RELATIONAL ASPECTS OF THE ASSESSMENT OF COMPETENCE LEVELS: THE EXAMPLE OF THE DIAGNOSIS OF OPERATORY LEVEL

A) Socio-cultural background and operatory level

If, in the past, psychologists had the ambition to construct "culture-free" tests which would place all individuals on equal standing, whatever their categorical membership, it must now be admitted that their attempts have run up against seemingly unsurmountable barriers.

In effect, differential psychologists have tried to construct their tests in such a way as to avoid a particular vocabulary (and references to culture-specific knowledge) in the formulation of their questions. However, they were forced to acknowledge the persistance of the relatively strong correlations observed on these tests between subjects' socio-cultural background and their I.Q. level as measured by such instruments.

> *In general, these studies report a correlation between social stratification and the hierarchization of performances on the tests used. Subjects who are the most advantaged by their social backgrounds are the most likely to be positively evaluated. There are few studies (Haroche & Pêcheux 1972 being one) that claim to have reversed this correlation by creating a test which was deliberately biased in favor of the socially disadvantaged group. But this successful inversion of the correlation between response level and social background once again illustrates the link between social category membership and level of performance in a given situation. No evaluation of competences appears to be independant of social determination.*

Piagetian psychology was determined not to limit itself to the study of comparison of performance levels and to avoid the difficulties encountered by differential psychologists in their attempts to expurgate all social bias from their measuring techniques. Its aim was to ascertain the universal structure of intelligence and the general processes of the construction of thinking. Piagetian cognitive psychology had thus hoped, at one time, to elucidate the fundamental mechanisms of intelligence whose structure and functioning would therefore be universal and not subject to social bias.

However, the comparative studies inspired by Piaget's tests (Bruner et al., 1966) or those of the Piagetian school itself have repeatedly described intercultural "décalages" between children of the same age but from different cultural backgrounds. These studies have often observed the cognitive advance of occidental subjects and particularly those from advantaged backgrounds as well as those subjects of non-occidental cultures who have attended formal schooling.

Operatory tests used in Piagetian experiments have a tightly structured procedure. The subject of the conversation between the experimenter and the child is centered around a particular task that structures thought (cf. Brainerd 1978). It can be argued that the questions asked by the adult, although open in form, are in fact closed as to their content in the sense that the adult knows the correct operatory response. It would therefore not be so surprising that observed operatory behaviours would be identical across social groups (Perret-Clermont 1982). However, this is not the case. Both age and social class interdependently affect the level of cognitive performances. Within the Piagetian approach the most frequent interpretation of this observed phenomenon refers to the notion of "different rhythms of development" [1], with certain subjects showing a more rapid intellectual development than others, in function of an environment qualified as more "beneficial".

> *Dasen (in press) reports differences in performances on certain Piagetian tests which favor subjects from non-occidental cultures. The very esistence of these 'décalages' is again the result of an interaction between cognitive and cultural processes. But we will still have to consider whether this interaction is due to the subjects former experience or to the testing situation itself.*
>
> *In Europe, a correspondance between operatory level and social background has been found repeatedly in different countries. Coll et al. (1974) have remarked the importance of the role that a particular type of teaching can play. In their study conducted in Spain, these authors have found that disadvantaged children attending a school using an "active" pedagogy attain higher operatory levels than their peers from the same social group attending more traditional schooling. In studies undertaken in Geneva (Perret-Clermont, 1980), we have also found that the proportion of pupils demonstrating an operatory level in tests of conservation of number and liquids varies in function of the socio-professional category of their parents. However, these differences disappear after a ten minute collective activity which induced a confrontation between subjects holding differing conserving and non-conserving points of view. Analogous results were found in a study conducted in the Italian-speaking part of Switzerland (Perret-Clermont and Schubauer-Leoni, 1981).*

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1) Here the question of the norms underlying all hierarchization should be examined, given the fact that the choice of concepts which eventually constitute a developmental scale is never culturally neutral. In Piagetian theory, abstraction is particularly valorised (for example: time is concieved independently from history; objects are disassociated from action; space is defined independently from all social structure, etc.)

In Spain again, Mugny and Doise (1978) corroborated this result in an experiment using a task demanding interdependent coordination of motor activities. They present data which suggests that it is at a particular given moment in the development of a competence that an individual benefits from the social interaction offered by a collective activity. Subjects from advantaged backgrounds seem to develop these competences at a younger age and therefore do not draw any particular benefit from the social interactions instigated by the experimenter. Whereas their peers from socially disadvantaged backgrounds profit from this same interaction to the point of bridging the gap which seperates the performance level of the two groups. It seems to us that the authors thereby demonstrate that the capacity to benefit from collective activity is not a characteristic specific to a particular social group nor a general fact, but rather the result of an interaction between various social and developmental factors.

The results presented by Mackie (1980) can likewise be interpreted in this sense. Individually confronted by a spatial representing task similar to the one used by Doise, Mugny and Perret-Clermont (1975), subjects from traditional Maori society of New Zealand performed at cognitive levels inferior to those of their peers of European cultures. But this difference between the two groups disappeared when their collective performances were compared.

Lautrey (1980) has observed the existence of strong correlations between the type of parental educational practice (i.e. the degree of regularity, flexibility, or rigidity) and the operatory level of their children. The observed differences between performances of subjects of different social backgrounds could be thus explained, according to Lautrey, by different educational models among social classes. This suggests the existence of an interaction between relational processes, (educational, in this case) and cognitive behaviours. Here we would suggest again that this interaction might have more effect on the child's understanding of the testing situation than on his general intellectual abilities.

We have presented the above examples in order to suggest that the differences found in the performances of different social groups would not be explained by such a global concept as "differential rhythm of operatory development" [1]. In fact, a notion with as large a sense as "rate of growth" cannot account for the disappearance of differences between performances which occurs after

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1) Another problem with the idea of "differential rhythm of development" is to decide whether it is biological or cultural.

a brief period of social interaction (Perret-Clermont 1980, Doise and Mugny 1981.) How can one speak of social environments that would be "particularly facilitating" for development when their effects differ in importance from one notion to another (as does Dasen's (in press) previous discussion of results)? There is a need for a theory which would account for the correlations reported between particular cultural experience and the development of certain concepts.

The existence of these differences of operatory levels between different social groups necessarily leads the researcher to reconsider the logical as well as the social significance of the task chosen by Piaget and his followers in relation to their ambition of testing universal (i.e. culture free) processes of intelligence.

> *The Piagetian model of intelligence itself did not develop in a social and cultural vacuum. It is marked by the definitions and representations of intelligence that are prevalent in our occidental cultures and, more particularly, in scientific environments [1]. The examination of this question could point to processes similar to those described by social psychologists like Tajfel (1973) and Doise (1976) to explain observed social categorizations and justificatory representations. These researchers have shown, in fact, that in many circumstances, (pluriethnic, institutional, etc.), the dynamic of intergroup relations, even in the absense of competition, favorizes the creation of representations which valorise one's own group and devalorise other groups. Following these studies, one can hypothesize that when the question of intelligence is discussed in an intergroup situation, as is the case for intercultural or educational psychology, this dynamic of intergroup relations and representations is likely to favorise the tendancy towards relative over-estimation in favor of one's membership group. Psychologists and especially researchers in psychology (even Piaget!) might not have always been free from this ethnocentric bias.*
>
> *These psychosociological processes are perhaps analogous to those described by Bourdieu (1980 p. 269-66) in his sociological analysis of contributions by intellectuals to the "racism of intelligence". According to Bourdieu: "There is not a racism but many forms of racism, in the sense that there are as many forms as there are groups who have need to justify their existence as such. This is the invariant function of racism. To me it seems very important to analyse the forms*

1) For example, Piaget's theoretical child has often been depicted as a miniature "researcher".

of racism which are likely to be the most subtle, the most difficult to recognise ... I am thinking here of the racism of intelligence, a racism which is specific to a dominant class whose reproduction depends partly upon the transmission of cultural capital. This capital, which is inherited, has the property of being incorporated capital, and therefore appears natural, inate (....) it is the "theodicy" of their proper privilege, in Weberian terms (...) it is this which makes the members of a dominant class feel justified in being dominant; which gives them a sentiment of superiority. Any racism is an essentialism ..."

Bourdieu goes on to explain that it is a question of "euphemized" racism and that "the most prevalent widespread method of euphemization today is evidently the apparent" scientification "of discourse. This is why he proposes to simply not broach the problem of the biological or social origins of intelligence to which psychologists have limited themselves. Rather than attempt to scientifically analyse the question, it is necessary to try to make a science of the question itself; i.e. to try to analyse the social conditions of the emergence of this type of question and of its subsequent racism. This Bourdieu does in the next pages of his exposé, by analysing the ideological function of the school and of educational psychology.

At a sociological level, Bourdieu proposes to elucidate the present debate about intelligence by understanding its ideological functions. At the level of cognitive and psychological dynamic of researchers themselves, we have proposed to examine the processes of identification, categorization, attribution, anticipation and justification which underly representations and which influence relations between groups.

But these analyses will be relevant to the field of education only if we extend them beyond the study of intelligence in its global sense to the apprehension of the contents of intelligence. It seems to us that one of the reasons for the apparent sterility of the present debate about intelligence is precisely this persistance in the search of a global definition of intelligence which is independent of the objects that it tries to apprehend. This search thus confines any investigation to a priori conception of a "general faculty". The recent history of cognitive and differential psychology could be re-written by recounting the trials and tribulations encountered in this search for a generality or universality of intelligence, as it has taken on different meanings according to the particular historical context. Contrary to racist theories which perceive intelligence as a trait specific to a certain type of "civilized" man, authors like Piaget have shown that the

roots of the psychological development of individual cognitive activity lie in general biological and psychological foundations which are a characteristic of the human beings and therefore universal. Empirical studies have been able to verify this observation in a wide diversity of human environments. However, neither the universality of the forms of their social realisation nor a psychological generality of these mechanisms in different tasks can be deduced from this universality of general cognitive processes. The inverse hypothesis is likewise true: i.e., that different cultural contexts induce diverse cognitive activities and that, in consequence, they will produce, in a psychological sense, different cognitive structurations even for the same individual. It follows that a person can show different competence levels that can vary according to the situation.

Thus, the question is no longer one of the nature of intelligence but of the conditions of appearance, functioning and disappearance of these cultural, social and scientific productions and of the forms which they present. The general concept of "knowledge" designates, in fact, a collection of specific cultural productions. One should then ask how these cultural competences emerge in children and adults, in function of individual or group situations and according to specific tasks. [1)]

It is interesting, especially for the educator, to identify the modalities characterizing psychological functioning in micro-situations where cultural advantages are transmitted (advantages which Bourdieu refers to as "heritage"). What are the characteristics of the processes by which the individual acquires or "appropriates" (i.e. extends by his own elaborations) these cultural advantages? Does this cultural transmission automatically result in advantaging some children and disadvantaging others or can one find situations where this does not occur? And what would be the characteristics of such situations? One can formulate the hypothesis according to which socio-culturally advantaged groups have the privilege of not only possessing inheritable advantages but knowing how to transmit these privileges as well. Thus, they have the double privilege of possessing, as it were, the knowledge as well as the "art" of this transmission. But what exactly

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1) See for example an analysis of the processes of transposition of knowledge in the teaching of mathematics and an observation of the functioning of these processes in the pupil's activity. (Perret-Clermont, Brun, Conne and Schubauer, 1981).

does this "art" consist of? And what is its bearing on education?

We have discussed earlier the observed correlations between intelligence level and socio-economic background and have found ourselves confronted with data which suggest the existence of socio- and ethno-centric biases in researchers themselves which would influence even their definitions of the terms of the debate about intelligence. However, it seems to us important to bear in mind the ideological function of the question of intelligence and to draw the researcher's attention to the risks of a too general conception which would be of little help to the specific comprehension of the concrete situations of production and transmission of knowledge. This specific understanding could reveal important mechanisms as well, such as the child's appropriation of cultural advantages.

To extend this reflection, we are now going to turn to the consideration of the hypothesis according to which the generality of behaviours evidenced by Piagetian research, could be explained, at least partially, by the social, cognitive and material specificity of the situations created by the experimental paradigms used in these studies. Their specificity could be described by refering to the social marking of the testing situation, the univocity of possible responses to problems to which the adults hold the solution, to the dialogue directed by the adult, etc. ...

By refering to empirical studies, we are now going to examine the roles attributed to the subjects and the cognitive activities required in the experimental situation. We will consider different types of notions, interpersonal relations and situations (individual or collective, didactical or non-didactical, etc.) This variety is deemed necessary in order to understand how the individual, when sollicited, elaborates his responses and activates his knowledge in function of social, cognitive and material characteristics of the testing situation, as well as in function of his past experience. In this perspective, we are going to examine different aspects of the assessment of an operatory level, putting forth the hypothesis that the subject's response is elaborated hic et nunc in the relation in which it is ellicited (that is, if it has not already, of course become an automatism or reflex).

B) Decoding, formulation and learning: The subject's elaboration of his responses

It is clear that when an individual attempts to respond to an operatory test or to a clinical interview at a given moment in his life, he will succeed only if a number of prerequisite conditions are fulfilled. He will have to have reached a certain level of biological maturity, constructed certain cognitive and relational instruments, systems of behaviours, cognitive and linguistic structures, languages, etc., and have acquired a physical, emotional and social

disponsibility permitting him to engage in the interaction proposed by his interlocutor. But these determinations are rarely simple and direct.

> *Mounoud and Hauert (in press) in their research on perceptivo-motrice tasks performed during the first months of life demonstrated that organic maturation in determination of behaviours is not linear. Following a non-linear ascendancy, maturation not only favorizes potential intellectual growth but also inhibits it at times. Thus, an identical psychological event does not have the same significance for the subject depending upon his level of growth at a given period in time. If such interferences are already present in the very young child (as studied by Mounoud) it could well be supposed that they are likewise present at later moments in life. The complexification of psychological processes at older ages evidently renders them more difficult to describe.*
>
> *We have been able to verify in our own experiments concerning the conservation of quantity (Perret-Clermont 1980) that children benefit from proposed social interactions only after they have mastered a certain number of elements required by the task. Rijsman et al. (1980) present analogous observations. Pain (1980) in her clinical and therapeutic practice concerning treatment remediation of learning difficulties states that the very absense of cognitive operations often fulfills a specific function in the constitution of the subject's personality. This does not signify however that the causes of cognitive deficiency are only to be found at the level of the emotional dynamics of the individual: the subject is always in interaction with a social and cultural context. In consequence, Pain (1980) observes that the "denonciation" (in the psychoanalytical sense of the word) of the function of a cognitive insufficiency not only produces therapeutical effects for the subject, but also clarifies the larger problem of the functions of ignorance: (...) "the gravest problem of learning is not the problem of who do not conform to statistical norms, but the social problem of this social oligophrenia which produces subjects who have diplomas but whose cognitive activity is often poor, automatic and passive* [1] *and well under what is possible in the structures of thought" (p. 11).*

What happens then when the above-mentioned prerequisite conditions are fulfilled and the individual engages himself completely in the proposed cognitive activity of an operatory test? In order not to

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1) Our underlining, to indicate that it is not this type of "cognitive activity" which we wish to study in the present paper, although it undeniably exists!

limit ourselves to the study of the "elicitation of thought reflexes" [1], we present to the subject rather complex tasks which demand a reflexion or a mental activity on his part. What type of activity will the testee develop? How is he going to respond to the actions (instructions, questions, silences) of the experimenter?

We are now going to retrace the stages by which a subject's responses are elaborated, but keeping in mind that all subjects need not necessarily go through each sequence every time.

> *Subjects from differing social groups faced with the same task are not necessarily faced with the same relational situation even if it is rigorously standardized in the eyes of the experimenter. The same question or the same material will not necessarily have the same semantic resonance for all subjects. Previous social and cultural experience is likely to "interfer" with the apprehension of a situation. It is well known that identical events can have different meanings for the same individual at different moments in his life.*

1. First phase: the Decoding and Interpretation of the Situation by the Subject

Operatory tests, as well as psychological tests, are inevitably a kind of staging supposedly representative of other situations requiring the same aptitudes. The experimenter has learned the role[2], that he will play in the experiment being part of the professional training of a psychologist. The role expectations regarding the testee are relatively precise in a testing situation. However, while the experimenter has been

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1) Tasks which are judged by the subject as too simple or boring are those which only elicit pre-fabricated responses or automatisms of thought. From this point of view, it is striking to note the lack of interest regarding classical operatory tests shown by children who are at levels of equilibrium (i.e. conserving and non-conserving). While, on the contrary, subjects who are on an intermediary level (i.e. who hesitate and oscillate in their responses) seem to be fully engaged in their cognitive activity. The same type of motivation was also observed in non-intermediate subjects, whether non-conserving or conserving, when they had to collectively resolve tasks with peers of conflicting points of view (Perret-Clermont 1980, Perret-Clermont and Schubauer-Leoni 1981).

2) We note here that, in certain aspects, pedagogical situations are homologous to testing situations: the teacher has also learned his role during his professional training which is also reinforced by a certain number of teaching procedures and programs. The role of the pupil is perhaps just as precise, but less explicit. Certain pupils are doubtlessly better socially prepared than others to identify and master their role.

initiated to the idea of role-playing, the subject has not. The exact role which the subject must fulfill is difficult to render explicit and is rarely communicated to him unless the subject has been specifically drilled in this respect. What is his role? What is the sense of all the testing ritual? To what must he respond? Certain subjects ask themselves these questions more or less consciously and with either pleasure, humor or anxiety according to the circumstances.

Therefore, from the beginning of an interview concerning an operatory notion, the subject will have to socially situate himself and comprehend what is expected of him.

> *However the test of conservation of liquids can prove to be quite ambiguous in regard to expected roles. In this test, the child is asked to give equal quantities of juice to the adult and himself. However, this equality of sharing can pose a problem for those subjects who are attentive to the fact that the intended attribution of juice concerns two persons of inequal social status. From a certain point of view, the adult could have the right to have more; or one could expect him to have a greater thirst, being physically larger ! This ambiguity could increase during the following stage of the classical test. The subject is then asked to pour the initial equal quantities in two other glasses having forms so that it seems, perceptively, that one of the partners suddenly has more than the other. If the "favorised" partner happens to be the child, the conflict will not only be perceptual in relation to the dimensions of the glasses but social as well. This social conflict stems from the fact that the child now finds himself in a situation where it seems that he has more juice: this is contrary not only to the experimental instruction but also to a social privilege claimable by the adult. What will the child think? The rest of the interview, by the manner in which the experimenter conducts it, will reveal to the child that, under the circumstances, a solution must be found without taking into consideration the social relation because only the perceptual conflict is considered important by the experimenter. In other words, in order to attain an operatory level on this test, the subject must understand:*
>
> - *that the partners must be considered as being formally equal,*
> - *that the outcome of the pouring of the juice is legitimate in the framework of the experimental instructions,*
> - *that it is the formal properties of the juice which are the object of the interview,*
> - *and that following the juice pouring, the perceptual illusions must be perceived as such and rationalized in such a way as to demonstrate the invariance of the quantities in question.*

Data from recent research (Perret-Clermont & Schubauer-Leoni 1981, p. 218) seems to show a stronger tendancy for boys rather than girls to exhibit conserving behavicurs in a social paradoxical situation where the subject seems to be more advantaged than the adult due to a perceptual illusion. (Perhaps this is because the boys would be less socialized as to the consideration of the social dimensions of the situation?).

While taking the test, the subject must therefore interpret the situation in order to comprehend its significance as indicated by the experimental staging, the instructions, the questions provoked by the material, the verbal productions and the gestures of the partners (be it an experimenter or peer).

The effect of the experimental "staging" was observed in the research cited above (Perret-Clermont & Schubauer-Leoni, 1981) when it was found that subjects produced operatory level behaviours more frequently if the testing procedure involved the sharing of juice between the experimenter and the child rather than a distribution between two look-alike dolls. One could venture the following hypothesis: the child must abstract from the testing situation only the elements which are necessary to the formulation of the response expected by the experimenter. However, the doll is a toy; the object of many ludic activities of the child. Perhaps these dolls could be seen as "distractors" in this situation (i.e., distracting the attention that the child must focus on the question of conservations of quantities) since the object of the interview is to talk about the juice and not to play. It should be noted, for the pretest used in this research, that although this effect of experimental staging appeared for all the subjects, it was stronger for the group of subjects from disadvantaged social backgrounds (and especially for girls of this milieu).

We will return later to the evolution of these effects in function of the subject's sensibilisation induced by the experimental paradigm itself. We will also discuss analogous processes in learning situations, described by Doise & Mugny (1981) and de Paolis (1981) in terms of social marking.

The interview itself provides elements to which the subject refers in order to understand what is happening and to finalise his responses by considering one dimension rather than another.

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1) One can note the ambiguity of the notion of "play" in the presentation of many psychological tests. The same ambiguity is likewise found in many educational "games" that the child does not really play with (if "play" implies a certain freedom of action).

Rose & Blank (1974) report, in fact, that during tests of conservation, the subjects who had to make two judgements (the one before the transformation and the other after) presented operatory responses less frequently than those who had only to judge once after the material had been transformed (cited by Light et al. 1979).

McGarrigle & Donaldson (1974) offer a similar interpretation of the observed differences in children's operatory performances in their research already mentioned above, using a teddy bear.

Light, Buckingham & Robbins (1979) have likewise performed experiments using tests of conservation and have observed that subjects gave operatory level responses to tests of length and discontinuous quantities when the transformations of material seemed accidental and marginal to the interview. For these authors, the attainment of the operational stage is, in fact, "the establishment of that degree of personal autonomy or detachment which enables the child to separate the meaning of words from the meaning of the contexts in which they are uttered".

Smedslund (1977) after many years of research concerning the notions of conservation, arrived at the conclusion that "there is a circular relation between logicality and understanding" (p. 3). "In order to decide whether a child is behaving logically or not, we must take for granted that he has correctly understood all instructions and terms involved. On the other hand, in order to decide whether or not a child has correctly understood a given term or instruction, one must take for granted that the child is behaving logically with respect to the implications which constitute his understanding" (p. 3). He continues: "Piaget's assumption of the existence of such purely structural entities as the additive grouping of classes, etc., is unacceptable to me because it implies that human beings can function abstractly, i.e., out of context and independently of content."

Smedslund considers that "the only defensible position is always to treat his understanding of given situations as a matter for empirical study (...). Only when presence or absence of logicality is studied and understanding is taken for granted, does it become legitimate to describe children as "non-conservers", adults as "mad", foreigners as "inconsistent and self-contradictory" and so on" (p. 3-4).

Heber (1981), in her examination of the methods of interrogation customarily used by Piaget and his col-

leagues, affirms: "It is not clear whether the children's own judgements are drawn from them by means of a fairly flexible discussion or whether the style of questioning constrains the child to give the correct description (...). Obviously comparison with other forms (are) now needed in order to discern effective interactive influence" (p. 190).

In this activity of interpretation of the situation (task, social relations, finality), the subject refers to his previous experience and to his systems of representations. This activity often implies the use of different semantic systems which the subject must abstract from or coordinate. The most facilitative situations are obviously those where the homologies between the evoqued universe and the present situation are such that the subject can refer to the former to structure the latter.

Rommetveit (1978) has observed a superiority in operatory performances in Norwegian children when, faced with identical figural material, the instructions make explicit reference to "snowballs" rather than "white circles" in seriation and cross-categorisation tasks. Rommetveit (1979) constates, however, that this prestructuration which selectively attracts the child's attention to a known category of objects (snowballs) does not suffice for an operatory resolution by certain subjects, especially those from disadvantaged backgrounds. Following other observations of this type, Rommetveit is led to believe that "what in such experiments is considered evidence of incapability to cope simultaneously with super- and subordinate classes may thus apparently often be interpreted as a spontaneous transformation of the task as intended by the experimenter. What is achieved by that transformation is some real life significance and plausibility for the social transaction: the task is not any longer (as intended by the investigator) a test of pure reasoning, but in fact a reasonable everyday problem. A correct response, on the other hand, implies acceptance of premises imposed by the adult, premises which are entirely detached from plausible real life contexts of practical significance" (p. 19). For this author, it is also clear that simple verbal explicitationsis not sufficient to establish an intersubjectivity between the subject and the experimenter because it stems, in fact, from a more complex social process (Rommetveit 1976).

Doise and Mugny (1981) invoke the notion of homology rather than the vague concept of an eventual "familiarity", to explain, in the experiments with Rilliet and de Paolis, the greater operatory progress made by subject dyads who worked with a structured material like a classroom or a playground rather than with a material with identical spatial structure but that was less socially marked for the child (houses and lakes).

We have been able to see, from the studies cited above that in order to successfully master a test situation, the subject must possess the right knowledge and pre-requisite experience and have attained a sufficient stage of maturation. Moreover, he must manage to decipher the social situation in which he finds himself in order to understand what is expected of him. He must be able to discern which elements (among those he is aware of) form the basis of the game led by the experimenter and to which he must respond. He must therefore choose which dimensions of the situation to abstract from. In order to do this, the subject must be able to refer to homologous situations previously encountered. The degree of facility of referal will be dependent upon the subject's previous experience and the nature of the circumstances. Once the expected response is identified how is the subject going to produce it?

2. Second phase: the formulation of a response by the subject

The activity of this phase follows directly from the first phase of decoding and interpretation described above. It can even be simultaneous if the child proceeds by a form of "trial and error", i.e. trying out his responses on the experimenter and watching for his reactions.

The subject's modalities of responses can be chosen from his pre-existing repertoire of responses (verbal expressions, behavioural models, systems of relations, etc.) which have been preconstructed by previous learning. They can also be produced by new coordinations provoked by the novelty of the task at hand. In any case, the subject adopts a particular model of behaviour and attempts to make it function in the resolution of the task, adapting it if necessary. During this activity of adaptation, the subject's simultaneous consideration of the reactions of the experimenter and of the characteristics of the task can lead him either to confine himself to his chosen model of behaviour or to attempt other strategies such as: the testing of another model, the modification of his apprehension of the meaning of the instructions, an abandon of the task or a refusal of the relation which the experimenter tries to establish with him.

> *An example of a reaction which is not merely cognitive is that of a 4½ year old little boy of working class origin who, after having been carefully questioned by the experimenter (in the presence of*

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1) Robinson & Robinson (1977) remark that when a message is not correctly transmitted between a locutor and its destinator, the young child is more readily inclined to attribute the causes of these errors to the listener rather than to the quality of the message itself. One could ask oneself if such tendancy is not likewise observable in certain researchers' (or teachers') reports of their interactions with a subject (or pupil) where the answer, more often than the question posed, is judged inadequate (immature, etc.)...

several students) about the conservation of number, leaves the room and then immediately returns, casts a glance around, and declares: "That's fishy!"

In an additional analysis of Perret-Clermont, Schubauer-Leoni's data (1981), it was found that already in the course of the first exchanges of the interview, and particularly after being presented with a counter-suggestion, a certain number of subjects modify their systems of response by switching to operatory responses after giving initial non-conserving responses. It appears that for these subjects this simple counter-suggestion "opens the way" to an elaboration of operatory responses. Perhaps this is because this counter-suggestion makes explicit the type of reasoning expected by the adult. It also seems that the counter-suggestion has a greater effect on subjects from advantaged socio-cultural origins. These subjects, more often than others, evolved during the pre-test itself.

Once the subject's interpretation of the situation permits him to establish an intersubjectivity with the experimenter, the subject elaborates his responses. He tries them out, retaining those which function in the task and which seem to be acceptable by the experimenter and at the same time, susceptible to resolve the problem. The subject is thus lead to eliminate certain behaviours and to retain others; to abstract from certain characteristics or dimensions of the situation and to concentrate on others. The responses that the individual produces can either be new and in process of elaboration or known and therefore "rediscovered" hic et nunc with or without the subject's being aware that they are the generalization of behaviours or concepts previously used elsewhere.

We will not consider here in detail the difficult problem of the generalization of responses. However, provided that a certain number of important precautions are taken in order not to simultaneously modify too many factors in the testing situation, it is interesting to vary the tasks in order to test the breadth of the newly-acquired competence. This is why we have used tests of generalization in certain researches (Perret-Clermont 1980, Doise et Mugny, 1981a). Such generalization can be regularly found.

Structures are not reified parts of the intellect of the subject. We consider them as heuristic models elaborated by the researcher to represent the dynamic of thinking of the subject. One could fear however that in many debates (concerning, for example, the precocious appearance of forms of a so-called "operatory competancy"), the notion of structure has often undergone such a naturalisation. Studies on child egocentrism, following the early works of Piaget, seemed to have been likewise the object of controversy between supporters and detractors of an essentialism of childhood.

3. Third phase: The subject adjusts his answer and elaborates an operation response

For many subjects, taking an operatory test is probably already in itself an occasion for learning. In the course of the experimenter's interrogation, the individual finds himself confronted with the necessity to understand the situation and to produce a behaviour, i.e. to formulate a response, which he learns is appropriate.

If, as we have just reported such experiments whose purpose was not to induce learning but to test subject's competence levels have nevertheless induced learning because of the psycho-social dynamic of the testing interaction. We would obviously expect to find the same type of psychosocial processes in experiments expressly designed to elicit learning or to observe development which we will now examine.

a) Testing and learning situations

In a given learning situation, an individual constructs a response. In so far as this response is new for him, one can say that he learns it. As mentioned above, this learning was observed even when such was not the intention of the tester. It seems however useful to make a distinction between testing situations which are designed as such by the researcher (psychologist or teacher) aiming at assessing the subject's level of behaviour at a given moment and learning situations (classroom or experimental situations) which are constructed in such a way as to give the subject temporal and relational space in which to explore reality, gather information and try out his behaviours and responses with the hope of attaining a superior state of knowledge.

Testing situations are marked by evaluative finality and the subject's responses are elaborated toward this end. Nearly all school learning situations are likewise marked.[1] In so far as all behaviour is, to a certain extent, a "response" (i.e. the result of an interaction with the social environment) it is clear that didactic situations can be considered as essentially analogous to testing situations on many levels. However, the social interactions which accompany didactic situations differ in significance and explicitness and vary in their relative importance.[2]

The tester guides the situation and expects acceptable responses in a relatively brief period of time. The eventual long-term learning

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1) It has been noted that in current educational practice, it frequently happens that the teacher confuses learning with evaluation. This is perhaps due to the habit of grading most of the student's work.

2) It would be necessary, however, to examine how the subjects perceive the testing and learning situations in function of their past experience: do they make such a distinction between these two types of contexts?

consequences of the testing itself for the subject are neither investigated nor even considered by those desiring to establish a cognitive assessment.[1] Yet in regard to research on learning, it is precisely these long-term effects which are expected and which will be evaluated (even though sometimes the subject is not explicitly informed of the nature of these expected effects: another way of negating the role of the subject's activity in the construction of meanings!).

These distinctions are helpful to understand individual situations. But the study of collective performances can also illustrate these points. Are group performances liable to be superior to individual performance? Moscovici & Paicheler (1973), in their review of literature on the subject, have already shown that it is not possible to establish a superiority (or an inferiority) of collective performances per se in regard to individual performances. In fact, the quality of collective performances depends upon a number of processes (the relation of the communication network to the structure of the task, the existence of an isomorphism between social relations and exchange network, etc.) which cannot always be optimized for greater group performance. Studies of children's cognitive behaviours have shown that, according to the circumstances, collective performances can be more advanced (in the sense of being more logically structured) or can be equal or inferior to individual performances depending on the experimental, psychological and sociological conditions of subject groups studied (Doise 1973, Doise, Mugny & Perret-Clermont 1975, Doise & Mugny 1975, Mugny & Doise 1978, 1979, Bearison in press).

> *In two recent studies, Russell (1981a, 1981b) has observed that performances of child dyads are not always superior to individual performance and that "when dyadic superiority did result in these studies it was by virtue of the influence of one child's correct judgement". After carefully observing induced interactions between subjects during the resolution of Piagetian tests, Russell declares, refering to Doise, Mugny & Perret-Clermont (1975), that "even if dyadic performances is superior to solo performance we can explain this by the notion that incorrectly judging children tend to adopt a correct partner's answer, rather than by the notion of socio-cognitive conflict". Russell goes on to say that "if the errors are ones of performance, not only are such conflicts impossible but the above tendancy of the incorrect child to comply with the correct partner's judgement is thereby explained; the maker of a performance error should realize he is incorrect*[2] *when this is pointed out to him"*[3]*. But how does the subject come to*

1) Pain (1980) makes an exception when she states that the diagnosis is part of the treatment.

2) Our underlining.

3) Opposite effects are sometimes observed. For example, Heber (1981) has noted that, in dialogues between children, "mere contention, even if it made the child realize other points of view, had little influence" (p. 111).

recognize the partner's answer as correct and to accept it? We suggest that "conflict" should be taken in larger sense than Russell's so as to include the simple confrontation of two distinct opinions.

The superiority of individual or collective performances seems not, in itself, an interesting debate. Rather, these researchers point to another important question: how subjects function intellectually when they realize their responses are incorrect and how do they validate their intuitions? To speak of a "correct" or "incorrect" response presumes the existence of a norm of correctness: what is its criteria? What material, cognitive or relational aspects of the situation does the subject take into account in order to respond to the problem in way that seems logical and legitimate in the eyes of the psychologist?

It is interesting to examine not only the testing situation (as Russell has done in the two experiments cited above) but also the important differences that can exist between various situations of socio-cognitive conflict by studying their long-term cognitive consequences for the participants. What effect does a confrontation with a differing response have on the subject's cognitive functioning in another situation at a later time? It is neither pertinent nor possible to resolve the question of a general superiority of individual vs. collective situations in regard to the cognitive performances of participating subjects. However, an examination of the long-term effects of collective situations could prove to be particularly illuminating for the understanding of the dynamic of the cognitive processes which produce observed performances. This is what we now will discuss.

b) *In what circumstances do collective situations have long-term consequences?*

Simple co-presence or any work in small groups (i.e. dyads or trios) or large groups (i.e. teams or classes) represent, at least potentially, an occasion for social interaction. The possible modalities of collective work are numerous. One could even include in the definition of "collective situations" those in which the presence of another is simply invoked. Yet, the precise cognitive repercussions of these collective situations on their participants have not all been systematically studied and are supposedly different. We will center here our attention on several experiments which have examined the possible effects of social interaction between two or three individuals on participants' performances and generalization on operatory tests.

Several of these studies have an explicit didactic purpose. i.e., eliciting learning, while others aim to observe a development. But they are all characterized by the fact that they are concerned with "closed" problems, i.e. problems to.which the adult holds the "correct" solution (by logical norms) and not open-ended problems (like for instance those investigated by scientific researchers and described

by Latour and Woolgar, 1979). The object of these studies can be dealt with in a limited temporal space and does not concern complex activities (such as those studied by Fiedler 1976) for example which, by reason of their complexity, would be more pertinent to a strictly pedagogical point of view).

These studies have diverse theoretical references as well as differing experimental procedures; some are concerned with group work, others consider more limited examples of social interaction like the simple confrontation with a model. The results of several of these studies are interpreted by their authors by reference to social learning theories (Bandura 1971, Rosenthal & Zimmerman 1978). Extending the hypotheses advanced by Smedslund (1966) about the social origin of cognitive decentration, other authors (Doise, Mugny & Perret-Clermont 1975, Perret-Clermont 1980, Doise and Mugny 1981, Perret-Clermont & Schubauer-Leoni 1981) in dealing with analogous experimental situations claim that they observe more general processes: not mere imitation and transmission of behaviour models, but the social construction (or reconstruction) of meaning.

In experiments using a three-step paradigm (i.e. collective situation with an individual pre- and post-test), it has been repeatedly observed that situations where individuals must co-ordinate their actions with one another lead them to produce new cognitive coordinations of higher competence. Subsequent individual performances demonstrate that these collectively attained competences are consequently interiorized by the actors.[1)]

> *Analogous results have been obtained using different tasks: judgement of conservation of quality, spatial representation, inter-dependent motor activity, replication of geometric figures (Perret-Clermont 1980, Doise & Mugny 1981) and mathematical formulations (Schubauer-Leoni & Perret-Clermont 1980). Other authors present similar results regarding these same operatory skills (Mackie 1980, Rijsman et al. 1980) or in regard to other mental operations: the evolution of the representation of distance (Fresard 1980) the structure of moral argumentation in adolescents (Bourquin 1981), the "Hanoi Tower" game (Glachan & Light 1981) and exercises of cross-classification (Valiant, Glachan & Emler in press).*

Most of these experiments report some generalization of learning: the subjects exhibit newly acquiered behaviours on tasks other than the specific learning one and in some cases they produce arguments which can be considered as evidence of a deep understanding, going beyond simple memorization or habit.

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1) In other words, in certain situations of social interaction, individuals construct an operatory "heritage" (cf. Bourdieu's use of the notion of heritage) and are thereby "priviledged" when they find themselves in such situations which allow them to do so.

We have already mentioned the theoretical difficulties which surround this concept of "generalization". In one of the experiments cited above (Perret-Clermont & Schubauer-Leoni 1981), we tried to consider not only the generalization of learning to other tasks but also to other social settings or experimental scenarios. Two types of social interaction between children of socially disadvantaged backgrounds were examined. In one experimental condition, the non-conserving child was instructed to equally divide the juice between himself and a conserving peer. In the other condition, the non-conserving child was confronted by a conserving adult model whose behaviour was matched to the conserving child in the first condition. These confrontations resulted in learning for both groups of subjects. However, the children performed on a more advanced cognitive level on the pre-test if they were in a situation of sharing with an adult rather than in an analogous one using dolls. On the post-test, these differences disappeared for those subjects in the experimental peer condition but not for those of the modeling condition. It seems thus that the learning situation invoked by peer confrontation is more susceptible than a modeling situation to produce behaviours which can be generalized to different socially marked situations. Is this difference between peer interaction and modeling a general one, i.e. is the explanation to be found in the nature of the subjects' social relations with the model or the peer? This is, in any event, what was observed for this operatory activity (at least at this specific developmental level, in these circumstances, with subjects from socially disadvantaged backgrounds).

Situations which are identical in the eyes of the experimenter, can, in fact, have different consequences for its participants. These consequences can be at least partially related to descriptors such as age, previous operatory level, socio-professional category of parents and sex (Perret-Clermont 1980, Doise & Mugny 1981) and also place of habitation (Fresard 1980). But the causes of the influence of such variables remain to be explained. It should be noted that "previous experience" of the subject does not only refer to what he has experienced and elaborated outside the experimental situation but also to the experience accumulated during the experiment itself.

We have already reported here that it makes a difference whether the subject is confronted by an adult model to imitate rather than by a peer with whom he must actively seek an agreement. We have also observed that the latter experience under certain circumstances permits children from socially disadvantaged backgrounds "to bridge the gap" between their operatory performances and those of peers from advantaged backgrounds: the social experience offered by the experiment leads them to perform as well as the others (Perret-Clermont 1980,

Doise & Mugny, 1981, Perret-Clermont et Schubauer-Leoni 1981).

Heber (1977, 1981) has studied these learning opportunities which are found not only in teaching acts but in conversations as well. She has presented evidence which suggest that "conversational interactions can significantly influence the growth of understanding in the child" (1981, p. 3). Heber suggests that "perhaps talking to another person produces interactive influences which have less to do with the semantics and grammar of the utterances than with learning to appreciate a problem from the standpoint of another". This author likewise finds that adequate learning conditions can eradicate observed differences between children of differing social backgrounds: "the lower working class children took longer to learn the description within the three sessions but by the second seriation post-test they had reached the same level of competence in seriation as their middle-class counterparts" (1981, p. 8). In comparing her different experimental learning conditions, Heber found a certain efficacity in situations where the subject had to either converse with the adult or explain himself when faced with the incomprehension of a puppet (or else when he received instructions explaining the rules of the game). However, simple disagreement with a peer or memorization of the correct explanations proved to be without effect in her research.

The antecedent experience of the subject as well as that accumulated during experimental social interactions are thus likely to play a major role in the subject's elaboration of his cognitive behaviour. These experiences could be said to shape the manner in which the subject interprets the situation, evaluates the social relations in which he is involved, and engages himself in a abstract cognitive activity. In several studies we have then varied the experimental conditions between partners in order to observe their specific learning consequences.

In our experiments (Perret-Clermont 1980), we found necessary the constitution of homogeneous groups of subjects regarding school grade so that the children would consider themselves as equal and hence would not escape from dialoging with their partner with excuses such as: "... he is too young, he cannot understand!".

Finn (1980) (cited by Doise, Rijsman et al., 1981 who replicated and confirmed Finn's results) obtains superior operatory performances when subjects had to share lemonade after invoking the right to equal recompensation for equal work. Doise & Mugny (1981) have conducted several experiments in which learning was greater when the situation was socially marked in a homological sense, owing to the fact that the social regulations directing the in-

teractions favour then the homologeous cognitive coordination.

But here again it is not possible to objectively define the social characteristics of situations. They are always marked by the subjectivity of the individual who perceives and interprets them. Thus, another field of investigation would be to identify which characteristics of a situation (cognitive, social, material and historical) are perceived as conflictual, as demanding a resolution. Pertaining to our study, we can ask ourselves in which circumstances and by what procedures can an individual be lead to believe that a conflict has such a "cognitive" solution.

Lévy (1981) has studied the effect of adult questioning on the reasoning of the child. She has shown that the simple questioning of the subject's responses, even if it does not confer any explanatory or correct information, can trigger a re-structuration of his thinking in the sense of greater perfection. However, this questioning loses its effects if, for social reasons, the adult's behavior seems aberrant to the child. It would be interesting to extend this experiment using other conflicting tasks with a number of possible outcomes other than "rational" elaboration. We know that all social interactions are not only likely to produce more rationality. Yet it would be illuminating to be able to specify in what circumstances so-called "logical" reasoning is elaborated. This could be done by varying different types of tasks and scenarios as well as the relational and sociological positions of partners. Finn (1980) has demonstrated that children will give clever answers to silly questions thereby showing that in an experimental scenario subjects construct meaning out of cues that do not pertain to the question itself.

We believe that the experimental studies reported here on thinking, and more specifically on operational thinking, although admitedly limited to occidental children in school situations, have illustrated certain aspects of the dynamic of cognitive activity in this particular cultural environment. It seems evident now that it is not possible to separate the cognitive and social origins of these behaviours. They are interdependant and should be considered within an interactionist approach.

If one now turns to the field of education, one could well ask: what are the possible applications of this understanding of the social and cognitive processes involved in thinking? Under which conditions can didactic intentions be realized in this same context?

III. MATHEMATICS IN DIDACTIC SITUATIONS

In the preceeding part of this paper, we have tried to show how, in every test or learning situation, the subject's responses depend upon his interpretation of other's expectations of him. This is also true for pedagogical situations: learning can only occur if the pupil has understood what he is supposed to do or know. The pupil's attempts to understand the questions posed by the experimenter or teacher can be undertaken in an active and conscious manner: one can observe him trying out his responses, modifying and validating them. But sometimes the interpretation of a situation imposes itself initially without a conscious effort on the part of the subject. This would imply a simple transfert operated by the subject using salliant analogies between the new situation and others previously experienced. This generalization of behaviours can be facilitating at times and at others the source of errors. It is always the subject's representation of the learning situation constructed in the framework of the "intersubjectivity" established between himself and others which is the base upon which dialogue and performances are elaborated (Rommetveit 1976, a,b).

The question which hereby interests us (and seems to be particularly susceptible to open a wide field of specifically pedagogical inquiry) is the following: how could one explicitly create "didactic"[1]) situations constructed in such a way so that, when the child seeks to understand and to respond to what is expected of him, he would already be lead by this very activity to elaborate cognitions which we would want him to acquire?

We have seen that the subject's capacity to actualize a competence is not independant of the social and cultural situation in which he must perform. Although these competences assuredly have a certain generality, it would be idealistic to consider them as abstract from the contexts in which they function. The examination, for instance, of the existence of "décalage" (pertaining to the notional content, the task, the relational context, the circumstances, etc.) permits to illustrate the limits of such an abstraction.

Most of the studies that we have reported until now have been concerned with operatory notions in a Piagetian sense. If we now turn to more complex and more culturally marked notions such as those found in primary school mathematics, we would expect to find that learning is also (and perhaps even more) dependant upon the situations and circumstances in which it is engendered.

> *On a paper-pencil test presented in class, most of the seven-years old pupils tested showed a mastery of mathematical skill previously taught, namely the solving of lacunary equations (for example: 5 + ... = 8). They*

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1) For a study of the meaning of this term as it is used in current pedagogical research in mathematics, see Brun (1981).

seemed accustomed to this kind of task. However, when we asked them outside of the classroom to solve similar additive problems in another context (using bouquets of flowers or trays of candy) almost all the children did not effectuate any transfer of their previously acquired knowledge (Schubauer-Leoni & Perret-Clermont 1980).

In order to construct social situations where pupils are lead to develop mathematical competences generalizable to other important contexts, it is thus necessary to understand the dynamic of thought in its cognitive and social complexity in the particularity of tasks, relationships and circumstances. The simple apprehension of the subject's operatory structures is not sufficient for the inference of his mathematical competences. It is necessary to differenciate the pedagogue's (or mathematician's) interpretation of the task from the interpretation developed by the learner through his attempts to respond (cf. Perret-Clermont, Brun et al. 1981).

a. Mathematics and Operatory Notions

According to Piaget, the operatory structures are foundamental instruments of thought whose origin lies in bio- and psychological processes of regulation. However, mathematics cannot be reduced to a psychological origin given the fact that it is an intellectual and cultural construction with a historical reality. Mathematics has an institutional and social reality well before a given child begins his own development and learning. Mathematics also differs from Piagetian operatory notions because it refers to socially elaborated symbolic systems retained because they have proved to be technically efficient.

Empirical studies of child development have shown that these two objects which are, on the one hand, operatory structures and on the other, the content of mathematical knowledge, are not as directly interdependant as previously imagined (Brun 1974, 1979, Vergnaud 1980, Schubauer-Leoni and Perret-Clermont, 1980).

Didactic study in the field of mathematics would have a too narrow scope if limited to merely observing the child assimilate pre-constructed knowledge which he could not "master" previously. Pure assimilation does not lead to active mastery if it is limited to automatized rules of action and thought. We hope to be able to contribute to the understanding of the pedagogical processes that permit the child to learn as well as to produce new mathematical understanding since no previously learned knowledge is directly applicable to all novel situations, as we have shown earlier. Therefore, we would want to know under which conditions the subject would not only acquire the particular modalities of reasoning or symbolisation taught, but also master the procedure of mathematization itself. This we would call "appropriation" of mathematical knowledge signifying by that: active construction or borrowing of systems of action and representation (and of actions on representation), making them functional, modifying or rejecting them when they do not correspond to the ends of particular tasks and/or situations at hand.

Thus the elaboration of mathematical knowledge is not an activity which can be explained by simple reference to the Piagetian notion of the elaboration of operatory structures. However, such transpositions of notions of genetic psychology to the domain of didactical mathematics have nevertheless been attempted.

Thus we find, in some curricula, the concept of classification for example transformed into an educational objective. From a Piagetian epistemological point of view, mathematical knowledge originates in the coordination of operations of the subject, it was thus thought that the systematic teaching of each Pagetian operation would provide the curriculum content and thereby guaranteeing the acquisition of specific mathematical skills. However, psychological reality is not identical to pedagogical reality (Brun 1974)!

Another aspect of this abusive transposition is found in the translation of certain epistemological definitions in terms of teaching objectives. The most striking example of this translation is found in teaching manuals which speak of the construction of number in reference to the Piagetian definition of number as a synthesis between seriation and class inclusion. The concept of number is thereby transformed into scholastic exercises using seriation and classification as curriculum content.

This positivization of the Piagetian epistemological definition of number alters its original meaning. It limits the child's activities because it ignores his possible experiences with number and quantification under the pretext of constructing "what is" the concept of number (Brun and Schubauer-Leoni 1981).

In such transpositions, the "coordination of operations" which Piaget describes as fundamental but which is (and should remain) the child's initiative is transformed into a curriculum structure whereby its complexity is reduced to banality while the child's experience is neglected. In fact, one finds there an interpretation of learning which reifies the psychogenetic description and reduces the problem of the acquisition of knowledge at school to one dimension: that of the construction of operatory logic. But the individual's development of his operatory structures in itself is not sufficient to ensure the appropriation of cultural knowledge. In order to understand the processes of mathematical learning (and its possible generalization) it is also necessary to be able to describe the particular situation in which the pupil is initiated to this subject: style of teaching, pedagogical methods (curriculum, manuals, particular exercises), type of pupil activity (alone or in interaction with adults and or peers), type of production (verbal or symbolic), etc. If the subject is indeed the originater, in collaboration with others, of his constructed meanings, research should find the means by which to observe his ways of appropriation of targeted knowledge. However, one must not confuse the

content of mathematical knowledge with general instruments of thinking, even if the two are interrelated.

This would suggest a certain prudence in regard to the eventual temptation to generalize the results of experiments on learning of operatory notions by considering them as directly transposable, without verification, to situations of learning mathematical notions in a school context. Thus, didactical experiments concerning the pupil's appropriation of mathematics cannot be directly derived from studies of the conditions of development of operatory structures. They would instead require specific experimentation examining the content of specific knowledge in different conditions.

> *This means that we cannot simply generalize the effects identified in our earlier researches (e.g. socio-cognitive processes at work in operatory tests), assuming an identical functioning in mathematical tasks. The content of learning changes the paradigm.*
> *For example, in our experiments on the formulation of additive operations by second graders, we observed that in message editing tasks in dyads the modalities of social interaction used in our other experiments contributed to an amelioration of performances (in the sense of the production of more explicit messages) only if they were formulated by two partners who were confronted by a targeted "decoder" who would not always understand (Schubauer-Leoni & Perret-Clermont, 1980).*

This concentration on notional contents does not necessarily lead us to a purely mathematical perspective which would confuse the provisional or partial knowledge appropriated by the child with that of mathematicians (Perret-Clermont, Brun, Schubauer-Leoni, Conne 1981). Nor would it simply submit the teaching of mathematics to the structuration of the mathematical discipline (such as it is presented in scientific articles, for example). The notional contents acquired by the pupil are the products of an interaction between the subject and the school context.

The complexity of mathematical notions implies that their appropriation by the pupil is progressive. In order to make a given notion accessible to the child and to elicit his activity, the teacher makes a new contextualisation of this knowledge different from the context of the mathematician. It is not sufficient to define "learning" as a simple succession or accumulation of activities. In fact, when the pupil undertakes a real mathematical task, he engages in a ensemble of activities: elaboration, validation and refutation of models of action, representation or thought.

> *We have often observed (Schubauer-Leoni et al., in preparation) that although pupils have learned in class the numbers and operatory signs of conventional mathematical formalism, they rarely spontaneously use them in a context of formulation of messages concerning additive activities*

outside of class (whose use would have seemed functional in this context to the adult researcher or teacher!). However, when such formulations are demanded of these pupils in an in-class collective situation their recourse to formalism becomes much more frequent.

In these same studies, we failed to observe any direct relation between the acquisition of operatory notions and the capacity to explicitly formulate mathematical compositions or to complete lacunary equations (a common school task for the 2nd graders who were our subjects). Although we have observed certain parallel evolutions of mathematical behaviours, we are as of yet unable to say if they stem from an interdependent construction (i.e. one competence depending upon the other) or if they are the result of a partial resemblance between the characteristics of these test situations which the subjects interpret differently according to the circumstance.

A notion which is considered as "elementary" in its presentation is often falsely so, as the notional field to which it refers is always more vast than first imagined (as witnessed elsewhere by pupils' learning "errors"). Moreover, the complexity of notions (on a mathematical level) and the multiplicity of possible responses (especially concerning the modalities of formulation) renders the hierarchisation of subjects' behaviours quite difficult.

One can certainly measure the degree of explicitation in pupils' productions elicited by activities of formulation: but how is one to evaluate and analyse this? The child is often explicit but this explicitness usually concerns "details" which the adult thinks the mathematical activity should be abstracted from. Thus, for example, we have observed that subjects often indicated "details" such as the color of the objects or the author of a particular action while it was the quantities in question that were deemed important by us as experimenters. In what conditions can the instructions given by the adult become explicit in their intentions and non-equivocal for the child?

Brun and Schubauer-Leoni (1981) have presented evidence showing different levels (absence, incomplete or complete presence) of composition of mathematical operations in productions of subjects. However, it does not seem possible (without refering to a cultural norm) to hierarchize the different forms which subjects use to reach their solution to a problem such as drawing, written language, mathematical formalism. Preliminary data from our studies make us think that it would only be under certain conditions of social interaction that the subject's recourse to habitual mathematical formalism would

systematically correlate with an increase in complete mathematical compositions.

The study of processes of transmission of knowledge leads us to look for the means not only to observe the subject's own mental operations but also to simultaneously discern the effect of different modalities of social and symbolic interaction on his thinking. In order to move from the study of the cognitive construction of the "universal epistemic subject" to that of the acquisition of historically and culturally marked knowledge, one is obliged to specify the relation of the personal activity of the learner (assimilation, restructuration, interiorisation) to the learning context. One is hereby lead to consider the problem of the study of the appropriation of knowledge as being, on the one hand, one of identification of the pupil's provisional models that function in given tasks (Vergnaud, 1977) and on the other, one of the process of the transformation of these models, as affected by material, cognitive and social characteristics of the proposed didactical activities (Brousseau 1978).

It is this type of transformation, for example, that Balacheff (1981) has studied by observing the evolution of attempts by secondary school pupils to administrate proofs during interactions of small groups.

Thus, one must study knowledge "at work". It coincides with the present preoccupations of genetic psychology to account for the functioning of thinking (see, for example: Inhelder et al. 1976, Saada-Robert, 1979). But the relations with the social and cultural context in which the function takes place remains to be specified.

b. Didactic situations and scholastic tasks

We have mentioned why it would be reductionist to assimilate mathematical learning to operatory development. We are now going to consider the risks of confounding the didactic "situation" with the "task".

We have already encountered this question relative to operatory tasks and the diverse interpretations formulated by subjects. We have noted that analyses of these tasks often concentrate on their formal characteristics (logical complexity for instance) to the detriment of the consideration of their relational and cultural dimensions.

Haroche & Pêcheux (1972) have described restrictions imposed by the current conception of "tasks": "In so far as cognitive structures appear to remain invariant across a multiplicity of situations, one thereby imagines that what one calls the "task" in experiments on the resolution of problems is precisely and exclusively

> *defined by the nature of the formal invariant ... Likewise, "the content of the task necessarily appears to be exterior to the formal invariant which constitutes the definition of the task. In other words, it intervenes as inessential situational modalities, as residues of cognitive filtering of the object".*

A didactic situation can be characterized as an encounter in a particular school setting between a learner and a teacher who carries a message or intention in regard to him. This specific modality of social interaction with its cognitive, social and material characteristics is in turn inscribed in a larger institutional context - i.e. the school - by which, as sociologists describe it, society constructs, reproduces and transforms itself. However, the subject's activity in the situation is not necessarily the direct reflection of its properties.

> *Thus, one can observe many examples in classroom situations where one can clearly see that a strategy which is adequate to the resolution of the problem is not used by the pupil despite the fact that it was given to him in the context of the situation and whose pertinence in relation to the task was emphasized by the teacher in class. Neither is it used by pupils who will later rediscover this same strategy without realizing that it is identical to the one given to them earlier.*

It is thereby interesting to understand the constructive exchange which takes place between the models adopted by the subject and the constraints of the situation. The didactician can arrange these constraints to his liking in order to render them explicit. His understanding of the representations actively formulated by the subject can guide him by making him sensitive to repercussions of his interventions. Mathematical knowledge thus appropriated by the pupil will have meaning for him if it consists of notions which he can identify and manipulate in the context in which they function. As Brousseau (1978) remarked: "We will admit that the constitution of meaning, such as we understand it, implies a constant interaction between the pupil and the problematic situations. This interaction is dialectic (because the subject anticipates and finalizes his actions) when he uses his prior knowledge by revising, modifying completing or even rejecting it in order to form new conceptions". The question is now "to study the conditions that would fulfill the situations or problems proposed to the pupil" in order to "favorize the appearance, functioning and the rejection of these concepts" (p. 109).

The didactic situations presented to pupils are culturally marked and invested with a significance which depends on the social experience of the individual. As mathematics is socially marked, subjects's behaviours in this field of cognitive activities likewise depend upon their own socio-cultural experiences and personal history with this particular subject. For example, our experiments dealing with activities of arithmetic composition and formulation have repeatedly reported differences between boys and girls, and sometimes between social groups. But we are not yet able to account for these differences.

Mathematics is the object of a particularly powerful social marking, especially in scholastic contexts. It holds an important place in educaton as indicated by the diversity and the duration of instruction. In addition, it often plays a primary role in the processes of scholastic selection. The subject of mathematics presently polarizes the attention and expectations of parents. It preoccupies teachers and school administrators who are engaged in the vast reforms of "modern math". All this concern has evident consequences for pupils (Degouy and Postic, 1981).

The question remains as to the exact circumstances in which pupils perceive a problem as "mathematical" or "mathematisable".

> *Concerning this subject, we have attempted to examine how individuals react when they have to solve a problem which they do or do not identify as mathematical. With Cavicchi-Broquet and Florimond (1981) it was observed that adolescents offer quite different responses (differing in their "correctness" from an arithmetical point of view) varying in function of whether the question seems to demand a calculation or, on the contrary, is open to other types of resolutions. Thus, arithmetic calculation was at times neglected by the subjects, to be replaced by a search for the social issue of the problem.*

IV. CONCLUSION

We have tried to show firstly that social interactions and their cultural contexts play an essential role in the elaboration of thinking and, secondly, that the subject himself is actively implicated in the acquisition of his instruments of comprehension. The child's activity is at the origin of his cognitive possibilites, however this activity is in constant interplay with the activity of others. The individual is, as it were, the "co-author" of the development of his intelligence. In his construction or appropriation of knowledge his partners are the persons (adults or children) with whom he interacts. He also inherits pre-constructed systems of meaning (symbolic systems, structured by social norms, elements of established or informal knowledge, etc.) which he must appropriate (i.e. reconstruct) in order to be able to use them.

From the studies examined here, it is evident that the learner cannot be considered as a simple receiver of the knowledge that one seeks to transmit to him. He appears to be actively engaged in an activity which is neither a total creation nor a simple assimilation but an appropriation of knowledge in a dynamic which can be described in terms of construction and interaction. This knowledge is either the result of a cultural production historically antecedent to the psychological development of the individual in question, or the hic et nunc fruit of an on-going collective elaboration in which he takes part.

We think it important to go beyound the simple observation of signs of a competence (operatory, for example) to re-situate them in the context of their elaboration in order to understand their dynamics.

When these signs are considered in abstracto (i.e. abstracted from the situational conditions in which they appear) they can only be interpreted as fundamental characteristics of the individual.

In fact they are the fruit of a social, psychological and cultural dynamic. The individual manifestation of competences (operatory levels, strategies of problem resolution, reasoning) can be understood as active responses of an individual who, with others, interprets the demands of the situation, attributes meaning to his behaviour[1] in function of his personal history and the specific circumstances in which he finds himself. It is certain that the individual is not always actively involved in generating meaning. However, we have deliberately eliminated from our study the consideration of activities (and their explanatory theoretical models) which transform the learner into a passive recipient of intentional external determinations (imposition of meanings, training, cramming, etc.[2]). For us, these determinations would only have meaning as an object of study in so far as the individual acknowledges the existence of these constraints on him. One can easily see that this already transforms the

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1) Not always consciously of course.

2) Or their scientific euphemization: drill, conditioning, modeling, etc. when speaking of educative intentions.

nature of the question by placing it in a domain which extends beyond the present exposé.

> *This question could nevertheless be taken up in later studies by examining, for example, in which circumstances the individual elaborates his cognitive faculties within constraints determined by an outside authority. Deconchy has identified the social function of orthodox thinking in religious groups. It could be interesting to likewise trace the social functioning of thinking as it becomes orthodox in school settings, i.e. "scholastic".*

The reader who has recognized our attempt to integrate various theoretical reflexions of widely different origins (Mead, Piaget, Vygotsky, to name but a few) will have probably judged our intentions over-ambitious, as they surely are!

In fact, our theoretical propositions in this exposé are admittedly disjointed and incomplete and are but tentative responses to "grand" epistemological and psycho-sociological questions ... But our preoccupation being the pertinence of these studies for pedagogical practice, we do not seek a "total" explanation. Reality is always more complex than experimental schemas. We see our experiments rather as means of analyzing our own representations of learning processes in order to test them (i.e., to elaborate, validate or refute them according to the particularity of the context studied). In some ways, our research process is analogous to the processes we have observed during subjects' activity of learning.

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