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THE SOCIAL CONSTRUCTION OF MEANING AND COGNITIVE ACTIVITY IN ELEMENTARY SCHOOL CHILDREN

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INTRODUCTION

The work of G. H. Mead (1934) considers the development of the mind as a process resulting in an interiorization of conversations in which symbols gradually replace elementary gestures and emotions. Vygotsky (1962) viewed the individual's acquisition of cognitive operations as the result of social transactions that allow the transmission of symbolic tools that are interiorized by the mediation of language through their use in joint actions. These two approaches have had an important theoretical impact in psychology. However, until the 1970s, there had been no systematic empirical investigation of how experimentally induced variations in the social environment affect observable cognitive processes. Empirical investigations of cognitive development within the Piagetian theoretical framework were numerous, but researchers had paid no real attention to causal links between individual and social factors because they made no distinction between *social* and

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cognitive factors, both concepts being reduced to logical operations regardless of meaning. Indeed, Piaget jeopardized reflection on this problem when he postulated that socially coordinated and decentrated actions (interpersonal cooperation) and mental operations (concrete operations) were "two faces of the same reality." These two types of processes were then confounded and identified with an elementary logical functioning because both processes seemed to imply reciprocity and reversibility. This confounding is illustrated by Piaget's research on the development of moral judgment (1965) and intelligence (1950), and in many of his other works.

Because we were interested in the specificity of cognitive and social processes that allow the transmission, creation, and acquisition of knowledge in institutional settings[1] with cultural aims, such as schools, we could not content ourselves with psychological descriptions of individual cognitive processes and interiorizations. We needed explicit accounts of the impact of various social features of the human environment on the individual's development, as well as an understanding of how the individual can actively operate on the social and physical features of his or her environment and gain knowledge from these experiences. This focus led us to undertake a series of experimental investigations that we will present here as our first generation of studies. In these studies, we were primarily concerned with how social factors affect cognitive performances and how individuals actively use social resources to solve given problems. Cognitive activity does not display itself in a social vacuum, and we wanted to identify how social circumstances induce subjects to reconsider their answers or strategies and how, in turn, this fact affects the development of their personal cognitive resources.

But in undertaking these studies, we were confronted by observations that made us doubt the validity of our theoretical premises. We became aware that understanding cognitive development is, at least to some extent, a metacognitive endeavor. The psychologist's a priori theories of what is cognitive, what is social, and what makes up development determine the focus of his or her observations and methods of data collection (not to mention the ways in which he or she, as a psychologist, learns from research, experience, and partners!). Hutchins (chapter

[1]Classical Western psychology has tended to consider educational problems as belonging to the domain of applied research. There has been a strong belief that a better understanding of fundamental psychological mechanisms and the processes of child development per se would promote better teaching, as if the modalities of adequate teaching could be deduced from this body of psychological knowledge. We see this matter differently. First, the child's psychological functioning reveals itself within social relationships (e.g., with teachers and psychologists) that elicit certain types of behaviors, and these behaviors cannot be understood independently of the context in which they emerge. Second, identifying the cognitive and social processes that permit the transmission and learning of knowledge in culturally defined settings is a fundamental endeavor that raises vital questions concerning the nature of knowledge and culture. In particular, it is important to understand to what extent so-called cognitive development is dependent on the acquisition of sociocognitive knowledge in specific contexts.

13 in this volume) suggests that it is essential in cognitive sciences to consider the attributional problem. Reflecting on our own research, we were struck by the large gap between our understanding of what was occurring and our subjects' understanding of the same phenomena. Was this just a question of ignorance on the part of our subjects, considered "naive laymen" ignorant of the psychology of cognition, or did our own understanding ignore what was at stake in learning and experimental transactions? To answer this question, we studied our subjects' metacognitive reflections and discovered that their cognitive activity was often not so much a struggle with the logical and symbolic features of the task (as we had hypothesized in the first generation studies), but an effort to give meaning to the persons and tasks with which they were interacting and to make sense of the processes (notably conversational) that they were undergoing.

This led us to our second generation research, which was primarily concerned with a close examination of the specific features of social interactions themselves, not as causal factors eliciting cognitive transformations within the subject, but as the vehicle mediating the transmission of meaning from the person who defines the problem and demands cognitive performances to the person (subject) who tries (or does not try) to comply with these demands. Our data from these second generation studies report recurrent misunderstandings between these two interlocutors (whatever their training or cognitive level). Our work points to the limits (or even the impossibility) of a content-blind or context-free psychology and indicates new directions for the study of the teaching–learning process, taking into account not only the objective characteristics of the social and physical environment in which subjects develop their cognitive resources but also the meaning that subjects attribute (and learn to attribute) to these objective[2] environmental characteristics.

We start this chapter by discussing our first generation studies concerned with the preconditions and consequences of social interactions on the individual's cognitive behavior. This is done in two ways: One is the experimental variation of social factors and the measurement of their subsequent impact on the operatory level of the subjects; the other is the examination of the subject's use of social resources to solve cognitive problems, particularly in the case of ambiguous information. We then discuss the limits of these studies, particularly their underestimation of the subject's endeavor to make sense of the social situation before solving—or even perceiving—the logical problem presented by the experimenter. This will introduce the second generation studies, in which the unit of analysis is no longer the individual's cognitive behavior but the social interaction itself. Social factors are no longer considered external independent variables affecting

[2]It is important to question whether these characteristics are truly objective. For the sake of research, at least in this contribution, we consider the experimenter's point of view as being objective cognition

the cognitive responses, but appear to be intrinsic parts of the process by which persons create meaning: The interpersonal coordination of actions and symbols create the task and the problems; the endeavor of finding solutions for these problems is not only a logical affair, but such identities, status, and role definitions are also at stake. We then illustrate this with data collected both in testing situations and in school situations.

SOCIAL FACTORS AND COGNITION: THE FIRST GENERATION STUDIES

The Social Construction of Operatory Structures

An interactionist and constructivist model of development

Our first set of studies, initiated with W. Doise and G. Mugny, aimed to observe the impact of social interaction on the individual's cognitive development and used Piagetian tasks of conservation of quantities (liquid, number, and length) and representation of spatial relations (Doise & Mugny, 1984; Doise, Mugny, & Perret-Clermont, 1975; Perret-Clermont, 1980; Perret-Clermont & Mugny, 1985; Perret-Clermont & Nicolet, 1988; Perret-Clermont & Schubauer-Leoni, 1981). The basic paradigm of these studies consisted of a pretest to evaluate subjects' operatory level followed by an experimental session (usually a week later) in which subjects underwent different experimental treatments (e.g., solving the task alone or with peers, observing an adult model, or being confronted by a contradictory judgment given by an adult or another child). A week later, a posttest (similar to the pretest but with additional items to test generalization) assessed progress made by the subject. We briefly review the results of this line of research and then list some of the questions these data raise.

Studies using this paradigm have repeatedly confirmed that, under certain conditions, children who were initially nonconservers on a Piagetian conservation task are likely to progress in the structurization of this operatory notion if an adequate experimental session gives them the opportunity to interact with peers concerning this notion. Such progress does not occur for control group subjects who have had no peer interaction.

Systematic variation in the composition of the experimental peer group has demonstrated that the number of participants involved (two or three) does not directly determine cognitive progress and that this progress cannot be explained in terms of compliance to a majority position. In fact, compliance alone cannot explain the results. A detailed examination of the content of peer-group discussions during the experimental session and of subjects' argumentation in the posttest reveals that the latter is not a mere imitation of the former. Those subjects who progress to the stage of conservation manage, in the posttest, to defend their newly

acquired cognition with "new" arguments (i.e., different from those heard from their partners during the experimental session). Likewise, the small but consistent generalizations to other conservation tasks observed during the posttest cannot be explained simply in terms of imitation of partners or compliance to their point of view. The responses that these experimental subjects have developed are hence cognitively superior to their previous ones. The subjects have become capable of a larger integration of viewpoints. They are not merely repeating a rigid response or imitating a peer; they are producing new reasoning that they can defend with arguments. Hence, the learning that occurs in these experiments is not of a restricted nature based on an associative or stimulus/response model but involves a complete restructuring of the subjects' modes of thinking, allowing them to perform at a previously unattained concrete operatory level.

What can account for this significant change in the child's own logic? According to Piaget, a change of developmental stage occurs as a result of a combination of four factors (maturation, physical and logico-mathematical experience, social experience, and equilibration) and is purportedly a relatively slow process. In the research we have discussed, subjects were observed to progress from one operatory stage to another over a very brief period of time (from 5 to 10 minutes). The lack of progress of control group subjects rules out mere maturation or personal familiarization with the physical and logico-mathematical aspects of the task as explanations of these results. If the observed progress was due to an equilibration process, what could cause the disequilibrium that engenders the observable restructuring of subjects' mode of thinking?

In the various studies, different experimental conditions were created involving different types of social interactions: confrontation with a peer of the same cognitive level or a more advanced or a less advanced level (Perret-Clermont, 1980); or confrontation with a correct or an incorrect adult model (Doise & Mugny, 1984; Lévy, 1981; Perret-Clermont & Schubauer-Leoni, 1981). These experiments show that it is not necessary to present the child with the correct solution during the experimental session. Even if the subject's partner or model does not reason at the concrete operatory level, the experimental session of social interaction can still be an opportunity for the subject to progress to this level on the subsequent posttest. But for this to happen, the subject must confront his or her own incorrect response with a different (although not necessarily correct) point of view. This means, for example, that a confrontation with another nonconserver can be a source of progress for the nonconserving child, provided that the partner's incorrect response is different from his or her own. This holds true even if the partner is an adult, but only if the partner provides plausible responses and not seemingly meaningless behaviors (Lévy, 1981). Confrontation with an incorrect response can be a source of progress, but the mere observation of an adult model has a lesser impact than does social confrontation with a peer. Hence, it seems that it is the sociocognitive conflict provoked by the confrontation of at least two di-

vergent responses that is the origin of the restructuring of the subject's thought. This is true even if the two divergent answers are equally wrong. This conflict is sociocognitive, not just cognitive, because the presence of another person obliges the subject to take into account the existence of a cognitive response different from his or her own. It is sociocognitive, not just social, in the sense that the confrontation's aim is not negotiating the participants' identities, their motivations, or any other affective or emotional aspect of the interaction, but only the understanding of the conceptual matters involved in the task.

Within the Piagetian theoretical framework, Inhelder, Sinclair, and Bovet (1974), as well as other authors, have stated that the source of progress lies in the cognitive conflict generated by the negative feedback to the child's response. Our research indicates that this feedback is always socially mediated. When confronted by negative feedback (i.e., a viewpoint different from his or her own), the child is faced with an objection to his or her mode of thinking. This objection can be presented directly to the child or through an experimental device designed for such a purpose. Our hypothesis is that the more direct the conflict that takes place in the social interaction, the more likely the interaction will trigger a cognitive restructuring.

But sociocognitive conflicts do not always result in developmental progress. At least two conditions must be fulfilled for progress to occur. One is that the subjects must have the necessary cognitive prerequisites to benefit from a given social interaction session. For example, for the conservation of number, only those nonconservers who can enumerate the tokens (count the number of tokens in the line) or who can place two sets of objects in one-to-one correspondence are likely to progress to the operatory stage after being confronted by a peer with an opposing viewpoint. Secondly, social confrontation is fruitful only if the gap between the partners' cognitive skills is not too wide (Doise & Mugny, 1984). That is, certain cognitive skills are needed for the child to benefit from the sociocognitive confrontation, which, in turn, strengthens his or her competencies.

These results can be integrated in an interactionist and constructivist model of cognitive development in which social and cognitive factors engender one another in a sequential order that reveals the progressive development of mental structures. New mental organizations make the subject capable of engaging in new social interactions, which, in turn, foster new mental organizations.

In formulating this integrative model of how cognitive and social processes interact to produce cognitive growth, a model that accounts for much of the results of the first generation studies, we are still left with a series of observations that cannot be explained by this model of development. We will now briefly present some results whose interpretation questions certain premises of this first model, notably the strong distinction we originally made between what is social and what is cognitive, and the idea of what is the content of development. We will see that cognition is not as autonomous a function as postulated initially but is the result

of the individual's dependency on the communication constraints of the settings in which the individual grows and the patterns of intersubjectivity that the individual's partners invite him or her to establish (see Hutchins' chapter in this volume for a related analysis in adulthood).

Some facts remain unexplained

One unexplained fact that has been repeatedly observed is sex and social class differences in pretest performances that sometimes disappear by the posttest under certain types of experimental conditions (Nicolet, Grossen, & Perret-Clermont, 1988; Perret-Clermont, 1980; Perret-Clermont & Mugny, 1985; Perret-Clermont & Schubauer-Leoni, 1981). It seems that, given the opportunity to interact in certain social settings, lower-class subjects are likely to catch up (after a 10-minute experimental session) with their middle- and upper-class peers and eliminate the "developmental lag" (or "sociocultural handicap") indicated in their pretest performance. This result is not predicted by Piagetian theory, because Piaget's model sees development following a slow, integrative process in which maturation has an important role. It also casts doubt on the adequacy of such global concepts as developmental lag and sociocultural handicap to account for differences in cognitive developmental levels when these so-called handicaps can be eradicated by a brief confrontation with a peer. What is it, then, that actually changes in the subject's cognitive level? Is it his or her cognitive level of competence (i.e., operatory stage) or his or her understanding of the type of thinking that is expected to be displayed in this context?

A second unexplained observation is Lévy's (1981) finding that cognitive progress subsequent to certain social interactions occurs most often when the subject has been associated with the same adult experimenter for the three phases (pretest, experimental session, and posttest) of the research. The integrative model predicts the importance of confronting a point of view that is cognitively divergent but does not account for this role of the personal relationship with the experimenter.

A third unexplained observation, made by Doise, Dionnet, and Mugny (1978), as well as Donaldson (1978) and other researchers, is that the subject's performance level for a given operatory task can vary according to task or type of instruction given. (For a review of this debate in relation to Piagetian theory, see Light & Perret-Clermont, 1989.) To what extent do these tests assess the subject's operatory level? Or do they actually test a subject's communicative competence? Does the subject engage in individual reflection before answering the experimenter's questions, or does he or she rely on cues implicit in the adult discourse? Perhaps the child's cognitive performance is the result of interpretation of not only the cognitive dimensions of the task but its social meaning as well (see Goodnow's, 1990a, report on the role of the audience). We will address these questions in the discussion of our second generation studies. But let us first consider another approach to the interdependence of cognitive and social behaviors.

The Subject's Use of Social Resources for Cognitive Tasks

Autonomous cognitive activity or compliance?

In another series of first generation studies, Perret's (1977, 1978) explorations of subjects' social behavior on cognitive tasks pose similar questions about the identification of cognitive tasks and relevant behavior to accomplish them. Some tasks are of such a nature that the knowledge and skills required to perform them correctly go beyond individual reflection and activity with objects. This is most evident in the resolution of tasks using conventional or technological information. Many signs, rules, and notations rely on social consensus and cannot be invented or discovered by the individual alone. Like social norms and habits, they are made accessible to the individual by social transmission. Although the development of subjects' understanding of such a task or problem can be a function of their own intellectual competencies, they cannot acquire the cognitive resources needed to solve the problem without drawing on the knowledge of other people. Likewise, the child is active not only in exploring the physical environment and the consequences of his or her actions on it, but also in questioning the social environment and obtaining information from others (Berlyne, 1962; Bruner & Olson, 1973). Questioning can be a very adaptive behavior under certain circumstances and sometimes is the only means of finding a solution to a given task. But when is a subject who undertakes a complex task likely to use social resources to obtain the information needed?

The study of questioning behavior is particularly complex; many factors and processes explain why subjects do or do not ask for needed information. In her review of research on help-seeking behavior, Nelson-Le Gall (1985) argues for a reconceptualization of help seeking to consider primarily the adaptive and instrumental function of this behavior, which is seen as an achievement behavior. In this perspective Nelson-Le Gall (1985, Nelson-Le Gall & Jones, 1990) pays more attention to the learning and cognitive processes involved than to the social meaning of help seeking. She also shows that an approach focused on personal and sociocultural characteristics is not sufficient to account for the observed variability of this behavior.

Inspired by Robinson and Rackstraw's studies (1975) on pupils' questions and answers, Perret's overall goal was to study the interdependence of cognitive and social factors, looking specifically at the connections among the child's cognitive apprehension of a task, perception of the situation, expected social role, and social behavior.

Perret's observational studies of 8- to 11-year-old children's resolution of technical tasks (e.g., geometrical drawing or construction of a mobile or electrical circuit) were aimed at eliciting verbalization during task resolution to explore the connection between the subject's mode of problem solving and his or her questions.

When presenting the task to the subject, the experimenter always insisted on remaining available to the subject in case the child had questions, difficulties, or lack of information, hoping that the child would establish a dialogue concerning his or her resolution of the task. Results showed that the majority of subjects had difficulty establishing such dialogue during their task resolution and asked very few questions. To elicit subjects' questioning, the experimenter was obliged to repeat the instructions several times. This device worked for a few subjects, who increased their questions almost for the sake of asking questions and not as an aid to their problem solving.

Subjects' questions could be regrouped into two general categories according to the function of the given question. About half of the questions posed corresponded to the experimenter's expectations and were aimed at a better understanding of the task (e.g., concerning properties of the material, details about information given or terms used, or characteristics of the actions required). The other half were aimed at obtaining the experimenter's approval of the subjects' behavior, with children checking to see if their productions were accepted. Such children asked questions in search of feedback, wanting to be told what to do. By asking these questions, subjects test the adult's behavioral expectations and check their conformity to (supposed) social norms of adequacy. Contrary to what might be expected, these observations indicate that children's remarks and questions embedded in the adult–child dialogue do not reveal their autonomous cognitive activity but rather their attempts to comply with the sociocognitive demands of the adult as mediated by the given task.

In some tasks, Perret manipulated the information necessary for task resolution. For example, 6- to 10-year-old subjects were asked to make drawings from incomplete instructions or to build constructions from ambiguous schemas. Perret wanted to determine whether subjects would be aware of the incompleteness or ambiguity of the task instructions and, if so, whether they would ask the necessary questions. Results showed that subjects' behaviors varied with age. The youngest subjects did not notice the deficiency of the task instructions. They solved the task on their own without checking their solution against possible alternative solutions. Their questions did not refer to the ambiguity of the instructions. Robinson and Robinson (1976) observed that young children, in the case of communication difficulties, tended to blame the listener more often than the speaker and never analyzed the message itself. Perret's results could be interpreted as demonstrating the same tendency: Instead of focusing their attention on the task instructions, children tended to take responsibility for resolving the task as best they could without profiting from adult help or other social features that could facilitate their efforts.

Although the older subjects were aware of the ambiguities inherent in the task instructions, many of them tried to solve the task by themselves without asking for help. They used various cues to infer the missing information and

reduce their uncertainty (without, however, checking to see if their inferences were correct). Other subjects did attempt to seek help from the experimenter, but fewer than half the questions these subjects asked concerned the information missing from the instructions. Instead, subjects were concerned with asking the adult about the "right" or "appropriate" thing to do. This "rightness" seemed to be more related to social approval than to the internal logic of the task.

More open questions

These observations show that research paradigms built on supposedly clear distinctions between what is social and what is cognitive will have an inherent weakness, because the causality of social and cognitive processes is, at the very least, circular and is perhaps even more complex (for a parallel discussion of the social nature of metacognitive processes, see Bell, 1985). The aim of the studies reported above was to identify the cognitive processes that permit the social activity of questioning. But these so-called cognitive processes do not apply only to understanding the task and the nature of the cognitive difficulties it presents (e.g., the need for supplementary information). They also include the simultaneous understanding of the social relationship established by the experimenter when presenting himself or herself and the task to the subject. The results of these studies have shown that the adult's signaling to the child that questions were welcome (and even desired) was not sufficient to trigger cognitive questioning. This observation leads us to wonder how the child interprets his or her role as subject in this situation. What does "solving the task" mean to the child? Does the child believe that displaying autonomous problem-solving behavior (even if the outcome is incorrect) is preferable to verbalizing and questioning the adult? Under what sociocognitive conditions do children feel they can legitimately draw on other people's knowledge as a resource for their own understanding?

Reflecting on these questions, we wondered about the school experience of these children. Does schooling cultivate (and if so, how?) the idea that the adult's presence is a resource that the pupil can use when faced with difficulty involving a complex task? How does instruction in schools promote (or discourage) children's reflexive and metacognitive capacities, their understanding of how to deal with ignorance, and their capacity to question others as well as themselves? And how do children think (and display their thinking) about specific objects, events, and notions and not only (or is it only?) about a supposed set of expectations in the adult's mind? This idea again raises the question of the content of development, which was our central concern in the second generation studies.

THE SOCIAL CONSTRUCTION OF MEANING: THE SECOND GENERATION STUDIES

The studies we have presented so far were based on (a) the premise that cognitive development is associated with information seeking and the growth of logical

competencies (and, in particular, of operatory structures) and (b) research paradigms that assume a disassociation of social and cognitive factors in order to study how these factors impact on individual behavior. Results have shown the significant impact of social factors on cognitive behavior and call for a detailed examination of the exact processes whereby social interactions affect children's understanding. Yet this interactionist and constructivist perspective cannot entirely account for a series of observations showing that the modalities of the social interaction, as well as the nature of the developing competencies, seem to depend on the meaning that the social interaction conveys about the context and content of the task. Operatory structures, in particular, do not seem to develop in a social vacuum independently of the content of the problems through which they are activated. Hence, we must study these social interactive contexts and take seriously the matters dealt with in discourse.

This concern led us to conduct a second generation of studies in which the "unit of analysis" (Wertsch & Sammarco, 1985) shifted. Up to this point, the child's cognitive responses had been the object of our focus and had been seen as related to social factors considered as independent variables. The unit of analysis had been the individual's behavior. But another possible unit of analysis is one that focuses not on the individual and his or her specific behaviors but on the social interaction itself. Instead of examining the preconditions and consequences of social interactions, we decided to observe the modalities of these encounters. How is the relationship constructed? How is the task mutually constructed? How do the interlocutors manage (or fail) to establish a common object of discourse? Who regulates the dialogue, and is this regulation social or cognitive?

We will see that the circular causality between social and cognitive factors that has been described is even more complex. Indeed, the cognitive activity of the subject applies not only to his or her understanding of the logical features of the task but also to the task's meaning within its context and to the understanding of the social relationships that partners (experimenter or peers) establish around this task. We will see that the perceived meaning of the social interactions, the reasons for their occurrence, and the context in which they occur will affect the way the subject considers the task, deals with it, and reflects and communicates about it. Our studies focused on two different contexts: the setting of diagnostic psychological tests and the context of teaching, learning, and assessment at school.

Operatory Structures and Context in Testing Situations

Experimental social history and prior experience

As mentioned earlier, when social factors are considered as independent variables, researchers observe regularities that are difficult to explain, among them the repeatedly found correlations between the sociological characteristics of subjects (e.g., sex, social class, urban or rural environment) and their operatory level.

Before developing hypotheses on the possible mediators of these effects, it is important to make two epistemological points: (a) that correlations are not necessarily signs of causal relations; and (b) that, because differences always seem to favor urban upper- and middle-class subjects, an ethnocentric bias on the part of psychologists cannot be excluded. A critical question regarding these repeatedly observed sociological differences, then, is how this bias operates. This question calls for an integration of sociological and psychological accounts of cognitive development (Goodnow, 1990b).

To explore this question, we have started to consider systematically the social groups to which subjects belong. It appears that certain experimental conditions have a greater impact on subjects' task performance than do others only for certain social groups (Perret-Clermont & Schubauer-Leoni, 1981). For instance, in this research sample, the performances of lower-class girls differ from the rest of the population. They do better on the conservation of liquids test if it is presented to them in the classical manner as a comparison between the experimenter's glass and their own, but their performances drop when the task is staged so that the juice is to be divided between two identical dolls. This task staging has no effect for boys and middle-class children.

In another study, concerned with social marking, Nicolet noted that children from rural areas (especially farmers' children) perform better on the conservation of liquid test after playing a cooperative rather than a competitive game with a partner, and when a rule of equity of distribution of reward is applied to sharing the juice between partners. But this emphasis on equity has no effect for their urban contemporaries (Nicolet, Grossen, & Perret-Clermont, 1988). These results mean that the reported effects of task presentation and experimental instructions (Donaldson, 1978; Light & Perret-Clermont, 1989) on subjects' performance are likely to vary as a function of sociological parameters. They are also dependent on previous experimental procedures experienced by the subjects. For instance, we observed in the above mentioned study that those lower-class girls who performed poorly in the dolls condition did better after interacting with a peer during the experimental session. This was not the case for lower-class girls who observed an adult model during the experimental session. Likewise, in this experiment, group differences occurred as a function of the type of glass used in the conservation of liquid task, with girls performing better when they were given the wider glass than when they were given the thinner glass, perhaps because the latter gives nonconservers the illusion that they have received more juice (see also Rijsman, 1988).

How can we account for such varied results? We suggest that subjects derive meaning from the *experimental social history* that they have undergone (prior experiences and interpersonal relationships within the test and social interaction situations). In other words, there is no "dolls" or "glass" effect as such, but rather a complex interaction between the sociocognitive components of the ex-

perimental episode and the characteristics of the staging of the operatory notion that is presented to subjects by the task.

Establishing a common object of discourse and reflection

Results on the impact of the task presentation led us to initiate a series of studies focusing on children's perception of the testing situation itself to understand better what elements play a role in the elaboration of children's responses and what social knowledge is required to interpret adults' discourse and, hence, succeed at the task. Testing episodes were videotaped, and observations of the social interaction between tester and subject during the pretest revealed all sorts of cues by which an intersubjectivity is established between the two partners that will permit the subject to abstract, more or less successfully, the adult's object of discourse (Bell, Grossen, & Perret-Clermont, 1985; Grossen & Bell, 1988; Perret-Clermont & Brossard, 1985).

A basic observation corroborated by several of our studies is that the adult and the child do not always share the same perception of the situation. For instance, Grossen (1988) has observed numerous misunderstandings between tester and subject at the beginning of the conservation of liquids test when the subject is asked to equalize the contents of the two identical glasses. Some children spend a lot of time on this preliminary equalization, as if they understood this first demand as the major activity of the interview and not just a step in the establishment of the premise of equality necessary for the rest of the task. Nonconservers are more likely than others to misinterpret this first demand.

During the pretest, certain nonconservers suddenly become capable of giving conserving responses and correct justifications after the experimenter's conserving countersuggestion. That might be because the presentation of a different answer makes the subject aware of the nature of the question and cues him to the adult's expectations. If so, the child's response is not necessarily a reflection of any cognitive progress made during the testing interview, but rather a matter of understanding what the adult wants to talk about. Siegal (chapter 2 in this volume) presents evidence of the importance of these conversational conventions. Understanding these conventions is both a cognitive process and a matter of adequate socialization or acculturation (see Rogoff, 1982, p. 143) to the experimenter's conversational patterns.

A close look at video tapes and transcripts has made clear to us that, on the one hand, all subjects are not necessarily faced with identical tasks or procedures, even if procedures are rigorously standardized in the eyes of the tester. On the other hand, in practice, the psychologist has to go beyond a standardized testing script to make the subject's mode of thinking converge toward his or hers, using various sociocognitive strategies. This is similar to what Rogoff (chapter 16 in this volume; Rogoff & Gardner, 1984) describes in situations of guided participation; there is a building of an intersubjectivity in which nonverbal monitoring

and adjustment are required on both sides. The subject must accept the interaction and enter into the game according to the adult's (normative) expectations if he or she wants to succeed on the test. We can observe a subject trying to decode the tacit assumptions of the adult concerning the definition of the situation, the expected roles, the locus of the discussion, and the taken-for-granted aspects of the interaction as the subject tries out answers and even tries to save face—all processes similar to those described by Levine and Moreland (this volume) in relation to the dynamics of a newcomer in a work group. In order to respond correctly to the conservation of liquids test, the child has to understand the requirement to abstract from, among other things, the perceptual evidence displayed (i.e., the dimensions of the glass, the level of the juice) and the social relationship of the partners (e.g., social rights due to age). Only under these conditions can the two partners discuss the abstract concept of the conservation of the quantities of liquid. In this negotiation of a common definition of the object of discourse, tester and subject are in an asymmetrical relationship in which the adult maintains control of the structure of the verbal exchange, giving the adult the power to define the object of discourse and the criteria of comprehension. Each testing interaction consists of social (and testing) routines, as well as individual strategies embedded in personal and relational experience taking place in a (more or less) staged and institutionalized situation that each partner interprets according to his or her own references.

The data just presented can also be read as illustrating that so-called individual testing is actually a complex social interaction in which the subject puts into play a wealth of social knowledge and skills, including the resolution of the task and the monitoring of the social interaction using interactive strategies. Is this the case only for psychological testing or does the display of scholastic competence rely on the same processes?

Scholastic Knowledge and Context in Testing Situations

Studying written formulations of addition problems (of the type a + b c = x) by 7- to 9-year-olds, we have observed that pupils questioned by an experimenter within the classroom context tended to refer to mathematical notation used in school to represent mathematical operations and actions in their problem solving. However, when pupils were given the same task outside the classroom in a one-to-one interaction, their written solutions were more heterogeneous in nature, using natural language and illustrative drawings (Schubauer-Leoni & Perret-Clermont, 1980, 1985; Schubauer-Leoni, 1984, 1986b, 1986c). Varying the experimental settings revealed that subjects considered the a + b − c = x type of notation canonic for classroom mathematics but used other notation (e.g., drawings or writing) more often to describe the same

operation (i.e., dealing with flowers, candies, or dice) outside the classroom. Pupils produced the expected canonic notation only if they associated (through a series of cues) the testing situation with their classroom experience. In such situations, we observed guidance and mutual interpretation processes similar to those observed in Piagetian testing situations. It seems that, during the interaction with the adult, the child becomes acculturated to the type of answers expected from him or her in specific situations as a function of what is at stake in the encounter. The child tries to determine whether he or she is expected to display school learning, verbal competence, or a graphic and aesthetic performance. Often the child enters into a sort of guessing game to decode the experimenter's expectations and satisfy his or her demands. The subject undertakes this decoding in reference to previous experience, which is notably scholastic experience. The child also relies on his or her understanding of the type of relationship established between him- or herself and the adult; seldom does the child perceive the experimenter as a playmate. Usually children believe the experimenter occupies the dominant position in a hierarchical relationship and holds the criteria of definition and interpretation of the situation. Children often seem to give priority to a demonstration of their good will to comply.

Experimental sciences such as physics have long been aware of the artifactitious nature of any observational measurement: The instrument used partly creates the phenomena observed (or at least interferes with the data collected). Similarly, our research has made us aware, as psychologists, of the importance that characteristics of the testing situation itself have in generating behaviors that have been misleadingly considered a reflection of the cognitive characteristics of the individual subject but that actually mirror a particular testing relationship between the psychologist and subject. As a consequence, it is no longer possible to decide a priori if a competence is purely cognitive or also involves the social competence of displaying that behavior. Intelligence, then, can be considered as intrinsically a sociability. In other words, the cognitive competence of a subject can only be "seen" by someone who has the necessary cognitive and social skills to relate properly to that subject. This view provides an argument for abandoning a uniquely individualistic approach to the study of the development of intelligence.

The Construction of Context and Content in Teaching/ Learning Interactions

We have just examined how a subject's performance in testing situations results from interwoven processes linked to past and present cognitive and social experience. It should, therefore, be possible to observe within the schooling process how the growth of the cognitive resources of pupils is tightly interwoven with

their socialization to the school context and is geared by regulations that are not only cognitive but also social.

Looking back at Perret's studies of children's questioning, we can ask if it is possible to observe processes that lead the children to regard their role as one of not questioning but merely displaying their thinking. (After all, many 3-year-old children spend hours asking questions, so why don't they do so at this later stage?) Perret's later studies (1985) gave him the opportunity to investigate these processes by observing primary school children learning about numbers and the numerical system and by studying teachers' background theories about this learning. The mathematics curriculum of French-speaking Switzerland was completely revised to meet the demands of teaching an integrated understanding of this subject matter (in the perspective of Bourbaki's unification) and to attempt to give the pupil access to the logical foundations of his own thinking (in the Piagetian sense [Piaget & Szeminska, 1952]). This reform of the teaching of elementary school mathematics has triggered detailed analyses (see Perret, 1988a, 1988b; Jacquet, George, & Perret, 1988) of the contents of school tasks presented to pupils. For a long time, however, no attention has been paid to the *psychosocial features of the context* in which these mathematical competencies are supposed to be acquired.

One activity used in math classes is teaching children to group objects and then code the results in the base used for grouping. The children learn to write the notation for their grouping from left to right in a table of the following type:

e.g., in base 5

1	0	3

(3 = three units, 0 = no second order grouping, 1 = one third order grouping)

The cardinal number of the same set written in base 10 would be:

2	8

The goal of such exercises is to have children explore the possibility of a multiplicity of notations for a given quantity and to learn how a positional system of numerical notation functions by using other bases. But Perret observes that, when children are asked the meaning of their productions, the large majority consider this activity in such a restrictive sense that they do not see the correspondence between the code used and ordinary counting in base ten. Even when presented with large sets of objects to be counted, they do not use such groupings for that purpose (Perret, 1987). For these children, a written numerical notation such as *34* indicates the result of counting (Perret, 1985) but not necessarily the result of a grouping. The ordinal and cardinal aspects of numbers, then, are not mastered. The code is seen as representing the value of the whole set when it has been grouped, but, for example, a series such as "1, 2, 3, 10, 11, 12" (in base 4) is seen as not permitting counting "because it jumps!" (i.e., after *3* comes

10), and this discontinuity with respect to base 10 (which serves as a reference, despite the curriculum's relativistic approach) impedes children's use of it for counting. Perret (1985) also asked pupils to count the squares while playing a board game that demanded advancing their token a given number of squares. Pupils could explain that "26 means 2 tens and 6 ones," but when asked to show on the game board where these two tens were, they often were unable. Some children even tried to explain that tens are what you get "when you put sticks together in packages of ten," recalling a previous classroom activity. When asked to count the squares by sevens, they could do so, inventing all sorts of ingenious methods in order not to lose track of their counting, but they tended not to recall the procedures taught in class with groups of objects and codes.

Resnick (1987, p. 15) makes the point that "The process of schooling seems to encourage the idea that the 'game of school' is to learn symbolic rules of various kinds, that there is not supposed to be much continuity between what one knows outside school and what one learns in school." Perret's examples mentioned above show that already *within* the school pupils did not necessarily perceive the relationship among the different tasks. They did not develop, in this case, the expected metareflection about underlying rules, concepts, and structures or about the teacher's "background" thoughts and intentions. Each task seemed to be an end in itself; that is, groups are for grouping and codes are for coding. Pupils seemed to respond only to specific instruction, searching for the expected answer, elaborating strategies to "get by," and looking for efficient procedures to avoid failure. Their responses were contextualized, deriving their meaning from the restricted setting in which they were constructed, and were embedded in current and past classroom experience. The pupils observed in these studies seem to have acquired a basic numerical expertise, but that expertise consists of unrelated principles of action used to solve specific types of scholastic exercises (or "practical situations" [Resnick, 1987, p. 18]). This understanding does not correspond to the expertise expected by the teacher and curriculum developers in terms of understanding the numerical system.

Teachers ask for groups and codes and prepare worksheets with tables already drawn. Pupils know that the usual way to complete the worksheets (in fact the only way in the classroom routine) is to fill them out from right to left. When the teacher asks a question beginning "How many. . ." pupils understand that the expected answer is a number written from left to right (with no table). This type of teacher–pupil communication limits task comprehension to routes to the correct (i.e., expected) response. Pupils seem to function as if their role is to demonstrate that they have "learned," (i.e., to display acquired knowledge in the adequate manner). In this sense, it is virtually impossible to distinguish "adequate display" from "learning," as such.

In observations of and interviews with teachers and pupils, it appears that math is seldom considered "in abstracto" in the school context (Perret-Clermont

& Schubauer-Leoni, 1989, Schubauer-Leoni, 1986a, 1986b). Teachers and pupils think of mathematical concepts, symbols, and problems within the specific context of their classroom activities. Cognitive processes and social regulations are so intricately interwoven in learning at school that it is difficult to separate them. It seems that, in these scholastic contexts (e.g., testing situations), the possibilities for children to display competencies depend on their interpretation of the situation, the task content, and the adult's discourse, as well as on what they perceive to be at stake in the interaction. The meaning is conveyed by the setting, the institutional framework in which the encounter takes place, the participants' dialogue and attitudes, their sense of social identity (as pointed out by Goodnow, 1990a), the objects manipulated, and the type of interpersonal relationship established. This meaning is not absolute. It is inferred and interpreted by the subject according to previous sociocognitive experience and the subject's goals in the interaction. The subject's initial interpretation is apt to be modified in the course of the interactions in response to the interlocutor's reactions.

CONCLUSION

Our research, initially aimed at studying the impact of social factors on cognitive performances, calls attention to the complex interdigitation of social and cognitive factors, whose causality is not simple. Our first generation research looked at the impact of social factors on cognitive development, and our results demonstrated the existence of causal relationships between cognitive development and social interaction. But this causality, first conceived in a rather mechanical mode, appeared to be more complex, with the construction of meaning interacting with the construction of logical reasoning, and both of these processes always being displayed within social interaction. This led us to reconsider exactly what is cognitive and what is social. For the second generation research, our object of analysis, therefore, had to shift from the individual and his or her cognitive performance to the social interaction in which this performance is produced. This shift of focus allows a description of the process of the social construction of responses: Social dimensions of the encounter contribute to its meaning, interact with the logical and formal aspects of the task in question, and even contribute to the definition of these aspects.

We have examined two specific contexts: testing situations and the school context of learning and assessment. An analysis of the modalities of social interactions observed in both contexts led us to conclude that competence depends on meanings socially constructed and shared within these situational contexts. In brief, what were traditionally considered intrapsychic logical processes are also social events with their past and present history within specific institutional and sociocultural contexts.

This does not mean that, given a "proper" situational context, any child can be capable of any performance at any time. Age trends have been reported; there is evidence for developmental acquisitions through varied personal and social experience. We have observed necessary sociocognitive prerequisites in order for a child to benefit from specific social interactions. The sociocultural context emphasizes the dimensions on which development is valued (Goodnow, 1990a; Damon, chapter 18 in this volume). In the microsituations of our observations, children obviously demonstrate efforts to converge toward the adult's expectations and task demands.

These progressive constructions of sociocognitive competencies are not purely endogenous phenomena located simply in the individual. They are artifacts of a chain of interlocutors' mutual expectations and adjustments in actions, verbalizations, and thoughts. These adjustments are sometimes asymmetrical between persons of unequal status and sometimes reciprocal between peers. For each person and for each group (e.g., experimental groups and classrooms, as well as family and scientific groups), these mutual adjustments have a history that contributes to the conferring of meaning on the present relationship in which the questioning and the display of competence take place (Hinde, Perret-Clermont, & Stevenson-Hinde, 1985; Perret-Clermont & Nicolet, 1988).

The perspective elaborated here opens the way for further research on the creation and transmission of meanings and knowledge in social interaction, the establishment of interpersonal relationships, the elaboration of intersubjectivity, and the construction of context. All these processes play an integral part in development, and their examination could contribute to a better understanding of the articulation of children's sociocognitive competencies in interaction. Intelligence can also be characterized as a form of sociability. A new question, therefore, arises: When and with whom does "logical reasoning" arise (i.e., when does reasoning develop on logical grounds and not on less rational ones)?

References

Bell, N. (1985). Quelques reflexions sur la métacognition [Some reflections on metacognition]. *Dossiers de Psychologie* (Tech. Rep. No. 25). Neuchâtel, Switzerland: University of Neuchâtel.

Bell, N., Grossen, M., Perret-Clermont, A.-N. (1985). Sociocognitive conflict and intellectual growth. In M. W. Berkowitz (Ed.), *Peer conflict and psychological growth* (pp. 41–54). San Francisco: Jossey Bass.

Berlyne, D. (1962). Uncertainty and epistemic curiosity. *British Journal of Psychology, 53*, 27–34.

Bruner, J., & Olson, D. (1973). Apprentissage par expérience directe et apprentissage par expérience mediatisée [Learning by direct experience and learning by mediated experience]. *Perspectives, 3*(1), 21–42.

Doise, W., Dionnet, S., & Mugny, G. (1978). Conflit socio-cognitif, marquage social, et développement cognitif [Socio-cognitive conflict, social marking, and cognitive development]. *Cahiers de Psychologie, 21*, 231–243.

Doise, W., & Mugny, G. (1984). *The social development of the intellect*. Oxford, England: Pergamon Press.

Doise, M., Mugny, G., & Perret-Clermont, A.-N. (1975). Social interaction and the development of cognitive operations. *European Journal of Social Psychology, 5*, 367–383.

Donaldson, M. (1978). *Children's minds*. London: Fontana.

Goodnow, J. J. (1990a). The socialization of cognition: Acquiring cognitive values. In J. W. Stigler, R. A. Schweder, & G. Herdt (Eds.), *Cultural psychology: Essays on comparative human development* (pp. 259–286). Cambridge, England: Cambridge University Press.

Goodnow, J. J. (1990b). Using sociology to extend psychological accounts of cognitive development. *Human Development, 33*, 81–107.

Grossen, M. (1988). *La construction de l'intersubjectivité en situation de test* [The construction of intersubjectivity in the test situation]. Cousset, Switzerland: DelVal & Dossiers de Psychologie.

Grossen, M., & Bell, N. (1988). Définition de la situation de test et élaboration d'une notion logique [Definition of the test situation and elaboration of a logical idea]. In A.-N. Perret-Clermont & M. Nicolet (Eds.), *Interagir et connaître: Enjeux et régulations sociales dans le développement cognitif* (pp. 233–239). Cousset, Switzerland: DelVal.

Hinde, R., Perret-Clermont, A.-N., & Stevenson-Hinde, J. (Eds.). (1985). *Social relationships and cognitive development*. Oxford, England: Oxford University Press.

Inhelder, B., Sinclair, H., & Bovet, M. (1974). *Apprentissage et structures de la connaissance* [Learning and the development of cognition]. Paris: Presses Universitaires de France.

Jacquet, F., George, E., & Perret, J. F. (1988). *Connaissances mathematiques a l'ecole primaire. Fascicule 2: Collection exploration* [Mathematical knowledge in the primary school]. Bern, Switzerland: Lang.

Lévy, M. (1981). *La necessité sociale de depasser une situation conflictuelle générée par la présentation d'un modèle de solution de probleme et par le questionnement d'un agent social* [The social necessity of overcoming a conflicted situation generated by the presentation of a model problem solution and questioning by a social agent]. Doctoral dissertation, University of Geneva, Geneva, Switzerland.

Light, P., & Perret-Clermont, A.-N. (1989). Social context effects in learning and testing. In A. Gallatey, D. Rogers, & J. A. Sloboda (Eds.), *Cognition and social worlds* (pp. 99–112). Oxford, England: Oxford University Press.

Mead, G. H. (1934). *Mind, self and society*. Chicago: University of Chicago Press.

Nelson-Le Gall, S. (1985). Help-seeking behavior in learning. In E. W. Gordon (Ed.), *Review of Research in Education: Vol. 12* (pp. 55–90). Washington, DC: American Educational Research Association.

Nelson-Le Gall, S., & Jones, E. (1990). Cognitive-motivational influences on the task-related help-seeking behavior of black children. *Child Development, 61*, 581–589.

Nicolet, M., Grossen, M., & Perret-Clermont, A.-N. (1988). Testons-nous des compétences cognitives? [Are we testing cognitive competencies?] *Revue Internationale de Psychologie Sociale, 1*, 71–91.

Perret, J. F. (1977). *Signification psychologique, épistémologique et intérêt pédagogique des conduits de recherche d'informations chez l'enfant: Mémoire* [The psychological and epistemological significance and the pedagogical interest of research on children's knowledge]. Geneva, Switzerland: University of Geneva.

Perret, J. F. (1978). Contribution à une psychologie cognitive de l'enfant en situation pédagogique [Contribution to a cognitive psychology of the child in a pedagogical situation]. Paper presented at the *Premier Congrès Portugais pour le Développement de l'Enfant*. Lisbon, Portugal

Perret, J. F. (1985). *Comprendre l'écriture des nombres. Collection exploration* [To understand the writing of numbers]. Bern, Switzerland: Lang

Perret, J. F. (1987). Pour quel apprentissage des mathematiques? [For what mathematics learning?] *European Journal of Psychology of Education*, 2(3), 247–260.

Perret, J. F. (1988a). *Connaissances mathematiques a l'école primaire. Fascicule introductif* [Mathematical knowledge in the primary school]. Bern, Switzerland: Lang.

Perret, J. F. (1988b) *Connaissances mathématiques a l'école primaire. Fascicule 3* [Mathematical knowledge in the primary school]. Bern, Switzerland: Lang.

Perret-Clermont, A. N. (1980). *Social interaction and cognitive development in children*. New York: Academic Press

Perret-Clermont, A.-N., & Brossard, A. (1985). On the interdigitation of social and cognitive processes. In R. A. Hinde, A.-N. Perret-Clermont, & J. Stevenson-Hinde (Eds.), *Social relationships and cognitive development* (pp. 309–327). Oxford: Oxford University Press

Perret-Clermont, A.-N., & Mugny, G. (1985). En guise de conclusion: Effets sociologiques et processus didactiques [In conclusion: Sociological effects and didactic processes]. In G. Mugny (Ed.), *Psychologie sociale du développement cognitif* (pp. 251–261). Bern, Switzerland: Lang.

Perret-Clermont, A.-N., & Nicolet, M. (Eds.). (1988). *Interagir et connaître. Enjeux et régulations sociales dans le développement cognitif* [Interacting and knowing. Stakes and social regulations in cognitive development]. Cousset, Switzerland: DelVal.

Perret-Clermont, A.-N., & Schubauer-Leoni, M. L. (1981). Conflict and cooperation as opportunities for learning. In P. Robinson (Ed.), *Communication in development* (pp. 203–233). London: Academic Press.

Perret-Clermont, A.-N., & Schubauer-Leoni, M. L. (1989). *The social construction of meaning in math class interaction*. Paper presented at the UNESCO Sixth International Congress on Mathematical Education, Budapest, Hungary.

Piaget, J. (1950). *The psychology of intelligence*. New York: Harcourt Brace.

Piaget, J. (1965). *The moral judgment of the child*. New York: Free Press.

Piaget, J., & Szeminska, A. (1952). *The child's conception of number*. London: Routledge & Kegan Paul.

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher*, *16*, 13–20.

Rijsman, J. (1988). Partages et norme d'équité: Recherches sur le developpement social de l'intelligence [Sharing and equity norms: Research on the social development of intelligence]. In A.-N. Perret-Clermont & M. Nicolet (Eds.), *Interagir et connaître. Enjeux et régulations sociales dans le développement cognitif* (pp. 123–137). Cousset, Switzerland: DelVal.

Robinson, E. J., & Robinson, W. P. (1976). The young child's understanding of communication. *Developmental Psychology*, *12*, 328–333.

Robinson, W. P., & Rackstraw, S. J. (1975). *Questioning and answering of school children*. Sydney, Australia: Macquarie University.

Rogoff, B. (1982). Integrating context and cognitive development. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology* (Vol. 2, pp. 125–170). Hillsdale, NJ: Erlbaum.

Rogoff, B., & Gardner, W. (1984). Adult guidance of cognitive development. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context* (pp. 95–116). Cambridge, MA: Harvard University Press.

Schubauer-Leoni, M. L. (1984). Formulations ecrites et resolutions de problemes additifs [Written formulations and solutions of additive problems]. *Interactions didactiques* (Tech. Rep. No. 5). Switzerland: University of Neuchâtel and University of Geneva.

Schubauer-Leoni, M. L. (1986a). *Maitres-eleves-savoirs. Analyse psychosociale du jeu et des enjeux de la relation didactique* [Teachers, pupils, knowledge: A psycho-social analysis of the game and of the stakes of the didactic relationship]. Doctoral dissertation, University of Geneva, Geneva, Switzerland.

Schubauer-Leoni, M. L. (1986b). Le contrat didactique. Un cadre interpretatif pour comprendre les savoirs manifestés par les éleves en mathématique [The didactic contract: An interpretive framework for understanding the knowledge displayed by pupils in mathematics]. *Journal Européen de Psychologie de l'Education, 1*(2), 139–153.

Schubauer-Leoni, M. L. (1986c). Le contrat didactique dans l'elaboration d'ecritures symboliques par des élèves de 8–9 ans [The didactic contract in the elaboration of symbolic notation by children of 8–9 years]. *Interactions didactiques* (Tech. Rep. No. 7). Switzerland: University of Neuchâtel and University of Geneva.

Schubauer-Leoni, M. L., & Perret-Clermont, A.-N. (1980). Interactions sociales et représentations symboliques dans le cadre de problèmes additifs [Social interaction and symbolic representations in the context of additive problems]. *Recherche en didactique des mathematiques, 1*(3), 297–343.

Schubauer-Leoni, M. L., & Perret-Clermont, A. N. (1985). Interactions sociales dans l'apprentissage de connaissances mathématiques chez l'enfant [Social interactions in children's mathematics problems]. In G. Mugny (Ed.), *Psychologie sociale du developpement cognitif* (pp. 225–250). Bern, Switzerland: Lang.

Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: MIT Press.

Wertsch, J. V., & Sammarco, J. G. (1985). Social precursors to individual cognitive functioning: The problem of units of analyses. In R. A. Hinde, A. N. Perret-Clermont, & J. Stevenson-Hinde (Eds.), *Social relationships and cognitive development* (pp. 276–293). Oxford, England: Oxford University Press.