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Abstract

This theoretical paper discusses some conceptual and methodological obstacles that one encounters when analyzing the contextual determination of thinking in psychology. First, we comment upon the various representations of the "cognitive" individual that have been formed over the years – from the epistemic subject to the psychological subject, and finally, to the psychosocial actor. Second, we recall the main criticisms of "methodological solipsism" found in cognitive psychology research, and we discuss heuristic methods for analyzing the contextual determination of thinking in psychological studies. Finally, we propose an analysis of some data using the approach based on interlocutory logic as a way to formalize reasoning moves and its transformations in the unfolding interaction.

Key words: human thinking, cognition, interaction, context, pragmatics

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The idea that conversational interaction organizes the contents of thought, and even structures the operations of thought, is an old assumption. Within the last century, this thesis has been developed considerably, so that today, it belongs to a complete and coherent paradigm at the junction of epistemology, linguistics, artificial intelligence, sociology - owing to ethnomethodology and its extension "conversational analysis" – and of course, psychology. Such a thesis is not the least surprising: human beings are social animals living in continuous interaction with their congeners, and the natural form of human interaction, using an expression from Schegloff's (1991) work, is talk-in-interaction.

Psychology - especially developmental psychology where the above thesis is embedded in a long-standing tradition (e.g. Baldwin, 1913; Piaget, 1932/1977, 1977/1995; Mead, 1934; Wallon, 1945; Vygotski, 1962) - has strongly contributed to the enrichment and development of this thesis. Within the last three decades, strong experimental evidence of the role of social interaction in the development of thinking has been provided by developmental researchers who have been following this long-standing tradition. Of course, the contribution of psychology research is not limited to the "simple" observation that significantly different "cognitive outputs" correspond to "interactional inputs". Researchers have undertaken to study social interaction as a complex phenomenon where several dimensions interact - cognitive, social and cultural ones - within a space-and-time-framework historically and culturally located, and marked by rules and values. In this context of investigations, interest in semiotic mediations not only revived the threads of the Piagetian tradition (where the role of communication via language is more or less neglected) and the Vygotskian tradition (where

language is important from a theoretical point of view but there is no relevant methodology to study it in depth), but also opened up some new prospects. However, this idea carried some daunting problems with it too. Some of the problems are theoretical. For example, how can we access the reasoning using speech without loosing the form of that reasoning, i.e., without neglecting its "mediations", which was one of the negative consequences of research that focused only on solving procedures? Other problems are methodological. What methodology(ies) should we use to describe reasoning *psychologically*? How is it possible to articulate the experimental and formal evidence of the impact of a variable on reasoning? In spite of significant progress in understanding these two topics within the last three decades, epistemological hurdles still remain. We would like to discuss these next.

1. From the Epistemic Subject to the Psychological Subject, Toward a Psychosocial Actor

Recalling the Epistemic Subject

The Piagetian framework of cognitive development focused on the genetic construction of the *structures* of intelligence. This so-called structural approach attempts to describe "macrogenesis", the stages and boundaries of development for various areas of knowledge (number, substance, weight, concepts of time, speed, space, etc.) and for cognitive structures as a whole (three main stages of cognitive development). Here, the explanatory factor of the formation and development of rationality, Piaget's *équilibration majorante*[1] (Piaget,

[1] The model of *équilibration majorante* was developed by Piaget (1975/1985), in parallel with the concept of reflective abstraction, to account for endogenous capacities of knowledge development: The "*équilibration majorante* (…) is an inherent process of psychological activity. It extends the processes of self-regulation that intervene in organic development. The equilibration produces regulations aimed at compensating for cognitive disturbances, which occur when an obstacle is presented for assimilation, and when the subject's schemes are sufficiently developed to become aware of the obstacle and to make room for increasingly elaborate

1975/1985), is endogenous. The structures are regarded as valid for all children who are at the same level of development. They are the general forms of knowledge, i.e., those of an "epistemic subject" that formed the basis of the Piagetian framework. In his first writings, Piaget (1923/2002, 1924/1928, 1932/1977) regarded a child's co-operative behaviors as the main responsible factor for the emergence of rationality, i.e. for the construction of mental operations (initially concrete then formal). Thus, he initially suggested a social explanation of cognitive structures by stressing the fact that the mental operation appeared as the child, escaping gradually from preoperative egocentrism, profited from the stimulations generated by the symmetrical exchanges between peers that are based on the reciprocity of points of view and on mutual respect, in contrast with the adult/child asymmetrical exchanges. Later, when he highlighted a form of "logic of sensorimotor action", before verbal language ability, Piaget acknowledged he had over-estimated the role of language and the social interaction in cognitive development (Ducret, 1990). He would maintain thereafter the idea according to which cognitive structures and mental operations come from the subject's own coordination and from his/her self-regulation of actions, even if he formulated the assumption of a close relationship between co-operation (or interindividual coordination of actions) and the constitution of operative structures (or intra-individual coordination of actions and operations): "cooperation itself constitutes an issue of co-operations: to put in correspondence (which is an operation) operations of one of the partners with those of the others, to join together (which is another operation) the knowledge of a partner to that of the others, etc; and, in case of disagreement, to eliminate contradictions (which supposes an operative process) or especially to differentiate the points of view and to introduce a reciprocity between them (which is an operative transformation)" (Piaget, 1977/1995, p. 347, French edition). Thus, the

modifications. Piaget connects the equilibration concept to that of adaptation, because equilibration results from the tendency of any cognitive system to feed itself, in other words, to assimilate and to accommodate itself to the assimilated elements. So, a perpetual adjustment of the subject's schemes occurs in the direction of an optimization" (Montangero, 2001, p. 84).

social factors were relegated to the status of necessary but non-sufficient conditions for the construction of knowledge (Piaget & Inhelder, 1966/1969). In the same way, the symbolic function was regarded as subordinated to the individuals' operative competences, and language only got an instrumental status in human thinking emergence: "(…) language is not sufficient to explain human thought because the structures, which characterize it, plunge their roots into action and into sensorimotor mechanisms which are deeper than the linguistic fact. But it is not less obvious, in return, than the more refined the structures of human thinking are, the more necessary language is to achieve their development. Language is thus a necessary but non-sufficient condition of the construction of logical operations. It is necessary because without the system of symbolic expression that language constitutes, the operations would remain in the state of successive actions without never being integrated in simultaneous systems or simultaneously embracing a whole of interdependent transformations. In addition, without language, the operations would remain individual and consequently would be unaware of this adjustment which results from interindividual exchange and co-operation" (Piaget, 1964, pp. 112-113).

However, a more detailed analysis of Piaget's research brings to light the social dimension of his theory, even if he did not translate this dimension into an empirical research program, because his top priority was to study the construction of necessary knowledge (Lourenço & Machado, 1996): Contrary to merely true knowledge, necessary knowledge goes beyond the functional explanations as well as the social regularities. Yet, it did not prevent him from recognizing, in his last writings, that the epistemic subject was not so universal as he had admitted it up to then (Bringuier, 1977/1980):

« [Jean-Claude Bringuier] – We cannot imagine that reality can teach us something about itself out of the scientific mind.

[Jean Piaget] – Yes, I'm convinced!

J.-Cl.B. – You're convinced because you are a Western man.

J.P. – Oh yes.

J.-Cl.B. – You are manufactured in Western science.

J.P. – Yes, if you like. But, there is a Chinese science which went extremely deep […] So I wondered about the problem of knowing if one could imagine a different psychogenesis from ours and which would be that of the Chinese child at the great era of Chinese science, and I think that it is the case" (Bringuier, 1977/1980, pp. 149-150, French edition).

Actually, if we put this aspect of Piaget's model into perspective in his historico-cultural context or if we read Piaget's theory from "the interior" (Lourenço & Machado, (1996), it seems that setting social factors aside is related to his rejection of the social empiricism of his time. Whatever option we take, as Chapman (1988, 1991) indicates, the in-depth study of the social (and cultural) characteristics of cognitive development remains compatible with the frame of mind of the Piagetian theory. For this purpose, Chapman (1991) proposed to integrate in a single model the communicative and operative components of social interaction that Piaget used on various occasions: such an integration would transform the binary structure of knowledge (subject/object) and of social interaction (subject/other) into a ternary structure: "The substance of both criticisms can be addressed simultaneously in the proposal that human knowing involves an irreducible *epistemic triangle*, consisting of an active subject, the object of knowledge, and a (real or implicit) interlocutor, together with their mutual relations" (Chapman, 1991, p. 211). As we will see further, such assumptions led to reinterpret the pragmatic dimension of situations and exchanges.

From the Epistemic Subject to the psychological Subject

Parallel to epistemological research, the functional conditions for knowledge acquisition began to be evoked, under the impulse of Inhelder's (1943/1968, 1954, 1955) work. Engaged in a research program on operative training aiming at "showing, in an experimental way, that real cognitive progress can be obtained from children, as (soon as) they do training exercises that unbalance their cognitive system" (Morgado & Parrat-Dayan, 2002, p. 650), Inhelder, Sinclair, and Bovet (1974) developed analyses for the cognitive advance that were no longer about the epistemic subject but about the "psychological" subject. In other words, they adopted a functional approach to a real individual called "microgenesis". "By contrast, the individual psychological subject (Inhelder et al., 1976; Inhelder & Piaget, 1979) is studied by an observer who attempts to detect the dynamics of the subject's behaviors, his/her goals, his/her choice of means and controls, and his/her own heuristics that can lead to the same result in different ways, in order to penetrate psychological functioning and establish the general characteristics of procedures or finalized and organized sequences of actions. […] The heuristic distinction between epistemic subject and psychological subject simply reflects complementary forms of development of the subject's knowledge, which tends either toward normative knowledge or pragmatic and empirical knowledge" (Inhelder & de Caprona, 1992, p. 21). In order to study such an issue, Inhelder and her colleagues have used the "methodology of experimental intervention in the processes of training form"[2] (Inhelder, 1966) which Morgado and Parrat-Dayan (2002) summarize as follows: a pretest and two post-

[2] "Our varied procedures obey the same frame: initially we establish a diagnosis, as subtle as possible, of the starting possibilities of each child which are examined using the tests of conservation, and which can extend from a level of actual preoperativity up to a level characterized by the actual concrete operations, going through all the intermediate under-stages. The same tests will be used after the trainings in order to estimate the possible transformations of the reasoning, whose stability and fragility will be checked with control tests four weeks later. Three-training-periods in one week offer the children many occasions to exceed the particular difficulties of their cognitive level. They include both a set of operative exercises and the possibility to continuously confront the anticipations, and feedbacks with the results of the experiment" (Inhelder, 1966, p. 182).

tests composed of Piagetian tasks on the studied field are presented to each child. The participants of the experimental group are assigned to several trainings with "operative exercises" whose purpose is to "grasp the microchanges of the child's behaviors in detail, the transpositions of procedure during the operative exercise as well as the confrontations between answers and the experiment's intervention" (p. 651). As the authors pointed out, the introduction of the second post-test into the experimental design constitutes "a real methodological innovation" that is fundamental to assert the stability of cognitive progress. This research avenue became essential when empirical evidence brought to light cognitive lags in the development of knowledge, which introduced "disorder" into the theoretical model: "The problem of cognitive lags[3] […] continuously triggered studies and controversies within the last two decades, to the point of questioning the relevance, even if only the descriptive relevance, of the concepts of structure and stage, and it stressed the importance of 'functional' aspects in cognitive tasks, more specifically - at least in our own work - the role of representations, of the meaning attributed by the subject to perceptual data and even to the transformation action" (Gréco, 1985, p.78). Thus Gréco (1985) recommended calling on the "pragmatics of cognitive activities".

Thereafter, research on cognitive functioning and development has focused on the cognitive processes themselves, i.e., independently of their relationship to cognitive skills. Solving procedures were analyzed specifically (i.e., the way stages or subgoals follow each other, and the path a child's thought takes when he/she is following a given target). To do this, a method of interactive observation was used which is more appropriate to study the strategies for solving problems: the experimenter's interventions were analyzed as an "integral part of the

[3] This corresponds to "achievements or non-contemporary applications of the same structure to different empirical contents" (Gréco, 1985, p. 78). For example, whereas it is assumed that children have the structure that allows them to carry out seriations, they are initially able to seriate sticks only and then later, weights. The same holds true for conservation: substance (by age 8), weight (by age 9-10), and volume (by age 11-12).

resolution process which is managed by the subject, that is, as a situational variable" (Saada-Robert, 1992, p. 141). This approach has shed a new light on the status of errors. Whereas in the structural approach, an error is a point of arrival that reveals the state of cognitive structures (for example, focusing on the length of the line-ups of tokens to assess the number of tokens indicates the non-conservation of number), the error becomes a starting point in the functional approach. It can explain the subject's self guidance, i.e., his/her cognitive progress and "mechanisms of control" for solving the problem. Two kinds of problems hold the attention of Inhelder's team (Inhelder & de Caprona, 1992): (1) what is the relationship between success and comprehension? (2) Does success lead to some progress in comprehension, or does comprehension come from cognitive conflicts revealed by partial failures? Consequently, this approach to the "authentic" subject uncovered the idea that an individual's knowledge determines both *the meaning* that he/she attributes to the problem situation and *the control* he/she exercises over the task (Piaget & Garcia, 1987/1991; Inhelder, Sinclair, & Bovet, 1974; Inhelder, Cellérier, Ackermann, Blanchet, Boder, de Caprona, Ducret, & Saada-Robert, 1992). Thus, Bärbel Inhelder's research threw a new light on cognitive development while being interested above all in the psychological subject and in the functional aspects of thinking of "a knowing subject, but with his/her intentions and values" (Inhelder & de Caprona, 1992, p. 22). It provided rich microdevelopmental descriptions of the subject's problem resolution *in real time*, thanks to the focus on new observable data which are the sequences of actions and the temporal unfolding of behavior[4]. Inhelder's analyses enabled us to detect the child's own guidance of his/her reasoning more and more clearly, from the analysis of meanings he/she attributes to his/her own actions and strategies in the advance of his/her cognitive discoveries: "the *équilibration* [one of the great functional

[4] Inhelder & de Caprona (1992) recall that "the analysis of the behaviors consisting in establishing correspondences, classifications and series is well known, but it is the first time that we have focused it on sequences of actions" (p. 53).

processes identified by Piaget] is the foundation of the genesis of the structures and expresses a constructivism of an epistemological type. We could wonder with Cellérier if it should not be supplemented by a more psychological dimension by observing the subject working in microgeneses which lead to create innovations. Indeed it is essential to work out a psychological constructivism which would be a theory of innovation" (Inhelder & de Caprona, 1092, p. 28).

According to Houdé (1998/2004), Inhelder's work allowed us to initiate a connection between the Piagetian structuralism and the cognitive psychology of data processing: "According to Cellérier's analysis, the Piagetian structuralism deals with epistemic transformation from action to knowledge in the long run, while cognitivism deals with pragmatic transformation from knowledge to action, in the short run. These two psychologies 'work' on different scales of time: one on a diachronic scale (macrogenesis or development), the other on a synchronic one (microgeneses on a given level of development). The challenge of the Neopiagetian psychology is to articulate these two viewpoints. The research trend which most explicitly took up this challenge, in the 1980s, is neostructuralism, represented in particular by Juan Pascual-Leone, Robbie Case, Graeme Halford and Kurt Fischer" (p. 133, French edition).

Toward a psychosocial actor

An additional step toward understanding *concrete situations* was taken when research began to focus on the cognition of *homo quotidianus*, i.e., when researchers began to take into account the social conditions of cognitive development, which is one of the questions that was not clearly studied by Piaget. Since the 1970s, a number of speculative assumptions have been circulating. Researchers in developmental social psychology (Doise, Mugny, & Perret-

Clermont, 1975) proposed the sociocognitive conflict thesis to explain the fact that, under certain conditions, working in dyads leads to greater individual cognitive benefits than working alone (Ames & Murray, 1982; Bearison, Magzamen, & Filardo, 1986; Doise & Mugny, 1981/1984/1997; Emler & Valiant, 1982; Mugny, 1991; Perret-Clermont, 1979/1980/2000). The Swiss researchers, while proposing to test the assumption of the structuring role of the "conflict of communication" stated by Smedslund (1966), enriched the theoretical and empirical investigations of the "conflict" concept in cognitive development. The "cognitive" conflict, which allows the thought to progress, was regarded as emerging either from the invalidation of an assumption due to observations producing intellectual dissatisfaction (Inhelder, Sinclair, & Bovet, 1974; Lefebvre & Pinard, 1972), or from the confrontation with situations in which the subject's operative schemes are non-sufficient to solve the problem; an internal disturbance emerges and then causes an unbalance and a search for compensation, which leads to new schemes or to the complexification of old ones (Inhelder, Sinclair, & Bovet, 1974). The "sociocognitive" conflict is at the root of "the hypothesis of 'cognitive conflict experienced and resolved socially'" (Doise, Mugny, & Perret-Clermont, 1975, p. 382): the contradiction with the individual's system of answer explicitly finds its source in the system of answers of one or more individuals (Mugny, Perret-Clermont, & Doise, 1981). In other words, it is an outstanding conflict of viewpoints between at least two people about the same object. As Psaltis, Duveen, and Perret-Clermont (2009) pointed out, the question was to capture the social dimension of the Piagetian decentration. In addition, they underlined that in this work, interpersonal coordinations are described as preceding the interiorization of intrapersonal coordinations, thus calling into question the Piagetian assumption which considered that the social and cognitive dimensions of thinking are finally the two faces of the same piece, expressing the same logic of the coordination of actions in different forms (Piaget, 1947/1950, 1977/1995).

A retrospective analysis may bring out three successive stages in the experimental study of the social conditions of cognitive development in which the place allowed to social context has gradually changed (Gilly, 1991; Sorsana, 1999):

Study of the Systems of Interaction and Measurement of the Cognitive Effects: Initially, researchers focused on the mechanisms of action of the social interactions, without considering the role of social meanings: they focused their attention on the study of the *systems of interaction* – observing performances after working in dyads or alone, and partners in interaction were regarded as "interchangeable". Explanatory assumptions of cognitive progress were proposed in terms of imitation (Winnykamen, 1990), of sociocognitive conflict (Doise & Mugny, 1981/1984/1997; Doise, Mugny & Perret-Clermont, 1975; Mugny, 1991; Perret-Clermont, 979/1980/2000) or of destabilization (of task representation as well as solving procedures) and social control (Gilly, 1991, 2001; Gilly, Fraisse, & Roux, 2001). The social dimension was perceived here as *influencing* the cognitive activity. In this way, the initial thesis of the sociocognitive conflict depends more precisely on the following proposal (Sorsana, 2003): a social condition which is favorable to individual cognitive progress is a co-operative interaction between two (or three) individuals who are led to produce (verbal and/or gestural) contradictory answers, and who are cognitively engaged in going beyond this social and cognitive disturbance. The simultaneity of incompatible answers is supposed to lead them to take into account the other's answers, and, in a corollary way, to decentrate from their own point of view. Moreover, new information included in the partner's answer is supposed to draw the attention on new features of the task (new representations and new solving procedures). Then, the will to go beyond disagreements on a sociocognitive mode (and not by submission, Mugny, De Paolis,

& Carugati, 1984) would lead to the interindividual coordinations of actions and ideas which will be interiorized by each partner. They will then become new mental tools involving a new cognitive organization. In the very first experimental Swiss research used within this theoretical framework, the independent variable was the social dimension with generally two modalities, "working in dyad" versus "working alone". The dependent variable corresponded to the evolution of the experimental groups' performances between pre-test and post-tests. This kind of analyses led to measure the *effects of acquisition*. Three types of data in post-tests enabled the researchers to evaluate structural change (Psaltis, Duveen, & Perret-Clermont, 2009): (a) particularly performances in the differed post-test show actual cognitive progress because they are stable in time and so, are likely to reveal structural change; b) children are able to generalize their very new knowledge on other tasks which have the same operative structure, and c) new forms of reasoning are identified because the new conservers uttered new arguments (never mentioned in the unfolding interaction phase). However, comparing cognitive levels at different times (pre and post-tests) only makes it possible to compare the product of cognitive change but not the process (Granott & Parziale, 2002). This "first generation of studies"[5] developed in Switzerland provided empirical evidence of the effects of social interaction, while being focused on child1-child2 interaction system (Schubauer-Leoni & Perret-Clermont, 1997). Today, we can say that such studies inferred the sociocognitive conflict process by, to some extent, comparing "static" states. This amounts to inferring the movement from pictures only, according to Granott and Parziale (2002)'s metaphor when they compared state-oriented versus process-oriented approaches in development and learning. What are the precise nature and function of the interindividual coordinations of points of view, which are the process probably central to transform interindividual functioning into intra-individual functioning (Vygotski, 1934/1962)?

[5] According to the expression of Psaltis, Duveen, and Perret-Clermont (2009).

Study of the Solving Procedures and First Links Between Cognitive Effects and Acquisition Process: Several criticisms were formulated concerning the sociocognitive conflict thesis (Blaye, 1989; Flieller, 1986; Russel, 1982; Russell, Mills, & Reiff-Musgrave, 1990). The criticism related to the insufficiency of the observations carried out *during the co-resolution phase* constitutes one of the weaknesses which have inspired a complementary research trend (Dalzon, 2001; Gilly, 1991, 2001; Zhou, 2001). These researchers have supplemented the very first analyses introducing the analyses of the solving procedures observed *during the unfolding interaction*, aiming at apprehending the *acquisition processes*. How do children proceed concretely when they work together? Will the ways of acting together then be used as tools to build new individual reasoning?

Studying solving procedures puts forward the role played by the social meanings and practices related to the tasks, and more generally by the social contexts of resolution of these tasks. The social context and the cognitive development have begun to be regarded as overlapping and indissociable since researchers highlighted that regulations of a social nature which govern a given interaction - such as norms, conventions, representations, familiar social rules, contract of communication involving roles and expectations - can also generate new cognitive coordinations. Some researchers preferred to insist on the role of the social meanings and practices which are dependent on the type of the task: they have developed the social marking thesis (De Paolis, Doise, & Mugny, 1987; Doise, Dionnet, & Mugny, 1978; Gilly & Roux, 1988; Zhou, 2001). Research undertaken in cognitive psychology on the pragmatic schemas of reasoning can also be included here (Cheng & Holyoak, 1985; Girotto, 1991; Girotto, Blaye & Farioli, 1989; Girotto, Gilly, Blaye & Light, 1989). Other researchers chose to study the social meanings and practices which are dependent on the social contexts

of resolution: they have developed research based on the concepts of "contract" (Schubauer-Leoni & Grossen, 1993; Schubauer-Leoni & Ntamakiliro, 1998) or of "modes of social integration" (Monteil, 1995; Monteil & Huguet, 2001). Finally, other researchers considered the role of the social meanings concerned in the relational history of the partners in interaction. They observed that the nature of the relationship shared between partners – positive relationship versus negative one - overdetermines the cognitive management of tasks, by affecting the cognitive processes used by the dyad: children in "friend" dyads had more exchanges which were more elaborate and more critical than children in "not-friends" or "indifferent" dyads; they interacted in a cordial work environment (laughter, exclamations, teasing) characterized by reciprocity of exchanges, and they were more attentive, more respectful, and more demanding of each other. All of these are behaviors that allow them to take their partner's suggestions into account (Bukowski, Newcomb, & Hartup, 1996; Dumont & Moss, 1996; Kutnick & Kington, 2005; Nelson & Aboud, 1985; Newcomb & Bagwell, 1995; Sorsana & Musiol, 2005).

As Psaltis, Duveen and Perret-Clermont (2009) pointed out, this "second generation of studies" – an expression that we can extend to the whole research of this period (including non-Swiss research) - granted a more institutionalized role to social variables: the task is not only an activity which a child carries out with two or three partners (if we include the presence of the experimenter). To solve it, children use a whole of social parameters related to it. So the task is perceived as having a power of "mediation" (Schubauer-Leoni & Perret-Clermont, 1997) which can express a system of social positions between the partners and the "agent" (Psaltis, Duveen, & Perret-Clermont, 2009) because it is carrying an institutionalized history defining the situation as well as one's position and others'. These investigations are

also prolonged in the studies led by Mugny and his collaborators in social psychology (Quiamzade, Mugny, Falomir-Pichastor, & Chatard, 2006).

Study of the Discursive Activities and In-depth Analysis of the Links Between Cognitive Effects and Acquisition Processes: we consider that the third stage of the experimental study of the social conditions of cognitive development corresponds to the fact that researchers have taken into account discursive activities in their analyses. If it is true that "conversation and reasoning are being built at the same time" (Trognon, Saint-Dizier de Almeida, & Grossen, 1999, p. 139), then discursive activities must reflect the links between cognitive effects and acquisition processes. However, at that time, the idea of "interindividual coordination" of actions (and ideas) had only been examined by looking at the partners' solving procedures. It was not until the 1990s (Gilly, Roux & Trognon, 1999; Light & Perret-Clermont, 1989; Perret-Clermont, Schubauer-Leoni, & Trognon, 1992) that researchers in this field started paying attention to utterances, also considered to be actions. More specifically, they were interested in the discursive "grounds" in which solving procedures are empirically embedded (Clark, 1992, 1996, 1999). They began to study such "interindividual coordination" as a process anchored in negotiation, negotiation that no longer pertained solely to what we do together but also to what we say about what we do, thanks to pragmatics[6]. Today, contemporary analyses consist in identifying the conversational "materials" that carry (or even constitute …) the "mindprint" of the operations that build knowledge, as we will specify further (Gilly, Roux, & Trognon, 1999; Psaltis & Duveen, 2006; Sorsana, 2003, 2005; Sorsana & Musiol, 2005; Teasley, 1995; Trognon, Batt, Schwarz, Perret-Clermont, & Marro, 2006; Trognon, Sorsana, Batt, & Longin, 2008).

2. Contextual Determination of Human Thinking: What Method(s) of Analysis?

The contemporary endogenous conception of cognitive development posits "as distinct *a priori* the social and the cognitive, and had [sought] *a posteriori* their possible articulations, [which] amounts to considering communication on one side and representation on the other side as two independent entities, and to wondering, afterwards, how we will be able to put them together" (Caron-Pargue, 1997, p. 10). However, how can communication and representation be articulated? Obviously, the idea that comes immediately to mind is that it thanks to interaction. And, it is true that owing to the interactionist research trend since the 1960s, the study of "inter"-behaviors has gradually taken the place of "intra"-behaviors (Cosnier, 1998). Because it gave inter-action a fundamental role, this shift of focus contributed to specify the essential role of action as a source of knowledge and as an organizing principle of thought. For example, in the specific domain of infant cognitive psychology, the impact of action moved from actions on objects to actions on human relationships, but the fundamental role of action seems to be preserved (Lécuyer, 1996, 2006). Given that, interactions, here, are social actions, interactional behaviors are necessarily intersubjective. However, even if intersubjective participation[7] is considered in current concepts of "psychological state", "propositional attitude", "modality", and in axiological expressions, it remains difficult to conceptualize this subjectivity "objectively" even though such a conceptualization appears to be more and more epistemologically essential (Auchlin, 1990). A possible way to conceptualize intersubjectivity consists of analyzing a fundamental property of interaction, that is, its sequential ordering (Duncan & Fiske, 1985; Schegloff, 1991). As Schegloff's (1991) work showed, sequentiality indeed creates the possibility of a

[6] In the field of linguistics, pragmatics is concerned with the relations between the signs and the users. In other words, pragmatics consists in describing the meaning of the statements **in context.**

[7] Some of the correlates of this term are the being-with-others, coexistence, reciprocity, dialogue, and communication.

"third position repair" that "may be thought of as the last systematically provided opportunity to catch (among other problems) divergent understanding that embody breakdowns of intersubjectivity, that is, trouble in socially shared cognition of the talk and conduct in the interaction" (Schegloff, 1991, p. 158). By creating such an opportunity, sequentiality acquires a function of scaffolding of intersubjectivity. At the same time, this function constitutes a *procedural* solution to the problem of intercomprehension, which is at the core of semiotic communication (Trognon, 2002; Trognon & Batt, 2010; Trognon & Saint Dizier, 1999; Trognon & Sorsana, 2005) when we try to tackle this question from a theoretical point of view.

From Methodological Solipsism of Cognitive Psychology to the Study of Pragmatic Structures of Knowledge

To reach this goal, we will deal especially with linguistic interaction: "language and more particularly conversation may be a place where this controversy is likely to be overcome, by considering that communication and representation are only two indissociable faces of the same entity that one could divide up differently" (Caron-Pargue, 1997, p. 10). Language, considered as an internal process in the past, is now also being studied from the point of view of its use in cognitive psychology (Hilton, 1995; Politzer, 2004; Politzer & Macchi, 2000; Van der Henst, 2002). However, even though Bernicot and Trognon (2002) announced a "pragmatic turning point in psychology", much ground remains to be covered.

Caron (1997) brought our attention to the fact that in Western cultures, the answer to the question "What does it mean 'to speak'?" contains the idea of a prototypic individual who speaks all alone! Such a conception is based on the way cognitive psychology generally

analyzes language functioning, which is considered as an internal process because the cognitive system does not have access to what is outside it (Fodor, 1983). According to Fodor, cognitive processes in psychology can only study computational operations carried out on internal representations (which are strings of symbols). Two stages are described: (1) the translation of *mentalese* into natural language (or vice versa) via a specialized module, and (2) reprocessing by the central systems in order to integrate the translation into the subject's knowledge system. However, only the first stage (which is modular, and goes from the phonetic *input* to the *logical form* of the statement) can be studied scientifically. Such a process conveys the idea that "cognitive subjects are monads closed within themselves, each one developing his/her own computational activity, and whose communication can be only the result of a pre-established harmony. Grice's maxims are precisely conceived in order to protect this harmony: like two well-set clocks that mark the same hour without having to interact, in the same way, two subjects can share the same representation because they apply the same rules" (Caron, 1997, p. 222). A consequence of such an assumption is that it dissociates language and communication by considering communication as a purely internal phenomenon too, as it is assumed in Sperber and Wilson's (1995) Relevance Theory. These authors claimed that language does not exist for communication but for data processing; its use for communication is an accident specific to mankind – similar to the elephant's use of its trunk, which is an olfactive organ, to grab things is an accident specific to that species!

In fact, this "narrow" idea about the individual is shared throughout the cognitive territory. Schegloff writes, "In the Western tradition, it is the single, embodied, minded individual who constitutes the autonomous reality. Organized aggregations - whether of persons or of activities - tend to be treated as derivative, transient, and contingent. They are something to be added on, after basic understandings are anchored in individual-based reality. It has

accordingly seemed appropriate in the cognitive science to study cognition in the splendid isolation of the individual mind or brain and to reserve the social aspect for later supplementary consideration" (Schegloff, 1991, p. 168). Still today, the cognitive tradition has some difficulty being separated from a "general approach in which the individual is considered as a generic entity of a species equipped with information-processing mechanisms and not as an operator viewed in his/her individuality or his/her specificity from an ergonomic, clinical, or differential point of view" (Dubois, 1993, p. 38). However, the increasing interest in the study of "concrete situations" has given birth to the need to broaden research on human cognition by "situating" individuals in the entire set of practices that constitutes their daily activities (Greenfield & Lave, 1982; Hutchins, 1995; Lave & Wenger, 1991; Light & Butterworth, 1992; Rogoff, 1990; Rogoff & Angelillo, 2002; Saxe, 2002; Suchman, 1987; Valsiner, 2009). Among the multiple dimensions of these ecological situations, researchers are now interested in the *actual* reasoning strategies and procedures carried out during conversations, *in real time*, by *concrete* individuals, to the detriment of the epistemic subject who was so crucial for Piaget. In line with the "situated cognition" research developed more particularly in the United States than in Europe, "real time" studies have made the complexity of daily situations salient. To reach a goal, logical reasoning that goes from the premises to the conclusion is not enough, but depends on interactions with and between various dimensions of the situation (Weil-Fassina, Rabardel, & Dubois, 1993). In other words, explanatory models of cognitive functioning are focusing more and more on contexts and, actors interpretations as a function of the implication of the situation, the goals of the action, and the subject's experience (see Light & Butterworth, 1992; Politzer, 2004; Politzer & Macchi, 2000; Vallée-Tourangeau & Krüsi Penney, 2005; Vallée-Tourangeau & Payton, 2007). Consequently, in Human Sciences too, explanatory models are enriched by introducing random elements. And, we settle less and less for "modelling mental tasks that are

well-defined in terms of their initial data but have ill-defined goals from the operator's point of view" (Weill-Fassina, Rabardel, & Dubois, 1993, p. 15).

So, the cognitive approach today is encouraged to take into account two facts that are observable in concrete situations: "(a) an individual's cognitive functioning involves interaction with others, and (b) this interaction brings language into play in a critical way. This means trying to re-examine some concepts in a more rigorous - and empirically founded – manner: among them, inference, representation, and language concepts" (Caron, 1997). Rather than starting from an idealization of cognitive functioning, certain researchers including Clark (1992, 1996, 1999) proposed an opposite approach, i.e., starting from *empirical observations* of language functioning: "His approach is essentially different from the former one [Fodor's approach] in that he adopts, in relation to language, what he calls the *action view* (which starts from what people do with language in order to find out how it functions) as opposed to the *product view* (which starts from the structure of language in order to find out how it appears in speech - Clark, 1992, p. xiii). Language use involves a joint process – the partners' adjustment" (Caron, 1997, p. 226). Consequently, "the methodological solipsism claimed by Fodor, rather than defining the scientificity of cognitive psychology, it reveals its essential weakness. The cognitive subject is not a monad: he/she permanently interacts with his /her environment and in particular with others. Accounting for this interaction, and in particular for the verbal interaction that is undoubtedly the most elaborated form of interaction, constitutes an essential challenge for cognitive psychology" (Caron, 1997, p. 234). Some researchers try to meet this challenge by raising the following question (Politzer, 2004; Politzer & Macchi, 2000): If the study of reasoning begins by analyzing the interpretation of the premises in context, we must re-examine all of paradigms using

pragmatics. Granted, but not any pragmatic[8] approach. In the above perspective, it is "talk-in-interaction" that is the specific topic of pragmatics "because our understanding of the world and of one another is posed as a problem and resolved as an achievement, in an inescapably social and interactional context - both with tools forged in the workshops of interaction and in settings in which we are answerable to our fellows. Interaction and talk-in-interaction are structured environments of action and cognition, and they shape both the constitution of the actions and utterances needing to be 'cognized' and the contingencies for solving them. To bring the study of cognition explicitly into the arena of the social is to bring it home again" (Schegloff, 1991, p. 168).

What Method(s) of Analysis?

Contextual determination of human thinking gradually became essential in psychology. As Grossen (2001) pointed out, we can identify three common views of the concept of context. Each view leads to a different definition of psychology's object of study. On the one hand, to the question "Where are cognitions?" researchers who focus either on the epistemic subject or on the psychological subject implicitly assume that cognitions are necessarily located in the brain. This "psychology of the individual" defines context as "a set of discrete variables" (Grossen, 2001) that are likely to influence the subject's cognitive functioning and that the researcher can manipulate (for example, variables such as task instructions, the individual's preliminary knowledge, management of participants' identities and roles, etc). This dualistic conception of relationships between the subject and the object acknowledges the role of the

[8] Different conceptions of pragmatics exist: (1) an empirical discipline that inventories occurrences of sign sequences in a given language in order to determine their proper contexts of use, both in psychological and sociological perspectives, (2) a formal discipline whose objective is to discover and to formalize relations of functional dependence between a sequence of signs, its possible contexts of use, and illocutionary acts that it permits, and (3) a "transcendental" discipline aimed at determining the relation between signs and general

physical and social environment, but in a correlative way, considers that we can isolate what concerns the individual him/herself. Thus, "even a constructivist version of human development, which acknowledges that internal reality is not a simple reflection of external reality, does not account for the fact that 'to think', 'to express emotions', 'to state one's opinion', etc. are activities that are always socially-directed, and therefore also depend on the particular way in which actors construct meanings within a heterogeneous discursive space" (Grossen, 2001, p. 68). On the other hand, researchers who focus on the psychosocial actor rely on one of the following definitions of context mentioned by Grossen (2001):

- When the context is regarded as the fruit of an intersubjective construction, researchers consider that cognitions are not inside individual, "but in a specific space that both pre-exists to individuals' meeting and is constituted by their interactions. This heterogeneous and dynamic space is created and moved thanks to the construction meaning, places, and identities; it is reduced neither to a set of objective characteristics, nor to subjective perceptions that interactants may have" (Grossen, 2001, p. 71). The topic to study is no longer the individual but the socio-discursive processes by which cognitions are accomplished in the interaction that is unfolding, and become social and cognitive resources for participants.
- According to the situated-cognition approach, context is a cognitive system in which both the interdependence of each element relative to the whole and the irreducibility of the whole relative to the parts are highlighted. In other words, to the question "Where are cognitions?" researchers answer, "They are inside the system that is formed by interactions between individuals and tools; consequently, the discursive space created by these interactions constitutes

conditions of interlocution, recognized as a constitutive dimension of significance: there is no possible

> only one of the various aspects that characterizes this system" (Grossen, 2001, p. 72). This defines what Grossen (2001) calls the "psychology of the situation", but we prefer to call it the "psychology of the cognitive system" to better emphasize that the human being belongs to the system.

How can we study "human thinking as a fundamentally dialogical and indissociable activity of human communication" (Grossen, 2001, p. 68)? As well documented by Wertsch (2008), the child can develop self-regulative capacities by functioning in communicative settings involving other-regulation. Does an effective prototype of sociocognitive dynamics exist? Gilly, Fraisse and Roux (2001) stressed the difficulties raised by this question and insisted on the fact that the impact of interaction is to be understood using a "systemic model of sociocognitive functioning" in which the relations of dependence between "the characteristics of the task, the individual cognitive functioning and the sociocognitive dynamics" appear to be indissociable. Currently, we have studies which make an effort to identify the cognitive level (or the functioning) of the subjects in the pre-test/ interaction/post-test(s) design. However, they focus on various judgement tasks or resolution tasks. In addition, the behavioural or verbal categorizations used by researchers to specify the partners' sociocognitive dynamics vary from one study to another, their relevance depending in particular on the analysis levels privileged by researchers (even a transcription of corpus cannot be regarded as a neutral activity). Then, what shall we do? Some researchers take the risk to propose an answer: for example, Mercer (2000) considers his "exploratory talk" and Psaltis and Duveen (2006) their "explicit recognition" as actual types of conversational interactions making it possible "to think together" while other researchers highlight the complexity to interpret an instruction like "work together" and to act it (Tartas & Perret-

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significance nor communication by signs unless it satisfies the dialogical constraint (Grillo, 2000).

Clermont, 2008). Then, how can we go beyond this composite mosaic of analyses? It would seem that the general proposition is not anymore to create "reasoned methodological conceptualizations" (Bastien, 1994) but rather to articulate, in a heuristic way, methodologies diversifying the analysis levels before connecting them.

We are convinced that a suitable method for describing and explaining the cognitive system composed of the thinking subjects' behaviors in interaction with others, and of the semiotic systems that they use jointly by reinventing them within their socio-cultural environment, must be viewed in line with the microgenetic[9] approach developed in Inhelder's work (Inhelder, Sinclair, & Bovet, 1974; Inhelder, Cellérier, Ackermann, Blanchet, Boder, de Caprona, Ducret, & Saada-Robert, 1992). In order to do this, it seems important to promote a microgenetic analysis that clearly locates individuals' activity within the inter-individual, semiotic space of training or problem-solving situations. Indeed, a detailed analysis of micro-changes in thinking that integrates at least the inter-individual and situational level of the socio-cognitive organization of an activity (Doise, 1982/1986) is likely to guarantee better identification of the sequential processes essential to understanding cognitive progress. Why? Because we assume that the intraindividual (level 1), positional (level 3) and ideological (level 4) levels defined by Doise (1982/1986) all are embedded in the interaction (or level 2) (Trognon, Batt, Bromberg, Sorsana, & Frigout, 2011). Indeed, in Inhelder's approach, "it is only gradually that we think we are able to identify the pathways taken by the subject, in order to detect his/her procedures or action sequences. There is a part of inference making in our analysis, but a certain degree of objectivity will be attached to it when we confront the observers' points of view and use video recordings in a reasoned way, which allows us to

[9] "The concept of microgenesis encompasses the idea of working on another temporal scale than that of macrogenesis, but more generally, the idea of analyzing cognitive behaviors in great detail and all their natural complexity. Studying microgeneses uncovers the characteristics of the subject-object interaction process, which

avoid both an obsolete mentalism and the illusion that a pure reading of experience is possible" (Inhelder & de Caprona, 1992, p. 24). Confronted with a concrete task to be solved with a partner, participants decide by themselves how they will act instead of being confronted with an alternative whose terms are imposed by the experimenter. Moreover, because solving a problem is in keeping with social actions and interactions, their respective modes of reasoning are made "publicly" available to others and consequently to observers. So it becomes possible to describe and to formalize these modes of reasoning, their transpositions, and/or their transformations in the unfolding of the interaction.

Contemporary microgenetic analyses seem to be primarily related to a psychology of the individual (Granott & Parziale, 2002; Siegler & Crowley, 1991; Siegler & Svetina, 2002, 2006). Microgenetic analysis of socio-cognitive interactions should be attempted. Currently, these detailed analyzes are carried out from protocols based on experimental designs. We can distinguish two principal methods of interaction analysis: (a) a systematic coding of behaviors and/or speech from predefined categories (Olry-Louis & Soidet, 2008; Mercer, 2000; Psaltis & Duveen, 2007; Tartas & Perret-Clermont, 2008), and (b) formal analyses of verbal interactions aiming at demonstrating reasoning raising from conversations (Trognon, Batt, Schwarz, Perret-Clermont, Marro, 2006; Trognon, Sorsana, Batt, & Longin, 2008). We can criticize the use of categorizations because, doing so, it implicitly conceives that interaction is a closed system. Formal analyses, when they are based on a constructivist method - for example, Natural Deduction and Dialogical Logic (Trognon & Batt, 2010) -, provide a procedure which takes into account the fact that representations are being built gradually and are embedded in the social action and interaction. However, expensive in time, such formal analyses cannot be applied to the interaction in extenso. Nevertheless, each method above

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was analyzed in too general a way by Piaget. It allows one to detect potential coordination and integration of the

mentioned has integrated the need to be rooted on the fundamental characteristic of interaction which is its sequential ordering.

3. Formal Analysis of Sociocognitive Interactions: an illustration

Why is it important to favor a formal analysis of the verbal interactions in problem solving situation or training? On the one hand, using a formal language to analyse psychological phenomena is, in the long term, likely to make the studies truly comparable and to reach a cumulative knowledge in psychology rather than to consider an ad hoc categorization of these phenomena for each study. On the other hand, giving up the predefined categories amounts to conceiving that interaction is an open system. However, faced with many reports which show differences between observed performance and expected logical answers, can we still connect logic, reasoning and psychology? Which role is it possible to grant to logic to describe and interpret our daily reasoning? In the "passably chaotic field of research on reasoning" (Andler, 1995, p. 31), a position consists in recognizing that human beings are equipped with a mental logic while another position consists in rejecting logic as a resource or a fundamental cognitive capacity. However, as Andler (1995) clearly shows, even if psychologists seem to have failed to isolate a fundamental logical ability (or "its psychological counterpart which is a basic deductive skill"), today no tool can replace traditional logic in order to build or validate any kind of reasoning, even if a free field for many non-logical processes exists, because traditional logic is not sufficient and must be supplemented[10].

succession of partial solutions and models made by the subject" (Inhelder & de Caprona, 1992, p. 24).

[10] "The modern logic opened out throughout its search of absolute certainty and in the hope to strengthen the building of mathematics. This hope was useless. Actually, our reasoning holds upright because we process the data in a dynamic and interactive way, and because we correct our beliefs when these appear unsuited. Thus logic is not posed as a guardian of eternal safety, in a world which one would have cleaned of its contradictions. Logic rather seems the dynamic immune system of thought" (Van Benthem, 2005, p.73).

In order to take into account the fact that the objects of knowledge are being built gradually, the analysis tool should not start from a whole of pre-given objects. In addition, such a tool must involve both a constructivist and dialogical approach, if we subscribe to the assumption that conversation and reasoning are being built at the same time. Finally, this analysis tool must respect the empirical properties (or "phenomenal constraints") of conversation (Trognon, 2002; Trognon, Batt, Rebuschi, & Sorsana, 2011): (1) the conversational events are both actional and representational; (2) they are achieved sequentially, the ones following the others; they are thus directed and irreversible; (3) their production is local (i.e., it is managed step by step) on a level jointly social and cognitive, and is distributed between interlocutors, and finally (4) they constitute an emergent architecture, organized hierarchically. Interlocutory logic was conceived as a function of the phenomenal properties of conversation in order to provide a language which formalizes the achievement of reasoning in interlocution. It allows us to demonstrate that a training – in the unfolding of the interaction or from the interaction - has taken place (Trognon & Batt, 2003; Trognon, Batt, Schwarz, Perret-Clermont, & Marro, 2006; Trognon, Batt, & Sorsana, 2010; Trognon, Batt, Sorsana, & Saint Dizier de Almeida, 2011; Trognon, Sorsana, Batt, & Longin, 2006, 2008).

Characteristics of Interlocutory Logic

The goal of interlocutory logic is to formally express the indissolubly socio-cognitivo-discursive events which occur "naturally" in the talk-in-interaction (Trognon & Batt, 2010). In order to respect the empirical properties of the conversational events pointed out above, interlocutory logic combines a language (the language of the General Semantics, and in a first approach, the language of the modal logic of the first order predicates) and logical methods (natural deduction, sequents, dialogical logics) (Trognon, Batt, Rebuschi, & Sorsana, 2011).

More precisely, in order to grasp both the actional and the representational functions of the talk-in-interaction, the syntax of interlocutory logic depends on General Semantics, a logic elaborated by Searle and Vanderveken from the speech acts discovered by Austin (Searle, 1969; Searle & Vanderveken, 1985; Trognon, Batt, Bromberg, Sorsana, & Frigout, 2011; Vanderveken, 1990). The speech acts, formalized as follows - F(p), where F represents the actional function (or force) of the speech act and where p represents its representational function (or propositional content) - constitute sociocognitive bricks of the interpersonal exchange. It is from them that interlocutors make inferences about the speaker's meaning, and then about the meaning collectively assumed by them. The statements produced in context are analyzed by the F(p) formula and the p propositional content is expressed with the quantified modal first-order predicate logic combined with more "primitive" logical languages. To approach the (indirect or implicit) speech act that is likely to be achieved in the interlocution, we confront the literal representation of the speech act potentially achieved by the speaker with the knowledge in relation to the contexts in which the statement is uttered (Trognon & Coulon, 2001). Moreover, as we previously pointed out, the interlocutory events are accomplished sequentially, the ones following the others, and they are like concatenations, hierarchically organized. Consequently, reasoning which occurs in the unfolding of the interlocution is represented with the method of Natural Deduction and more precisely, with the Sequent calculation because this method presents the logical connectors as diagrams of inference, i.e., like processes and so, it can be applied to any type of reasoning (i.e., monotonous or non-monotonous reasoning). Finally, interlocution is the product of the interlocutors' joint activity; in other words, it is distributed. To grasp this last property, we prefer to use the dialogical method among other methods in relation to intersubjective processes managing interlocution (Trognon & Batt, 2010; Trognon, Batt, Rebuschi, & Sorsana, 2011). We will illustrate that in the following section.

Interlocutory Logic of a Sequence of Co-Resolution of the Hanoi Tower Problem

We present a verbal sequence between two 8-year-old children, confronted with the joint resolution of the tower of Hanoi problem, in a traditional experimental design (pre-test/social interaction/post-tests). This research, carried out with a sample of 44 dyads, aimed at understanding how the positive versus negative relationships shared between children can support a differentiated social and cognitive management of the problem. Audrey and Vanessa are friends and have to build a four-disc-tower from peg A to peg C (cf. figure 1).

- INSERT HERE FIGURE 1 -

Dialogue sequence

1Va: Let's put it (disc w) there (peg B)
2: co-action
3Va: let's put it (disc p) there (peg C)
4: co-action
5Va: after we take the other disc…
6Va: let's put it (disc w) there (peg C)
7: co-action
8Va: let's put it (disc g) there (peg B)
9: co-action
10: (lift up disc w)
11Va: on the green (disc g)
12Au: on the brown (disc b)
13Va1: no
13Va2: on the green
14Au1: no
14Au2: let's put the pink one there (on disc g)
15Va1: wait, wait
15Va2: (looks at the experimenter)
15Va3: let's put it on the green
16Au1: no
16Au2: afterwards let's put that one there (disc p on disc g, using her hand gesture)
17Va1: yes
17Va2: but we must build the tower there (peg C)
17Va3: ah yes

17Va4: that’s it
18: co-action (disc w on disc b on peg A)
19: co-action (disc p on disc g on peg B)
20Va: OK
21Au: (smiles)
22: co-action (disc w on disc p on peg B)
(…)

While the conversational sequence begins with moves initiated by Vanessa and jointly carried out, Audrey who was previously very reserved opposes a contradictory proposal to Vanessa in (12Au), by justifying her choice in reference to the further move: they agree about the choice of the disc to be moved (they lift up the white disc jointly) but they disagree on the peg to put it on. The disagreement emerges following the simultaneous stating of two contradictory propositions (11Va: "on the green (disc g)"; 12Au: "on the brown (disc b)"). The dissension is formulated by Vanessa who disputes and repeats her proposal (13Va). It is increased by Audrey who disputes the dispute (in 14Au) by referring to a future move (14Au2: "let’s put the pink one there (on disc g)"). This does not convince Vanessa who seems to seek the experimenter’s support by taking a look at her (15Va2) and she repeats her proposal once again (15Va3: "let’s put it on the green"). Audrey maintains her dispute by reformulating the move which comes "after" the move that she proposes and by miming the moves with her hands in order to probably try to make the anticipation of the 5th and 6th moves clearer (16Au). Vanessa puts an end to her successive dissensions (in 17Va), after she pointed out the final goal of the task (i.e., to build the tower on peg C).

How shall we formalize the reasoning implemented by the children?

The Interlocutory Table in Order to Prepare Interlocution for the Analysis

The transcription of the speech of each interlocutor is noted in two separate columns in order to materialize the property of dialogicity of conversation. Each column is subdivided into sub-

columns: in the first sub-column the statements are registered, in the order of their appearance to respect the property of sequentiality of dialogue. These ordered elements then receive their illocutory interpretations. The force of the speech act, defined by its goal, appears in the second sub-column, the propositional content in the third one. In the middle columns, the analysis of the inter-statements relations and the state of the world represented by the task and the children's body actions are noted step by step (cf. table 1).

- INSERT HERE TABLE 1 -

The Sequent of Dialogue as an Elementary Component of the Analysis of Interlocution: This term – sequent of dialogue – is taken from logic and indicates a couple noted as follows: $\Gamma \vdash F$. "Γ is a *finite* set of formulas. Γ represents the hypotheses that one can use. This set is also called the sequent context. *F* is a formula. It is the formula that one wants to demonstrate. This formula is said to be the *conclusion* of the sequent" (David, Nour, & Raffali, 2003, p. 24). Interlocutory logic adds the formulas of General Semantics to the extension of the sequent. By adopting a way opened by Carlson (1983), each utterance is represented by an expression ϕ of the system: $<M_i, \{M_{i-k}\},\{M_{i-k}\} \vdash M_i, RD, DG>$. M_i is the conversational move accomplished by the utterance under examination. $\{M_{i-k}\}$ is the set of all the conversational moves that precede the move M_i and from which M_i follows. M_i can then be conceived as a *conclusion* that results from *premises* $\{M_{i-k}\}$. The reasoning that leads from $\{M_{i-k}\}$ to M_i, and that is represented by the schema $\{M_{i-k}\} \vdash M_i$, is called, in logic, a sequent. RD is the whole of the rules of dialogue used by the speakers to accomplish their movements in the dialogue. Finally DG corresponds to the dialogue game(s) played by the speakers in the analysed sequence.

Let us consider the first utterance emitted by Audrey in the unfolding conversation about the problem resolution:

12Au: on the brown (i.e., disc white on disc brown)

This elliptic utterance is only a Prepositional Group. It is literally an assertive speech act and, non-literally, a directive as well as a commissive speech (because a commissive act is a directive act that the speaker aims at himself). Its conversational function here is 1) to make a proposal for a joint action and, 2) in consequence, to refuse Vanessa's proposition (11Va) suggested in the preceding speech turn. Using expressions of the quantified modal first-order predicate logic, the propositional content of 12Au (i.e., the cognitive function of the speech act) is the modal expression which describes a future action of the children, as follows (Trognon, Sorsana, Batt, & Longin, 2008):

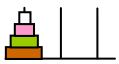
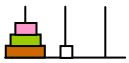
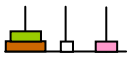
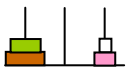
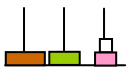
12Au: E_a {[shall E_{v+a} (Awb)]}

E_a: means the (E) action achieved by Audrey (a). The propositional content of this action: [shall E_{v+a} (Awb)], with the Awb formula which means *white disc on brown disc on peg A*, is describing a state of the world (Awb) which would be realized in the future ('shall' is the modal marker of the future) by the joint action of the two girls, Vanessa and Audrey (E_{v+a}).

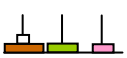
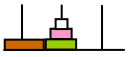
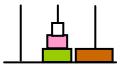
In order to be more understandable, we can simplify the formulas as presented below. Once the 9 co-action is carried out, the four discs arise on the pegs as follows: the brown disc is on peg A, so we write [A(-, -, -, b)], the green disc is on peg B, so we write [B(-, -, -, g)] and the white and pink discs are on peg C, so we write [C(-, -, w, p)]. When several discs are on the

same peg, they are written from the smallest one to the biggest one. Thus, the overall configuration of pegs and discs is: [A(-, -, -, b) & B(-, -, -,g) & C(-, -, w, p)].

The different stages followed by the children until the preceding configuration are as follows:

Initial situation	A(w, p, g, b) & B(-, -, -, -) & C(-, -, -, -)	
1Va then 2 co-action	A(-, p, g, b) & B(-, -, -, w) & C(-, -, -, -)	
3Va then 4 co-action	A(-, -, g, b) & B(-, -, -, w) & C(-, -, -, p)	
5-6 Va then 7 co-action	A(-, -, g, b) & B(-, -, -, -) & C(-, -, w, p)	
8 Va then 9 co-action	A(-, -, - , b) & B(-, -, -, g) & C(-, -, w, p)	

The children have two options when they lift up disc w. Either Vanessa and Audrey put it on peg B (on the green disc) as suggested by Vanessa: [B(-, -, w, g)]. Either they put it on peg A (on the brown disc) as suggested by Audrey: [A(-, -, w, b)]. The choice is strategically decisive because the girls are very close to reaching an essential subgoal in the solution of the problem. In order to do so, they have to proceed from 9 as follows below:

A(-, -, w, b) & B(-, -, -, g) & C(-, -, -, p)	
A(-, -, w, b) & B(-, -, p, g) & C(-, -, -, -)	
A(-, -, -, b) & B(-, w, p, g) & C(-, -, -, -)	
A(-, -, -, -) & B (-, w, p, g) & C(-, -, -, b)	

Why is this procedural choice so crucial? From a logical standpoint, it is obvious that to move the white disc on the brown disc (Audrey's proposal) is more efficient than to move the white disc on the green disc (Vanessa's proposal) because, in the first proposal, the pink disc may be moved on the green one, then the white disc on the pink one, and finally the brown disc on peg C. From a psychological standpoint now, in their modelling of the solution of the problem, Richard and Poitrenaud (1988) and Richard (1991) demonstrate that in this solving stage the participants (including adults) invent an additional rule which consists in avoiding placing another disc on the larger disc – finally released – and favouring the movement of the white disc onto peg B.

From 11Va to 21Au, the children will reach the best solution. However, they will have to exceed a sociocognitive conflict before, which develops as follows. From 10 to$13Va_2$, the conflict emerges. Each girl states the goal she wants to carry out (11Va versus 12Au), then the incompatibility with the partner's goal ($13Va_1$ versus $14Au_1$): the contradiction of the propositional contents involves an incompatibility of the acts (Searle & Vanderveken, 1985). An argumentative phase follows, where each player argues her thesis ($14Au_2$-$16Au_2$ versus $17Va_2$). Then, a phase of resolution *may* close the conflict, where one of the girls adopts the option initially suggested by her partner.

A simple reasoning *ad absurdum* leads each girl to deduce a contradiction by calculating her proposal with her partner's proposal taken as an assumption. Because each girl cannot indefinitely repeat her point of view, except by entering a "dialogue of the deaf", the children must adopt another dialogue game if they wish to prolong their cooperation. Then they

engage in a mixed dialogue of argumentation (Rips, 1998; Walton & Krabbe, 1995), which consists in persuading her partner by using a battery of strategies. One of these strategies is to challenge her partner to argue in favour of her own thesis. If a player receives a challenge, then he/she must put forward an argument, otherwise he/she looses the game. In this interaction, no challenge is uttered, but the children put forward their arguments respectively. Let us examine both the justification put forward by Vanessa ($17Va_2$) and the arguments uttered by Audrey in order to reject Vanessa's proposal ($16Au_1$ + $16Au_2$). The former follows from the latter: ($16Au_1$ & $16Au_2$) → $17Va_2$

According to the dialogue game theory of persuasion (Walton & Krabbe, 1995), a player wins the game when he/she manages to demonstrate his/her thesis starting from the opponent's concessions. If we suppose that Vanessa took Audrey's assertions for assumptions in her own reasoning, then she should deduce $17Va_{2.}$ Consequently, Vanessa hasn't got any more reason to reject Audrey's proposal. At this step of the task resolution, Audrey's proposal and Vanessa's both lead to the same situation - the release of the peg C – but Audrey's proposal remains strategically higher, because it makes it possible to reach a key subgoal of the problem more quickly. It is subjected to the condition that Vanessa's proposal will be followed by a move of the pink disc on the brown one, proposal which is not uttered by Vanessa. In any case, the positive relationships between the two girls are likely to support the resolution of the disagreement ($17Va_{3\text{-}4}$). Therefore they accomplish Audrey's solution (18-19), and Vanessa approves its accuracy (20Va) to Audrey's satisfaction which she expresses with her smiles (21Au).

Vanessa will not need to devote herself to a comparative study of the consequences of both her proposal and Audrey's on the rest of the play to adopt her partner's standpoint: the interest

of Audrey's proposal is "staring her in the face". In other words, Vanessa's understanding (17Va3: "ah yes", 17Va4: "that's it") seems connected to the fact that Audrey's proposal is compatible with the recall (made by Vanessa) that the tower must be built on peg C. Finally Vanessa accepts her partner's proposal, as if the fact of being friend and of obtaining satisfaction to the request formulated in 17Va2 was enough. The positive relationship between the two girls here functions as "an affective operator" which prevents that the interaction becomes a "dialogue of the deaf". In addition, the success of Audrey's strategy, that the children will then test, will reinforce their decision positively. It may be thanks to a contingent interaction like the one that we have just examined that Audrey and Vanessa acquired the solution of the Tower of Hanoi problem.

Conclusion

Human activities are never carried out in a social vacuum. So why do we persist in studying the cognitive development and functioning of a virtual "monad"? According to Bruner (1990), the study of the human mind is so difficult, so deeply entangled in the dilemma of being at the same time the object and the agent of its own study, that psychologists should not limit their ways of thinking to those borrowed from physics. A psychological analysis of the contextual determination of human thinking can find a heuristic way of combining methods (Deleau, 2004; Hinde, Perret-Clermont, & Stevenson-Hinde, 1985; Richelle, 1993; Shotter, 1990; Wassmann & Dasen, 2006). At the end of their book, which proposes to clarify the methodological criteria for identifying interactional events, Duncan and Fiske (1985) wrote, however: "The challenge to interaction research is to devise methods for dealing with this ongoing effect of each participant upon the other. To an essayist or interaction theorist, the process of common participation (not to mention continual mutual influence) might appear as

a fascinating theme to be developed and elaborated in all its variety and complexity. However, to a researcher, that fascinating process might be seen as more of an infernal, convoluted tangle of simultaneous effects. The research task becomes an exercise of a delicate and complex disentangling of these effects" (Duncan & Fiske, 1985, p. 301). Trying to "clinically" establish the impact of interaction structures and their products on a cognitive individual's performance is a promising avenue of investigation, and a difficult task that consists of disentangling the processes that lead to the expression of knowledge that is "distributed" between interlocutors and "situated" in a dynamic interpersonal and socio-cultural context.

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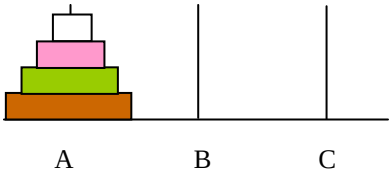
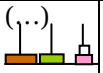
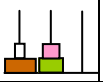
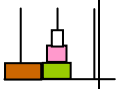


Figure 1. The Tower of Hanoi with four discs (D1 is white (w), D2 is pink (p), D3 is green (g), D4 is brown (b))

Table 1: *Interlocutory Analysis Table*

AUDREY					VANESSA		
Utterances	Illocutory goal	Propositional content	Relationship between utterances	State of the world	Utterances	Illocutory goal	Propositional content
				 10: (lift up disc w)			
			Proposition		11Va: on the green (g)	Directive-commissive	B(-, -, w, g)
12Au: on the brown (b)	Directive-commissive	A(-, -, w, b) => ¬ B(-, -, w, g)	Proposition and implicit rejection of 11Va				
			Explicit rejection of 12Au and repetition		13Va1: no 13Va2: on the green	Assertive Directive-commissive	¬A(-, -, w, b) B(-, -, w, g)
14Au1: no 14Au2: let's put the pink one there (on disc g)	Assertive Assertive	¬B(-, -, w, g) B(-, -, p, g)	Explicit rejection of 13Va Argument				
			Request Repetition		15Va1: wait, wait 15Va2: (looks at the experimenter) 15Va3: let's put it on the green	Directive Directive-commissive	B(-, -, w, g)
16Au1: no 16Au2: afterwards let's put that one there (p on g, using her hand gesture)	Assertive Assertive	¬B(-, -, w, g) B(-, -, p, g)	Explicit rejection of 15Va3 New formulation of the justification of the rejection, using a temporal term (afterwards)				
			Recall of the final goal of the task		17Va1: yes 17Va2: but we must build the tower there (peg C)	Assertive Assertive	C(-, -, -, -) => C(w, p, g, b)

			Agreement		17Va3: ah yes 17Va4: that's it	Expressive Assertive	
			Success and satisfaction of 12Au	**18** : co-action 			
				19 : co-action 			
			Agreement		20Va: OK	Expressive	
21Au: (smiles)	expressive		Satisfaction				
				 **22:** co-action (…)			