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Cognitive Style and Operational Development: A Review of French Literature and a Neo-Piagetian Reinterpretation*

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The first objective of this chapter is to present the French-language studies conducted in the realm of individual differences (ID) approaches, in order to stress their original contribution. These studies are indeed little known within the English-speaking community of psychologists, probably both because of long-standing differences in epistemology and of language barriers. The stress that French differentialists have laid on the necessary integration of general and differential (as ID approaches are traditionally referred to in French) approaches, particularly on the bringing together of the Piagetian model and of the differentialist methodology and empirical findings, will be described. Indeed, Piaget’s theory was never intended to account for individual differences, and cannot in itself do so, although it can provide some useful heuristics, as will be demonstrated below. Nevertheless, numerous studies have pointed to the existence of a relatively great individual variability with respect to operational development, demonstrating that individual differences represent more than errors of measure or “noise,” or mere differences of speed, as many generalists or probably Piaget himself would have liked to believe. This problem can be tackled from two perspectives that are not exclusive: One approach consists in looking at individual differences from within the Piagetian model, by relying essentially on operational tasks and focusing on the intra-individual variability in order to determine whether it conforms to lawful patterns.

A second approach consists in resorting to outside of the theory or independent variables, such as differences in cognitive styles, and assessing their influence on (or at least their covariation with) operational development. Among the different cognitive styles defined in the literature, French studies have essentially focused on field-dependence-independence (FDI); more recently, several studies have tried to validate the existence of a new cognitive style on the basis of Reuchlin’s suggestion of a dimension of formalization-realization, meant to account better than the Piagetian model for everyday situations. The distinction established between these two perspectives is somewhat akin to that existing in differential psychology (e.g., Reuchlin, 1969) between approaches, such as the factorialists’ analyses, trying to define a posteriori the organization of behaviors, on the one hand, and approaches trying to determine whether a priori distinctions (e.g., a priori distribution of individuals according to sex, or socioeconomic status, etc.) have an equivalent in terms of psychological differences, on the other hand. A number of studies will be discussed below with respect to each approach. The second objective here is to demonstrate the relevance of Pascual-Leone’s Theory of Constructive Operators (TCO), for clarifying the links between operational development and the two cognitive styles under discussion; the model evolved out of the Piagetian theory precisely in order to account for individual differences in cognitive development, and can be considered to integrate the two trends just described, which increases its predictability.

It has been an originality of the French differentialists for many years to have required that the study of individual differences be integrated in general psychology. Reuchlin played an essential role in suggesting a general constructive-rationalist approach (for instance, Reuchlin, 1962) and several very fruitful hypotheses with respect to the integration of general and differential psychology. Indeed, differential psychology or psychometrics has often been restricted to a description of individual differences and of their magnitude, essentially in an applied context (construction of tests, etc.) By way of contrast, Reuchlin requires that it be tied to general psychology, in the sense of individual differences being accountable for in terms of general laws. Whereas Cronbach’s recommendations (1957) for bringing together general and differential psychology were not followed for many years in North America (e.g., Resnick, 1976: Sternberg, 1981), Reuchlin not only suggested theoretical ways to integrate Piagetian psychology and differential psychology, but his recommendations were followed relatively quickly at an empirical level (for instance, Longeot, 1969).

A first step toward integration of the two disciplines consists therefore in relying on general laws in order to understand the well-established empirical facts of the differentialists. Reciprocally, a second step consists in asking from general theory to accommodate to individual differences, and determining whether it can do so without major modifications. One of the main questions raised by the Piagetian model for instance, as will be developed below, is how much it can accommodate to the magnitude of intra-individual variability. As Reuchlin (e.g., 1964, 1969, 1977, 1981) demonstrated, an ID approach can prove useful in that it provides a method for assessing the extent of individual variability and contesting the randomness that generalists have often associated with it; individual variance may result from systematic factors that refine and/or modify general laws. Further, an ID method may support the hypothesis that different individuals of a similar general level use different processes for solving the same problem (Reuchlin’s vicarious process; see below). It can also demonstrate that individual differences present a relatively great stability across psychological domains; i.e., that they are predictable (at least partly)

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from one domain to the other, on the basis of standard situations. The cognitive style of field-dependence–independence (FDI; e.g., Witkin, Dyk, Faterson, Goodenough, & Karp, 1962; Witkin & Goodenough, 1981) for instance could be considered to constitute one of those standards, as numerous publications in different domains attest.

The first part of this chapter examines the compatibility between the Piagetian model and the existence of individual differences. A number of French-language studies interested in the intra-individual variability of operational development in general will be reviewed; studies trying to account for this variability in terms of cognitive style will then be discussed, first those studies focusing on FDI, then those dealing with Reuchlin’s cognitive style of formalization and realization. The potential relationships of these two cognitive styles will also be discussed. In the second part, Pascual-Leone’s Theory of Constructive Operators (TCO) is briefly presented, and the model is used as a heuristic tool for attempting to reinterpret some of the results described in the first part.

The Piagetian Model of Development and the Individual Differences Approach

Reuchlin proposed as early as 1964 to use the Piagetian model for explicating some of the factorialists’ empirical findings; in particular, he emphasized the relevance of Piaget’s concept of operational development, or equilibratory process, for understanding the existence of the factor $g$. Reciprocally he suggested the insertion into the Piagetian model of notions such as that of “regional acquisitions,” i.e., stable acquisitions in certain areas only and not in others, analogous to the factorialists’ group factors. He later (Reuchlin, 1973, 1977) hypothesized that Piaget had only taken into account one type of cognitive processes, the Formalization (i.e., the elaboration of different forms of knowledge) while there was another type, more directly linked to natural situations, Realization. He also suggested (Reuchlin, 1978) that each individual disposes of several adaptive processes that, despite a certain redundancy (frequent in nature), might function vicariously or alternatively. These processes differ by the extent of their evocability and could be scaled accordingly; their hierarchy might in turn differ from subject to subject, and as a function of experience (whether and how much each process has been reinforced). Note that, as was later developed by Huteau (e.g., 1981), the preferential use of one type of processes could be related to cognitive style differences. The very notion of vicariousness demonstrates that, consistent with Witkin’s postulates, cognitive style has never been confounded in France with general intelligence. Reuchlin’s different hypotheses propelled numerous research projects. Longeot (1969, 1978) took up Reuchlin’s suggestions to use a differential method with Piagetian tasks, and in particular to look for an isomorphism between operational development and factor $g$. Lautrey (e.g., 1980a) also adopted one of Reuchlin’s proposals (Reuchlin, 1972), that is, that the Piagetian model of equilibration be used to understand how socio-economic differences and educational practices influence cognitive development.

Finally, Longeot (e.g., Longeot, Dupraz, Giraud-Charpier, Hollard, & Paturel, 1982a) and Carbonnel (1978), among others, attempted a test of Reuchlin’s hypothesized dimension of Formalization–Realization.

Two main lines of research already mentioned above seem to have emerged with respect to the integration of methods: One trend of studies focused on intra-individual operational variability with the objective to determine whether it corresponds to stable lawful patterns (that in a second time could possibly be related to stable individual differences). A second trend focused directly on the association between operational development and stable individual differences such as cognitive styles, in order to assess their influence on the ages of acquisition of different notions and/or on the extent of operational heterogeneity.

Intra-individual Variability of Operational Development

Along the first line of research, Longeot (1969) was among the first ones to follow Reuchlin’s suggestions, by applying a differential approach to formal operational development. He conducted factor analyses on a battery of operational tasks elaborated on the basis of Piaget and Inhelder’s (1951, 1955) work; results demonstrated that these tasks can, just as psychometric tasks, yield a general factor, and that there is indeed some sense in understanding the existence of a general factor as a manifestation of equilibration. Reciprocally, however, they also pointed to the presence of group factors, i.e., of individual variations in the clustering of formal performances. In this case two group factors emerged, identified with the two main structures postulated by Piaget and Inhelder to underlie the formal operational stage: the combinatorial and the INRC structures.

Later, Longeot (1978) suggested further modifications of the Piagetian model in order to account for individual variations in development: During the phase of preparation of a stage, different individuals might follow different paths in the construction of notions, whereas during the phase of achievement (and before the phase of preparation of the next stage) all trajectories would converge. Development would therefore consist of a series of successive loops. His 1969 studies could be considered as a demonstration of the existence of two paths during the phase of preparation of the formal operational stage: one path leading from INRC to combinatorial structures, and the other in the reverse direction. Such results are not compatible with the unidimensionality of development implicit in Piaget’s model. According to a unidimensional perspective, all subjects are supposed to follow the same developmental trajectory (in this case all subjects should construct in parallel the two formal structures), whereas Longeot’s work demonstrates that different subjects can access the formal stage through at least two different routes and well develop one structure while not yet demonstrating any signs of the second structure (and vice versa). Longeot later (1978) suggested to link these two types of operational construction with verbal and spatial contents (in accord with the two well-established psychometric group factors). This results in at least four different ways to enter the formal operational stage (and more for a further progress in the stage): combinatorial structure applied to a verbal or a spatial content, INRC applied to a verbal or a spatial
content. He also suggested definition of content group factors on the basis of Piaget's distinction between logicomathematical and infralogo logical operations. Recall that, for Piaget, the distinction between logicomathematical and infralogical operations refers to the "scale" of the objects on which they are applied: logicomathematical operations structure sets of individual or discrete objects while infralogical operations deal with part-whole relationship within an individual object, taking their spatiotemporal relationships into account.

Longeot's empirical studies finally demonstrated, although he did not insist on this point, that the closing of one structure might not be complete before the next structure begins to be constructed. Some subjects exhibited already some formal competence in one domain, while concrete operations were not yet achieved in another. This points to individual differences still greater than expected. Lautrey (1980b), elaborating on Longeot's data, demonstrated that intra-individual variability was not limited to decalages of one stage, and emphasized qualitative differences, pointing to the importance of figurative aspects of knowledge (see below) in monitoring the transition from concrete operations to formal operations.

Similar work has been carried out within the stage of concrete operations by the present author in collaboration with L. Rieben in Geneva and J. Lautrey in Paris (e.g., Lautrey, de Ribaupierre, & Rieben, 1981, 1985, 1986, 1987; de Ribaupierre, Rieben, & Lautrey, 1985; Rieben, de Ribaupierre, & Lautrey, 1983, 1986). The main objective of the research project was to assess the magnitude and form of intra-individual variability, by using tasks representative of different domains. It also attempted to provide a valid methodology for studying within stage relationships between tasks. This constraint not only requires to remain within a strictly ordinal scale, but also to tackle the problem of horizontal decalages (defined by Piaget as a time lag in the mastery of two concepts supposed to pertain to a same structure) by trying to dissociate the intricate aspects of complexity and of individual differences. For this purpose a structuralist type of analysis was developed in terms of dimensions of transformation in order to establish correspondences between tasks (or between items), to account for differences in complexity, and to help bring out more clearly variations imputable to individual differences.

Although still in progress, the research demonstrates that intra-individual variability is indeed very important, and cannot be simply interpreted as differences of speed along a same development. The existence of individual decalages, that is, of decalages that are in different directions for different subjects (e.g., Lautrey et al., 1985) points to the presence of different forms of development. The observed intra-individual decalages also tend to demonstrate, on the one hand, that the distinction between logicomathematical operations and infralogical operations is valid and, on the other hand, that figurative aspects of knowledge (e.g., perception, imitation, mental imagery, and memory) are not simply subordinated to operative aspects (e.g., mostly actions and operations) as Piaget assumed; they also play a monitoring role in development. Moreover, the relative role of these two aspects of knowledge could differ for different subjects. The results obtained led us to suggest recently (de Ribaupierre, Rieben, & Lautrey, 1986) the definition of two types of information processing (digital versus analogical) in interaction with two types of situations (logico-mathematical versus infralogical); the digital mode is supposed to be more adequate for treating logicomathematical situations while the analogical mode is more appropriate for treating infralogical situations. The digital-analogical distinction is akin to that used by Globerson (this volume, 1986) between formal and intuitive thinking.

In terms of individual differences, these distinctions lead to the definition of at least four types of subjects: subjects that shift easily from one type of treatment to the other as a function of situations, with the probable consequence of presenting a synchronous pattern in terms of performance on the operational tasks used in the project; subjects that rely preferentially on the digital mode and use it in both types of situation, with the likely outcome of presenting an intra-individual decalage in favor of logicomathematical operations; subjects that rely preferentially for each type of situation on the analogical mode, with the consequence of an advance of infralogical over logicomathematical operations; finally subjects for whom both modes of treatment are equivalent in terms of their accessibility, but who do not know which mode apply to which situation. This distinction between types of subjects in terms of privileged modes of treatment could of course also be linked to cognitive style differences, such as FDI; the relationship has not been tested on our data yet, although Wittin's CEFT has been administered to all children, but it would be concordant with the work to be presented now.

Field-dependence—Independence and Operational Development

Many studies dealing with the links between FDI and operational development have been devoted to demonstrate that some operational tasks are very sensitive to differences of style and/or that FDI modulates the ages at which certain notions are constructed. As soon as the FDI cognitive style was known in France, differentialists were interested, following the pioneering work of Pascual-Leone (1969) in the integration of Piaget's and Wittin's approaches, to test its covariation not only with ages of achievement, but also with individual variability of cognitive functioning.

Huteau, who contributed greatly to spread the knowledge of Wittin's work, by writing several thorough reviews in French (e.g., 1975, 1980), was among the first in France to conduct empirical work on the topic. He adopted Pascual-Leone's proposal to consider FDI as the ability to overcome a situation of cognitive conflict. The embedding context is supposed to inhibit (like in Embedded Figures Task) or to modify (as in the Rod and Frame Test) the perception of the element. Huteau suggests to link this definition of FDI with Piaget's distinction between operative and figurative aspects of knowledge: The FDI dimension could be identified with the subjects' ability to overcome resistances raised by figurative aspects. The Conservation tasks, whose similarity with standard FDI tasks had already been demonstrated by Pascual-Leone (1969), represents a good example of this type of ability.

The figurative-operative distinction can be further operationalized by referring to the distinction between logicomathematical and infralogical tasks: Although the correspondence is not univocal, figurative aspects play a greater role in the latter
type of tasks. Therefore, Huteau directs his reviews of question according to this hypothesis. Most studies using Conservations and Spatial tasks (infralogical tasks) point to the presence of differences between field-independent (FI) and field-dependent (FD) subjects, whereas this is not the case of many logicomathematical tasks. In his own work, Huteau (e.g., Huteau, 1981; Huteau & Rajchenbach, 1978) predicts not only that some tasks will yield differences between the two types of subjects, but that FD subjects should prove more heterogeneous, since they are more sensitive to field aspects in situations. In terms of vicarious processes (according to Reuchlin’s terminology), this prediction means that FD subjects cannot rely as easily on figurative aspects of knowledge when such aspects could help solve the problem nor can they shift as smoothly from figurative to operative aspects as FI subjects; they might therefore present some specific delay in infralogical tasks (when figurative aspects are misleading) over logicomathematical tasks.

In a study with adolescents, Huteau and Rajchenbach (1978) used three operational tasks (taken from Longeot’s battery), which can be ordered with respect to the decreasing influence of figurative aspects: Conservation of Volume, Quantification of Probabilities and Permutations. Subjects that performed at the higher operational level in the first two tasks (preformal for Conservations and formal for Probabilities) were more FI than subjects who were still at a concrete level. There were, however, no difference in terms of FDI between concrete and formal subjects on Permutations. Moreover, the subjects whose intra-individual variability was greater were also more FI. Huteau found similar results with younger girls, who were administered Conservation of continuous quantities (Liquids) and Seriation, i.e., an infralogical and a logicomathematical task: Girls who were already at the concrete operational level for Conservation task were more FI, but there was no FDI difference between concrete operational and preoperational subjects in the Seriation task. The hypothesis of a greater heterogeneity of FD subjects was not supported in this second study, although the form of heterogeneity was congruent with the hypothesis: Subjects who were conservers while still nonincluders were indeed more FI than those presenting the opposite pattern. In general, such results attest that a distinction has to be established between cognitive style and cognitive development: FD subjects can be equivalent to FI subjects in terms of operational level, provided the situations are not too “saturated” in figurative aspects. Nevertheless, the relationship between operational development and FDI is complex, as demonstrated by Ohlmann’s results.

Like Huteau, Ohlmann (1986; Ohlmann & Mendelsohn, 1982) hypothesizes a greater heterogeneity and dispersion in FD subjects, or, in Reuchlin’s terminology, a lesser evocability of vicarious processes and a lesser flexibility. He first (Ohlmann, 1981) demonstrated that FD subjects present a greater discrepancy between visual and tactualokinesthetic evaluations of the length of rods than FI subjects, and are more sensitive to a change of material. According to Huteau’s hypothesis, he predicted specific difficulties and consequently a greater heterogeneity of FD subjects in tasks involving figurative aspects. He found on the contrary (Ohlmann & Mendelsohn, 1982) that the most homogeneous subjects were FD; it suggests, this time, a specific advance in FI subjects of infralogical operations over logicomathematical operations. This leads to the conclusion that age modulates the relations between heterogeneity and cognitive style. In a sample of relatively young subjects (in this particular study, the average age was 9 years 6 months), FI subjects would present an advance in infralogical tasks: because they can rely as easily on operational as on perceptual and/or spatial processes, they supplement (or probably even replace) operational by more perceptual activities. They might as a consequence, and at an age of transition (i.e., when operations are not completely achieved yet), present an advance in the infralogical over logicomathematical situations. In relatively older subjects, i.e., when age well corresponds to the acquisition of the notion, FD subjects would present an elective deficit in infralogical operations. All results seem to go in this direction: in younger (9 years 6 months; Ohlmann & Mendelsohn, 1982) and in older subjects (Marendaz, 1984), field-independence leads to greater success in infralogical situations as evidenced by the greater heterogeneity of FI subjects; the opposite pattern is found in intermediate ages where, when there is decalage, it is to the detriment of infralogical operations (Bajard, 1984; Huteau, 1981; Marendaz, 1984). Such a hypothesis implies of course that different processes concur in shaping the development, which as a consequence can no longer be considered to be unidimensional.

Ohlmann (e.g., Ohlmann et al., 1985) also attempted to deal directly with the definition of the FDI dimension itself, and to show that FDI indicators themselves can be heterogeneous, because they represent different dimensions. His present hypothesis is that the necessity of overcoming a cognitive conflict induced by a misleading context (as assumed by Pascual-Leone and Huteau) cannot in itself explain the similarity among FDI indicators, but that, consistent with Witkin’s later work (Witkin & Goodenough, 1981), FDI results from the differential use of internal versus external referents. FD subjects are supposed to be more sensitive to exteroceptive characteristics, while FI subjects essentially rely on internal referents.

Ohlmann attempts to demonstrate this difference by studying more closely the problem of horizontality (after, for instance, Pascual-Leone, 1969). He submitted the subjects to a series of variations of RFT (vertical as in the usual RFT, horizontal, inclined) in order to assess whether subjects rely on internal or on external referents, to CEPFT considered as an indicator of cognitive restructuring, to operational tasks of horizontality and verticality, as well as to a general factor task. The tasks formed two different clusters in girls (one cluster consisting of the RFT tasks, and the second of the other, more cognitive tasks); by contrast all these indicators tended to covary in boys. Further, where there was a difference between both groups (age 9.6) for the RFT, there was no difference for EFT nor for operational tasks. His conclu-

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[1] FD subjects are supposed to rely mainly on operational structures and less on other processes such as figurative aspects; they therefore have to wait for a complete achievement of these structures before mastering tasks that could (and apparently are as attested by FI subjects’ performances) be solved by other means. One can even add to the hypothesis that the construction of infralogical operations takes more time in FI subjects because it is not facilitated by other processes.
sions are that girls, like FD subjects in general, essentially rely on operations in all problems implying horizontality and verticality, whereas boys can also resort to internal or postural informations. The conclusions are not very convincing, however: if indeed boys were using two types of processes versus a single one for the girls, one might as well expect inverse results, i.e., overall correlations in the latter group and two clusters in boys. The relationships are probably still more complex, and not only do they point to the presence of an interaction between tasks and sex as mentioned by Ohlmann, but to the multiplicity of processes underlying the performance in FDI tasks and also to an interaction between the subjects' age and the task's complexity. The subjects' operational development could just be not advanced enough for the tasks to function differentially, that is, they could not discriminate subjects in terms of individual differences per se; tasks would only serve as developmental evaluations.

Formalization—Realization and Operational Development

Reuchlin (1973, 1978) suggested what he called a "hypothesis about natural thought" in order to account for the fact that subjects do not necessarily behave as logicians when they have to react quickly (in everyday situations for instance); neither do they function consistently at the highest level reached during development (the latter part of the hypothesis is that developed by Longeot, see below). In consequence, the Piagetian model can be considered to have addressed only one type of thinking, the formalizing thought or Formalization, analogous to the logician's thought; there is another type of thinking, the realizing type or Realization.1

The two types of thinking are supposed to coexist and interact in all subjects; they constitute vicarious processes, the evocability of which might vary from subject to subject. Formalization would essentially serve to elaborate, through the developmental schema described by Piaget, the forms necessary to the solution of certain problems. The main function of Realization would be to manage contents; its characteristics would be qualitatively distinct from those of Formalization. Informational units assembled through Realization consist in interlocked, unitary, and indivisible blocks. They are immediately (in both senses of at a great speed and with no mediator) accessible and establish immediate links between stimuli and responses. This direct linking is obtained through a suppression of intermediate steps that existed earlier, i.e., during the collection and assembling of information. The advantage of Realization resides essentially in its economy: Informations can be easily retrieved and used, the subject does not have first to determine which aspect of the situation is more relevant to treat; this frees a hypothetical central processor, which will stay available for Formalization. However, this economy is counterbalanced by a higher risk of error. Resorting to "shortcuts" may lead to errors as soon as the situation is slightly changed and requires a modification of the blocks which cannot be dissociated, unless the subject reverts to Formalization. Reuchlin, in his proposal, assumed that Realization is posterior to Formalization, although it can also correspond to individual and to situational differences. Longeot, in his work, retained this temporal distinction, whereas for an individual-differences approach attempting to demonstrate the existence of different forms of development, it seems more interesting to retain the notion of vicariousness. Reuchlin also described different types of interactions between both processes. Note that the distinction is reminiscent of the one that has been established between automatic and controlled processes (for instance Schneider & Shiffrin, 1977), or the one mentioned by Globerson (this volume, 1986) between formal and intuitive thinking.

The hypothesis is appealing at two levels: At the situational level it can provide a way to understand horizontal decalages. Even if, provided appropriate learning, each situation is susceptible to be treated in a Realization manner, some situations probably call essentially for a Formalization treatment, whereas others lend themselves more easily to a Realization treatment. As Reuchlin mentions, there are situations where both processes lead to inconvertible results, Formalization leading to a success and Realization ending in an error. The hypothesis also appears interesting at an individual level: The preferential use of either process could represent an individual variable characteristic of the subjects' general functioning and distinguish Formalizers from Realizers; this cognitive style corresponds to what Longeot (e.g., Longeot, Fazelier, Roulin, & Valensi-Zarpas, 1982b) referred to as differential sensitivity to content. As a result, there would be an interaction between individuals and situations: Formalizers would be privileged in Formalization situations, while Realizers would be at an advantage, for instance quicker, in Realization situations. Once more it should be stressed that the problem is really treated in terms of style and not of general aptitude.

Reuchlin's theoretical hypothesis has as yet received more empirical support from a situational point of view than from an individual-differences approach, although it would be very interesting at this level. Indeed, many situations can be analyzed in terms of Formalization—Realization, even if this does not correspond to the initial intent of the authors. Thus, the description of Realization can be likened to Markman's (e.g., 1978; Markman & Seibert, 1976) or Carbonnel's (1978) suggestions concerning different types of classification and inclusion. Although the approach of these authors is primarily developmental, they have outlined the existence of at least two types of classifications. Markman suggested that the correct responses given by children about 8 years old to questions of class inclusion remain at an empirical as opposed to a logical level: The greater numerosity of the whole is treated as an empirical fact rather than logically deduced from the relation of inclusion. This corresponds to the distinction that Markman established between classes and collections, which differ by membership criteria (the member of a collection has to present relations with other members, whereas the member of a class has to be related only to the superordinate), and by the type of part-whole relation (inclusive for a class versus partitive for a collection). Markman also suggested that col-

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1 Piaget also distinguished two types of knowledge: logico-mathematical knowledge, derived through reflexive abstraction from the actions that subjects exert on objects, and empirical knowledge dealing, through empirical or simple abstraction, with the properties of objects. In both cases, however, it can be argued that Piaget essentially studied Formalization; moreover, these two forms of knowledge are not truly independent from each other, given the leading role that Piaget has given to logico-mathematical knowledge. By contrast, the function of Realization, which probably relies on other types of constructive mechanisms, is to manage contents and produce easily available blocks of information.
lections represent better psychological units, and are more easily conceptualized because they correspond more closely to "natural" realities that subjects have encountered. Note that Markman's studies were essentially concerned with demonstrating the anteriority of collection over class groupings, rather than considering them as vicarious processes in Reuchlin's sense, i.e., processes which are called for more easily in certain types of situations or in certain types of subjects.

The similarity between collection groupings and Realization is explicitly proposed by Carbonnel, on the basis of studies similar to Markman's. Referring to Lesniewski's mereology, he compared collective classes with set classes, using a same material (for instance, a set of objects such as engines, wagons, airplanes, buildings, cyclists, some of which can be grouped according to their common characteristic of being vehicles or being green—set classes—or because they are all part of a railway station). A collective class has to be distinguished from what Piaget called a figural class (Piaget & Inhelder, 1959), since the main criterion for the members of a collective class is their belonging to a same whole, and not their spatial disposition; moreover, the resemblance between objects is not relevant. The distinction between the two types of classifications cannot be reduced either, according to Carbonnel, to the distinction established by Piaget between logical and infralogical aspects. Collective classes can be used with discrete objects as well as with continuous objects (for instance the body). Results showed that the construction of collective classes also undergoes development. While it precedes somewhat the development of logical classes, it subsists as a mode of classification besides set classes.

These studies point indeed to the existence of different types of treatments for a same situation, without a necessary hierarchy between them, even if one type of classification appears somewhat earlier. Further, although it is not yet completely supported by the facts, it is tempting to hypothesize that Formalizers would more often group objects in terms of classes, while Realizers resort whenever possible to collections. Carbonnel and Longeot (1979) pursued further the study of situational differences in certain mathematical problems, that can be analyzed as presenting a conflict between purely logical constraints of mathematical notions (Formalization) on the one hand, and notions of a lower level, acquired previously (realization—note that this is part of Reuchlin’s definition that Longeot essentially retained) and evoked by the situation, on the other hand. They hypothesized that even adults refer frequently, at least in everyday situations, to complex objects and partitive relations as opposed to logical elements. They set up experiments to control the mastery of set notions with students who had been taught set notions at school. They devised items such as the following, written in extensional notation (Carbonnel & Longeot, 1979; Longeot et al., 1982b; Longeot, 1986), called EM4 tasks, for Ensembles Méréologiques or mereological sets:

*(Example 1)*

| F is the set of the French cities |
| Given a set A = {24, 365, 170,000} |
| Grenoble is a city of 170,000 inhabitants, |
| Questions: |
| is Grenoble an element of set F? |
| is Grenoble an element of the set A? |

65 to 75% of the students, who demonstrated in other tasks both that they were familiar with the set theory and that they could function at a formal-operational level answered yes without hesitation to both questions, demonstrating that, in certain situations, they revert to more "primitive" responses. They could, however, answer correctly to questions presenting the same structure (but not the same misleading features):

*(Example 2)*

| X is the set of the people that own a bird. |
| Given the set y = parrot, pigeon, sparrow, |
| Jacqueline has a pigeon. |

Questions:

| is Jacqueline an element of the set X? |
| is Jacqueline an element of the set Y? |

Longeot (1986; Longeot et al., 1982a, 1982b) attempted to generalize the dimension of realization and to define individual styles, first designated sensitivity to content, then object-dependence-independence. Note that there are also modifications in the operationalization: whereas in EM4 task, the dependent variable was errors, in the recent studies it is frequently types of strategies. In a first series of experiments (Longeot et al., 1982a) the style was tentatively defined on the basis of the Quantification of Probabilities Task. In this task (Longeot, 1969; Piaget & Inhelder, 1951; Rieben et al., 1983), subjects are presented with two collections of chips, each of which contains varying numbers of chips with and without a cross (or of two different colors); they have to decide in which collection there is a greater chance to draw first a chip with a cross. It is therefore a task of proportionality, considered formal (at least for the more difficult items) by Piaget and Inhelder (1951).

Keeping only subjects of a same operational level (those that solved all items including formal ones), Longeot distinguished Realizers and Formalizers on the basis of their justifications: subjects that reasoned directly on the chips, by comparing the subcollections (comparing the numerator of one collection with the numerator of the other, or both denominators, or still the numerator with the denominator within each collection), were designated as realizers; they tended to treat the chips as objects. By contrast, those subjects that treated the entire problem in numerical terms, by for instance computing numerical ratios, that is, establishing a total set of possibilities to which the two sets of realities (the chips) can be compared, were defined as Formalizers; they were considered to treat the chips as mere indexes of numbers. Formalization procedures were rather rare, due probably to the subjects' lack of mastery of the mathematical tool; this led Longeot to conclude that Quantification of Probabilities could be a style indicator only with adults, that is with subjects presenting a sufficient mathematical mastery of the tool. Recently Longeot (1986) suggested the existence of a more general style, object-dependence-independence, subsuming both the Formalization–Realization and the sensitivity to content dimensions; it has, however, not received a strong empirical support yet. For this purpose, he used four tasks: Permutations (a combinatorial task in which Mendelsohn, 1981, demonstrated the presence of numerous algorithms), Quantification of Probabilities, Object Classification (Carbonnel's material described above) and EM4 items (items identical to the two examples above). Results demonstrated the presence of correlation between Permutations and EM4 task, but
not between Permutations and Object Classification. In order to explain this lack of correlation, Longeot refers to differences in complexity between the tasks, and in particular to a lesser difficulty of Object Classification.

Pernias (1985) attempted to demonstrate empirically the coexistence, within a same subject, of the two types of procedures, by introducing situational variations to induce a shift from Formalization to Realization. Elaborating on Reuchlin’s suggestions, according to which Realization relies on the use of immediately available units (or “blocks”), thus enabling a quicker and more “economical” processing, while Formalization develops mediatised and probably longer strategies (even though Formalization strategies might some time be rapid), Pernias’s main hypothesis was that time constraints imposed on subjects should lead to a greater frequency of Realization “blocks” or strategies. Thus, the probability of obtaining Realization performances should be higher when the response has to be given immediately than when there is no time constraint. Pernias used a number of operational tasks, first designed by Piaget and his collaborators, only two of which will be described here in some detail, under two conditions: stress or short-time condition and no time limit condition. Note that all the tasks used were described in the Piagetian studies as corresponding to the end of the concrete, operational stage, therefore rather complex, and subject to developmental changes. The objective of the original studies was, like in most Piagetian tasks of causality, to determine how children gradually construct and explain principles of causality. Again, Pernias’s goal was different since he wanted to demonstrate that subjects who theoretically (in terms of their general competence level) could apply formalization strategies to the situation and understand the principles involved, would, under certain conditions, revert to realization responses, defined as more immediate. By administering them to high school students, Pernias ensured that the tasks were well within their competence from a developmental point of view; moreover, in the long-term condition, he could show that they indeed were able to solve the problem, using formalization strategies.

Only two of the tasks used by Pernias will be described here, and will be analyzed again below in terms of Pascual-Leone’s model: the Plaquette and the Sling Tasks. In the Plaquette task (adapted from Fluckiger–Geneux, 1972; Lautrey, 1980a), subjects were presented with a small, rectangular metal plate, presenting a centered notch on the right side of the lower border. The plate was placed on a sheet of paper, about 20 cm away from a target drawn on the same sheet. Subjects were instructed to imagine that the plaquette was slowly pushed in the direction of the target until it reached it, with a pencil placed in the notch, and had to draw the trajectory of the notch (the trace left by the pencil). In the short-term condition, the target position was only indicated after the complete instructions had been given (to ensure that subjects could not anticipate the trajectory followed while still listening to the instructions) and subjects had to draw as fast as possible. In the long-term condition, subjects had all their time. When studied developmentally, in the original Piagetian context, subjects could actually experiment by pushing the plaquette and had to discover the fact that the plaquette was rotating, due to the deceleration of the notch; the developmental aspect precisely consists in the growing possibility of children to take this rotation into consideration (at the beginning, they completely ig-
than at the individual level), an obvious question to raise is that of its similarity, or resemblance, with FDI. For Longeot, if FDI is defined as a preponderance of internal over external referents, the resemblance appears theoretically obvious. The problem is, however, to determine whether the analogy is only verbal with completely different underlying mechanisms, or whether both styles are based on similar processes, in agreement with Witkin’s hypothesis of a general style stable across situations. One way to test their relationship is of course through their correlational patterns. Longeot assumes that the common characteristic of Formalization–Realization and FDI resides in an analytical or global approach. Adopting Ohlmann’s hypothesis, according to which RFT represents an intermodal conflict between postural and visual informations, while EFT indicates whether the approach is analytical, he predicts a strong correlation between DIO and EFT, but no correlation with RFT. Apparently some results tend to support this hypothesis, but empirical work remains to be done on this topic.

Ohlmann and Carbonnel (1983), studying the relationship between FDI and Formalization–Realization through the use of set classes versus collective classes, found indeed a stronger tendency in FD subjects to group elements according to collective classes. However, this was only true for the second grouping (while the first grouping was related to general cognitive development) and in girls. Huteau (1981) also studied the relationship between FDI and Formalization–Realization, assuming their connection through the sensitivity to content. Indeed, Huteau’s hypothesis is the following: since Realization is defined as a process allowing the subject to adapt quickly and economically to different situations, its contents can be assumed to be somewhat analogous to Gestalt totality, and therefore more salient in FD subjects. Given also the greater difficulty of restructuration exhibited by FD subjects, they should show a greater resistance to change when the solution requires to shift from Realization to Formalization. This should appear both in perceptual situations such as the weight–volume illusion, and in cognitive situations susceptible to unveil the subjects’ sensitivity to content. In the illusion weight–volume (measured through motoric expectations or through comparisons of different weight values), subjects systematically predict that the greater or bulkier an object, the heavier. The reasons given for such expectations are based on associative learning: Statistically speaking, heavy objects are voluminosous, hence a progressive establishment of a link between weight and volume, that allows predictions about the weight of objects from their volume. Huteau showed (1981) that FD subjects (assessed through a composite score based on RFT and EFT, or through EFT score alone) tend indeed to be more sensitive to the illusion. This effect is stronger for FET than RFT, and for boys than for girls. Huteau apparently expected, however, the effect to be stronger.

Huteau has also been interested in the relationship between FDI and sensitivity to content in situations requiring complex, cognitive processes, such as the Pendulum Task and the Permutations Task. For the first task, the hypothesis of a difference between FD and FI subjects in terms of a greater sensitivity to content was not really supported by the facts. In the Permutations Task, he found, as expected, an interac-

tion between style and situation: The difference between FI and FD was greater when the letters to be combined were letters not frequently associated in the language (s-x-t-z-r, instead of a-u-o-a-n). Likewise, the strategy used by FD was less efficient.

In conclusion, although the hypothesis of a connection between FDI and Formalization–Realization seems intuitively sound, it has not yet been empirically validated. The present author wants to argue that the ambiguity of results originates in the lack of a general theoretical framework in the field, which would address underlying processes in contrast to the performances observed in the different tasks. Following Pascual–Leone, whose theory constitutes the core of the next section, it is suggested that cognitive styles (as operationalized by a given type of performance in a given type of task) are overdetermined or multidetermined by a number of different underlying or organismic mechanisms. Therefore the presence of between-task correlations can be taken to indicate that the tasks do indeed share certain fundamental processes while they also may call for different processes; therefore correlations could only be moderate. Since Pascual–Leone’s theory, in particular its method of task analysis, is here supposed to clarify the relationships that should be expected between situations, it will be used below to reanalyze some of the tasks.

A neo-Piagetian account of cognitive styles

Pascual–Leone’s model, the Theory of Constructive Operators (TCO) offers means to analyze and dissociate, at least at a theoretical level, or even at a “metatheoretical” level, the intricate factors susceptible to underlying a performance in a FDI task, and in other types of tasks as well, by directly embodying both developmental and individual differences; it was first designed to realize an integration of Piaget’s (hence its qualification of neo-Piagetian model) and Witkin’s. Therefore, the cognitive style that Pascual–Leone analyzed in greatest details is FDI. However, the theory is more general and can certainly be applied to other types of cognitive styles.1

A Brief Overview of the TCO

A brief summary of the model seems necessary before discussing Pascual–Leone’s interpretation of FDI and attempting to generalize it to the tasks analyzed here. As there is a contribution by Pascual–Leone himself in this volume, only the main concepts of the model, directly relevant to the present discussion, will be rapidly reviewed. The reader is also referred to other publications (for instance, Pascual–Leone, 1970, 1983, 1984; Pascual–Leone & Goodman, 1979; Pascual–Leone, Goodman, Ammon, & Subelman 1978; de Ribaucpierre, 1983).

From a general standpoint, the TCO models the psychological organism (the

1 Pascual–Leone himself mentioned in some analyses (e.g., 1969, 1974) the style of adaptive flexibility. Another widely spread cognitive style is that of Reflectivity–Impulsivity, which could probably be accounted for within the model by differences in executive and pre-executive schemes.
metasubject in the TCO terminology) as composed of two interlocked systems: the subjective system of schemes and the silent system of operators. The subjective system represents the informational level (the software), consisting in a repertoire of schemes, that is, structures reflecting situational invariants abstracted through interactions with the environment. Schemes are very active assimilatory units, that determine the content and the form of performance. There are affective, personal, and cognitive schemes. Cognitive schemes can be classified in two manners: according to their function in the processing of information, and according to their content and the relationships between their elements. Thus, Pascual-Leone describes action schemes (operative and figurative), executive schemes, operations and operational systems, on the one hand, and merological versus logological schemes or structures on the other hand. Merological schemes (i.e., particular schemes) are “experiential structures (perceptual, intentional-motor, spatial, temporal, and so on) that embody the constraints experienced in reference to the distal objects or things of the actual environment” (Pascual-Leone, 1984, p. 190). As described for collective classes (Carbonnel, 1978), merological schemes rest on part–whole relations.

In contrast, logological structures (the distinction between these two types of structures is somewhat similar to Piaget’s distinction between logical and inferential operations) are generic structures composed of concepts, relations, and propositions. The silent system consists of modular components (metaconstructs) of the organism’s hardware, these hardware components or operators are silent in the sense that they influence the subject’s mental state by acting not directly on the input, but only on the schemes in order to modify their assimilatory strength. Up to now, Pascual-Leone has distinguished seven such operators: A, B, M, I, F, L, and C, of which only the last five will be presented here. The M operator (M for mental energy) is a quantitative construct, conceptualized as a reserve of mental energy that can boost the activation weight of those schemes that are relevant for a problem while not weighted directly by the input or other factors. The amount of M available is limited; its quantity (the subject’s M-capacity) is measured by the number of relevant schemes (other than those directly activated by the input or by other operators) that can be boosted within a single operation. This measure of M is called M-power; it is assumed to grow with age and thus constitutes the main developmental aspect in the model. The I-operator represents the system’s intrinsic capability to actively inhibit irrelevant or incompatible schemes. M and I, together with the executive schemes, are construed as the basic attentional mechanism of the organism.

The TCO postulates the existence of two types of learning operators, C-learning and L-learning, both of which can lead to the construction of structures enlarging the subject’s repertoire of schemes. C-learning (where C stands for content) implies a differentiation of the schemes by extension (accommodation) of their conditions and effects; such differentiation leads to the construction of more differentiated schemes, with a higher density of connections. L-learning corresponds to the construction of superschemes or superordinate structures, that reflect the structural and functional relationships existing between their constitutive schemes. It is analogous to Piaget’s coordination of schemes, or integration of schemes. L-learning enables the elaboration of ever more complex structures (acquisition of strategies, general plans or procedures) and can take two main forms: LC-learning and LM-learning. LC-learning occurs through repeated exposure to the same situational invariants. As overlearning accumulates, progressively more schemes related to the same invariant come to be integrated into a chunk or LC-structure. Thus, LC-learning consists in a relatively slow, cumulative process, with the consequence that the associative bonds of LC-structures are quite dense; LC-structures are strongly context-bound, and of a holistic type. This associative, conglomerate nature offers the possibility of a fast activation, counterbalanced by a relatively great proneness to interferences (note the similarity, that will be described below, with Reuchlin’s definition of Realization). By contrast, LM-learning occurs when M-energy is mobilized and applied to the relevant schemes; it has for effect to equate the activation weight of the schemes (a condition for L-learning to occur), and, given a certain time of coactivation, to produce chunks. Since M boosts only relevant schemes without creating associative bonds with other schemes in the repertoire, LM-learning can be fast, and leads to relatively context-free, mobile, and analytical structures.

Finally, a last operator whose influence on FDI has been emphasized is the F-operator, which accounts for field effects or figural factors described by Piaget, or for the Gestaltists’ field factor. The TCO distinguishes between a sensorial F-operator (Fs) that consists in organizing the perception in conformity with the most salient psychophysical characteristics of the input, and a processing F (Fp), operative or figurative, that will tend toward a representation as compact and coherent as possible, i.e., toward minimizing the complexity of cognitive performance. Fs tends to apply as soon as schemes are activated by the input, in weighting those schemes whose cues correspond as closely as possible to the salient properties of the situation. By contrast, Fp applies after the other silent operators, in order to strengthen the assimilatory weight of those schemes whose application will result in a structurally coherent and economical performance. Rules of application of the F-operator consist both in minimizing the number of schemes to be applied and in maximizing their structural connections. These criteria of simple coherence and of informational minimization are most frequently met by LC-structures, since psycho-technically the LC-structures develop in the direction prescribed by the F-factor in the learning situations (unless tutoring or mediational learning intervenes to cause the contrary). Thus Pascual-Leone assumes that an activation by F is often tied to an LC activation.

A Neo-Piagetian Account of FDI
The analyses that Pascual-Leone (e.g., 1969, 1974, this volume; Pascual-Leone & Goodman, 1979) conducted of FDI tasks, in particular of Witkin’s situations (RFT
and EFT) and of individual differences in these tasks, demonstrate that they present a common functional structure: (a) the situation activates a number of schemes weighted by F and/or L (LC-structures) that prove misleading with respect to the correct solution. For instance, in Witkin’s EFT, schemes embodying a representation of the whole figure (drawing) are activated, while the solution requires to perceive the simple figure in the drawing; perception of the whole figure is weighted by LC because subjects had many occasions in their life to develop global visual perceptions, and by F, because it maximizes the structural coherence of the pattern, and minimizes the number of schemes to be applied in the final output; (b) the solution depends on the activation and application of a number of schemes that are neither activated by F, nor automatized; (c) the two sets of schemes encode, at least in part, the same features of the input (the elements of the simple figure also belong to the complex drawing); since the two perceptual interpretations are, as Gestalt totalities, mutually incongruent, they are logically incompatible, and only one set or the other can apply to the input; (d) in order for the relevant strategy to apply, it has to be dominant in terms of activation weight. This dominance results necessarily from the intervention of M, since the initial weight of the relevant schemes is low and is not increased by F or L. The structure of this type of situations is resumed in the following formula, called processual or metasubjective—MS—formula in the TCO terminology:

$$\text{FDI} = (M \cdot \text{Xi})x \sqrt{V(LC \vee F)}$$

where \(x\) and \(y\) stand for respectively the relevant and the irrelevant strategies. The subscript \(f\) means that in this case, the conflict occurs between figure schemes, i.e., perceptual representations of the input characteristics (in other tasks, for instance RFT, the schemes can be operative). The mutual exclusion between the two sets of schemes is represented by the symbol \(V\). The dot between \(M\) and \(\text{Xi}\) stresses the functional conjunction between \(M\) and Executives, together with the \(f\)-operator. Finally, the disjunctive symbol \(V\) between \(F\) and \(LC\) suggests that the misleading schemes are activated by \(F\) or/and \(LC\).

Pascual–Leone has predicted on the basis of such task analyses and empirically demonstrated through factor analyses in particular (e.g., 1969) that a number of cognitive tasks present this functional structure, in particular Witkin’s EFT, RFT, his own Copy the Stripe Test, and a number of Piagetian tasks, such as Water Level and Conservations. The performance depends on the activation strength of one strategy relative to the other; the correct solution requires that the \(M\)-weighted schemes be stronger than the schemes activated by the other operators. FD subjects will tend to fail while FI subjects will tend to succeed, because both groups differ by the weight obtained by each strategy, therefore by the way in which the conflict is overcome. The interest of such analyses lies in the demonstration that the same mechanisms are operating for all types of subjects, i.e., that FI as well as FD subjects experience a conflict. However, the resolution of the conflict will vary: it will be to the advantage of the \(M\)-weighted schemes in FI subjects, and to the advantage of the LC- and \(F\)-weighted schemes for FD subjects or for subjects with a low M-power, i.e., relatively young subjects. It also shows that a same performance in a FDI task can be obtained in different manners, resulting from distinct although not incompatible organismic sources.

There are several reasons why a subject could be FI. First note that Pascual–Leone explicitly rejects the hypothesis of a difference in \(M\)-reserve, that is of a difference in Spearman’s g-factor of general intelligence, between FI and FD subjects reputedly normal and of the same age. Globerson’s results (1985) provide strong empirical support to the equivalence of FD and FI subjects with respect to \(M\)-capacity. Differences in cognitive style could thus result from the following causes, alone or in combination: (a) FD subjects would have a relatively less efficient repertoire of executive schemes, whereas FI subjects would dispose of more sophisticated executive and LC-structures that could help mobilize and allocate the \(M\)-power in a more efficient way; (b) FD subjects would have strong \(LC\)-structures, resulting in a strong activation of the misleading strategy; (c) FD subjects would have a strong \(F\)-factor, resulting again in a particularly strong activation of the misleading strategy; (d) FD subjects would present a strong \(A\)-factor, together with a relatively small repertoire of affective and motivational schemes, so that emotions would easily interfere in relevant responses in cognitive tasks; (e) finally, FD subjects would have a relatively low \(I\)-factor, i.e., a limited possibility of interrupting irrelevant schemes, probably due to a lesser development of executive schemes. Such characteristics are apparently supported by the literature, at least partly (Pascual–Leone, 1974). What makes this type of analysis particularly interesting, is that it is not tied to any particular content, but can serve (as will be illustrated below) to predict the subjects’ performance in any situation, provided that the situations be analyzed in terms of the metaconstructs that they are geared to (note that in the TCO metaconstructs are anchored both in subjects and in situations). It is also noteworthy that, to use Reuchlin’s terminology, the mechanisms can work vicariously, which explains the rather moderate correlations across tasks.

The class of situations described by the above formula is called class of misleading situations. Pascual–Leone has also analyzed the functional structure of other types of situations. In distracting situations, irrelevant strategies are also activated by the situation; however, they do not share features with the relevant strategies, and consequently do not involve a relation of mutual exclusion; they only compete with the relevant strategy for the subject’s central attention, and therefore might impede performance. In facilitating situations, neither misleading nor irrelevant schemes are activated, but every strategy leads to the correct solution. Note, for instance, that while in \(F\)-misleading situations subjects with a strong \(F\)-factor (FD subjects) might fail because the \(F\)-operator activates an erroneous strategy, they might have an advantage in \(F\)-facilitating situations.

A neo-Piagetian Reformulation of Formalization—Realization

Analyses such as those conducted by Pascual–Leone on FDI tasks, that is, both in terms of the differential role of the metaconstructs and of their mutual relations of
compatibility and incompatibility, should help clarify the tasks designed for studying the dimension of Formalization–Realization (called for purposes of brevity Formalization–Realization tasks). I would like to argue that in most of these tasks the type of processes involved and their interactions, (or their "processual formula" according to Pascal–Leone’s terminology) are similar to those involved in FDI tasks. Namely, a strategy conforming to Formalization needs to be boosted by $M$, $I$, and the executives, while Realization strategies receive a stronger activation weight by $LC$ and/or $F$. Depending on their activation weight in different subjects, one strategy or the other will prevail. Thus, the definition of processual formulas or at least the evaluation of the metaconstructs involved in a task, together with their mutual interactions, should help bring out the tasks’ similarities and differences, because they are geared to underlying processes and not directly to task content. The predictions is that situations which belong to the same class (i.e., misleading or facilitating), and where the same metaconstructs play a role, will tend to be differentially intercorrelated. For example, two situations that are both misleading and $F$-sensitive should correlate more than two situations that are also both misleading but one of which is sensitive to $F$ ($F$-misleading) and the other to $LC$ ($LC$-misleading). In turn, these last two situations should present a stronger correlation than for instance an $L$-facilitating task and an $F$-misleading task.

Before attempting to analyze tasks with respect to the processes involved, note that Reuchlin’s definition of Realization finds general equivalents in essentially two aspects of the TCO: $LC$-learning and $LC$-structures on the one hand, and merological schemes on the other hand. As mentioned above, $LC$-learning weaves dense associative bonds between schemes, and leads to holistic context-bound structures, just as the realization process is supposed to. In Pascal–Leone’s model, there is no univocal relationship postulated between merological (particular-experiential) and logical (generic) structures on the one hand, and $LC$- and $LM$-learning, on the other hand; however, merological structures are more often associated with $LC$-learning, although they can also be built through $LM$-learning, while logical structures most often require $LM$-learning, but may become $LC$-structures later on.

Recall that Longeot (e.g., 1986) used essentially four tasks (Quantification of Probabilities, Permutations, Object Classification, and EM4) for assessing the dimension of Formalization–Realization, whereas Huteau stressed the interest of Permutations and of the Weight–Volume illusion, and Pernias focused on situational variations within several tasks, among which the Plaquette and the Sling tasks. An important point to stress first is that, in some tasks, the distinction of Formalizers versus Realizators rests on the level of their performance, i.e., correct solutions versus errors (this is the case of EM4 and Weight–Volume, where the score consists of the magnitude of the illusion, or of Pernias tasks where Realization leads to wrong answers), while in other tasks it is tied to types of strategies: types of arguments given in Probabilities, type and rate in changes of algorithms in Permutations, use of collective classes versus set classes in Object Classification. Further, in the latter tasks, the degree of association of cognitive style with performance varies. In Probabilities, the cognitive style does not seem to affect the performance since Realizators as well as Formalizators reach the formal stage; in Permutations, Realizators apparently tend to produce a slightly smaller number of correct and nonredundant solutions, while in Object Classification they might have more difficulties to shift criteria.

As a consequence, and given the kind of scores used for determining the subjects’ cognitive style, only the first four tasks (EM4, Weight–Volume, Sling, and Plaquette) can be consistently assigned to a class of situations in Pascal–Leone’s sense; the class of situations to which the other tasks belong will vary, depending on the score retained (level of solution, type of argument, etc.). These four tasks appear to constitute misleading tasks: They elicit two strategies, a relevant one and an irrelevant one, which are elicited by the same cues in the input, are incompatible in terms of their outcome, and of which the latter one is strongly activated by the input. The correct solution, which is not directly weighted by the input, can only be reached through $M$- and $I$-activation. In the Weight–Volume Task, the irrelevant strategy (that is, the positive correlation between weight and volume) appears to be weighted, like in typical FDI tasks, both by the processing $F$-factor (since it is indeed more "economical" and more congruent with the properties of the input to correlate an increase in apparent volume positively with an increase in assumed weight) and by $LC$ (because, during earlier everyday life experiences, subjects have learned to associate weight and volume, as Huteau already stressed). The correct solution can only be found if the subject is able to interrupt or inhibit these misleading schemes; the operator I has to exert a strong activation. The task, however, does not seem to present a high $M$-demand.

In the EM4 task, the activation of the incorrect response seems to depend principally on $Fp$ in the sense of aiming toward the most coherent and "economical" representation. $LC$ could be important, e.g., in this case the degree of familiarity with set theory, but in this case, it would be facilitating; however, this operator might play an indirect misleading role because of its frequent association with merological schemes. An additional feature seems to consist in the use of merological versus logical schemes. The incorrect response shows that subjects treat the sets proposed in terms of merological relations, as Longeot and Carbonnel showed, whereas they should resort to logical relations. They rely on partitive or part–whole versus inclusive relations. Therefore, performance in Weight–Volume and in EM4 could be correlated, because both tasks present an F-misleading structure. However, differences are also to be expected since the misleading aspects are reinforced by LC in Weight–Volume versus the use of merological schemes in EM4. Finally, another source of difference appears to lie in the degree of complexity of each task. The Weight–Volume task probably presents a relatively lower

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1 For instance, in the following item: "Given the set G (all the persons living in France); given the set V (Paris, Brest, Marseille); given the fact that M. Martin lives in Paris. Question: is M. Martin an element of G? Is M. Martin an element of V?" (Longeot et al., 1982b). An affirmative answer to the last question indicates that the subject relies on a partitive instead of an inclusive relation: Since M. Martin is a part of Paris, and since Paris is a part of the set V, then, by transitive inference, M. Martin is a part of V.
A similar analysis can be conducted with respect to the two other tasks. In the Sling Task, LC and F reinforce strongly the tendency to release the mobile just underneath the target. Subjects have learned in their everyday life experience to throw an object, a ball for instance, straight ahead (LC); moreover, the target offers a salient point of reference (Fs), and it proves more "economical" (Fp) to link it to the releasing position via a straight line. Similarly with the Plaquette: In everyday experience, when one wants to link two locations, the shortest route often proves best (LC); the target is in line with the plate, and it is the only visible reference point (Fs); finally, it is more "economical" not to introduce another route (Fp), which in addition is not suggested by the input.

The three other tasks mentioned above (Object Classification, Permutations, and Probabilities), do not appear to present missing but at most distracting aspects: Strategies are not mutually exclusive, in the sense of the application of one preventing the application of the other and leading to an erroneous response; the use of a Realization strategy might just hinder an optimal performance. In Permutations, the sensitivity to content was measured by the rate with which algorithms were changed as a function of the material (letters, digits, or colors). Further, it also appeared in Huteau's study (1981) that cognitive style was associated with a higher degree of redundancy. The variations in strategies could result from an LC-effect, depending on the familiarity with the material. Subjects, at least adolescents, have already learned the order of letters or digits, whereas there is no "natural" order for colors; thus LC could induce the use of a more systematic ordering strategy for letters and digits, and therefore cause changes in strategy altogether. F could also have an effect, not so much in inducing changes in strategy as in privileging certain types of strategies, or even leading the subject to repeat some possibilities (this constitutes the distracting aspect).

In Object Classification, the subject has to shift (decenter) from one type of classification to the other; the first classification represents a distractor with respect to the facility with which a second classification can be established. Further, the preference for collective classes is clearly dependent upon both an LC-activation and the use of mereological schemes. Subjects have overlearned links between or among elements of the material (such as persons, wagons, buildings, railway tracks) and treat them as the collection of parts of a single spatial and experiential reality (e.g., railway station).

The Quantification of Probabilities can perhaps best be analyzed as a distracting task (or even misleading) in terms of performance (Pascual-Leone, 1969). As regards arguments given, which is what Longeot (Longeot et al., 1982a) retains as indicator of style, it can be hypothesized that Realizators resort to mereological schemes and Formalizers to logological schemes. Reasoning in terms of subcol-

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**Table 1. Hypothetical Relations Between Metaconstructs and Empirical Tasks**

<table>
<thead>
<tr>
<th>Tasks</th>
<th>I</th>
<th>Fp</th>
<th>LC</th>
<th>M-demand</th>
<th>Mereological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sling task</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>middle</td>
<td>X</td>
</tr>
<tr>
<td>Plaquette</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>middle</td>
<td>X</td>
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<tr>
<td>Weight–Volume</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>low</td>
<td>X</td>
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<tr>
<td>EM4</td>
<td>X</td>
<td>X</td>
<td>high</td>
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<tr>
<td>Permutations</td>
<td>X</td>
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<td>Objects Classification</td>
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<td>Probabilities</td>
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* If scores deal with the degree of redundancy in the productions and not only with the change of algorithm.

* If assessing the shifting facility from one type of class to the other.

In adult or scientific samples only; note that in this case LC facilitates the use of a formalization strategy.

The fact that the redirection of particular chips, and treating them as objects, while referring to the total set of possibilities and computing a ratio (Formalization procedure) corresponds to treating the chips as mere indexes of generic numbers. The use of ratios certainly also depends on the subjects' familiarity with numbers, as shown in Longeot's experiments, i.e., an LC-logical effect, this time facilitating a Formalization strategy. Many adults (especially those mathematically oriented) can be expected to present such LC-effects; in adolescents, however, unless following a scientific curriculum, a Formalization and thus logological procedure needs to be M-weighted. Longeot also showed that providing the subject with a blank sheet of paper induced more often Formalization procedures; this can be interpreted as replacing a lack of automatization by a cueing of the school situation, that is of a situation that easily induces executive schemes which bring up more Formalization or logological procedures.

On the basis of these sketchy analyses, briefly summarized in Table 1, it can be predicted that the relationships between those tasks should be complex, which explains in part why no clear pattern had emerged in the empirical studies described in the first section. Indeed, they all present some common characteristics, while they also differ from pair to pair. Different clusters can thus be predicted, depending on which metaconstruct is taken into consideration: Sling Task, Plaquette (both tasks as used in Pernis' version), Weight–Volume, and EM4 share a F-misleading as-

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* Note that Table 1 also contains a rough estimate (high/middle/low) of the M-demand of the tasks, i.e., of their complexity, which has not been discussed above. Although no formal task analysis, in Pascual-Leone's sense, has been conducted and would be beyond the limits of this chapter, there are probably three classes of tasks in terms of their difficulty: (1) Weight–Volume, rather easy, since the score simply embodies the deviation from the objects' true weight; (2) Object Classification, which, in Piagetian terms and despite the more recent results about class inclusion (e.g., Bideau & Lautrey, 1983; Markman, 1978; Voelitz, 1976) should be mastered by the end of the concrete operational stage; similarly, the Sling and the Plaquette tasks correspond to the end of the concrete operational stage; (3) Finally, EM4, Permutations, and Probabilities, the two last ones considered by Piaget to be formal tasks.
pect and the correct solution depends on a strong $I$-activation, while they differ by their $M$-demand; Sling Task, Plaquette, Weight–Volume, Permutations, and Object Classification share an $LC$-aspect, but differ in other ways; EM4, Object Classification, and Probabilities are susceptible to call for a mereological treatment. In terms of types of subjects, several predictions can be made, provided they all present a same $M$-level: Subjects with low $I$, low repertoire of executives and/or strong $F$ will tend to fail on Sling Task, Plaquette, and EM4 and to present an important illusion in Weight–Volume; subjects with a strong $LC$ might present an important illusion in Weight–Volume, draw straight lines to the target both in the Sling and the Plaquette tasks, change algorithms in Permutations, use collective classes in Object Classification, and, if they are well trained in manipulating numbers, focus on the total set in terms of numerical ratios in Probabilities. Subjects preferring mereological to logical type of knowledge may fail in EM4, use collective classes in Object Classification and give arguments based on the subcollections in Probabilities; but the use of mereological schemes should not cause problems in the other tasks.

Consequently, the correlations between the two types of tasks will tend to be only moderate if not null. Of course, there can be interactions between the metaconstructs as well. For instance, subjects with a strong $F$ might nevertheless succeed in EM4 if they have a strong $I$, etc. Note further that all these highly speculative but empirically testable predictions can be modulated by $M$, in both its applications to the situational level ($M$-demand) and to the subjects’ level ($M$-power).

The above hypotheses need of course to be refined further and detailed (which is beyond the scope of this chapter) before they lead to specific and precise predictions about the tasks and their empirical relationships. In order to bring to light the respective influence of each operator, a very careful methodology should be built, as has been argued elsewhere (e.g., Pascual–Leone, 1978; Pascual–Leone & Sparkman, 1980; de Ribaupierre & Pascual–Leone, 1984). A first step toward empirical validation, however, would consist in testing the overall correlational patterns predicted above. To this purpose, all tasks should of course be administered to all subjects; in order to control indirectly for differences in $M$-demand, subjects should be adolescents or adults. To summarize the above predictions, only one clear cluster should emerge, consisting of the Sling, the Plaquette, and the Weight–Volume tasks, since they are closest with respect to the operators that they call for; subjects assessed as Realizers in one of these tasks should also give more Realization responses in the two others. The four other tasks (presenting more difference in terms of underlying mechanisms) are not predicted to cluster together, but rather to present much lower and differential degrees of correlations both with these three tasks, and among themselves. It is therefore not surprising that Longeot’s results did not support the hypothesis of a general dimension across situations. They were all based

\footnote{Note that the term of correlation is adopted here in a broad sense of similarity across performances, without presuming of a particular statistical technique. Given the type of tasks and scores used, subjects might just be classified (or ranked) according to the number of Realization-versus-Formalization responses given.}

on the latter tasks. Sling, Plaquette, and Weight–Volume should represent better indexes of a Formalization–Realization style, if indeed such a cognitive style exists. In order to determine the construct validity of Formalization–Realization as a style, as opposed to a developmental construct, it would also prove necessary to include in the experimental design other tasks as well, which should be as complex while not as sensitive to the $LC$- and $F_p$-operators (they should not be FDI tasks; see below). On this second set of tasks, subjects defined previously as Realizers should no longer differ from Formalizers.

With respect to the possible relations between Formalization–Realization tasks and FDI tasks, the analyses just presented, together with Pascual–Leone’s prosesual formula for FDI, lead to the prediction that Weight–Volume, EM4, Sling, and Plaquette should also correlate most with Witzkin’s situations since they apparently share many characteristics; the relationship could, however, be lower for EM4 on the one hand, as it is not assumed to present an $I$-misleading aspect, and for Weight–Volume because of its reduced $M$-demand. Note once again that the correlational pattern is not predicted on situational similarities, but strictly on procedural grounds. This implies that FDI subjects will tend to fail on these four tasks. The correlations between FDI tasks and the other Formalization–Realization tasks should be lower, depending on which operator is called into play. Subjects who behave as field-dependent because of a strong $I$-operator might resort to Realization strategies in Permutations and Object Classification. There is, however, no reason to expect overall correlation between FDI tasks and these two tasks. Subjects who present a strong $F$-operator, and may therefore be field-dependent, will not be prevented from using Formalization procedures in these tasks; vice versa, subjects who use primarily mereological schemes, and therefore manifest Realization strategies, will not necessarily be field-dependent. As already mentioned, the prediction of more precise empirical relationships rests on careful and detailed task analyses, since the boosting of the different operators does not depend on the task as a whole (for instance Weight–Volume in general) but on the very specific conditions in which the problem is stated (the visual condition in Weight–Volume does not necessarily call for the same degree of activation by the same operators as the tactile condition).

The main theoretical interest of the above process structural analyses, however gross they remain, is to have supported the hypothesis according to which cognitive styles are multidimensional and therefore cannot be expected to yield completely coherent correlational patterns across tasks. Further, and consistent with Pascual–Leone’s model, they have shown that the same mechanisms are operating for all types of subjects, i.e., that Realizers as well as Formalizers (just like in FDI tasks, FI subjects and FD subjects) experience a conflict between the same strategies. Indeed, the strategies and their activating mechanisms are supposed to be the same for all subjects, and only the resolution of the conflict will vary: it tends to be to the advantage of the $M$-weighted schemes in Formalizers (or in FI) subjects, and to the advantage of the $LC$ and $F_p$-weighted schemes for Realizers (or FD subjects) or for subjects with a low $M$-power, i.e., relatively young subjects. Analyses
also show that a same performance in a task is not necessarily the result of identical processes in different subjects, but can originate in the activation of distinct although not incompatible organismic sources.

Finally they point to the need for considering cognitive development and cognitive style as two different constructs altogether. The theoretical framework adopted here provides means to distinguish both concepts and to consider, despite the controversy existing in the literature with respect to this topic, cognitive development as obeying to general or universal laws, that is, to laws applying to all subjects; thus, Pascual-Leone and his collaborators have been able to predict and demonstrate empirically general developmental patterns of performance across types of subjects and types of tasks (e.g., Goodman, 1979; Johnson, Fabian, & Pascual-Leone, in press; Pascual-Leone & Goodman, 1979). By using a slightly different theoretical model, Case (1985) reaches similar conclusions with respect to the existence of general developmental laws. However, the developmental trajectory, in terms of the structures or schemes effectively constructed, is modulated by several variables or organismic mechanisms, acting in interaction, of which some occur more systematically together (like, for instance, the I.C.- and F-operators in the above tasks). The relative intensity of their activation characterizes types of individuals in a relatively stable manner. The differential role of these underlying operators as well as their grouping corresponds to what is usually defined as cognitive style. The performance obtained on tasks considered to assess cognitive style (such as FDI tasks or Formalization–Realization tasks) should be taken to indicate which factors, alone or in interaction, tend to be stronger in types of subjects, that is which “biases” individuals may present while confronted with certain types of tasks. Different cognitive styles can then be defined, according to different modes of interactions between organismic variables; however, none should be construed as unidimensional in the sense that a same performance would originate in one and only one underlying factor.

References


Cognitive Style and Operational Development


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