Chapter 11

General Conclusions and Recent Developments

Since this chapter is the last one, I take the liberty of conjecturing about questions which seem important enough to warrant critical imagination. Several old themes are revitalised and combined so as to weave new fabric. A prefatory qualification is in order. The speculations rarely concern matters of fact. The facts are given in some adequate sense; for example, they are consensually undisputed or positively demonstrated, or (when factual options remain open) the minutiae are experimentally decidable. What is at issue is a view of the world, sometimes a composition of views; the question for debate is whether any or all of these world views are worth adopting. Such judgments, if formalised at all, rest upon criteria of utility and aesthetic compass. Insofar as I have made certain affirmative personal judgments in choosing a gaggle of speculations, it is only fair to comment (since many readers may disagree) that though I surely respect pragmatism, my choice is also weighted strongly and unashamedly by aesthetic preference. I think the new fabric has a beautiful pattern, and its threads establish fascinating connections between otherwise disparate notions. Locally at any rate recognition of this pattern has often proven useful. As pure opinion, hunch or belief, the same pattern may have general utility and lead to some sensibly fundamental discoveries. The following aphorisms and mental exercises are intended to support this opinion, hunch or belief.

1. CHARACTER REPRESENTATION

There is nothing unfamiliar about the idea of a character appearing in the context of a play or a novel, and it is also fairly common to encounter classes of characters or roles (for example, town clerks, solicitors). Using some specific instances, for the possibilities are legion, we shall argue that the notions of character and role are of the utmost educational significance. Yet, for various reasons, the subject of characterisation is either treated intuitively (the art of an author is involved) or avoided like the plague. The reasons for avoidance appear to involve ways of viewing reality rather than the inherent difficulty of the subject. Hence, we shall attempt to clear away some conceptual brushwood and lay the foundations for an approach to this matter.

According to the present thesis, a character is a *representation* (π_A) of a *P-Individual* (A) and a role, in the sense of a class of characters is a representation of a class (π) of π_As with certain features in common. By prior definition, A is the execution of π_A in some existing but unspecific L-Processor, and taken thus, is a coherent and self-replicable set of beliefs; conversely, π_A is a static representation of these beliefs, minimally as a coherent set of propositions (Chapter 4). Extrapolating, π is required to maintain coherency and to have member representations (for example, π_A), all of which have some coherent subset (the role specification, at least) in common. Though freshly introduced, these definitions are probably uncontentious, but all of them are qualified by the existence of a context in which the characters or roles appear (Mr. Jingle is a character in the context of *Pickwick Papers*, and Miss Prism is a character in *The Importance of Being Ernest*). Such a contextual binding seems to be an essential ingredient of characterisation (hence, the static representation of P-Individuals) and is written "Q"; thus "π_A in Q" is the proper statement of π_A. Usually, Q is a story, a plot, or a scenario, but it need not be.

It is essential to distinguish between characters in general (such as π_A in Q, Mr. Jingle in *Pickwick Papers*, Miss Prism in *The Importance of Being Ernest*) and particular static inscriptions of these entities. Confusion is virtually impossible in literature or drama (we do not get mixed up between *Pickwick Papers* and a particular printed edition of *Pickwick* on that bookcase). In contrast, confusion is quite likely when these notions are generalised.

If the character is executed in some L-Processor (π_A to realise a P-Individual A), it is also essential to distinguish between the general and the particular enactment. To press the point home, Mr. Jingle is executed in any reader's brain, and even if differences in interpretation are discounted, the general execution is distinct from Joe's or Jim's particular execution. Similar comments apply to dramatic enactments; the general case of Miss Prism is distinct, even if differences in interpretation are discounted, from enactments by different and specific actresses or the same actress on different nights.

In general, a play or a novel involves more than one character; as a rule, we speak of "π_A in Q" and of "π_B in Q" and notice that a rendering of the novel or a performance of the play involves "π_A and π_B in Q".

In particular, we have constructed a framework in which an assertoric thesis T stands as a special case of characterisation, and the student who learns T acts a *null* character; his enactment is of the expert's perspective, when expounding T.

2. EDUCATION PARTICULARS

To see how this bears upon education and epistemology, let us consider a few of the situations discussed up to this point and take the opportunity to indicate their significance.

2.1. *Innovative Learning*

Many aim situations (Chapter 7 onwards) and innovative situations in particular (Chapter 10) involve characterisation. Minimally, this is of the type, "A's image of B's image of a topic T," which serves (rather than a plot or a story) as the context, Q = T. The characterisation is genuine insofar as this statement can be rephrased, "A's image of B in the context of T," or "π_B in T," which is generally executed to form a P-Individual in A's brain. Under these circumstances, the image itself is A-constructed so that we may either talk of the general execution of "π_{BA} in T" performed by an unspecified L-Processor, or else of the execution of "π_B in T," subject to the constraints imposed by executing A's image of T (π_A in T) within the same brain; that is, of an internal conversation on topic T between the execution in A of π_A and the execution of π_B, and generally leading to an internal agreement about topic T. Since we have already stressed that transactions of this type whether internal or external to a brain play a critical part in innovation, no further comment is needed.

2.2. *Rival Hypotheses*

There is increasing empirical evidence that certain theses can only be understood if their *progenitors* are characterised. For example, rival theories S, T (the wave/corpuscular controversy) can only be represented in a conversational domain if their progenitors A, B (Huygens/Newton) are also represented as characters π_A, π_B in the same conversational domain. The proposition is not altogether surprising, for it is common practice to laden instruction with historical and personal detail sufficient to characterise protagonists (not Huygens and Newton but adherents of each school of thought). But the empirical claim deserves careful formulation since a strongly affirmative finding, indicated by the data so far available, would place a stamp of approval upon current practice. If we are right about understanding rival hypotheses, then the historical and personal background is *essential*. It is not, as often supposed, gratuitous enrichment material to be employed as an optional embellishment. The claim is that students can *understand S and T* only if these theses form the context for characters π_A and π_B who are debating the merits of S and T, so that the context of *understanding S and T* is a series of A, B agreements and disagreements.

A very similar claim is made with respect to the ambiguous figure in Chapter 7, Section 3. Clearly, a student might understand S alone and understand T alone and link S and T by some tenuous indexing scheme, permitting concepts of S and T to alternate in consciousness. By the same token, a student can understand the geometry of three dimensional lines and three dimensional blocks, and he can conceive or envision the ambiguous figure; even draw it with the perceptual tricks. But understanding S and T means understanding a dispute (the wave/corpuscular theories are really taught to illustrate the process of scientific development, not primarily as a bit of optics). We claim that a student cannot understand this dispute unless there is character representation, any more than he can understand the ambiguous figure (qua figure, rather than as a series of tricks).

2.3. An Invitation to Act as a Dramatist

The last example (rival hypotheses) rests upon the existence of a peculiarly constrained representation of characters; namely, representations of "π_A in S, T" and "π_B in S, T" within a conversational domain (rather than in a book, play, or as any unspecified mental scheme). The question is, "Do such representations exist?" And, if they do, there is a further question, "What do they look like?"

These questions are tackled in stages. As a first step, we show that a *context* Q of the usual form (a plot, story or scenario) can be constructed. An exemplary construction is shown in Fig. 11.1, which depicts the entailment structure for the "Spy Ring History" test of Chapter 3. True, this is a special case, but there are no obvious limitations, sheer complexity apart, upon the plots, stories or scenarios which may be represented in the same manner.

Further, this special case is worthy of study, for there are circumstances under which the "Spy Ring History" task acts as an invitation to dramatise within a contextual framework that is virtually a *tabula rasa*.

Although the structure shown in Fig. 11.1 is moderately complex, it is also extraordinarily arid; the syntactic or systemic similarities are quite specific, but the structure is semantically barren. Since almost any choice of distinguishing predicates will suffice, the student can give any meaning he likes to "spies" or "countries". The degree of freedom permitted by such a sparse description is, of course, deliberate. Not only are we anxious to find out how different students recall the material (by operation learning or by comprehension learning the relations, as in Chapter 3), we also desire to find out how the student clothes the structure in descriptors of his own invention in order that he can actually learn these relations.

First of all, there is no reason why students should not conceive the entire Spy Ring History as an *it*, an *object*. For example, they could construct the spy networks as graphs from lists, or as others do, could reconstruct them from the Cartoon function. A slightly more sophisticated approach, also observed, is to construct finite-state-machine-like-representations that generate the communicative behaviours.

On the other hand, there is no reason why students *should* con-

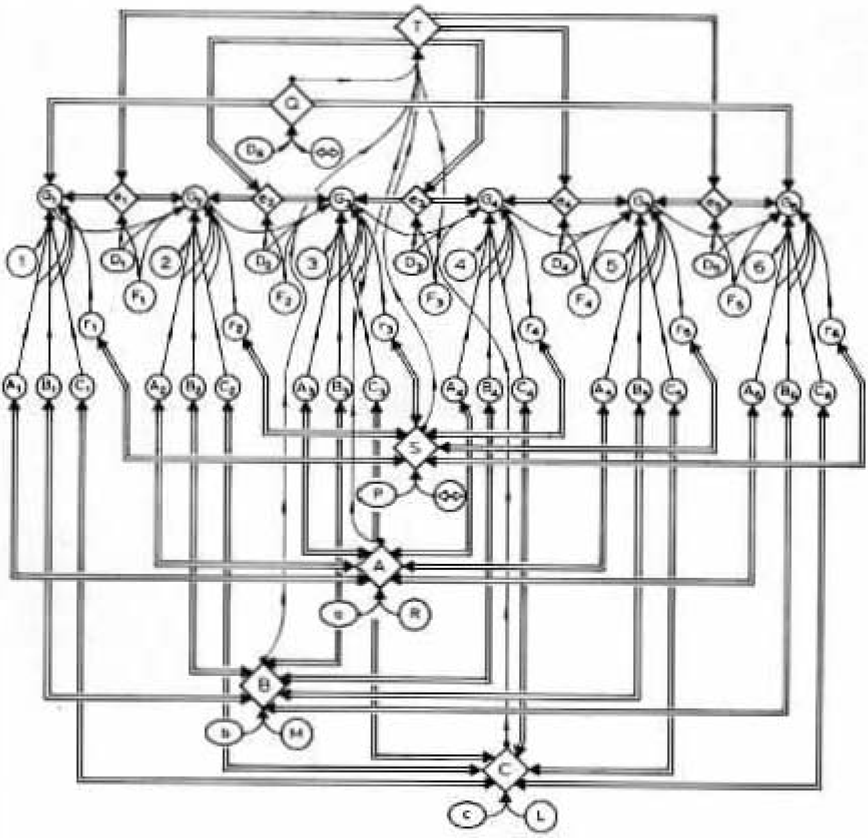

Fig. 11.1. Entailment structure for "Spy Ring History" test described in Chapter 3. The "Spy Ring Graphs" or connection networks are $G_1 \ldots G_6$ (only G_1 to G_5 are presented in test but G_6 may be inferred) for years 1880, 1885, 1890, 1895, 1900 (and, inferred only) 1905. A, B, and C are the countries' predicates; L (left), R (right), and M (middle of) being the systemic (i.e., geographical) component, and a, b, c an arbitrary (invented) series of semantic distinctions. $D_1 \ldots D_6$ are arbitrary (invented) distinctions between indexed eras. $F_1 \ldots F_5$ are the cartoon (graph product) functions establishing similarity component of between-era analogy relations $e_1 \ldots e_5$. Q, the cyclic part of the product, is determined by the isomorphism between G_1 and G_6 (the network in 1880 and in 1905). $A_1 \ldots A_6$, $B_1 \ldots B_6$, $C_1 \ldots C_6$ are countries predicates, arbitrarily distinguished in each era (1880 to 1900), provided they respect the geographical constraint, which is invariant. The graphs, G, may be generated by combining these predicates with the ordered-pair lists; 1, 2, 3, 4, 5 (recall 6 is not spelled out to a student), or by combining the predicates with role specifications $r_1 \ldots r_6$ sufficient to generate the behaviours of the "spies". S is a role isomorphism; the analogy relation that preserves roles but distinguishes different "spies" (by the arbitrary, or invented, distinction P). The entire system specification, T, can be learned in many ways; amongst others by a join of the analogy relations A, B, C, S, Q.

ceive the Spy Ring History as an *it*, and some of them do not do so. The latitude of the scenario allows any student to conceive the spies as characters, or even to characterise the social organisation of a spy ring or a country. Some students take advantage of this possibility and dramatise the system as a story involving P-Individuals, persons, or societies quite literally and non trivially pronominalised as "He" or "She". Notice, these students are acting as authors or dramatists. It is quite incidental that they act in this manner *in order to recall* some rather banal syntactic or systemic relations. It is far from incidental that whenever students act as dramatists they do *and must* to some degree participate in the enaction of their own drama.

Using the "compromise" techniques employed in the "learning to learn" experiments, it is certainly possible to exteriorise some facets of the student characterisation, and thus to gain some insight, albeit an inkling, of how characterisation proceeds. In other words, our data are not confined to verbal reports, though these are extremely valuable. For all that, a more general treatment of characterisation is required in order to support the contention that characters (as well as the context) can be represented adequately in a conversational domain.

3. A CLOSER LOOK AT THE CONVERSATIONAL LANGUAGE L

Even though I wrote them, I find the contents of this section quite strange and fully expect the reader to share this perplexity. So far as I can see, the argument holds water for all that, and an attempt is made to dissipate the feeling of oddity in the commentary that follows in Section 5.2 (some readers may prefer to look it over before continuing).

Any P-Individuals, A and B, have a language L in common, however primordial it may be. This is a conversational (or addressed programming) language, and it is an *interpreted* language; its universe of interpretation being a class of L-Processors.

By the same token, the representations π_A and π_B, of A and B in a conversational domain have something in common, and it is necessary to see what it is at this stage in the discussion. These entities (π_A, π_B) are static, not dynamic like A and B. But we wish to argue that what π_A and π_B have in common (regardless of any differences in their constitution or their interpretation) is in one sense the same as the communality between A and B; namely, the rudimentary elements of L.

Consider any non-trivial L metaphor. It appears in a conversational domain as one or more analogy relations, themselves *replicable* and coherent, between two or more sets of coherent propositions (Chapter 4). If the entailment structure of the conversational domain is augmented by a specification of the set of $\underline{\mathrm{Proc}}^1$ (or, if preferred, of *DB* and *PB* operators as in Chapter 5) needed to execute structures that exist and to create further structures (i.e., the $\underline{\mathrm{Prim}}^1$ of the previous monograph), and if the *BG* of the entailment structure of the conversational domain is augmented by the $\underline{\mathrm{Proc}}^0$ needed for this same purpose (i.e., the $\underline{\mathrm{Prim}}^0$ of the previous monograph), then the original structure, though still static, is of the form π_A or π_B. Let the conversational domain also contain the representation of a context Q made up of topic relations, T in Q, and to secure observability, let one L metaphor designate a personal analogy between π_A and π_B in Q. Certainly, the structure even at this point is static. However, if there is an L-Processor (or a set of them) in which the static encoding can be realised, it becomes an observable conversation between two or more P-Individuals, A and B. The question is, "What does it mean to realise π_A, π_B in Q, within an L-Processor." (And notice that the static encoding to be realised is augmented by a specification of $\underline{\mathrm{Prim}}^1$ to execute derivations and $\underline{\mathrm{Prim}}^0$ to execute explanations.)

L contains (at least) an operation sign, call it "$\Rightarrow$" to avoid specificity, which stands for implication or production or derivation. Although this sign is regarded as identical by any collection of P-Individuals A, B ..., this should not suggest that $\Rightarrow$, as judged impartially by an external observer, has the same meaning in A and B. On interpretation in an L-Processor, the operation sign $\Rightarrow$ stands for an *act*; something occurs. But, without further specification, this act may be a doing or an explication step or a derivation step.

L also contains at least an agreement sign, call it "$\Leftrightarrow$" to avoid specificity, which stands for correspondence. Although the sign is identical to any collection of P-Individuals A, B ..., this should not suggest that $\Leftrightarrow$, as judged impartially by an external observer, has the same meaning in A and in B (from his point of view, agreement is not identity). When $\Leftrightarrow$ is interpreted in an L-Processor, it indicates syntactic or systemic equivalence, but this may be an equivalence of doings or explanations or derivations.

The signs $\Rightarrow$ and $\Leftrightarrow$ appear in the conversational domain insofar as the derivation arcs in the entailment structure correspond to occurrences of $\Rightarrow$ when the static inscription is augmented by the Prim^1 (or the *DB*, *PB* operators), and they correspond to the delineation or execution of the *BG* when the static inscription is augmented by the Prim^0. Similarly, occurrences of $\Leftrightarrow$ mark systemic analogies; namely, groups of $\Rightarrow$ occurrences that are distinctly placed, but otherwise identical in form.

The compilation and interpretation of π_A, π_B, Q in an L-Processor is predication: a realisation of the semantic descriptors in the conversational domain. Some predication exists since L is an interpreted language. But, in *general*, it is ambiguous in respect of the interpretation of the imperative given to $\Rightarrow$ (as doings or derivations or thinkings, etc.) and the interpretation of $\Leftrightarrow$ (as various kinds of equivalence). With this interpretation ($\Rightarrow$ replacing derivation arcs by real derivations, or production arcs by real explanations), π_A and π_B in a purely *formal* sense become two or more P-Individuals, A and B, in the context of Q.

Under the *particular* circumstances specified, the realisation is, however, disambiguated and observable as a strict conversation (in the sense of this book and the previous monograph) between participants A and B. That is, L may be stratified by an external observer into levels L^1, L^0 and a free level (L^{-1} or L^2 as desired), and the A, B conversation is anchored upon the topics T in Q, which an external observer regards as fixed, and *the* conversational domain. That is, Q is the *support* of the previous monograph. Within that framework, L^1 occurrences of $\Rightarrow$ stand for cognitive acts or derivations; L^0 occurrences of $\Rightarrow$ for acts of modelling or explanation; and occurrences of $\Rightarrow$ in the free level (L^{-1} or L^2) stand for behaviours or the execution of models. Similarly, L^1 occurrences of $\Leftrightarrow$ signifies A, B cognitive agreement; L^0 occurrences of $\Leftrightarrow$ signify in A, B agreement over a model or an explanation; and occurrences of $\Leftrightarrow$ at the free level (L^{-1} or L^2) stand for A, B behavioural equivalence. But, further postulates are needed if the realisations A, B of π_A, π_B are to count *non-formally* as P-Individuals. These postulates are conditional.

(a) Even if $\pi_A = \pi_B$, their realisations are distinct ($A \neq B$). One obvious and common possibility is that π_A is realised in one L-

Processor α, and π_B in a different L-Processor β, and that α and β are distinguished independently (that is, α and β are distinctly M-Individuated in the sense of the previous monograph, for example, spatially demarcated brains).

(b) Even if $\pi_A = \pi_B$ and A, B are realised as P-Individuals in the same L-Processor (for example, an external observer does not see α and β as distinctly M-Individuated brains but as the same brain), it is still true that $A \neq B$. In other words, the predication of π_A and the predication of π_B carve out distinct universes of compilation and interpretation in the same processor.

4. CONDITIONS FOR INDIVIDUALITY

We sum up (a) and (b) as a principle of *privacy in the face of agreement*. Even if A and B are utterly agreed in respect of all topics T in Q, there are distinct individuals. Under $\Leftrightarrow$, occurrences of $\Rightarrow$ may be tagged $\Rightarrow_A$ or $\Rightarrow_B$. Equisignificantly, the predication (alias interpretation) of π_A is distinguished semantically from the predication or interpretation of π_B.

As soon as A and B operate upon Q, the conditions of a strict conversation are contravened, especially since further encodings (π^*_A, π^*_B) emerge when the conversational domain evolves (the "breeding" paradigm of Chapter 6). But "privacy in the face of agreement" is preserved.

5. WHY NOT CALL L-PROCESSORS BRAINS AND LEAVE IT AT THAT

Of (a) and (b), case (b) appears to be more general, and the evolution of P-Individuals beyond the confines of a strict and anchored conversation appears to be the rule. Otherwise, we might as well have said "brain" instead of "L-Processor" throughout.

One example will be sufficient to spell out the scope of these comments and some of their epistemological impact. The example stems from a series of carefully written papers by Lakatos (1968, 1973), which should be consulted for historical perspective, as well as a philosophically defensible statement. * My summary does

* As noted in the Introduction, another example is an educational system as it is conceived by Daniel. In that case, distinct πs would characterise the mores and career structures of educational systems which encouraged or discouraged analogical reasoning.

scant justice to the original, but so far as it goes, is accurate.

Lakatos argues that scientific development, though it does involve various well-accredited tactics such as Popperian falsification, has primarily to do with social organisations which he calls "research programs" and which roughly correspond to "schools of thought". These "organisations," whilst employing standard modes of inference and deduction in respect of particular hypotheses and data, are basically self-perpetuating; that is, they are coherent systems of belief which maintain their coherency very often by operations that do not have immediate recourse to factual validity. Lakatos cites and details numerous cases and pursues the development or evolution of several such organisations.

I propose that a "reserach program" in Lakatos' sense is a P-Individual with a representation of the form π (a role or character class). The realisation of π is an L-Processor (a societal one) but is neither a brain, nor even only a collection of brains, for the compilation and interpretation of π also involve current technologies and other inanimate components. Further, an adherent or advocate of π is a P-Individual with representation π_A, π_B ... in a context Q which includes at least some of π. Surely, π_A, π_B ... are realised L-Processors, but once again, these are not generally unique brains.

Perhaps A, B (the realisations of π_A, π_B) act as progenitors or theses about some or all of the beliefs in the realisation of π: by hypothesis, *all* theses are of this form for some A, B and some π. Such theses (and by hypothesis *only* such theses) are represented in conversational domains with A, B as subject matter experts.

Because of the caveats encompassing the modes of inference in π (and the interpretation of $\Rightarrow$ in its realisation), it is possible, likely, and perhaps necessary that π contains rival theses. Suppose these are S and T of the previous discussion and are espoused by A and B, respectively. We maintain that a representation of S and T of π in a conversational domain may only be understood if accompanied by a partial or complete representation of π_A and of π_B in a context Q which depicts the realisation of π (that is, Q is a story or scenario for the enactment of π on a par with the story or scenario in Fig. 11.1).

5.1. Monism and Pluralism

I can neither prove nor disprove the rectitude of these conjectures; they are advanced as plausible and useful means of throwing light upon certain epistemological issues and their claim to plausibility will be backed up by culling examples from other fields of educational concern (notably, the nature of educational media and developmental psychology). There is nothing which forces anyone to accept, or even consider, this view of things.

However, *if* the view is considered and deemed plausible enough to merit tentative acceptance, it *is* possible to avoid a species of pluralism (the P-Individual/M-Individual pluralism of the previous monograph; akin to, but not identical with, mind/body dualism) which is otherwise strongly suggested. Overall, I am proposing that *the* universe of compilation and interpretation *is* an L-Processor which may be locally carved up into portions α, β ... separated by regions in which only a more restricted interpretation of $\Rightarrow$ and of $\Leftrightarrow$ is possible i.e., processors of lesser capability. The carving up and local specialisation is due in the first place to the compilation and subsequent execution of encodements like "π_A in Q" or "π_B in Q" or (in a restricted but not essentially different case) like S or T. Since coded inscriptions (like π_A, π_B or S, T) are built in the last resort by progenitors A, B ... (the realisation of π_A, π_B in the L-Processor, albeit, with local compartments like α, β and their separating boundaries), we retrieve in evolution a systemic monism and with it the convenient permission to see each stage of the evolution as the creation, compilation, and execution of a program.

5.2. Commentary on the Previous Sections

As promised at the outset, I shall try to indicate why this argument, though basically sound, seems strange and curiously tortuous (to me, at any rate).

The trouble arises in working with distinctions between static entities, like entailment structures or other coded representations, and the dynamic entities which realise whatever is encoded in usually many, and always more than one, way (for example, representations are realised as programming or modelling operations, as program construction operations, as program executions). Simultaneously, we need to work with different kinds of particularity and generality, keeping them mentally distinct if the argument is to make sense. For example, it is necessary to distinguish π (the general organisation) from π_A (a particular organisation), whilst noting that π is (in a different sense) more general than a particular, spatially localised inscription of π; that π_A is more general than a spatially localised inscription of π_A; that particular inscriptions are realised more generally (in yet another different sense) by one or many processes, A, in any L-Processor; and that the realisation of a particular inscription of π may incorporate all of these processes.

Mental gymnastics of this kind are familiar enough in biology and genetics where global argument relies upon distinctions between general and particular organisations (genotype, phenotype); between organisations and static inscriptions in DNA or other hereditary material (the set of *possible* alleles, the alleles realised in the gene pool of a population, the genetic makeup of the chromosomes in a particular zygote); between static inscriptions and their realisation (organisms in a subspecific population, a particular organism including its growth and differentiation, as well as the manufacture of gametes that are fed back, both material wise and information wise, into the system). By custom, such gymnastics are not called for very often in psychology or epistemology since these subjects are reputed to exist in two forms: broadminded but deliciously soft, and hard but delightfully simple.

An equally barbed parody could have been aimed not too long ago at biology/genetics/evolutionary studies, as they were popularly conceived. But the content of such epigrams, for what it is worth, underlines a prevailing contentment with a limited field of enquiry, rather than making a substantive comment about our science.

My contention is that the problems germane to education tax the full apparatus of psychology and epistemology. If that apparatus is employed by assimilating systemic and information theoretic notions to harden the broad perspective, then global argument (which is mandatory for resolving the problems in question) does involve mentally elusive distinctions of the type encountered in biology or genetics.

It should be emphasised that the parallelism is intended to relate two ways of thinking and not to establish a similarity between the subject matters. Genetics and educational psychology have more differences than similarities. Some of them are very fundamental (for example, whereas the concept of an "organism" is fairly well defined in genetics until you consider its immunological as well as its spatial integrity, the concept of a "person" in psychology depends for most practical purposes upon the type of measurement and the enquiry in hand). Our main point is that interesting educational applications of psychology and epistemology demand a degree of sophistication which nowadays seems natural in genetics or biology. The strangeness of the argument in the last section is due to the fact that comparable ways of thinking are currently alien to education.

The question at issue is whether or not the trouble taken (over this theory or any other theory) is likely to pay dividends. We contend that this question can be answered in the affirmative and believe the discussion in the body of the book lends support to this view. However, as a concluding endeavour to press the point home, we shall turn to two educationally crucial matters (a useful theory of media and a useful interpretation of data from developmental studies) and show that the present approach leads to novel insights, hypotheses, etc., which could only be formulated within an inherently complex frame of reference, either this, or some equally difficult theory.

6. EDUCATIONAL MEDIA

With the exceptions referenced in the sequel, current attempts to classify media (as televisual, radio, written material, spoken utterance, mime, gesture, and so on) rely upon perceptual characteristics. The medium itself is regarded as a kind of signal channel linking spatially distinct transmitters or receivers (teachers and students, for example). Undeniably, this is a valid way of looking at media and the taxonomies derived from it are often valuable. But it is not the *only* way of looking at media and it is insufficiently general.

For example, studies based upon the signal channel scheme are seldom able to answer salient questions like, "Should this subject matter be purveyed by ETV or radio or by course modules?" or "What is lost or gained by transferring the *Goon Show/Sesame*

Street/Blue Peter from radio to television or vice versa?" It is relevant to remark, as people do, that "television provides a larger communication bandwidth than radio"; or that "books are at hand for reference, whereas radio transmissions are not"; but, however precise, these remarks are insufficient to furnish guidelines for the cost-beneficial deployment of media resources.

To deal with deeper questions, we need a broader theoretical base and a more subtle estimate of the degrees of freedom available to an educator/producer/director (or for that matter an advertiser) who employs the media to convey a message.

6.1. Prerequisites for a General Theory

McLuhan (1970) stated the prerequisites for a theory of media in two comments, "Media are extensions of the brain," and "The medium is the message". We have arrived at much the same conclusions by a different and possibly devious route. The advantages (if any) of our approach are that constructive recommendations, not unlike McLuhan's, can be issued from a theoretical and potentially quantitative platform and that the two superficially disjointed statements are seen as near complementary, at any rate as intimately related.

Let me translate "Media are extensions of the brain" as follows. (a) Media are precisely modelling facilities, qua processors in which programs are compiled, interpreted and executed as demonstrations or explanations or learning strategies. Modelling facilities act as extensions of the brain qua L-Processor and may, given a liberal design, approximate an L-Processor, or to go one step further: (b) Brains are distinct just because they are carved out of a pervasive L-Processor or general medium by more restricted and specialised regions (still modelling facilities but of more limited capability than an L-Processor).

6.2. Constraints Imposed Upon General Media

Of these propositions, (a) is relatively uncontentious and suggests a classification of media in terms of ability to accommodate demonstrations, etc.; that is, in terms of the interpretation which can be given to the L signs $\Rightarrow$ and $\Leftrightarrow$ together with the number of a-priori-independent subprocessors, each able to accommodate in parallel some different interpretation of $\Rightarrow$ and open to coupling or local synchronisation signified by the L sign $\Leftrightarrow$.

For example, the most restrictive facilities or media only permit the execution of compiled programs (the working of models) and thus accommodate no more than simple behaviours, in the limit the null or static "behaviour". The next category provides for the inscription and display of serial programs as well as permitting their execution. In order to represent analogy, several independent processors of this kind must be colligated in parallel. Each processor is able to accommodate a different (but L^0) interpretation of $\Rightarrow$, say $\Rightarrow_x$ and $\Rightarrow_y$, and the processors are coupled by a further facility giving an L^1 interpretation to $\Rightarrow$ and realising systemic equivalence $\Leftrightarrow$ between submodels realised by occurrences of $\Rightarrow_x$, and other submodels realised by occurrences of $\Rightarrow_y$. Scenarios, per se, are dynamic analogies (i.e., in the literal sense, parables) which can be accommodated within an indefinitely extensible medium of the type required to model analogies. Characterisation, on the other hand, involves a medium corresponding to an L-Processor, and story telling (though still a form of modelling) calls for the colligation of several L-Processors within the contextual frame of a scenario. It is not inordinately difficult to devise classifications of this sort, but further work is needed to determine a canonical and generally useful way of classifying the available degrees of freedom.

The degrees of freedom and the essential constraints upon each class of modelling facility can be realised in many kinds of fabric and using the attributes (visual, colour visual, auditory) of various modalities. Some embodiments are more convenient than others (it is no accident that we rely, in our own work, so much upon multiple image, visually oriented facilities, or that independence is conveniently represented by separation of sensory modalities). But, over a wide range of variation, the material factors and perceptual factors are not limiting. For example, it is often possible to tell a story, to depict it in a cartoon strip, or to mime it on television.

The crucial trick, which puts a bite into this way of thinking, is that modelling facilities (and, by hypothesis, media also) may either be represented and typified by spatial and physical construction (i.e., making an equipment like STATLAB, making an L-Processor), or with equal legitimacy and more general utility, by the constraints of the conversational domain which carries the "message". We have argued that the entailment mesh and the *BG* of a conversational domain represent any assertoric thesis and that if the thesis incorporates analogies (as it does, except for trivial cases), then the entailment mesh has distinct substructures determining a-priori-independent universes of compilation and interpretation, connected at a cognitive level by the analogy relations. * We have also argued, in the earlier part of this chapter, that characters and roles can be represented in a context Q (usually a plot or story) and that a context of this form can be represented in the entailment mesh given the augmentation of Section 3.

The present point is that the entailment mesh for any or all of those entities (theses, messages, or whatever) is sufficient to determine the modelling facility required to realise the entity(s) in question, and so in this sense to characterise the necessary medium. Moreover, if the most liberal kind of medium, an L-Processor, is available, then the entity(s) can be realised; either using its full capabilities or some restricted version.

6.3. Linguistic Status of Medium

This is probably a fair translation of (the intention behind) McLuhan's dictum, "The medium is the message". But it is possible to proceed further by invoking our own slightly cryptic proposition (b); that "the medium" is a pervasive L-Processor carved up into portions by boundaries that are more restricted processors. The carving or specialisation is determined by an (augmented) entailment mesh. Rephrasing the matter, a medium is the constrained universe of interpretation for a language of which the (augmented) entailment mesh is a semantic grammar (a point made in the previous monograph but emphasised in the present book). Conversely, the most general kind of conversational domain is an interpreted language L, of which particular versions correspond to demonstrations and learning strategies and P-

* In this respect it is instructive to build representations, as we have done, for popular non verbal entertainment. Disney's films (perhaps the best examples are his musical allegory sequence on the "Bobby Sox" movement but the "Samba" sequence is comparable) have rich interlacing and (non formally) rational structure.

Individuals (A, B) generated by particular behaviour graphs' *BG* entailment meshes and representations such as π_A or π_B. It is significant that L Metaphors designate analogical topics and that the class of analogies includes interpersonal analogies (the provocative transactions of the previous monograph, which play an attention directing as well as a communicative part). If all this were true (in the sense of useful and plausible), we have already advanced, though not as yet metricised, a general theory of media.

6.4. Relative Merits, Plausibility and Unification

On casual scrutiny, the suggestion of a pervasive L-Processor seems implausible if not outrageous. During maturation, adult human beings develop sensory and motor organs that effectively encapsulate their brains so that communication seems to involve an input/output bottleneck at the interface. Under these circumstances (or from this point of view), the notion of a medium as a substantially inert signal channel looks altogether more sensible. The difficulty is that perceptual studies employed to quantify the signal channel representation are bound to overemphasise the (real and undisputed) input/output bottleneck.

Such studies (rightly, in their own province) dissociate the linguistic and receptive functions. By virtue of the transmitter-channel-receiver paradigm, they deal only with the reception of signals which later on are internally symbolised and synthesised into percepts or concepts. Signal reception and signal processing have well-known limitations; for example, that words are read as strings of symbols. The appreciation of sights or sounds obeys similar sequential constraints, imposed by the sensory apparatus. The analysis of media along perceptual lines is based upon these findings; correctly, insofar as a medium is conventionally viewed as a signalling channel.

We regard this view as insufficient (not as inaccurate) by noting that an interpreted natural language is commonly used to relax the signal channel paradigm and create a situation in which distinct brains act as though they were a pervasive L-Processor. * The chief implements are attentional, provocative and metaphorical transactions; in this respect, the facts of everyday observation support

* Recall, a Fuzzily interpreted language (Goguen's hypothesis).

the general image developed in this Section, with L in the role of a natural language. Retrospectively, it looks as though human natural language has the calibre of an adaptation which compensates for the fact that adult brains are encapsulated by maturation, and allows them to function as though they were not.

6.5. Summary Discussion

On these grounds, our general theory of media stands out as quite a plausible candidate to complement, rather than vie with, the signal channel theory. It is necessary to show, of course, that L sufficiently approximates the richness of natural language. * If so, the general theory (pervasive L-Processor and all) has predictive power. Moreover, it opens up constructive possibilities for fabricating entirely novel types of media, some of which have been realised (for example, Chapter 8, Section 1, those due to De Fanti and Negroponte).

7. A CONVERSATIONAL VIEW OF CHILD PSYCHOLOGY

In Chapter 1, we emphasised the essential equivalence of conversations as we have described them, paired experiments, and Piagetian interviews. All of them are program sharing and/or programming operations, as well as contrivances for exteriorising cognition; they differ chiefly in the degree of constraint imposed as the price paid for external observations (and with it the extent to which concepts, etc., may be formally specified).

With these equivalences in mind, the following notion is by no means original, "The proper unit for study in developmental, as well as adult and/or educational, psychology is a conversation between P-Individuals" (the conversation also being a P-Individual in its own right).

Perhaps the most incisive statement of this principle appears in Luria (1961), the gist of Luria's lectures in 1958 at University College, London. On p. 20, Luria recalls Vygotsky's insistence upon paired experiments as the paradigmatic experimental situa-

* Or some liberalised and Fuzzily interpreted version of L; the present form does not meet this requirement.

tion. Luria revitalises and augments the dictum as follows: The entity which develops and is studied in psychology is a functional system (or a set of coherent functional systems) having their origins in socially encoded representations (p. 2). Paired experiments exteriorise functional systems and render them observable as they develop under physiological and environmental constraints, including the maturation of the human brain. Insofar as the child in a paired experiment has a brain which is only partially developed, whereas the other human participant, commonly an adult, has a fully developed brain, the influence of maturation can be factored out for special observation.

Given the proper equivalences, this point of view is not at odds with the Piaget school, or in fact the practice of most developmental psychologists who use conversational techniques (in contrast to the stimulus-response and constant-condition techniques which Luria calls "Static"). Perhaps because this approach is so widespread, the quite revolutionary consequences of Luria's basic statement appear to be overlooked. In order to highlight the issues involved, I shall "translate" Luria's statement and slightly extend it; using the equivalence between paired experiments and conversations (in our sense) to identify "Functional System" with either a "P-Individual or part of one," and to identify "stable or replicated functional system" with P-Individual.

(a) The classes of stable functional systems seen under development are P-Individuals A_1, A_2 ... which are exteriorised for observation either in paired experiments or conversations of the form A, B, Q (where B represents the participant experimenter and Q the context of a conversational domain), or (using the "cognitive reflector" construction in Fig. 6.1.) of the form A_1, A_2, Q.

(b) A_1, A_2 ... have their origin in socially encoded representations (characters, roles) π_{A1}, π_{A2} ...

(c) Since A_1, A_2 ... are integral symbolic systems, they may be expected to obey definite laws proper to such systems, notably, "fixity" as proposed in Chapter 2 and "breeding" (a form of symbolic evolution) as proposed in Chapter 6. This clause is an addition to the original statement but is in the same spirit (for example, Luria notes linguistic laws of much the same kind, and the Pavlovian laws governing the higher or linguistic signalling sytems).

(d) Human brains are integral, spatially localised concrete systems and are designated α_1, α_2 ... as proper units of observation (spatially localised; M-Individuated, using the nomenclature of the previous monograph). α_1, α_2 ... obey laws proper to concrete systems; for example, adaptation, Pavlovian first order conditioning, and habituation. In fact, we may go further than that, applying for example the general laws for concrete systems discussed by Miller (1973, 1974).

(e) α_1, α_2 ... have their origin in Genetic codes; call them $G_{\alpha 1}$, $G_{\alpha 2}$ ... and so on.

(f) As a result of maturation, α_1, α_2 ... commonly *acquire* the capabilities of L-Processors. For example, the embryonic nervous system is not an L-Processor, and the infant brain *becomes* such a thing quite gradually. It is a moot point whether all human brains *do* become L-Processors (see, for example, studies of extreme autism by Bettelheim (1967) and histories of isolation *). It may be true that $G_{\alpha 1}$, $G_{\alpha 2}$ do not necessarily generate L-Processors, and it is certainly true, as stressed repeatedly, that a human brain has many functions which do not involve L-Processing. If, and only if, α is an L-Processor can a P-Individual A or a conversation A_1, A_2, Q be executed in α. This is an extension of Luria's statement but seems to be fairly uncontentious.

(g) In general, A_1, A_2 ... are distributed under execution in several L-Processors; for example, in the paired experiment A, B, Q, if the respondent's brain is α and the participant experimenter's brain is β, then the execution of A is distributed over α, β, both of which are assumed to be L-Processors. If A or a conversation of the form A_1, A_2, Q is executed in one L-Processor or brain α, we say that A is spatially localised in α.

(h) Let α, β, γ be spatially localised concrete systems; α and β are brains; β is also an L-Processor. Let γ be an inanimate modelling facility such that α and γ jointly constitute an L-Processor. The conditions upon the spatial localisation of A are summarised in Table 11.1.

(i) Fuzzy Computation is the rule: non-Fuzzy Computation

* Edward Goldsmith was kind enough to lend me his remarkably comprehensive file of reports and tests of "wolf children" and other cases of human maturation in isolation from human contact. Scrutiny of these records (which vary from careful reporting to apocryphal anecdotes) indicates that linguistic exchange is needed to set up ingrained symbolic routines in the absence of which the brain is not an L-Processor.

TABLE 11.1
Spatial Localisation

Available Processors	Is L-Processor	Is Not L-Processor
α	A in α	A not in α
α, β	A in α or A in α, β	A in α, β
α, γ	A in α or A in α, γ	A in α, γ

(germane to formal schemes involving unique complementation and negation) is the exception. Formal schemes have value as the most efficient means of conducting other-than-analogical cognition. The generation of a character or role only *need* involve analogical processes. *Further Postulate* (but still in the spirit of Luria's statement): If a brain matures to become an L-Processor, it is able to accommodate (to compile and to execute) Fuzzy Procedures (in particular a character or a role) before it can accommodate non-Fuzzy Procedures.

(j) Let "child" mean a spatially distinct infant with brain α. From (f), a child cannot at birth accommodate a P-Individual A for which there is a social representation π_A: the mother-child or the family-child complex (α, β of (h)) *may* do so. The test for whether or not α is able to accommodate A, so that A may be spatially localised in α, is suggested by clause (i); namely, it is possible to show self-and-other recognition going on in α and evidenced by an internal conversation of the type A_1, A_2, Q (with A_1, A_2, factors of A). All studies of egocentricity and related phenomena appear to seek evidence of this kind. From (i), we predict that formal operations cannot be manifest as localised in α unless a character A_1, A_2, Q may also be localised in α.

(k) It follows, from the foregoing clauses, that a conversational approach to developmental studies (which is advocated by Dienes, Inhelder, Landa, Luria, Papert, Piaget and a host of other researchers) carries the following perspective as an at least implicit concomitant. Developmental Psychology is concerned with the incarnation of stable symbolic systems A_1, A_2 ... generated by social representations π_A, π_{A2} ... in a population of maturing concrete systems (brains) α_1, α_2, generated by genetic codes $G_{\alpha 1}$, $G_{\alpha 2}$ ... The execution of A may be spatially localised in α only insofar as α has matured as an L-Processor, and though special interest is attached to this case, the science also countenances distributed executions of A. On execution in α, the procedures of A modify the maturation of α, and vice versa, the constraints imposed by α at a certain stage of development modify A; say, "A becomes A*." This, in turn, leads to novel social representations π_A*.

Systemic Monism (symbolic systems and concrete systems have basic laws of operation and development in common) has already been recommended. It is of material consequence insofar as the development of A (that is A becomes A*) may operate upon the coded representations of concrete systems ("G_α becomes G_α*," on a par with "π_A becomes π_A*"). Until recently this transformation was inadmissable, at any rate, in practice.

It is worth noting that two mechanisms exist due to the development of our civilisation (in particular, due to research programs in Lakatos' sense). One mechanism is genetic engineering, applicable in case α_1, α_2 ... are brains. The other is the development of L-Processors, other than brains, able to accommodate P-Individuals.

It is hard to appreciate the gigantic impact of these two complementary developments, and it is important to recognise how radically they change the objects and perspectives of developmental studies in general and educational studies in particular. Notably, the universalist approach of Section 6.3. is seen, in this context at any rate, as more than a curiosity of possible academic interest. It is a viable and practicable way of dealing with reality.

8. COMPARATIVE STUDY OF DATA

It is instructive to compare data obtained by the conversational (paired experiment) technique and data from "static" studies, sometimes data obtained in the same laboratory. A gross comparison is given by Luria (1961) citing results from non-Fuzzy problem solving due to Minskaya (1954), the form of which is sketched in Fig. 11.2. Success is markedly higher at all ages if problem solution is preceded by paired experimentation, and the solution methods adopted by the conversational students are completely different, being integrated and purposeful, rather than fragmentary. In the conversational age/performance curve, we are looking at an overall summary of a P-Individual's ability to execute non-Fuzzy Programs, either in a pictorial/visual representation, or a formal/linguistic representation. In context, at least, it is fair to re-

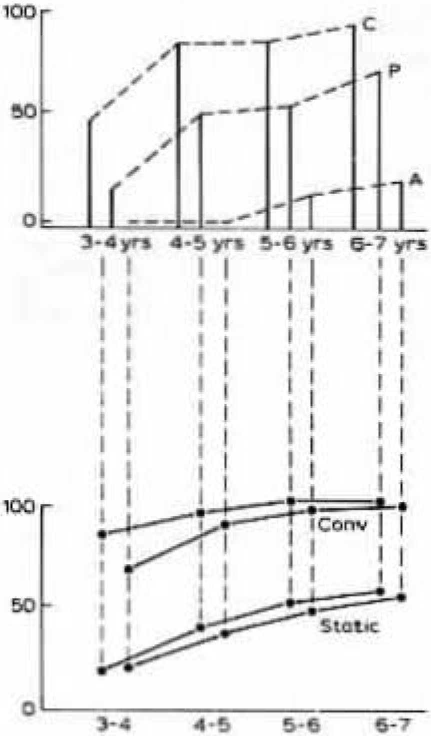

Fig. 11.2. Sketched from Luria (1961). Below: Age/performance curves for conversational (paired experiment) subjects and for static experiment subjects. Above: Relative performances for concrete, pictorial and algorithmic (linguistic) presentation. In each case vertical coordinate represents mean success, as a percentage, in problem solving task used for study by Minskaya. C = Concrete representation, A = Algorithmic representation, P = Pictorial representation.

gard pictorial/visual as one Fuzzy Transformation of a non-Fuzzy problem. In contrast, formal/linguistic is an algorithmic and non-Fuzzy Representation. The P-Individual is the child as augmented by the experimenter (A, B). Its locus is in the child's brain α, supplemented cooperatively by the experimenter's brain β. From time to time for test, execution is isolated in α.

8.1. Static Experiments

In contrast, consider the "static" performance/age curves. The experimental conditions now include a concrete/practical representation; meaning that there is a modelling facility (γ) in which problem solving programs may be compiled. Insofar as the programs are partially compiled in γ (that is, the relevant processor is the pair, α, γ), the results are fairly coherent; for the pictorial/visual and the formal/linguistic representation, they are increasingly fragmentary. In all cases, observation of the child as a functional system (Luria) or a P-Individual (present nomenclature) is imperfect since program execution is only incidentally exteriorised. With the possible exception of the concrete/practical data (where the behaviours in γ can be examined), the data primarily refer to the child's brain (α) in *its capacity as a non-Fuzzy Processor.* Moreover, by token of the attention lapses and distractions which occur repeatedly, information about α is adulterated by the co-existent compilation in α of a (Fuzzy) P-Individual A. This adulteration stays with the experimenter until A is able and willing to accept instructions that isolate some aspect of α (the problem of mental testing in preadolescents). Luria's own work upon the regulatory function of speech is a beautiful example of the latter kind of experiment. In order to illustrate the distinction, some of his results are overviewed in Table 11.2, as a profile of how α acquires the ability to act deductively and execute if-then-else statements.

By way of a summary, two quite distinct interpretations can (and should) be given to the experimental data from developmental studies. We maintain that the distinction is not a matter of fact (that human beings develop as two kinds of system) but depends upon the existence of two observational methods. It happens that the information obtainable by one method is maximised by expedients that adulterate the information obtainable by the other method.

TABLE 11.2

An Overview of Luria's Results and Interpretation in Terms of the Ability of Child's Brain to Deal with "If-Then-Else" or "Conditional Imperative" Statements in a Non-Fuzzy Program. The experiments are concerned with a situation in which a carefully recorded manual response (showing hesitation, etc.) is made to a visual stimulus and according to instructions. The situation is augmented by speech on the part of the experimenter or the child, and the overt or external utterances are regarded as parts of non-Fuzzy or algorithmic programs. Two modelling facilities (or two external-to-the-brain compilation media) are used: Overt feedback and the child's own speech.

Age	Findings	Proposed Interpretation of the Findings
6 Months to 18 Months	Speech initiates action but does not modify autonomous acts. "Press when light appears" results in intermittant pressing.	Brain acts as reactive device in respect of this task.
18 Months to 2.5 years	Specific reaction to speech or visual signal. Negation absent. ("Do not press if no light" often leads to more pressing.) If external feedback is provided (for example, bell rings after the pressing movement), reactions are discrete.	Brain can compile part of imperative implication but can process conditional imperative if, and only if, part of program is externally compiled and executed (the feedback loop).
2.5 Years to 4 Years	Role of feedback is taken over by child's speech. If he makes overt ejaculations after each act, these terminate act.	Child's own speech used as modelling facility. Compilation of simple conditional imperative, but if, and only if, overt vocal response is involved in execution.
4 Years to 5 Years	Overt speech internalised for simple task. For complex instruction like "Press n Times" or "press n times until". Overt speech is needed to regulate and negation is still unreliable.	Internal manipulation of simple conditional imperatives is possible; other instructions (nesting or sequencing) require augmentation or overt response.

TABLE 11.2 (continued)

Age	Findings	Proposed Interpretation of the Findings
5 Years to 6 Years	Negation handled adequately. Speech, if present, becomes overt. If the child repeats instructions, he can obey them for quite complex tasks.	Brain activity with non-Fuzzy complementation (the proper acceptance of negation). Complete "If then or else" statements compiled and executed, but linking program uses speech as modelling facility for compilation and execution.
6 Years Onwards	Gradually, repetition of (program) instruction is covert rather than verbal.	Program is compiled and executed internally.

8.2. Discussion

Postulates (a) to (k) have predictive as well as descriptive potential insofar as they can be reapplied in complementary form to generate a series of interacting organisations. These organisations appear to recapitulate in system theoretic jargon the structures discovered and described by insightful developmental psychologists, many of them by Piaget and his collaborators. So, in particular, A will pass through many complex and context specific identities as A develops, and these identities can be classified; for example, A's body identity, A's world of Fuzzy (pictorial?) images, and A's world of formal procedures. The coexistence of such worlds (and the fact that the sequence is interlaced and context specific to begin with) leads to distinctions of the kind we have made between "descriptions of topics" and "topics".

Throughout (as may be inferred from (c) and (d)) an "external world," A's concept of what he has learned, is juxtaposed with an "internal world" of A's imaginatively generated procedures (Chapter 4). So it is that Luria's "functional systems" or our "P-Individuals" appear to evolve.

It is natural to ask whether, at this stage, there is a breakpoint marking a change in kind or quality of the basic entity A (not merely accretion, specialisation and generation). Our hunch is that just such a breakpoint occurs in "learning to learn" and that its resolution, in order to construct an essentially novel entity, is "innovation".

By "learning to learn" A imposes an internal structure on the environment, primarily upon the social environment. The crucial step (many aim operation is required) is "breeding" whereby $A \rightarrow A_1, A_2$ (Chapter 6). The compensating process, by which A as well as A_1, A_2 ... maintain integrity, is an agreement (common meaning resolution) together with "privacy in the face of agreement". Of these compensating steps, the former alone is sufficient to account for the act of innovation; the latter (so our notion goes) is responsible for the ownership of innovation. It is ownership in the peculiar sense that A has a world of ideas shared with others, albeit generated by their efforts, but from A's point of view as a participant in society, this world of ideas is his identity.