Chapter 6

Conversations with Many Aim Topics

The discussion in this chapter develops the conversational paradigms, represented by Icons in the previous monograph, and sets the stage for an essay into situations characterised by more than one aim selection at once. There are several objects in view.

(a) More than one user can learn a subject matter represented in a conversational domain; the most interesting situations involve group or team activity (as distinct from "multiple access" to a large CAI system).

(b) Although some work has been done with groups (the verbal communication between members is extremely informative), the data have not been fully analysed and are not reported. Instead, we take the opportunity to introduce multiple user versions of CASTE and INTUITION in which the verbal communication between the users is replaced by a series of quasi mechanical and exteriorised transactions. The crucial feature of these transactions is that they exteriorise not only hypotheses (on the part of one participant or the other) about topics in the conversational domain but also mutual or personalised hypotheses on the part of one participant about the other.

(c) It is quite possible for more than one aim topic to exist in a suitably liberalised operating system, even if there is only one user. Formally, this state of affairs represents the coexistence of more than one P-Individual (externalised at the interface with the conversational domain) in the same brain or L-Processor. Intuitively, the same state of affairs images one person having more than one focus of attention or more than one concurrently entertained perspective and roles.

In order to make sense of this statement, we digress in Part B, Sections 9, 10, 11, into some distinctions between the notion of an aim topic and the similar but only superficially identical notion of a focus of attention. Salient aspects of the literature are reviewed in order to bring these ideas into register.

The effort is eminently worthwhile, for during the earlier part of the discussion, it is possible to show that analogy construction is dependent upon a (usually transient) many aim condition and that nearly all analogy construction is loaded with innovation. Loosely, one student with many foci of attention is organisationally equivalent to many students with one focus each, and both organisations are capable of innovation.

Part A. Representation of Many Aim Operation

1. GENERALISATION TO CONVERSATION WITH MANY PARTICIPANTS OR MANY AIM TOPICS

In order to obtain a facile representation of many participant and/or many aim, conversations within a uniform framework, it is necessary to simplify the Iconic schemes of the first monograph. Of course, the simplified schemes must accommodate all of the one aim constructions, of which the fundamental construction is the neutral and minimally biassed "cognitive reflector", of Icons 3 or 4 (previous monograph), repeated as the first part of Fig. 6.1.

An initial step in this direction is taken by drawing the transcription in Fig. 6.1 which also depicts a "cognitive reflector". The regulatory heuristic, B, which maintains a strict conversation on a fixed conversational domain $D^1(R)$, $D^0(R)$ — or, under concrete interpretation, $ES(R)$, $TS(R)$ — is accommodated in a separate processor (not usually an L-Processor) corresponding to β in Icon 3 or 4. Due to the action of this heuristic and the norm accepted with the tutorial or experimental contract, the participant A (usually a student) is divisible into a learnerlike component a_L and a teacherlike component a_T. These components are also "participants" but they are restricted by the constraints just mentioned, so that for any occasion, n, there is one and only one common aim topic which is psychologically one focus of joint attention. However, the composite participant $A = a_T, a_L$ may learn about, and

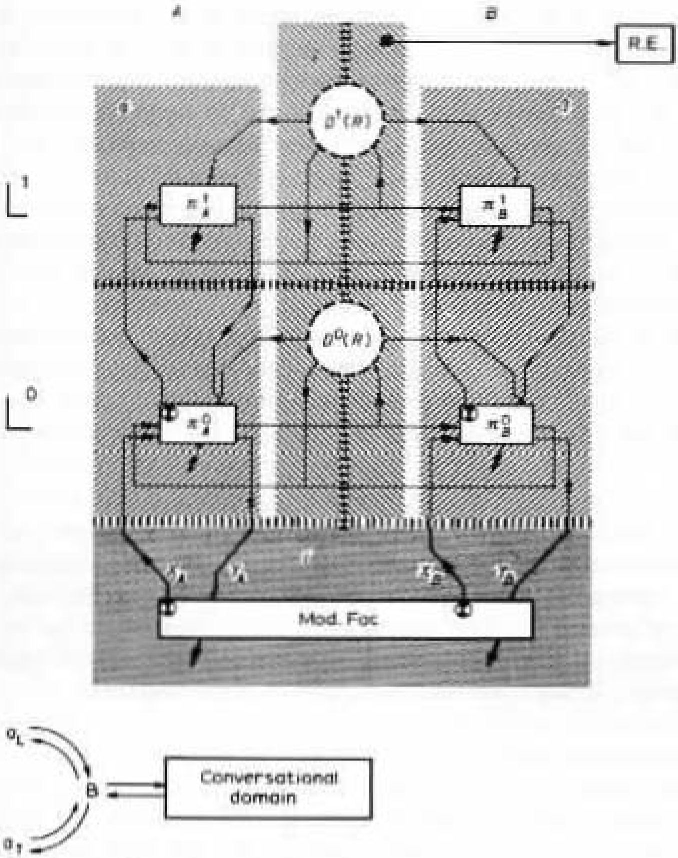


Fig. 6.1. "Cognitive Reflector" icon (from *Conversation, Cognition and Learning*, first monograph) and crude outline of "Cognitive Reflector" as pair of cognitive organisations a_L, a_T and a regulating heuristic B which controls access to conversational domain.

come to understand, one or several topics selected as goals which are members of his workset.

By the expedient employed in Fig. 6.1, we have thus represented learning as a conversation between the component participants of A; namely, a_L and a_T, regulated by the heuristic procedure B (rather than representing it as we did in the original Icon 4 as a conversation between A and B, with B occupying a neutral role as the "cognitive reflector"). So, if topic i is the aim and if topic j (or a topic class j) is the goal it is permissible to speak of a_L, a_T agreement with respect to an explanation of R_j in the context of B and of a_L, a_T agreement with respect to a derivation of R_j, under R_i, in the context of B. Together, these agreements correspond to the sprout or growing point of a strict conversation as defined in the previous monograph.

From a mechanistic or operational (or dynamic) point of view, the essential constraint imposed by the one-aim-at-once condition is a "local" or "partial" synchronicity with respect to the aim topic and all transactions that refer to it.

Since a_L and a_T are both executed in an L-Processor (and generally the same L-Processor, one brain) their constituent procedures (both $\underline{\text{Proc}}^1$ and $\underline{\text{Proc}}^0$) may be executed asynchronously. But, insofar as a_L and a_T coalesce to form an unspecific P-Individual A, the pertinent procedures must be locally synchronised. If the P-Individual A is unspecific, the synchronising events are not directly observable, though we have conjectured that A's awareness arises from (indeed *is*) the local synchronicity (alias, "information transfer" alias "program sharing") of an internal and generally unobservable "conversation". The peculiarity of the constructions in Fig. 6.1 and (later) in Fig. 6.2 is that the synchronising events are mediated through B and, given the experimental contract, synchronicity is enforced by B with respect to an aim topic in the conversational domain. That is, when both a_L and a_T attend to one aim topic, the procedures executed by these participants are coupled with respect of that particular aim. Hence, "local" synchronicity gains meaning as an observable; it is "synchronisation of $\underline{\text{Proc}}^1$ (aim) in the L^1 repertoires of a_L and a_T," which is manifest as A's learning strategy (i.e., a marker distribution model executed in the entailment structure display *ES*). By the same token, there is a local synchronisation of $\underline{\text{Proc}}^0$ (goal) where the goal is legitimate under the chosen aim and is a member of A's workset. This synchronisation is the construction of a model representing the (agreed) $\underline{\text{Proc}}^0$(goal) in the Lumped Modelling Facility shown as *MF*. If there are several goal topics (R_j is a class of topic relations), then either the models are built and executed (under the control of a modelling facility processor clock) in sequence as subgoal models, or else these models are constructed in the a-priori-independent parts of a Lumped Modelling Facility, one to each part. Moreover, since each part of the modelling facility has a distinct processor clock, the models are executed in a facility-wise independent manner. But all of the models for goal topics refer to the aim topic, as a result of which their construction is coupled through the L-Processor which executes A.

In the special case when the goal topic is an analogy relation (as discussed in the last chapter), several models are built and executed in different parts of the Lumped Modelling Facility (the models representing the terms or relata of the analogy), and these a-priori-independent models are *executed* (not simply *constructed*) in a locally synchronous manner. The introduction of the couplings that secure this degree of synchronisation represents the analogy relation itself; this, in other words, is the model for the analogy relation between the terms.

The functional coordination of the composite participants a_L and a_T is shown in Fig. 6.2 where the "interface" of the original Icon is made explicit. At level L^0 (of $L = L^1, L^0$) there is a modelling facility (in general, a Lumped Modelling Facility containing several a-priori-independent processors), which is the vehicle for demonstrations given by a_T to a_L and explanatory models produced by a_L for agreement by a_T. The L^1 box, *ES*, is also a modelling facility, in practice the entailment structure display in which derivations of topics are modelled as learning strategies or state marker distributions.

Moreover, the aim topic is selected by choosing values of the semantic descriptors (L^1 predicates) of a conversational domain and the aim is validated, perhaps after a sequence of explore transactions, as noted in Chapter 1. (Recall that aim validation has been introduced into CASTE fairly recently; the validating transactions are not mentioned in the previous monograph, though they correspond to estimation of d_0, which was discussed in theoretical terms.) The conversational domain ($D^1(R)$, $D^0(R)$ or *ES*, *TS* under interpretation) is elided in Fig. 6.2 and its remnant is the Box D. That is, we assume that topics and their entailment relations are described and that for each topic i there is a pointer to some *PG*(i). Both kinds of data are available to $A = a_L, a_T$ (the unidirectional connections from D to a_L and from D to a_T), under the restrictions imposed by B. Moreover, B regulates all interactions at the interface (explanatory or demonstrative modelling in *MF* and the determination of learning or teaching strategies in *ES*) as indicated in Fig. 6.3 by the (dotted) bidirectional connections. In particular, B

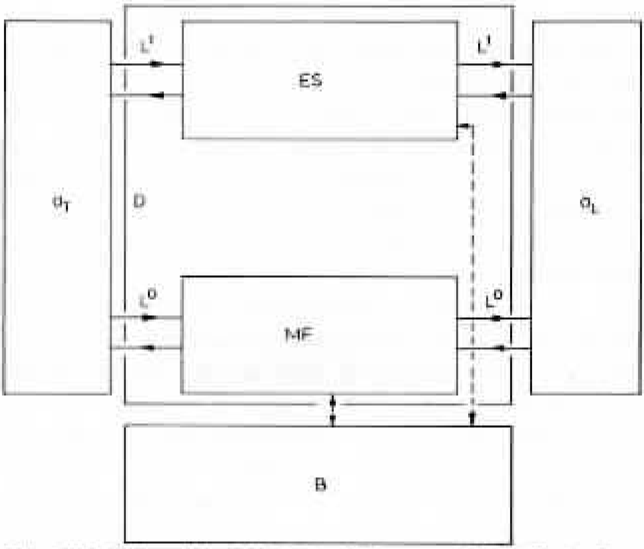


Fig. 6.2. "Cognitive Reflector" in enough detail to show *understanding*. As before, a_L and a_T are cognitive organisations, usually embodied in the same brain and B is the regulating heuristic securing *understanding* for each topic picked out for learning. B exercises overriding control upon access to entailment structure and modelling facility. *ES* = entailment structure for accommodating L^1 (derivation) models as overt learning strategies. *MF* = lumped modelling facility for L^0 explanation and for L^0 demonstration.

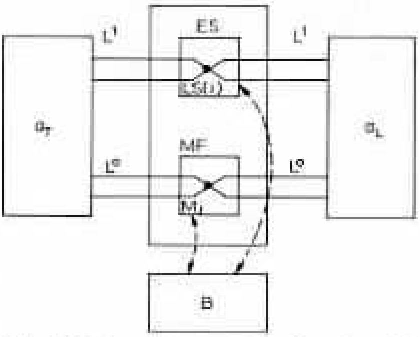


Fig. 6.3. Insertion of aim i and goal (or set of component goals) j. Any learning strategy delineated in the ES display acts as a model. LS(i), under aim i (of how topic i becomes known). The model M_j for any goal j under aim i is constructed in the modelling facility, MF.

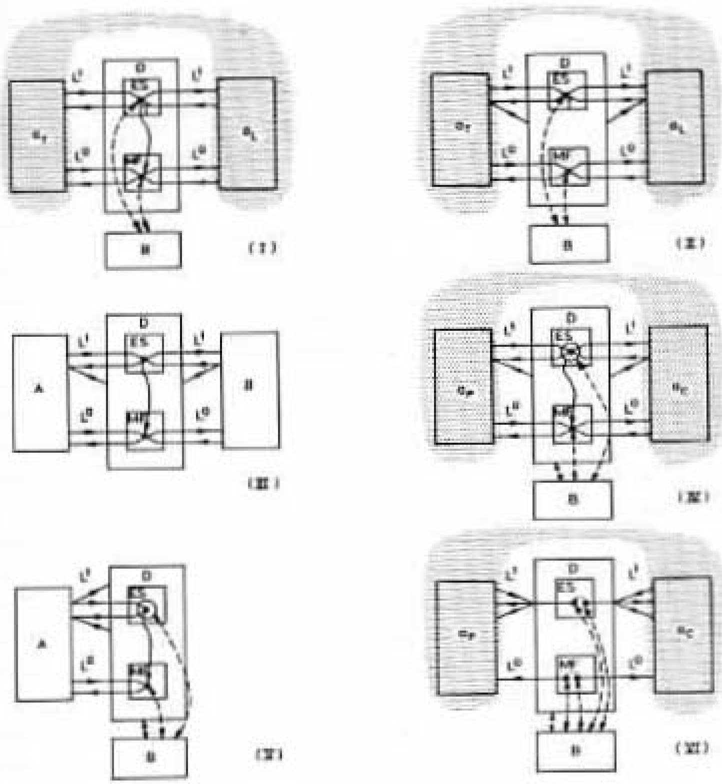
regulation ensures (as in the first monograph) that a strict conversation is reducible to ordered occasions, n, n + 1, ... upon each of which there is an *understanding* of some topic relation.

The construction is completed in Fig. 6.3 by inserting the aim and goal current at the n^{th} occasion.

Equipped with these conventions, it is possible to represent in outline all of the conversation types developed in the Icons of the first monograph, and to encompass without changing the conventions many participant and many aim conversations which have not previously been represented.

The conversation types due for discussion in this book are shown in Fig. 6.4(I) to (XII).

Of these pictures, (I) and (II) show the cognitive reflector construction, with (I) and without (II) the possibility of selecting



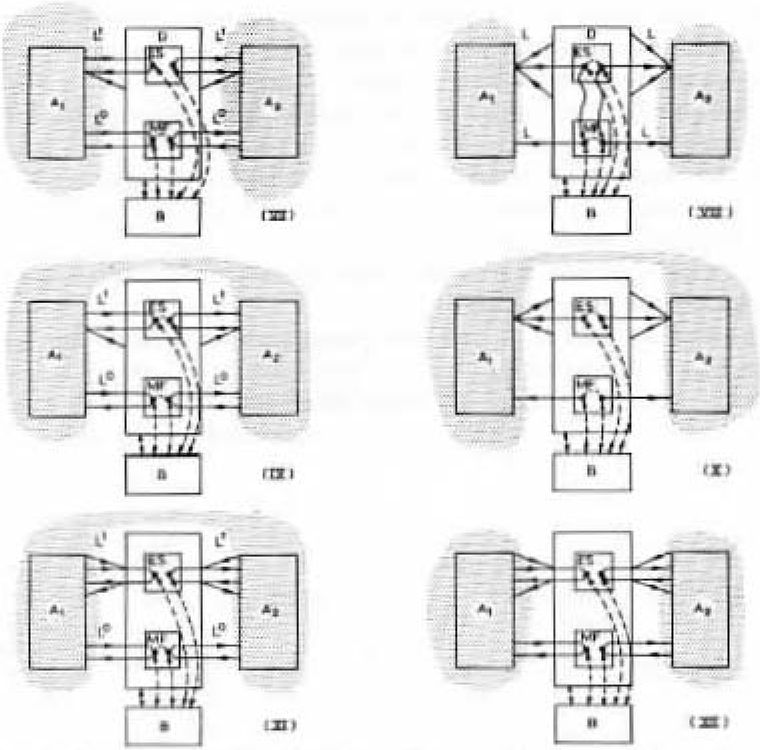


Fig. 6.4. Paradigms for one aim and many aim conversations discussed and detailed in the text. Of these 4(VII) to 4(XI) count as many aim conversations of various types, and Fig. 4(I) to 4(VI) as one aim conversations only. Shading distinguishes one or several brains (L Processors) $\alpha\beta$.

amongst several families of descriptors of the conversational domain. T_i in *ES* (at level L^1) is the aim topic and is connected by a data link to the program graphs (task structures) of one or more goal topics in workset, which are being modelled in *MF* at level L^0.

Picture (III) shows a conversation between a pair of distinct participants which *happens to be* a strict conversation because one of the participants (B) is not only a sentient individual, but *also acts* as a regulating heuristic. This circumstance, which was introduced initially in the first monograph (Icon 4), is exemplified — supposing the transactions are an approximate to those of a strict conversation — by a Piagetian interview or a paired experiment (B the interviewer), by an implementation of the teachback technique (B the participant experimenter), or by a real life tutorial (B the teacher).

In picture (IV), B is a heuristic pure and simple, as in (I) or (II). However, it is an evolutionary heuristic, encouraging development of the conversational domain, such as the EXTEND program in the first monograph. A is a source or subject matter expert (possibly a student who has opted into this role). The circle surrounding the aim topic indicates that the source or subject matter expert is free to originate a topic which is not part of the conversational domain. Insofar as he is able to satisfy the constraints upon learnability and memorability imposed by B, the topic will *become* part of an *enlarged* conversational domain. It is still the case that one and only one aim topic exists at once, namely, the novel topic currently undergoing incorporation.

The gross representation of (IV) is refined in (V) and (VI), by depicting two internal participants which make up A. Since A is a subject matter expert, these components are more aptly called "proposer" and "critic" (Minsky's locution), and they are labelled a_p and a_c (rather than a_T and a_L) for this reason.

The two distinct refinements, (V) and (VI), appear because it is both propitious and operationally mandatory to distinguish between the syntactic and the semantic components of a thesis which is under exposition (at this stage in the exposition just topic T is being added to the thesis).

On the one hand, Picture (V), the description of the conversational domain is held constant and a fresh syntactic derivation is established; this is the basic operation governed by EXTEND. On the other hand, Picture (VI), the form of the thesis is held constant whilst this form is given a fresh semantic interpretation by way of a new description. This is the "choice and the evaluation of descriptors" phase of EXTEND, using the repertory grid technique (Chapter 1, Chapter 3, and Icons 15, 16, and 17, in the previous monograph).

Before turning to the many aim conversations shown in (VII) and (VIII), notice that all of these one-aim-at-once conversations, either on a fixed or an evolving conversational domain, can be accommodated as special cases of the scheme outlined in Chapter 4, Section 1. The specialisation is introduced by setting $L = \mathcal{L}$ (just one language), or in case there are analogy relations, by setting $L = \langle S, \underline{\text{Inter}}\ i, \underline{\text{Univ}}\ i \rangle$ or $\langle S, \underline{\text{Inter}}\ j, \underline{\text{Univ}}\ j \rangle$ so that any analogy is depicted as a morphism (usually an isomorphism) between different models for some identical or similar syntactic expressions. This expedient is satisfactory provided that analogies are learned (from their descriptions in the conversational domain) and are not constructed de novo. The expedient remains satisfactory for the limited, and far from innovative, analogy constructions encompassed by EXTEND; that is, the analogy relation is treated as a fresh topic on a par with others, since it relates topics which already exist in the conversational domain without recourse to the analogy relation. To go further than that, and to accommodate forms of conversation in which the analogy relation is invented first of all and the terms of the analogy (its relator) appear as a result of this invention, it is necessary to introduce the two (or more) aim-at-once constructions shown in (VII), (VIII), (IX) and (X).

We use the notation A_1, A_2 to represent two coexisting P-Individuals, each of which might be factored independently to yield restricted participants: $A_1 = a_{T1}, a_{L1}$ and $A_2 = a_{T2}, a_{L2}$ (or $A_1 = a_{P1}, a_{C1}$ and $A_2 = a_{P2}, a_{C2}$). These P-Individuals are not locally synchronised by the heuristic B and may act independently as indicated by the simultaneous presence of two aim topics. Psychologically, A_1 attends to one topic and A_2 to another; A_1 models a topic in one universe of interpretation, A_2 models a topic (perhaps the same topic) in a distinct universe of interpretation. From the perspective of Section 1, A_1 and A_2 have different languages (so that L is a set of languages $\mathcal{L}_1$, $\mathcal{L}_2$ ...), though certain A_1 statements in $\mathcal{L}_1$ of L may be agreed, at the syntactic level of consensus to have the same formal consequences as certain A_2 statements in $\mathcal{L}_2$ of L.

If it happens, as in (VII) and (VIII), that A_1 is executed in a processor α and A_2 in a distinct processor β, then the syntactic agreement is a consensus between people or cohesive groups A_1, α and A_2, β which may later be strengthened by semantic agreement into a common meaning (accord, cooperative interaction, mutualism).

If it happens, as in (IX) and (X), that A_1 and A_2 are executed in the same L-Processor, a brain, then this agreement sets the stage for an innovation which will occur if the syntactically common statements (call them set E) can be given a compatible interpretation by A_1 and A_2; that is, E gains a common meaning for A_1 and

A_2. If so A_1 and A_2 fuse into one P-Individual $A = A_1, A_2$ with respect to the innovation which is the meaning of E.

Such a fusion is also the "analogy relation first" construction of an analogical topic. By parallel with (V), Picture (IX) represents the syntactic component of an innovation, where distinct universes of interpretation are held constant as a framework. By parallel with (VI), Picture (X) represents the generation of further universes of interpretation as means for realising distinct compilations of the same program.

The artificial calibre of the convenient demarcation between syntax and semantics is conceded immediately. In the sequel, particular significance is credited to the case in which (IX) and (X) coalesce as a hybrid form, approximated by Picture (XI), in which changes of program structure and changes of interpretation are inseparable. In the fields of social anthropology and sociology, similar interest may be attached to the hybrid of Picture (XII). Though it is beyond the scope of our empirical enquiry, we conjecture that (XII) represents a peculiarly stable social group, a persistent cult, an urban civilisation, or a cohesive society.

2. IDENTIFICATION WITHIN THE GENERALISED THEORY OF LANGUAGE

One of the chief results of the work on the theoretical scheme outlined in Chapter 4, Section 1 is an account of the conditions under which entities with different sublanguages, $\mathcal{L}_1$ in L and $\mathcal{L}_2$ in L, may communicate. These theoretical results have been applied (by Gergely and Nemeti) to the interaction between scientific disciplines having disparate languages, or calculi, or models, and to the interaction between social systems.

An indication of the process, as they envisage it, is given in Fig. 6.5, and may be regarded as a cooperative or mutualistic interaction between persons or societies C_1 and C_2. Using the notation of Chapter 4, Section 1, C_1 and C_2 are characterised (given calculi 1 and 2) as a pair of systems $\mathcal{L}_1 = \langle S_1, \underline{\mathrm{Inter}}_1, \underline{\mathrm{Univ}}_1 \rangle$ and $\mathcal{L}_2 = \langle S_2, \underline{\mathrm{Inter}}_2, \underline{\mathrm{Univ}}_2 \rangle$, where S_1 and S_2 are the true statements (or productions under the given calculi) of $\mathcal{L}_1$ and $\mathcal{L}_2$ ... That is, there are models M_1 in <u>Univ</u> 1 (for S_1) and M_2 in <u>Univ</u> 2 (for S_2), which are interpretations of these statements. The truth criterion, in this

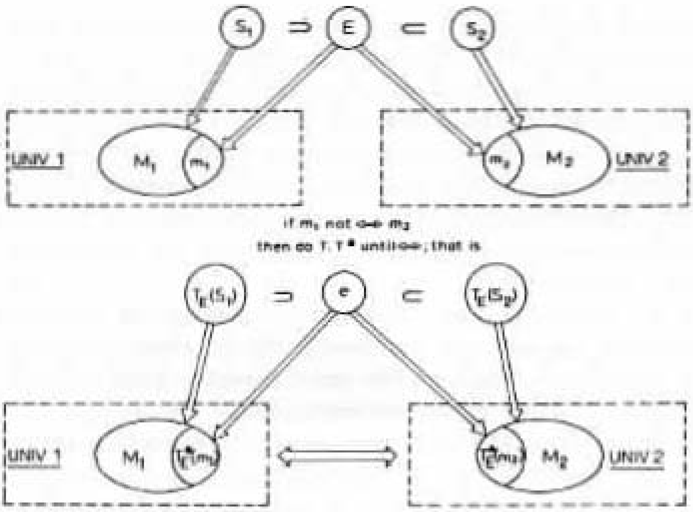


Fig. 6.5. Outline of the transformation required for "common meaning" agreement between participants. Broad unidirectional arrows stand for relation between a class of statements and its model; the bidirection arrow ⇔ stands, as usual, for isomorphism.

case, is veridicial, (for example, the result of empirical testing carried out by C_1 and C_2 independently) and the truth in question is a correspondence truth.

Suppose that certain statements $E \subset S_1$, $E \subset S_2$ are held in common as (syntactically) agreed by C_1, and C_2; that is, the statements of E form a coherent set. Agreement hinges upon a *consensual* agreement; that is, upon a coherence ordained syntactic agreement (Ch. 4 Sect. 7). We are anxious to investigate the circumstances under which C_1 and C_2 attach the same meaning to statements in E, given the existence (as parts of M_1 and M_2 of models m_1, m_2, for E in Univ 1 and Univ 2 that are held, by C_1 and C_2 to represent the correspondence truth of statements in the set E. The required equisignificance obtains if there is an isomorphism from m_1 to m_2 (written, $m_1 \Leftrightarrow m_2$).

Usually, this condition is not satisfied; at most, there is homomorphism preserving only some of the relations in the models and losing specificity. However, it is possible to construct transformations, which we shall here designate T and T*, that are coupled and operate upon S_1, S_2 and m_1, m_2, respectively,* with E as a parameter such that $T_E(s_1)$ and $T_E(s_2)$ generate a usually more complex set, e, of agreed statements, and $T^*_E(m_1)$ is C_1's model of e. $T^*_E(m_2)$ is C_2's model of e, and $T^*_E(m_1) \Leftrightarrow T^*_E(m_2)$ is the common meaning of the (usually more complex) set of statements, e, that are shared by C_1 and C_2 (obtained as a closure of the model space under the originally agreed set of statements, E). The crucial feature of this construction is the fundamental coupling between T and T^*; in order to obtain common meaning, it is generally necessary to modify the statement set and the interpretations. Moreover, although these processes might be isolated under special conditions, they are as a rule inseparable.

To obtain an immediately apposite identification, notice that T represents the act of reaching a syntactic (coherence based) agreement and that T^* represents the act of reaching a semantic (correspondence based) agreement, together an act of establishing a *common meaning.* Now call $C_1 = \langle A_1, \emptyset \rangle$ and $C_2 = \langle A_2, \emptyset \rangle$ (where $\emptyset$ is a variable with values α, β, ...). The legitimacy of this identification is evident in the case when $\emptyset$ assumes distinct values (corresponding to α and β in Fig. 6.4), since the L-Processors are specified at the outset as distinct universes of interpretation. The legitimacy of this expedient when $\emptyset$ assumes the same value (the P-Individuals are compiled and executed in the same brain, or L-Processor) depends upon the assumption that procedures contain a compiler and that they construct distinct "possible worlds" upon compilation. We took this as a plausible hypothesis in Chapter 4, Section 1 and certainly consider it to be experientially (though not empirically) justified. Later on it will be possible to buttress the hypothesis and support it on logical grounds.

Now the argument just put forward, that T and T^* are *in general* coupled, has as a consequence that the most general constructions of Fig. 6.4 are the hybrid organisations in 6.4(XI) and 6.4(XII),

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* As in the previous monograph, the normally Fuzzy reproductive processes can be represented or simulated (Loefgren 1972) as a productive/reproductive Turing Machine which produces and reproduces Turing Machines (representing Progs in the repertoires π_1, π_2, of A_1, A_2). S_1, S_2 are sets of their code numbers and productions. The interpretation functions may be given as fixed (the form I/F of Section 1) or, since α and β are discriminated, in the generative form (Inter of Section 1) calculus 1 and calculus 2 are production systems for these (abstract) machines.

where the act of reaching syntactic or coherence based $\langle A_1, \alpha \rangle$; $\langle A_2, \beta \rangle$ agreement (reflecting T in these pictures) is inseparable from the act of reaching semantic or correspondence based $\langle A_1, \alpha \rangle$ $\langle A_2, \beta \rangle$ agreement, reflecting T^*. Reintroducing the postulate of Section 2, 6.4(XII) is identified with a *natural language* dialogue; L^1 and L^0 coalesce into a natural language, L. The modelling facilities *ES*, *MF* likewise coalesce and become the universes of interpretation of a natural language, namely, as postulated in Chapter 4, Section 2, a set of Fuzzy Sets. Under this identification e is a social metaphor, and it designates, as its *common meaning*, an interpreted analogy relation.

On the other hand, 6.4(XI) represents a slightly different situation insofar as the P-Individuals are compiled and executed in the same L-Processor, and agreements are reached within this medium (between $\langle A_1, \alpha \rangle$ and $\langle A_2, \alpha \rangle$). Once again, L^1 and L^0 coalesce and so do the modelling facilities, *MF* and *ES*. The only kind of modelling facility which satisfies this requirement as a physical entity is an L-Processor, and if this is identified with a brain, then the common meaning encompassed by e and its interpretation is *thought* — constructive or *innovative* thought, if e is, as usual, greater than E.

The remaining, more tractable, pictures in Fig. 6.4 represent special cases of these general paradigms.

All of the "many aim" (more than one coexisting P-Individual) pictures 6.4(VII), (VIII), (IX) and (X) represent an act of agreement about *common meaning*, and as a corollary of the present argument, such situations are likely to foster creativity or innovation which can be observably exteriorised under particular constraints proper to the interpretations (of course assembly and so on) furnished in Section 1.

In contrast, the one-aim-at-once constructions (namely Fig. 6.4(I), (II), (III), (IV), (V), (VI)) do not have this property. The inference is not that a human being *cannot be creative* under these circumstances. The constructions simply assert realisable experimental, tutorial or expository situations in which creative or inventive acts cannot be sensibly *exteriorised for observation*; so that, even if they occurred, such acts, insight apart, would be confused with mistakes or haphazard events.

Moreover, within the experimental framework of the many aim conversations (reified as a many user version of CASTE or its surrogate INTUITION, and a course assembly system called THOUGHTSTICKER), it is possible to suggest mental mechanisms for the creativity and invention which *is* observed and to provide evidence that these mechanisms are in human beings responsible for the transformations T, T^*.

3. GENERAL DISCUSSION

The innovative mechanism to be postulated is readily conceived in terms of the thoroughly tangible analogy modelling operations which were discussed in detail in Chapter 4, Sections 10 and 11. Any model for an analogy relation R_k between topic relations R_i and R_j is a coupling M_k between a pair of distinct models M_i, M_j realised in a-priori-independent parts of a Lumped Modelling Facility. Usually, this does involve a partial synchronisation between the a priori asynchronous processors X, Y in the Lumped Modelling Facility, and at a theoretical level the partial synchronisation is always mandatory.

However, M_i and M_j are compilations of serial representatives S Prog i, S Prog j, of Proc i and Proc j, so that synchronisation is achieved by expedients such as "interruption" and "hold" signals. Hence, M_k is really the compilation of a further serial program (of a kind often called an executive program).

A more general proposal for a mechanism realising the coupled transformations T, T^* depends upon the apparatus discussed and developed in both Chapter 4 and Chapter 5. The procedures under consideration are Fuzzy (Chapter 4, Section 5; Chapter 5, Section 11), and their interaction, coupling and local synchronisation in an L-Processor is imaged in Chapter 4 as the interplay of memories or concepts or both. Chapter 5, Section 10 and 11 presented a more specific mechanism using the Proc^1 categories of *DB*, *PB* and *PC* operations.

Moreover, at that juncture, we posited a boundary condition upon the interaction (here identified with the outcome of T, T^*) to the effect that the Fuzzy Procedure resulting from local synchronisation or coupling is usually larger than the original procedures. Isomorphism between a pair of original concepts is the limiting case, the exception rather than the rule. Generally, the syntactic component (<u>Prog</u>) of a concept must be modified and enlarged before it is possible to secure isomorphism between compilations of models. Thus, in the context of Chapter 5, speaking of analogy construction, most analogies are founded on generalisations, only a few on isomorphism. Within the overall picture of agreement between P-Individuals executed in the same brain or in several, the analogy construction is a special but important case of

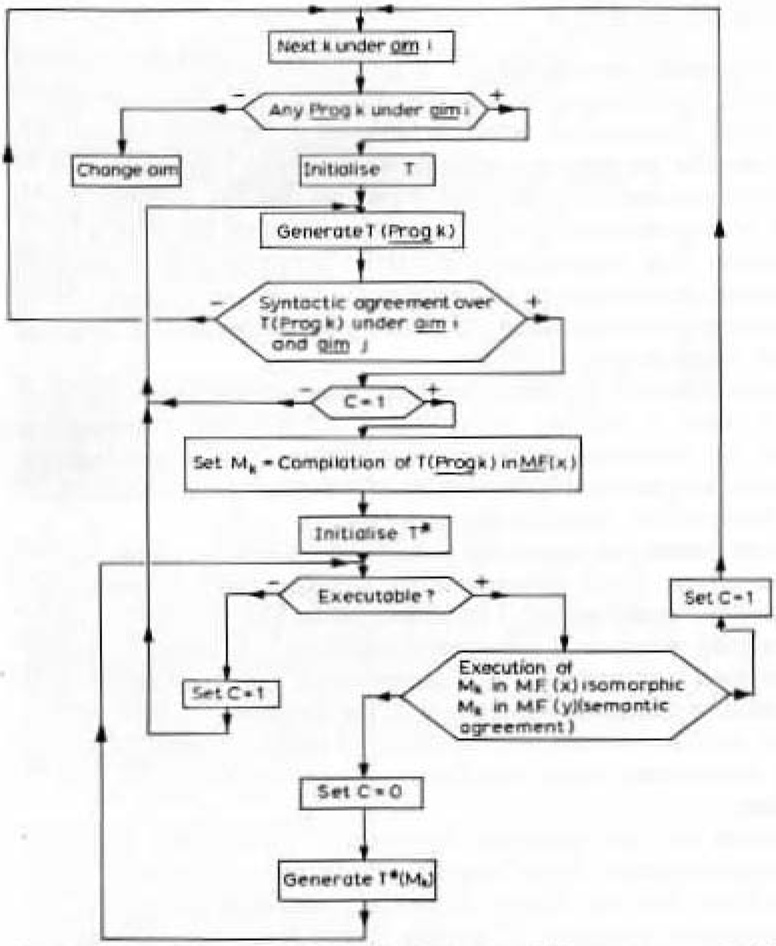

Fig. 6.6. Flow chart approximation to part of "common meaning" process realised in *one* participant. *Both* participants are involved in evaluating the tests in "syntactic agreement" and "semantic agreement" and the process is interrupted at these points. Parameter C is artificial expedient used to represent process serially.

achieving agreement that furnishes a common meaning. For interpersonal dialogue $\langle A_1, \alpha \rangle$ with $\langle A_2, \beta \rangle$, the analogy exists at the syntactic level between the productions of A_1 and A_2; at the semantic level, it induces an isomorphism between compilations/interpretations in the distinct L-Processors α and β. For analogy construction, where only one L-Processor (α, say) is involved, the analogy exists between distinct internal compilations (Inter x/Inter y) or between models M_i, M_j in distinct modelling facilities $MF(x)$, $MF(y)$.

The argument is summarised as follows: a mechanism is believed to exist in mental activity and to have an intimate relation to awareness (since, in conversation theory, consciousness depends upon local synchronisation of a priori asynchronous processors). To reach steady states, this mechanism must be augmented by a boundary condition, and this was introduced as a postulate in Chapter 5, begging the question of what the boundary condition *is*. Starting from the argument in Chapter 4, we imported a set of results (Andreka, Gergely and Nemeti) on model matching and interpreted the transformations T, T^* as the genesis of common meaning, but without stating a mental mechanism which would secure this result. Finally, it is proposed that common meaning is the boundary condition required to govern the process in Chapter 5, and this process is the mechanism required to realise T, T^* and achieve a common meaning.

Fig. 6.6 is a crudely flow-charted approximation to the entire process. It is assumed that distinct P-Individuals exist, that their universes of interpretation and compilation (α, β or X, Y) are held distinct, that each P-Individual has the *isomorphism* operator in his repertoire, and that there is an internal or external channel of communication sufficient to establish local synchronicity.

4. TWO AIMS, ONE TO EACH OF TWO USERS

Suppose there are two users (people, respondents) indulging in dialogue. How should an external observer of their conversation detect the existence of two aims (in a non trivial sense), and what evidence should he accept for the coexistence of two P-Individuals. Since I am anxious to maintain the possibility of experimentation, the conditions to be listed are almost obsessively mechanical.

First of all, the conversational paradigm must be modified to allow for the existence of many aims at once, and this involves replicating all of the apparatus underlying the entailment structure display, the modelling facility, and most of the other parts of an operating system — either CASTE or INTUITION (Fig. 6.7). There are two distinct entailment structures (two replicas) on which separate marker distributions are displayed as the two separate learning strategies of the participants; two records are kept of their explanatory models.

Finally, there are two aims, one to each user. Though the aims may point to the same topic (that is, the node picked out in one

Fig. 6.7. Group learning on INTUITION system for a pair of participants (1 and 2). A = Entailment structure (as in Fig. 1 for participant). B = Entailment structure (a duplicate of participant 1 structure). C = Random access slide projector for descriptive materials. D = Screen visible to participant 1 and to participant 2 jointly. E = STATLAB modelling facility used by participant 1 and participant 2. F = Conditional probability "boxes" and "delay" boxes for modelling stochastic processes. G = Mini BOSS equipment. H = Control and recording equipment for regulating interaction.

user's entailment structure may be in register with the node picked out in the other user's entailment structure), the two aims are separately validated. This means (as in Chapter 1) that each user separately has a substantial zero value of doubt, d_0, regarding the topic description occupying his attention, and even if the aims are in register, the users may have reduced their attentional doubt, d_0, by entirely different explore transactions. Of course, the users *need* not have aims in register and (before they interact) are very unlikely to do so.

In such an arrangement, associated with a fixed conversational domain, it is possible for two participants to learn independently and for the operating system to gather information about the independent learning strategies and the independent explanatory models they produce. Similarly, the heuristic can react to them independently.

If the two participants, human beings, $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ are to engage in collusion, then they must be furnished with a communication channel. Surely, this may be verbal and graphical; for example, $\langle A_1, \alpha \rangle$ may talk to $\langle A_2, \beta \rangle$ and they could look at each other's learning strategies exhibited on their entailment structure displays. They could also cooperate by demonstrating topic relations to each other and by joint model-building. Unfortunately, some aspects of the interchange are not readily interpretable by the heuristic B, and in particular B is unable to sense the fact that $\langle A_1, \alpha \rangle$ does (or does not) entertain hypotheses about $\langle A_2, \beta \rangle$ (in contrast to hypotheses about the topics being learned); and vice versa, of course, $\langle A_2, \beta \rangle$ may or may not entertain hypotheses about $\langle A_1, \alpha \rangle$ of which B is necessarily ignorant. This defect is damaging because if B takes $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ as a-priori-independent (on the grounds that A_1 and A_2 are housed in different brains α, β, and need not interact through the operating system), then B must sense the extent to which A_1 and A_2 do interact with each other (not simply with the operating system) in terms of their mutual and person directed hypotheses. Similar remarks apply to the external observer if he remains utterly dispassionate and refrains, for example, from interpreting spoken dialogue.

The minimal sampling arrangement for mutual (I/You, not I/it) hypotheses is an IPM interchange between $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$, mediated by the FRIM device described by Icon 24 and Fig. 9.10 in the first monograph. (Recall the change in notation: to tackle many aim systems the participants are now called A_1 and A_2, while in the first monograph they feature as A and B.) With the changed notation, an IPM response to a PQuest (multiple choice, list, or assessment question) is a double hierarchy of replies; for example, regarding the evaluation of some property of *topic* i, presented jointly to $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$, we have:

1 (i) What A_1 thinks of *topic* i,
1,2 (i) What A_1 thinks A_2 thinks of *topic* i,
1,2,1 (i) What A_1 thinks A_2 thinks A_1 thinks of *topic* i.

On repeating the hierarchical construction for the other participant, independently, the following responses are obtained from the perspective of $\langle A_2, \beta \rangle$:

2 (i) What A_2 thinks of *topic* i,
2,1 (i) What A_2 thinks A_1 thinks of *topic* i,
2,1,2 (i) What A_2 thinks A_1 thinks A_2 thinks of *topic* i.

In the simple IPM test, the scores are collected independently as lists and compared for later reference. Using FRIM, the participants, having stated their (independent) hypotheses, receive an immediate stage by stage feedback (first monograph) which allows them to resolve differences and reach agreement (if they wish to do so) on the spot; not necessarily agreement over topic i, more often agreement to differ and agreement about why they differ (Fig. 6.8).

We intend to use the existence of feedback manipulable mutual hypotheses as the evidence for cogent interaction between the participants $\langle A_1, \alpha \rangle$, $\langle A_2, \beta \rangle$ and to say, in general, that two P-Individuals exist if there are aims i, j such that appropriate matching scores or comparisons are obtainable with respect to the values of the descriptors of the aim topics, and similar matches are obtained in respect of PQuests (as in the first monograph, multiple choice or list questions) spanning topics k that are goals, under the distinct aims, common to both aim topics.

The argument depends quite critically upon the fact (given, in an operating system) that the aims chosen by the participants are both validated. As a result, both participants have a near zero attentional doubt, d_0, in respect of their own aim, or differently phrased, both participants have some description of the aim topic which is compatible with the (possibly redundant) descriptor

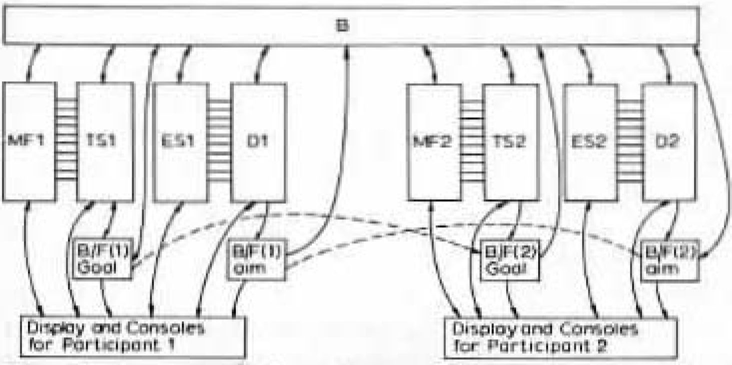

Fig. 6.8. A many participant (many user) operating system in which interpersonal communication takes place through the boxes B/F(1) aim, B/F(1) goal and B/F(2) aim, B/F(2) goal. The label "B/F" denotes "BOSS/FRIM equipment"; the B/F aim boxes are aim validation devices and the B/F goal boxes are confidence estimation devices.

values assigned on the conversational domain, by the subject matter expert.

Since the point is important, it is worth looking at the matter from a viewpoint which some readers may find more explicit. Consider the descriptors as semantic differential indices (Osgood et al. 1957). If *topic* i is validated as one participant's aim, and *topic* j is validated as the other participant's aim, then both participants have located the topics they appreciate as points (relative to their own perspective in the matter) in an Osgood-like semantic-space. Quite possibly, *topic* i and *topic* j are distinct. Whether or not this is so, the possible set of (semantic differential) attributes is available to both of them. They both have unlimited explore transactions. It makes sense to compare their attitudes, noting that participant A_1's perception of *topic* i may (or may not) differ from A_2's perception of *topic* i; that A_1's perception of *topic* j may differ from A_2's perception of *topic* j; and that A_1 and A_2 may or may not see *topic* i and *topic* j as similar.

Use δ to denote a descriptor having real values (+, — not the null value*) on a *topic* i and index it (δ_i). If $\langle A_1, \alpha\rangle$ and $\langle A_2, \alpha\rangle$ are anxious to interact, then they must satisfy the conditions given below. (Note the inversion of indices, i is still A_1's aim topic, and j is still A_2's aim topic.)

$1(\delta_i)$ may or may not match $2(\delta_i)$
$1(\delta_j)$ may or may not match $2(\delta_j)$

But, if not, then

$1,2(\delta_i)$ must match $2(\delta_i)$
$1,2(\delta_j)$ must match $2(\delta_j)$

and

$1(\delta_i)$ must match $2,1(\delta_i)$
$1(\delta_j)$ must match $2,1(\delta_j)$.

If this condition is satisfied for all the descriptors with $(+, -)$ values on topic i and topic j (as a matter of practice, all those used by the pair of participants for gaining access to the aim topics), then: Either $\langle A_1, \alpha \rangle$, $\langle A_2, \beta \rangle$ agree about the description of their (possibly distinct) aim nodes, or even though the aims have a different meaning, the participants are alive to the differences and have accurate hypotheses in this respect. This is a *semantic agreement* index and an approximation to Fig. 6.4(VIII).

If $\langle A_1, \alpha \rangle$, $\langle A_2, \beta \rangle$ enter into these mutual hypothetical transactions and also provide the required matching scores, then one participant's entailment structure display (its configuration of markers is this participant's learning strategy *LS*) is made available to the other participant, and vice versa. Moreover, if this combination is satisfied, $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ share the results of explore transactions, and in addition to this, $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ may adopt a joint learning strategy, worked out on the entailment structure display. The participants are now in a position to cooperate in learning. As a rule (though various heuristics have been used and are being tested out experimentally), the potentially possible modes of cooperation are as follows.

(a) $\langle A_1, \alpha \rangle$ models a topic as a demonstration to $\langle A_2, \beta \rangle$ (thus, $\langle A_1, \alpha \rangle$ is acting as a genuine teacher), and vice versa.
(b) Within restrictions (noted in Chapter 4) upon complete overall explanation, $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ build and submit a joint explanatory model.

Either (a) or (b) or both are permitted for any topic k, such that k is both in the EntSet (i) and in the EntSet(j) (hence, it is a possible goal topic), and such that the following conditions are satisfied for R_k. For any R_k it is possible to construct a list of spanning PQuest k of alternative sets (AltSets, previous monograph) in which only one alternative (Alter$^+$) is correct. In essence, the Alter in AltSet k figure as plausible solutions to problems posed in respect to realising R_k, and the groupings into AltSets are designed to set up a one-and-only-one-correct situation.

Using BOSS (Belief and Opinion Sampling System, previous monograph, Chapters 4 and 6), each participant can provide an index of veridical certainty, a confidence estimate that peaks for Alter$^+$ in the AltSet k of PQuest k. These indices disignated θ (the Shuford Scores of the previous monograph) are written θ_1 for $\langle A_1, \alpha \rangle$ and θ_2 for $\langle A_2, \beta \rangle$, and θ values are elicited in respect of any R_k for which the participants wish to cooperate. Let θ_0 be a criterion value (about 0.8 is usual), then the condition that $\theta_1 > \theta_0$ *or* $\theta_2 > \theta_0$ *or both* indicates that one or other participant or both of them are able to set about solving problems under the topic relation R_k.

It is also possible to obtain an unconstrained confidence estimate indicating the participants' doubts about problem solving under R_k, whether or not the participants favour a *correct* solution (that is, an estimate of each participant's prospective doubt, d_2 of Chapter 11 in the previous monograph). Moreover, the d_2 estimate makes sense since attentional doubt, d_0, is nearly zero (assured by aim validation). As a slightly different exercise, it is easy to match BOSS responses to PQuest k, obtained in the unconstrained mode, in an IPM or FRIM hierarchy.

Use $1(R_k)$ for $\langle A_1, \alpha \rangle$'s confidence estimate; $2(R_k)$ for $\langle A_2, \beta \rangle$'s. Use $1{,}2(R_k)$ and $2{,}1(R_k)$ for the confidence estimate obtained to express A_1's belief about the confidence estimate that A_2 will produce, and A_2's belief about the confidence estimate that A_1 will produce (both of them given the same question, namely PQuest k).

Notice, as an operationally important point, that both matching scores based on the form of prospective doubt and correct belief scores, θ, are obtained from the same response, for θ is derived by a mechanical comparison between the confidence estimate and Alter$^+$ (which is unknown to the participants).

If the participants desire to cooperate at *topic* k (either by method (a) or method (b)), and if the EntSet condition is satisfied, then they may do so provided that

(1) $1(R_k)$ matches $2(R_k)$ or, if not, then $1{,}2(R_k)$ matches $2{,}1(R_k)$

(from which, since d_0 is nearly zero for both participants, these participants either have the same form of prospective doubt, d_1, or if not, they recognise the difference that exists between them). And

(2) Either $\theta_1 > \theta_0$ or $\theta_2 > \theta_0$ or both

(an optional, but salutary, condition; at least one of the participants has a chance of solving problems correctly with respect of R_k).

If so (and if cooperation takes place), the participants are reducing their individual prospective doubts, d_1, by information about the form of their mutual prospective doubt. This realises the syntactic agreement of Fig. 6.4(VII).

5. IMPROVED OPERATING SYSTEMS FOR TWO USERS

Both the *semantic agreement* index and the *syntactic agreement* index can be refined, using the following techniques:

To refine the semantic agreement, the FRIM responses to a PQuest are replaced by FRIM responses to Thomas's "Exchange Grids" where the participants are allowed to construct and compare their own descriptors as well as the values of fixed descriptors. The technique is an elegant and basic extrapolation of the repertory grid technique for eliciting "personal constructs" (alias descriptors), mentioned in Chapter 1 and crystallised in Icons 15, 16 and 17 of the first monograph. Although only recently introduced into our operating systems, Thomas has employed the "exchange grid" method extensively, both manually (Thomas 1971) and using computer administration (Thomas 1970). The results from these studies are extremely coherent and informative.

The previous notation $1(\delta_i)$; $1,2(\delta_i)$, and so on, is generalised to accommodate exchange grids by writing δ_i for the constructs or descriptors at *topic* i and Δ for a vector $\delta_{i1}\delta_{i2} \ldots \delta_{j1}\delta_{j2}$ so that an exchange grid comparison has the form:

$1,2(\Delta)$, $1(\Delta)$ For $\langle A_1, \alpha \rangle$

$2,1(\Delta)$, $2(\Delta)$ For $\langle A_2, \beta \rangle$.

This process of reaching semantic agreement is a more informative realisation of Fig. 6.4(VII), in which the descriptors are regarded as personal constructs (Kelly 1955), rather than the attributes in a semantic space; i.e., the system is an open system, rather than a closed system.

Regarding the *syntactic agreement*, the refinement is obtained (A) by adjoining a "dummy" (L^0) modelling facility to each working position, so that one participant can deliver an IPM response by "making the model he thinks the other participant will make", and (B) by adding further markers, so that one participant can model on the entailment structure display "the learning strategy he thinks the other participant will adopt". This L^1 or learning strategy hypothesis may contain a redundant semantic component (picked up already by the exchange grid system) insofar as the entailment structure display represents some (but not all) of the L^1 semantic descriptors.

Insofar as the participants reach agreement at the syntactic level, they not only reduce their individual prospective doubt, but also their retrospective doubt (d_1 of Chapter 11 in the previous monograph) and do so by exchanging information about the form of each other's doubt (both prospective, d_2, and retrospective, d_1).

The "dummy" models and the hypothetical learning strategies enter into FRIM comparison and feedback, as before. They are shown in Fig. 6.9, using the following notation.

$1(LS_i)$ is $\langle A_1, \alpha \rangle$'s learning strategy under aim *topic* i.
$1{,}2(LS_j)$ is $\langle A_1, \alpha \rangle$'s hypothesis about $\langle A_2, \beta \rangle$'s learning strategy under aim *topic* j
(and, vice versa, $2(LS_j)$ and $2{,}1(LS_i)$, for $\langle A_2, \beta \rangle$.

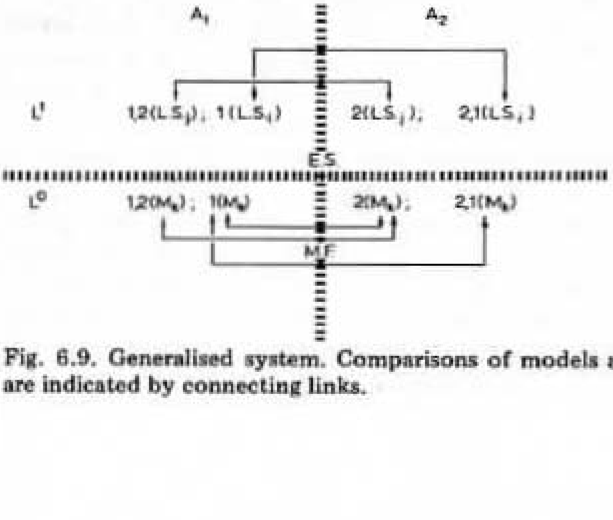

Fig. 6.9. Generalised system. Comparisons of models and learning strategies are indicated by connecting links.

$1(M_k)$ is $\langle A_1, \alpha \rangle$'s explanatory model, complete or incomplete, for any *topic* k in EntSet i and in EntSet j.

$1,2(M_k)$ is $\langle A_1, \alpha \rangle$'s hypothesis about the explanatory model which could be, or is, constructed by participant $\langle A_2, \beta \rangle$ at the same *topic* k (and, vice versa, $2(M_k)$ and $2,1(M_k)$, for $\langle A_2, \beta \rangle$.
(and, vice versa, $2(M_k)$ and $2,1(M_k)$, for $\langle A_2, \beta \rangle$.

Thus, Fig. 6.9 depicts a realisation of Fig. 6.4(VII).

The modified operating system is a realisation of Fig. 6.4(VII) and Fig. 6.4(VIII), in which these constructions are alternated in reaching syntactic and semantic agreement. The kinds of agreement are, however, phased distinctly, and the system should not be confused with the hybrid form of Fig. 6.4(XII).

6. OPERATION

Experiments have been carried out with the system described in Section 5 and a simplified version (common modelling facility) of the refined system. The chief importance is to provide a standard condition for group learning on a par with CASTE or INTUITION as a standard condition for individual learning. The systems are quite practicable, but the experimental work must be regarded as a pilot study.

(a) Some (but not all) pairs $\langle A_1, \alpha \rangle$, $\langle A_2, \beta \rangle$ interact to form groups. Once formed, a group of participants appears to have stability due to a fixity effect. Not surprisingly, stable groups learn successfully and benefit from cooperative interaction.

(b) As might be anticipated, the personality (chiefly manifest in the participant's choice and use of descriptors), as well as the learning style and competence, influences the formation of groups which act as P-Individuals in the conversational domain.

It looks as though matched combinations (serialist/serialist, or holist/holist) are more effective and thus are predicted to have a greater chance of being stabilised by cognitive fixity. However, a serialist participant and a holist participant can also coalesce, and a few instances have been observed. The aims of the participants remain distinct, and there is a division of labour in respect of model building and demonstration. Though $\langle A_1, \alpha \rangle$ has accurate hypotheses about $\langle A_2, \beta \rangle$, and vice versa, they do not agree to adopt the same learning strategy, even though each participant knows why the other learns as he does.

7. THE MEANING OF STABLE CONFIGURATIONS WITH MUTUAL HYPOTHESES

Let $\pi_1^1 i$, $\pi_0^0 i$ denote (as in the first monograph) the cognitive repertoire of a given P-Individual A_1; similarly, $\pi_2^1 i$ and $\pi_2^0 i$ stand for the cognitive repertoire of P-Individual A_2; in each case, the π^1 component is the L^1 component and π^0 is the L^0 component (of $Proc^1$s and $Proc^0$s). This notation is extended to cover the mutual hypotheses entertained by the P-Individuals A_1, A_2 (or the participants $\langle A_1, \alpha\rangle$ and $\langle A_2, \beta\rangle$ by the following expedient.

$1(\pi^1) = \pi_1^1 = \{\underline{Proc}^1 i\}$ in A_1: $2(\pi^1) = \pi_2^1 = \{\underline{Proc}^1 i\}$ in A_2.

$1(\pi^0) = \pi_1^0 = \{\underline{Proc}^0 i\}$ in A_1: $2(\pi^0) = \pi_2^0 = \{\underline{Proc}^0 i\}$ in A_2.

Iterating the notation

$1{,}2(\pi^1)$ = A_1's hypotheses about A_2's L^1 repertoire.

$1{,}2(\pi^0)$ = A_1's hypotheses about A_2's L^0 repertoire.

And, vice versa, for the P-Individual A_2, as

$2{,}1(\pi^1)$ = A_2's hypotheses about A_1's L^1 repertoire.

$2{,}1(\pi^0)$ = A_2's hypotheses about A_1's L^0 repertoire.

The repertoires π^0, π^1, $1(\pi^0)$, and so on are specified "relative to the <u>EntSets</u> of the <u>aim</u> of $\langle A_1, \alpha\rangle$ and the <u>aim</u> of $\langle A_2, \beta\rangle$ insofar as these <u>EntSets</u> have members in common". But, if the participants agree with respect of their semantic interpretations (that is), $1(\Delta) = 2(\Delta)$, as well as the mandatory condition, that $1{,}2(\Delta) = 2(\Delta)$ and $2{,}1(\Delta) = 1(\Delta)$), then if both participants aim for the head topic under the agreed descriptors, all members of their <u>EntSet</u> are held in common. So the disclaimer is not, in practice, as drastic as it seems to be.

Suppose there is a joint semantic agreement and syntactic agreement between participants $\langle A_1, \alpha\rangle$ and $\langle A_2, \beta\rangle$ (with constituent P-Individuals A_1 and A_2). This joint agreement implies the existence of a further P-Individual A constructed in Fig. 6.10. Further, the

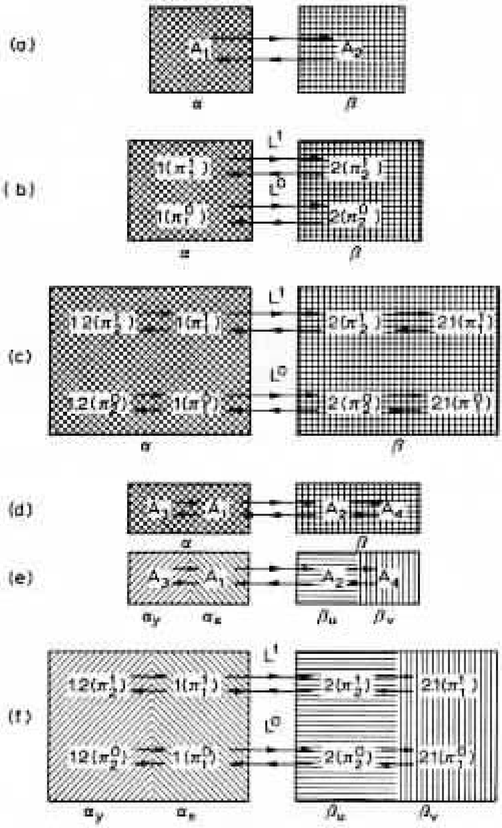

Fig. 6.10. "Conversation breeding". Common meaning agreement may give rise to the construction of further, viable, P individuals insofar as 1's hypotheses about 2 and/or 2's hypotheses about 1 are self replicating. If so, the compilations in α and/or β are partitioned (the notation "α_x, α_y; β_u, β_v"). Key: (a) $\langle A_1, \alpha\rangle$ reaches common meaning with $\langle A_2, \beta\rangle$. (b) Expansion of (a) prior to common meaning agreement representing hypotheses about the agreed topic. (c) Expansion of (a). The hypotheses entertained by 1 (alias $\langle A_1, \alpha\rangle$) about 2 (alias $\langle A_2, \beta\rangle$) and vice versa. (d) Condensed form of (c). (e) Condensed form showing segregation of independent compilations in previously homogeneous L processors (in distinct brains). (f) Expansion of (e).

matching of representative models and hypotheses (Fig. 6.9) is evidence (so far as an external observer is concerned, *the* evidence) for the existence of such a configuration.

The really important point is that $1,2(\pi^1)$, $1,2(\pi^0)$, and $2,1(\pi^1)$,

$2,1(\pi^0)$, respectively, *may also* be self-replicating and, consequently, count as P-Individuals *in their own* right (albeit, compiled and undergoing execution in the same brain α or β, as $\langle \pi_1^1, \pi_1^0 \rangle$ and $\langle \pi_2^1, \pi_2^0 \rangle$, respectively). As a result, a larger P-Individual containing the concepts and memories that are common to $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ is generated by a common meaning agreement between these participants. But there is a converse and equally important result.

If the conversation between $\langle A_1, \alpha \rangle$ and $\langle A_2, \beta \rangle$ is halted, for whatever reason, then an *internal* to α or *internal* to β conversation may take place between the fresh P-Individuals induced by mutual hypothesis-making, and it will be recalled, *some* conversation *must* take place. Finally, conversations of the external or the internal type *must* take place whilst consciousness is maintained (previous monograph, "man is designed to learn"). One reason for truncating a particular conversation (say $\langle A_1, \alpha \rangle$ with $\langle A_2, \beta \rangle$) is that A_1 and A_2 reach common meaning. Or, phrasing it differently, transactions addressed by A_1 to A_2 or by A_2 to A_1 feature as the *provocative* transactions (i.e., such transactions involve mutual hypothesising). From the previous monograph the learning condition can be alternatively stated as, "there must be some (any, in fact) provocative transactions".

Thus, conversations breed conversations provided only that the personally hypothetical structures are self-replicating. The mechanism is sketched in Fig. 6.10 and is dubbed a "conversation breeder" for later reference.

Amongst the other prerequisites for conversation breeding (for example, that personal hypothetical structures are syntactically self-replicating), there is one of special interest; namely, that $\langle 1,2(\pi^1), 1,2(\pi^0) \rangle$ and $\langle 1(\pi_1^1), 1(\pi_1^0) \rangle$ must have an independent compilation and interpretation in α (the brain or L-Processor), similarly for $\langle 2,1(\pi^1), 2,1(\pi^0) \rangle$ and $\langle 2(\pi_2^1), 2(\pi_2^0) \rangle$ in β. It is thus, perhaps, that distinctions are generated; at least this is one view to adopt about the otherwise slightly arcane notion of "predication" (previous monograph). In Fig. 6.10 the independent portions of the brains or L-Processors are symbolised α_x, α_y, and β_u, β_v. The P-Individuals "bred" by the process are concisely designated by $A_3 = \langle 1,2(\pi^1), 1,2(\pi^0) \rangle$ and $A_4 = \langle 2,1(\pi^1), 2,1(\pi^0) \rangle$. Certainly the process may be iterated within a brain or L-Processor and is limited only by the fact that not all the conditions for self-replication of the "offspring" (A_3, A_4) are satisfied. As a further point, the process has a base definition, "There is a conversation". But this may be an internal conversation, in α for example, obtained by setting $\alpha = \alpha_x, \beta = \alpha_y, A_2 = A_3$ in the first stage of the process.

One unsatisfactory aspect of the notion "conversation breeding" is lack of any cogent reason why distinct P-Individuals operating as unities in distinct interpretations (α_u, α_v, or β_x, β_y) should come into existence. The question is not absurd; without importing further constraints, there is nothing to prohibit undifferentiated growth, rather than the development of discrete entities. Very similar difficulties beset generative theories in biology and are typified by asking why organisms should be distinct rather than aggregated into splodges like the polyps in a coral reef.

Sometimes it is possible to answer the question on energetic grounds; sometimes this mode of argument is less convincing, even though energetic and spatial considerations surely contribute to the observed segregation of organisms (critical mass/volume ratio, critical efficiency/communication balance, and so on). In all cases, there is recourse also to immunological or genetic incompatibility, both as a special discriminating agent, and as a means of maintaining the biological individuality of an organism during its life span.

By the same token the present difficulty, "Why are there distinct perspectives rather than one gigantic splodge of attention?", calls for similar treatment. One answer is furnished in Chapter 7, Section 4.

8. COMMON MEANING AGREEMENT IN A HYBRID SYSTEM

Since the internal conversations do not penetrate an interface, they are not open to direct external observation. But conversation breeding is not a strange phenomenon. Really, it rephrases the contention of phenomenological and transactional psychology that a "self" exists insofar as there are "others" and that if there is a "self", there must be "others" and that in a slightly obscure sense (though here some clarity is gained), the "self" is "made up from many others".

A more pedestrian, but no less important, interpretation is as follows:

Suppose that L is a *natural language* (Fig. 6.4(XII)). If so, the joint P-Individual A may be *realised*, rather than evidenced, to an external observer. Alternatively, suppose the construction is performed when $\alpha = \beta$, so that there is a *uniform L-Processor* and that participants $\langle A_1, \alpha\rangle$ and $\langle A_2, \alpha\rangle$ inhabit it (the position indicated in Fig. 6.4(XI)). If so, the joint P-Individual A of Fig. 6.10 may also be *realised*, rather than *evidenced*.

Succinctly, the barriers of an interface and a stratified conversational language $L = L^1, L^0$ no longer block certain transactions. Under these circumstances, not only can $1(\pi^1)$ construct $1(\pi^0)$ and $1,2(\pi^0)$, but also $2(\pi^0)$. Vice versa, not only can $2(\pi^1)$ construct $2(\pi^0)$ and $2,1(\pi^0)$, but also $1(\pi^0)$; not only can $\langle 1(\pi^1), 1(\pi^0)\rangle$ construct $1,2(\pi^1)$, but also $2(\pi^1)$; not only can $\langle 2(\pi^1), 2(\pi^0)\rangle$ construct $2,1(\pi^1)$, but also $1(\pi^0)$. The system is self-replicating in its proper conversational domain.

Fig. 6.4(XII) represents a depth interview using natural language (and is the last elaborate construction that captures the essence of such a conversation). Fig. 6.4(XI) is (as maintained in Section 2) the minimal construction for thought. In this case, however, the empirical enquiry can penetrate further into the inscrutable mental activity called innovation; moreover, the enquiry can be conducted without relinquishing the convenience of operating systems that are at any rate partially mechanised.

Part B. Attention

9. P-INDIVIDUALS, THE FOCUS OF ATTENTION AND ONE OR MORE AIM TOPICS

The term *attention* is used ambiguously in some of the psychological literature. The different shades of meaning are probably most obtrusive to psychiatrists with information theoretic training who are anxious to apply measures of signal rate, redundancy, etc., in comparing normal and abnormal behaviour (Thomas 1970), and to educational psychologists eager to employ information processing schemes in the context of full blooded learning and teaching situations (Entwistle 1975). Naturally, we experience similar problems with the present approach, and at this point it becomes necessary to deal with the matter.

Our discussion closely parallels Thomas' (1970) analysis and is not likely to cause much dispute. Psychologists such as James

(1890) or Bartlett (1932) or Kelly (1955) use "attention" for a locus of awareness; the field of attention is the scope of awareness; its content determines the nature of awareness, roughly the usage employed in this book. Thomas has a slightly narrower interpretation in mind (maximising information feedback with respect to satisfying a task criterion in the current environment). Interestingly enough, a similar idea is implicit in Bryan and Harter's (1899) classic paper on the telegraphic coding skill, though measures of selective information were not available at that date.

Two other meanings (at least) are given to "attention". For circumstances under which the respondent receives and processes an input of sensory data (auditory, visual or whatever), it is customary to speak of "selective attention" (the extent to which "relevant" signals are processed and "irrelevant" signals excluded). This meaning is employed by Broadbent (1957) and Treismann (1966) in connection with "missed signal" and "perceptual filtering" experiments, Welford (1968) in the context of single channel operation, and by Tanner and Swets (1954) when discussing receiver operating curves and signal detection theory in general. As an alternative, when there are several modalities, criteria of relevance, or signal sources, the "division of attention" is of primary interest; for example, in studies of vigilance and perception (Broadbent 1971) or in the multiple channel and scanning experiments performed by the authors already mentioned and by Conrad (1954), Poulton (1953, 1960), Mackworth (1959), or Yntema and Mueser (1960, 1962). Under these circumstances "attention" unqualified is sometimes used as an index of the receiver's capacity and flexibility, the number or variety of information channels he is able to deal with successfully. The two meanings "selective attention" and "division of attention" are obviously compatible, and under special circumstances, come into register with attention as a "scope of awareness". Hence, our usage often conveys the flavour of attention as an omnibus term for the overall properties of an information processor, for which Atkinson and Shiffrin's (1965, 1967) scheme (sketched in the Introduction) is an appropriate paradigm.

Formerly, "attention" and "span of attention" were sometimes taken as synonyms for "size of sensory buffer", or "span of apprehension" (digit span or Miller's 1956 "Magic Number 7 ± 1" of "chunks held in immediate memory"), thus making attention a property of the register, or the short-term store, rather than a property of the entire system. This usage is nowadays substantially abandoned. So far as this book is concerned, at any rate, no such connotation is intended.

What are the differences between "attention" as scope of awareness (SAA) and "information processing attention" (IPA)? The outstanding distinction between them is that SAA refers to an awareness or perhaps to a consciousness (with *someone* of *something*), whereas IPA is uncommitted in this respect. In contrast, IPA has a very strong commitment to the input and output operations of the processor, including the function it/he is designed/instructed to perform, whether it/he is aware of the performance or not. Similarly, unless SAA is constrained by the requirement that something (a relation to be computed) exists in consciousness, the respondent's awareness might refer to any inputs/outputs, or to none at all. There are thus a number of plausible situations in which SAA and IPA may be used independently, and under these conditions, the indices attached to SAA and IPA should not be expected to covary.

Surely, most conditions are *not* of this kind; most conditions of immediate concern are *not*. Even so, SAA and IPA still have a modicum of independence. Nobody overlooks this fact. For example, Treissmann points out that there must be a leakage of information around sensory filters (the leakage being part of SAA, though the filtered messages are formulated in terms of IPA), and Sutherland (1964, considering "sensory analysers" rather than "filters") makes a similar observation.

10. ATTENTION AND "PARALLEL ACTIVITY" AS A "PSEUDO-PROBLEM"

In the present theory of conversations we are, however, treading over perilous ground. The aim of the participants was introduced as a surrogate for their attentional focus (in one-aim-at-once conversations) for several reasons; one of them, to avoid confusions which might easily arise if "attention", a more usual term, had not been continually qualified as "SAA" or "IPA" or "so much of one and so much of the other". No great difficulties crop up in loosely equating aim and "focus of attention" (or awareness of goals under aim), provided that only one-aim-at-once conversations are under discussion. The only problem which does appear in this context was considered in Chapter 5, Section 11, but is illuminating enough to bear recapitulation.

For *either* a serialist *or* holist participant (A) the aim topic in the conversational domain is a locus of awareness in one of the following senses.

(a) It is a topic (the maximally distant topic) which A is able to appreciate and describe.

(b) If A is on his own (interacting with the cognitive reflector heuristic B) then the aim topic is a point at which normally asynchronous processes are locally synchronised (the region of synchronicity includes goals in workset under the aim, intermediary topics, and the aim topic itself). If the processes in question are exteriorised by B's action, then "A's awareness" becomes "A's consciousness" (apparently, *with* B *of* aim) and the statement is empiricised.

(c) If several participants (A_1, A_2) are learning, then statement (b) stands, given the further condition that some of the processes which become locally synchronised under a common aim topic belong to A_1 and other to A_2.

Of these clauses, (a) is normative and it appeals to a notion of consciousness (the appreciation of the aim topic).

Even so, the scope of consciousness is operationally determinable to the extent that it is exteriorised in any strict conversation. At the outset, when topic i is the aim, A's awareness is the description of topic i which is given as the basis for the aim validation (to secure $d_0 = 0$). Later on, if aim becomes understood, the scope of A's consciousness is the series of L transactions or L statements that are exchanged with B and lead towards the achievement of an *understanding*.

In contrast, Clause (b) or Clause (c) or both form the basis for a partial mechanistic explanation of consciousness, insofar as (b) or (c) delineate the conditions prevailing at any point in the conversational domain where SAA exists and (by hypothesis) prevailing for any conscious event, observable or not.

In the case of a serialist, for whom goal = aim, it seems easy to equate SAA with aim and to place SAA in register with IPA, since the participant is working on/learning about the (one) goal topic which (usually) is the aim topic. For a serialist having one goal in his workset and one (but a distinct) aim, it becomes necessary to recognise that the content of SAA is broader than that. The participant entertains hypotheses, images, and thoughts other than those proper to the one goal topic, and as a result, it is provident to revise the seemingly easy equation between SAA and IPA for all occasions in a serialist learning strategy whether goal = aim or not. To be conscious of a topic in a learning situation means more than simply behaving sensibly in respect of that topic. We may equate SAA (goal) with IPA (goal) but not SAA (aim) with IPA (aim). When using aim in place of the participant's *focus of attention*, we refer to SAA (aim). There is no need to comment further unless it is pointed out that we have thus contrived a plausible but unusual meaning for "having one thing in mind at once" or "attending to one thing at once".

The behaviour of a holist, however, is more difficult to square up with ready identification between aim and a *focus of attention*. For, in this case, there are several goals simultaneously in the workset. These may be learned about in any order or in parallel, though the learning processes are invariably referred to the current aim topic and in this manner are coupled together and synchronised.

Now, on sound evidence, both from experience and from experimental studies, the most significant aspects of cognition are serial and take place literally one-at-once. There is only one focus of attention (SAA) at once, and (apart, perhaps, from the parallel loading and unloading of sensory buffers) there is one dominant operating channel at once (one IPA). Arguments of this kind are used by Simon (1973), for example, in the context of problem solving, learning and other highly intellectual skills.

The fact that only one event can be reported at once in a protocol is incidental (after all, metaphors, especially poetic metaphors, stand for many events). The curious singularity of mental activity is no artifact of reporting method; it is a deeply investigated phenomenon, the meaning of which is captured best by inspecting tailor made information processing programs such as EPAM (Simon and Feigenbaum 1964, Fiegenbaum 1964), although the same organisation is embodied in most of the larger scale artificial intelligence programs.

It is undetermined (Chapter 5, Section 11) whether the holistic participant, for whom the aim topic synchronises learning over several goals, really learns in parallel or addresses the goal topics in some idiosyncratic sequence. Hence, the holist behaviour in no way denies the general statement of singular mental activity. Nor, of course, does it affirm the statement, but (as a conjecture in the matter) most holists address goals by idiosyncratic scanning sequences, replete with interruptions. If anything can be said on this score, holist behaviour furnishes evidence in *favour* of Simon's view; indeed, the view generally espoused by cognitive psychologists.

The position is summarised in Fig. 6.11 where the goals are associated with specific loci of IPA and so is aim itself; the plain lines stand for an arbitrary (but typical) series of activity initiations; the dotted lines stand for couplings, control interactions, or synchronising operations and may be much more complex (for example, extending from goal to goal). In such an arragement, there is one locus of IPA attention at once with the possible exception of autonomous processes which may overlap if they have determined stopping criteria. There is also one SAA locus of attention at once; namely, SAA (aim) carries an awareness of the process bearing the name of the aim topic. SAA (goal) is not defined, nor, so we believe, may it be defined (it is approximated only, even in the case when the aim topic is the one goal topic).

So far, in other words, conversation theory is in accord with the consensus of informed opinion and the vast majority of observations. At first sight, this conclusion seems to be at odds with the previous insistence that L-Processors, and brains in particular, are concurrent and a priori asynchronous systems. On closer scrutiny, however, the impression of disparity is seen to be spurious. For an aim topic corresponds to the control centre of a stable organisation (a P-Individual), and although an L-Processor is made up from a priori asynchronous parts, the P-Individual is a synchronous system, executable just insofar as these parts are brought into local synchronicity.

Our contention, spelled out in greater detail, is that one P-Individual has one aim and one locus of SAA attention at once; it may or may not have several IPA loci of attention; if so, then one is active at once (with the generally conceded exceptions noted during the description of Fig. 6.11). For a one-aim-at-once conversation, this contention tallies with a statement like "each person has one locus of attention at once" which, with due precautions to

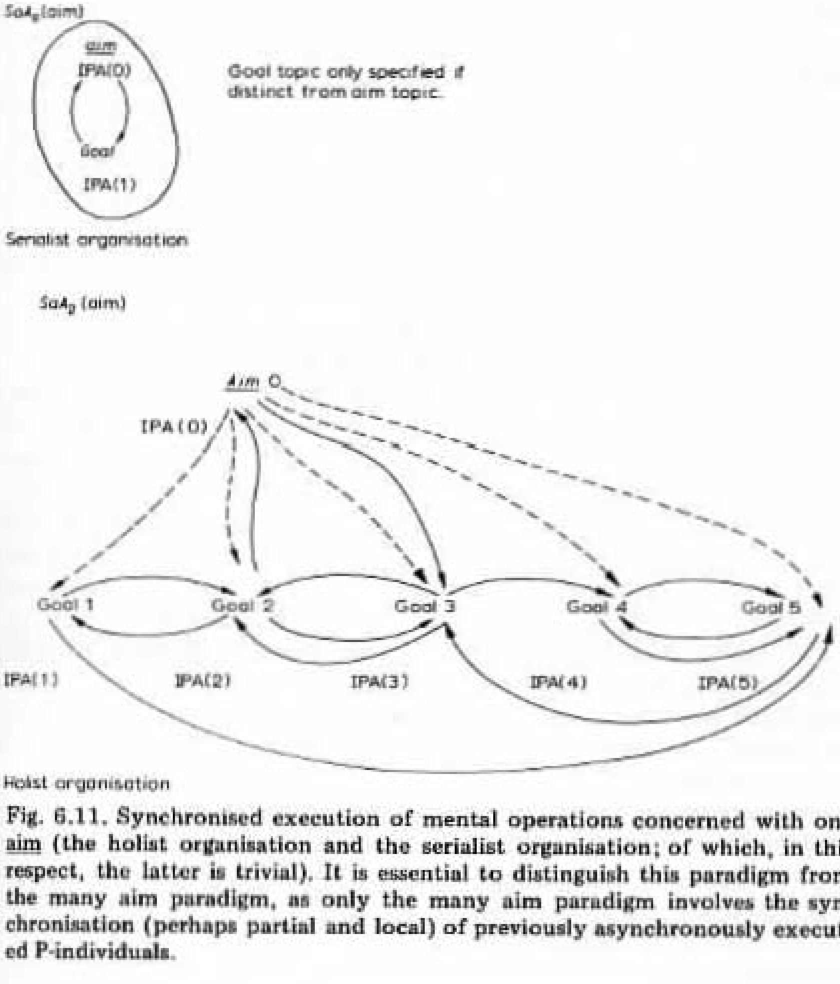

Fig. 6.11. Synchronised execution of mental operations concerned with one aim (the holist organisation and the serialist organisation; of which, in this respect, the latter is trivial). It is essential to distinguish this paradigm from the many aim paradigm, as only the many aim paradigm involves the synchronisation (perhaps partial and local) of previously asynchronously executed P-individuals.

avoid confusion between SAA and IPA, applies for "either kind of attention". For more than one-aim-at-once (two P-Individuals), conversation theory leads to some novel, though not counter-intuitive, predictions, especially in the perplexing case when the two P-Individuals are accommodated in the same brain.

This circumstance might be dismissed as merely imaginary. If you are asked what you are attending to, there is a school of thought (*not* the one-focus-at-once school of cognitive psychology) which maintains you will always reply "*topic* 1" or "*topic* 2" or else "nothing". Without denying the fact that you can be and often are so single minded (the experimental contract of a strict one aim conversation demands this attitude, for example), it is counterfactual and even nonsensical to assert that your reply is always single minded. Could you really attend to "nothing" for instance. Perhaps all you mean by "nothing" (supposing the response is uttered) is that you cannot think of an apposite phrase. Here, the reporting method *does* produce artifacts, "nothing" and various "absurd" topics, just as surely as it *does not* produce artifacts in the earlier mentioned studies.

Again, from a factual point of view, is it possible to have an attentive organism that cannot change its attention? Presumably not, though the argument is complicated by the different usages of "attention". For example, *most* of the "leaks" around Treissmann's filters could be ascribed to regarding "attention" as IPA, and the change from one IPA to another as taking place under the governance of an unspecified SAA. However, if *all* the leaks were of that kind, the SAA mechanism would become a switching homunculus, distinct from or outside the organisation.

More parochially, the formulation of conversation theory holds that the minimal observable event is a conversation (albeit, a conversation taking place in the one brain), and any conversation can be factored into more than one P-Individual (A_1 and A_2 in our pictures). Of these, only one need have an aim topic in a conversational domain, and using the present equipment, only one is fully observable. The operating systems of the next chapter permit greater freedom in this respect.

11. ATTENTIONAL UNCERTAINTY

It is possible to overcome some of the constraints imposed by a reporting language by recourse to the expedient discussed in the previous monograph. There we considered the estimation of degrees of doubt, d_0, d_1, d_2. Of these, d_1 and d_2 specify doubt about *how* to solve a problem and doubt in regard to a set of specified *outcomes* or solutions, given that d_0 is substantially zero; d_0 is an index of doubt about which topic occupies the attention (in the sense of doubt over the current aim topic), and a problem is specified if, and only if, d_0 is zero valued, otherwise d_1 and d_2 remain undetermined.

When the possible topics are displayed (for example, in the entailment structure of a conversational domain), d_0 is fixed most of the time at a vanishing value. But, in between occasions in a conversation, d_0 may (with individual differences) assume a transient high value and typically does so each time the aim is reselected. When the conversational domain is open ended (as it is in the systems of the next chapter), the values of d_0 are more regular (though still individually distinct); quite appreciable intervals are occupied by a state of uncertainty when the aim is undecided.

It is fairly easy to obtain a more telling measure (call it d^*) by calculating an uncertainty index from a confidence estimate over any finite set of topics and permitting bimodal or multimodal (subjective) probability distributions. If $d_0 = 0$, then $d^* = 1$ (for one topic is selected with certainty). Otherwise $1 > d^* \geqslant 0$.

Under these circumstances, participants give the following types of introspective reports upon the occasions when d_0 decreases (and $d^* > 0$), "I saw it" or "I had a flash of insight". On these grounds (taken in conjunction with the theoretical argument already presented), it seems reasonable to suppose that the moments of insight are in register with the coalescing of two P-Individuals to form a (usually larger) P-Individual with a freshly constructed aim topic of which the larger organisation is conscious and is able to describe insofar as the fresh aim is validated.

Some linguistically competent people are also able to report the *process* of coalescence, which in theory should image the construction of an analogy relation. The reports, when they are elicited, turn out to be verbal metaphors and thus *do* designate analogies. For the case in which two P-Individuals co-exist, the most that can be done is to obtain reports (preferably through the sampling arrangements described in this chapter) of one individual's hypotheses *about the other*, in addition to an hypothesis of his own about the *current aim topic*. Apart from this mechanism of describing a dual situation in terms of oneself and another (real or imaginary) participant, there is a phase prior to a coalescence in which the participant is unconscious of the duality and is conscious only of thought.

Such moments, followed by insight (we hypothesise by coalescence), are not much studied and are often believed to be uncommon. The evidence of uncontrolled introspection/retrospection does not support this belief apart from situations where there is a definite task (for example, learning in a fixed conversational domain). Preliminary observations of behaviour in an open conversational domain also suggest that the frequency of insightful incidents is fairly high, and the relatively regular variation of d_0 under these open ended circumstances lends credence to this point of view.