In February 1980, Gilbert Voyat interviewed Jean Piaget with contributions from Bärbel Inhelder. The interview in French was recorded in two ways, on a typescript and on film.

The typescript is stored at the Jean Piaget Archives, based at Uni-Mail in the University of Geneva. I located it serendipitously during a research visit to the Archives in October 2010. It is not clear whether its audio-transcription was made at the interview itself, or later from the film. There was only one copy and I do not know whether it was the first or final draft, but it had not been properly edited.

The film is available as a DVD in the Library of the University of Geneva (Voyat, 1980). I located it through an online Library search in 2011. It was made by the Centre Audio-Visuel Universitaire, probably from an original video-tape. It has an over-dubbed English translation, attributed to Klaus Schultz (1935-2000) at the University of Massachussets. I do not know whether it was made from the audio-transcription used for the French typescript or made independently. The Library Catalogue shows that the film was intended for use in Inhelder's presentation at the next Meeting of the Jean Piaget Society, i.e. its Tenth Meeting. Lynn Liben has confirmed that the programme shows "there was a 'SPECIAL EVENT' that was held on Friday evening May 30th, listed as 'Videotaped Interview with Jean Piaget and Bärbel Inhelder' " (Liben, 2011). The programme indicated that the event would be introduced by Barbara Presseisen (2011) who has confirmed that "I introduced the video in 1980". Neither of the Genevans actually attended this presentation that was well received, as noted in a letter later in the same year from Barbara to Bärbel: "over 200 Society members were at the presentation and everyone was very stimulated by the ideas discussed in the interview. We thought all three of you did very well" (in Liben 2011). A likely explanation for their absence was the decline in Piaget's health — he died in September 1980.

The interview has a dual importance. One is biographical: it was Piaget's final interview, supplementing several others (Piaget, 1968a, 1970, 1972, 1972/1981, 1973, 1973/1981, 1977/1980) and complementing his final paper (1980/2006). The other is theoretical: its focus was on the relationships between the concepts and their applications that were central to his constructivist studies, notably during the last decade of his work (see Table 1 of Piaget, 1980/2006). These concepts have received scant attention, and two reasons for this may be noticed. Their relationships are complex and their interpretation difficult. One merit of the interview is its
capacity to clarify and to facilitate their better comprehension. In the interview, Voyat's questions were penetrating, leading Piaget to provide accessible answers about the links between many of his main constructs. The other reason is that Piaget continued to re-analyse them right to the end. In a Postface, Piaget noted that he had delineated a "general skeleton that was more or less obvious but still full of missing parts" (1976, p. 223), and no doubt that was why he regarded himself to be "one of the chief revisionist of Piaget" (1970/1983, p. 103). As usual, his chief colleague focused on a crucial feature of his modus operandi evident at the symposium organised in 1976 to signal his official retirement from his chair at the University of Geneva. The symposium had its focus on Piaget's (1975/1985) book that was already being revised by its author in that "Piaget shows himself to be the least orthodox of the piagetians. Always in advance with an idea, he had arranged for the circulation before the symposium of his 'additional theses' " (Inhelder, 1976, p. 6).

The DVD has three parts and lasts about one hour:

- Introduction in English by Gilbert Voyat (1937-1983)
- Paper in English by Bärbel Inhelder (1913-1997)
- Interview in French by Gilbert Voyat with Jean Piaget (1896-1980) and contributions by Inhelder with an over-dubbed English translation

The credits show the date to be March 1980. The typescript is dated February 1980. A plausible explanation of the difference in date is that extra time was required to add the English translation and credits to the DVD.

In preparing my translation, the typescript was my main source with the DVD used as supplementary evidence. I have augmented the typescript by remedying omissions detected in November by Jean-Jacques Ducret who had access to the French recording, and these are marked thus JJD. There are several reasons for using the typescript in this way. Firstly, I made the first draft of my translation in Spring 2011 before gaining access to the DVD later in 2011. Secondly, due to over-dubbing, it was impossible to listen to the whole interview in French on the copy of the DVD that I obtained, and so the typescript is the sole record of the words spoken in the interview. Thirdly, as far as I can tell, there is no text corresponding to the English aural translation. Nor is it clear whether it was made at the interview itself, or from the film, or from the audio-transcription for the typescript.

The typescript differs from the DVD in several ways and my translation differs from both as follows:

(i) I have corrected minor (spelling) errors in the typescript and these are listed in the Appendix, marked in the text thus ±. I have also added Endnotes,
marked in the text thus\(^1\). All the references are mine to related work with a view to clarifying what remains implicit in Piaget's laconic but insightful answers. This means that in what follows the Appendix, Endnotes and References are mine. Since Piaget was a prolific author with multiple publications annually, references are shown with dual dates of French and English texts to identify their chronology and to fix the reference. My emendation of a standard (published) translation is identified by an asterisk after a relevant page number to the English publication — for example (Piaget, 1936/1953, p. 12*).

(ii) Voyat's Introduction is included in English on the DVD but excluded from the typescript. I made an audio-transcription of his orally delivered text. Although he spoke in good English, his accent and the quality of the recording made it almost impossible to understand specific words. I have annotated these as note 2.

(iii) Inhelder's Paper is included in English both in the typescript and on the DVD. I have corrected minor (spelling) errors listed in the Appendix.

(iv) Piaget's interview is included in the typescript in French, and on the DVD in French with an over-dubbed English translation. The latter made it very hard to listen to exactly what was said in French. But it was possible to compare my translation with the over-dubbed translation which I used to check two things. One was the authenticity of the typescript, i.e. whether the interview had taken place. The other concerned errors that I had detected in the typescript — more on this next.

(v) The DVD did not include all the exchanges in the typescript. In translating the typescript, I numbered these exchanges as Q1-Q35. The DVD excluded exchanges Q33-Q35.

(vi) There several minor differences between the DVD and typescript, usually re-statements on the DVD that I have omitted other than those shown in angle brackets <thus>. I have annotated substantive differences thus\(^2\). In this example, the DVD records Piaget's answer to Q23 as referring to the work of "Temin and Baltimore"; the typescript refers only to the former whose name is misspelled — see note 29. See also notes 19, 28, and 31.

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who checked the French typescript and French audio-recording at crucial places in the interview. Any remaining errors or deficiencies are, of course, mine.
It is a great pleasure for me to introduce Jean Piaget and Bärbel Inhelder who represent an important direction and centre of ideas in genetic epistemology, the subject matter of this year's symposium of the Jean Piaget Society. My purpose is not to present Piaget's and Inhelder's multiple contributions, but rather to make it clear that Piaget's main interest is an epistemological one. Above all, Piaget's is the theory of cognition; that is, Piaget is interested in the manner by which intellectual operations are constructed, how they form, are stabilised in the child's mind, and from where they derive. He is interested in that aspect of psychology because his main intent is an epistemological one — the understanding of the construction of knowledge and the comprehension of its ontogenetics with the history of science. Thus if Piaget can be said to be mainly interested in cognition it is because his intent is not, as has often been stressed, a psychological one, but a philosophical one. For him, to take an example, the study of the construction of geometrical concepts in the child is geared at its evaluation from the point of view of the history of geometry as it unfolded over the centuries. In this context Piaget comes to simultaneously extract developmental data relevant to this area and to relate it with its phylogenesis. He finds them parallel, which sheds light not only over the developmental foundation of this paradigm area but also with its epistemological grounds.

Thus Piaget's intent is twofold. On the one hand, he wants to understand how various concepts are constructed by the child and, on the other hand, he analyses their historical ramifications. In short, Piaget is a psychologist almost by derivation, by derivation because he has at the core of his enterprise the understanding of the nature of knowledge.

The subject matter of today's interview deals with the on-going interest that Piaget is actually pursuing, namely the problem of

- equilibration
- necessity
- phenocopy
- causality
- reason

Those have been on-going concepts which have come to light quite recently in Piaget's theory, but probably the most significant one is the concept of reason which is at the core of the International Centre for Genetic Epistemology this year.
From this point of view it may be of some interest, before beginning the interview, to clarify what is meant by reason. The general purpose of the work is to determine the reason of an affirmation, in other words the "why" as opposed to the "how". It leads to the analysis of the meaning of actions, of operations and in general to the analysis of the structural characteristics of the relationship between the operatory structures and the reason.

In short, the general hypothesis is that there always exist a deep relationship between the reasons, the "why", and the structures which means that whenever we find reasons, we will find structures. This is at least the basic hypothesis that Piaget is actually pursuing.

It is now time to let Bärbel Inhelder say a few words concerning the discussion of today.
As Piaget said on his 70th birthday, \(^5\) towards the end of a career, it's better to change one's perspective than to be condemned to repeat oneself. The work which he has accomplished since then with his team of young researchers and which at the age of 83, he still leads with the same old enthusiasm and rigour, continues to explore new territory in the areas of psychological data, analytical models and the refinement of epistemological conceptions. We shall illustrate the creative dialectics inherent in his scientific work by means of three examples.

(1) The first relates to causality. In the early seventies, a vast amount of research was dedicated to the understanding of causality, most of which is still in press. \(^6\) Piaget has been interested in children's spontaneous \(^2\) interpretation of physical phenomena since his early books which I had the honour of writing with him — *The Child's Conception of Quantities* — with the subtitle *Conservation and Atomism*. We \(^2\) were interested in atomism as an explanatory model in physics and in its \(^2\) development. Nowadays Piaget shows that in explaining reality one attributes an operatory model to this reality, this model being constituted by the subject during his cognitive development. If models are adequate to account for physical reality, it's \(^2\) because they're constituted in interaction with that reality. This is a powerful demonstration of a truly interactionist conception of knowledge. The physicist Garcia has shown that analogies exist between the mechanisms underlying the historical progress of scientific thought at least up to the time of Newton and cognitive development in children. \(^8\)

(2) The second example is that of the logical thought of the child — a problem which has been one of Piaget's constant preoccupations \(^2\) from the beginning and which proved much richer than was first thought.

Piaget has always maintained that research which only confirms what one expects is without interest and that successful research comes up against unforeseen \(^2\) obstacles and new problems. For example, when Piaget began his research on the logic of the child, he thought he would find only a pale reflexion of the logic of logicians. In fact, in analysing the reasoning of 7-10 year old children \(^2\) Piaget and his collaborators were led to discover the laws of an elementary structure, which is widely used by biologists and which he called the logic of operatory groupings. In the beginning, professional logicians smiled at such naïvety \(^2\) but today some of them are actually engaged in refining and formalising these structures. More recently, Piaget has become aware that this research is still too closely tied to the extensional aspect of logic and the time has come to study \(^2\) the intensional
aspect. In other words, the logic of meaning. These meanings are generally not isolated but linked together and this led Piaget to the hypothesis that there exist implications between actions, just as in formal logic there are implications between statements.

(3) As a third example, we can mention the recent work on the possible. Nowadays, Piaget puts emphasis on a functional aspect of thought which has in fact been the since the Origins of Intelligence (Piaget, 1936/1953). The general role of possibility in thought processes is quite obvious. It provides the best justification for a constructivist epistemology. It involves the subject's capacity to envisage an increasing number of possibilities which leads him beyond current reality, and gives rise to new constructions. To give a very elementary example, if you ask a child to find as many ways as possible of placing three counters on a rectangular sheet, 3 year olds only find one way to place them, for example in the three corners. If you push the child to find another way, the only one he can imagine is to place again the three counters in the corners of the sheet but maybe different corners. With increasing age, children are capable of finding several alternatives, but it's only towards 12-13 years that children will say that there's an infinite number of possibilities. Now infinite possibilities don't correspond to any observable reality. Piaget considers the gradual construction of the idea of infinite possibilities to be an argument against both the empiricist and nativist theories of knowledge.

After this glimpse of recent work, I hope you will be convinced that Piagetian theory is not a closed system but is in a continual state of refinement and development. To get an idea of Piaget's current thinking, Gilbert Voyat is going to converse with Piaget on this subject.
Q1 Voyat
The first question that I would like to ask you is about the relations between equilibration and operatory structures. In your position, how can they be distinguished and what criteria can be invoked to differentiate them?

Piaget
It is very easy to distinguish them, or so it seems to me. Equilibration is a completely continuous process which characterises each and every response given to questions. For example, when you ask me a question while I was thinking of something else, that creates a disequilibrium, that is to say a new need to be satisfied, this need being to make a suitable reply to the question that you asked me. I am therefore in a state of disequilibrium up to the moment when I have replied to your question, a reply that, I hope, becomes manifest as being in equilibrium. Structures, on the other hand, amount to a the stable outcome of cognitive work. Equilibration is a process, structure is a set of stable coordinations such as, for example, classification laws that are the same irrespective of the objects to be classified. What is always at issue is to place classes with greater specificity in classes with greater generality, which are nested in classes that are even more general. Structures are the set of these nestings. Stable structures do not rule out their later completion, and that means their later integration in new structures whilst at the same time preserving their own character. Take for example that quite fundamental and yet quite early structure, the sequence of natural numbers 1, 2, 3, etc. The set of natural numbers is a stable structure in the sense that when it is inserted in a larger structure, the set of whole numbers both positive and negative, well then the structures of natural numbers become a part of this new structure, the set of whole numbers, but without being in the least bit changed; there is enrichment by insertion in a more stable structure. Equilibration is the process that will lead to this. The structure is the, so to speak, atemporal set which is stable and which remains integrated in the sequel.

Q2 Voyat
Using these criteria, at what point in development do you think the subject attains these stable structures?

Piaget
There are stable structures from the sensori-motor level. The discovery of object permanence leads to a stable structure. Once understood that the hidden object is always in the last location where it was left, the infant makes a synthesis that combines object search and the displacement group.
From then on, this displacement group is a more or less stable structure that is encountered at all levels. For the baby, displacement is small, whilst for the geometrician, it is any displacement at all.\textsuperscript{15}

Q3 Voyat
There is no innateness in stable structures, they are all constructed?

Piaget
The problem of innateness is a venerable question. I don't believe in complete innateness. Still, innateness is everywhere. Right now, I am replying to the question you asked me. My reply is something I construct. I improvise on the basis of the present situation, but for that to work, my nervous system has to be coherent and to function normally in the replies that I am making to you. The nervous system is clearly innate. That is not something constructed by the individual. It is constructed on the basis of general laws of protein synthesis, epigenetic synthesis, etc.

Q4 Inhelder
You say somewhere that structures are located between the nervous system and conscious thought, which really means that structures are not observable. Could you say something more about the intermediary position of these structures, between the nervous system and thematisation?

Piaget
Intermediaries are quite natural, and consist in progressive conscious realisation such that the structure is already at work before conscious realisation occurs.\textsuperscript{16} Take, for example, seriation where there is a very early onset of conscious realisation by the child: when you show a child some sticks to place in a series and you ask the child to place them in order, the child will immediately say that they make a staircase. The staircase amounts to a conscious realisation of seriation, though restricted to this specific case.\textsuperscript{17}

Q5 Inhelder
It is what the child knows how to do, not what the child thinks.

Piaget
Yes indeed. The child knows how to make a staircase but cannot always tell you what its properties are. For example, in a very nice recent study, the child is asked where the mid-point of a structured series is, that's to say, for eleven items, it will be the sixth, etc. After that, the child is asked if it is possible to get the mid-point bigger than all the others, or smaller than all the others. Only the older ones say: it's very simple, all you have to do is to
take away those above or those below. The younger children are far from that. They point to the middle one and put it at the beginning of the line. This puts paid to the serial order but in such a way that makes the middle one bigger by its position and not by its size, whilst after that they simply remove anything extra left over.

Q6 Voyat
Could you say something more on the problem of the relations between structures and reason?

Piaget
We are in the middle of our study of reason right now. The question you are asking presupposes that the problem is already solved or at least studied sufficiently to give you a solution, when really we are still at the beginning of that solution. Reasons can be distinguished through two categories, what philosophers used to call ratio cognoscendi and ratio essendi,¹ reasons for a truth and reason for a phenomenon external to the subject.¹⁸ In both cases, reasons are systems of meaning that are bound by inferences, inferences that are always implications.¹⁹ These implications and inferences depend on structures. Reason is always either the underlying structure or some part of that structure, one element of its composition.

Q7 Voyat
You say that there is a close relationship between any such structure and reason, but on the other hand there are distinctions to be drawn. What in your opinion is the distinction to be drawn between these two cases, hypothetically speaking since you at the start of your study?

Piaget
Reason depend on a structure and structure has its intrinsic reasons. Reason is the use of a structure or one of its composing parts, which is not the whole structure.

Q8 Voyat
In that case, how do you distinguish the problem of proof and of reason?

Piaget
That's not easy. Within different arguments on offer, reason has to be carefully distinguished from mere verification. I think that it is Spinoza who gives this excellent example: if a circle is defined as a figure in which all lines between the centre and circumference are equal, you merely give a property of a circle and not the reason for it. The equality of radii is a consequence, not the reason. But if a circle is defined as a figure traced by a line starting
in the centre and made to turn with moving end-points, you base the definition of a circle on the operation of rotation and thereby give a reason, not merely a particular property.

Q9 Voyat
What do you call an incomplete reason?

Piaget
All reasons are incomplete. As soon as in science there is a reason for a phenomenon, the question immediately rises as to the reason for that reason. Take reason presented in chemistry, molecules and atoms, as though there was no reason for the properties of atoms, whereas all current nuclear physics has displaced the problem of reason and located at a deeper level.

Q 10 Voyat
Another important question concerns the relations between structures and procedures.

Piaget
A procedure is chaining in a sequence linking step-wise processes, actions, etc., directed on a goal to be attained. And it is merely chaining in the sense that anyone is at the end of a study — you have every right to forget and to disregard whatever there was at the start of that procedure. What you see is the goal to be attained and chaining sequence is such that, in forgetting its beginning, it is enough that your attention is centred on the current state of your chaining. By contrast, a structure is something stable, the stable set of properties. You could say that a set of procedures constitutes a structure.

Q11 Inhelder
I think there is much more in procedures, since they presuppose planning, they presuppose in fact, as you said, a goal with its external finality on which the steps taken by a subject's actions converge: goal representation, sub-goal representation, and that aspect of underlying representation about the different steps of the subject who regulates the pathways that the individual follows in searching to resolve a problem — that is very important.

Piaget
You are right that there is a chaining sequence there and not a simultaneous set.

<Inhelder>
That temporal aspect is important.

Piaget
Structure is extra-temporal.

Q12 Inhelder
Structure has its internal finality. As they say in English: \(^2\)
— *knowing how*, that is procedure
— *knowing that*, that is in some sense the structural aspect
— *knowing why*, that is what reasons are.

Q13 Voyat
At the observable level, how do distinguish between procedures and structures? You said before that structures were not in themselves observable, but procedures, of course, are because they have a temporal aspect. I would like you to clarify the problem of the relations between structure and procedure from the observable point of view.

Piaget
We know procedures only by reference to what the subject does. There is therefore a set of observables. With structure, we see as well what the subject is doing: when a subject is classifying or making a series, there are still observables that bear on different contents. With procedures, there is process. With structure, there is over-arching organisation.

Q14 Voyat
How do you distinguish equilibration as a process and procedure as a process?

Piaget
A procedure is always a form of equilibration. Equilibration is always a procedure and any procedure is a process of equilibration. Everything is given in the observables that the psychologist is led to interpret. The big problem is to know if the psychologist’s interpretation is going well. If the interpretation is going badly, the subject’s structure is easy for you to distinguish from the experimenter’s structure. If it turns out that the interpretation of what the subject does is going well, a very coherent structure is generally found. The INRC group is a structure very easy to observe. The 12 year old subject has of course no conscious awareness of the existence of such a group that had its birth in the history of science with Galois. Even so, the subject presented with a problem such as the equality of action and reaction brings to bear the INRC group on it, that is to say, is you can increase or decrease either pressure or the reaction — increase or
decrease the relation of reciprocity between the two. You see in the analysis of the subject's responses all the elements on the INRC group. For the observer, this is a well-known mathematical structure. For the subject, this is a discovery made with regard to the observable relations.

Q15 Voyat
Do you accept the idea that strategy and procedure can be taken as synonymous?

Piaget
As to that, you must ask my colleague, Inhelder.

Inhelder
Synonymous, no. They are complementary aspects of discovery processes. Either there is thinking in progress, an on-going activity, or there is a set of elements from which a combinatorial principle can be singled out. Nevertheless, there is a difference, a complementarity.

Q16 Voyat
In other words, neither can be conceived without the other.

Inhelder
Procedures cannot be analysed without taking account of structures. On the other hand, it very much easier today than it was in the past, I believe, to single out the aspects of a procedure contributing to a structural set. But that does not mean that one is synonymous with the other and my belief is that one of the key differences consists in the choice of models. For structural analysis, it has been possible to have recourse to algebraic models, whereas for procedural analysis, recourse has to be made to alternatives, for example, cybernetic models.22

Q17 Voyat
There is a paper in the Harvard Educational Review published four years ago in which the problem of logical necessity was called into question in the following sense: it seemed that you were not making a clear enough distinction between on the one hand the necessity experienced by the subject and on the other logical necessity.23 <Could you elaborate on this point?>

Piaget
Logical necessity is common to the subject and observer, if it is truly logical, whilst necessities experienced by the subject are not always true necessities. It is with great interest that we have discovered the occurrence
of what we now call 'pseudo-necessities', that is to say, the fact that children believe to be necessary any property and predicate at all just because it is general. Take this as an example of pseudo-necessity: a square is almost always presented resting on its base that is itself standing horizontally. If you place the square on its corner or at an angle other than its base, children will say: it isn't a square, it's a double-triangle, <and the child goes so far as to believe that the oblique sides on top are longer than those below, so a real pseudo-necessity>.\textsuperscript{24}

Q18 Voyat
The problem raised in that paper was the problem of empirical necessity. You were criticised on the grounds that when you require an empirical necessity, your justification is through logical necessity, and vice versa in that when you require a logical necessity, you justify it through empirical necessity. The problem of finding a criterion that differentiates them was central to the argument of this paper. Perhaps you could provide a criterion to distinguish them, empirical necessity from logical necessity.

<Piaget
But what do you mean by empirical necessity?>

Voyat
Put it like this, not the feeling of necessity experienced necessarily by the subject, but the empirical necessity of a logical necessity. That is to say, the necessity experienced by the subject at the level of experience,\textsuperscript{±} for example conservation where for the subject things are identical because they have to be the same. In other words, a feeling of empirical necessity in relation to lived experience that at the same time can be justified by logical\textsuperscript{±} necessity.

Piaget
The two go hand in hand. If the empirical necessity discovered by the subject is right, it's a logical necessity.

Inhelder
Two small beakers are presented in front a child with three beads placed in one, whilst the other beaker remains empty. The child is asked to keep on adding one to each all day long. And then the question is asked whether there will be a time when there are as many beads in each. For the little ones, there is equality, whilst from 5\textsuperscript{1,2} years\textsuperscript{±} onwards you find children saying: it isn't possible, "once you know, you always know" — there's an inequality, there's always more in one.

Piaget
I well remember the words of a 5½ year old child: once you know, you always know.  

Q19 Voyat  
In other words, reasoning from the impossible leads to necessary reasoning.

Piaget  
You find necessity everywhere, correct of course in some cases and pseudo in others.  

Q20 Voyat  
And the criterion by which you distinguish pseudo-necessity and necessity, is it the exterior element in the subject's experience, or is it internal to the subject?

Piaget  
Listen, if you say that it is the experimenter who invents all this and projects it into the subject's head, there is very simple reply: you merely have to take older subjects and you'll see that they have moved on from pseudo to true necessity. When I have been criticised for substituting my own ideas in place of the subject's, these are not my ideas at all — the correction is the subject's own two or three years later. By comparing these different ages what comes from the subject and what comes from the experimenter is distinguished for you. <There are never fixed criteria for deciding whether it's the subject or the experimenter.> Careful experimenters will only make claims about what they are sure is going on in the subject's head.  

Q21 Voyat  
That explains the importance in genetic epistemology of continually having recourse to subjects, to the experience of children, and to look at development there.  

Piaget  
Yes of course, it is development that shows us where something leads and not the experimenter  

Q22 Voyat  
I remember the argument you defended in your book on philosophy, that without experience there are no means to make coherent deductions at the level of genetic epistemology.  

<Piaget  
Yes, of course.>
Voyat
I would like to move on to another subject, and this is about biology. You ask the question of understanding what the relations are between knowledge constructed by the subject and biology such as it exists today: it regards, as you know, selection along with chance as a determinative mechanism of the evolution of living beings. I would like to understand how you reconcile these polar opposites, on the one hand psychological constructivism, and on the other neo-darwinian selection.

Piaget
I reconcile them in a radical way. I have not the slightest belief in the explanation of evolution by chance and selection after the event. Because if you generalise that thesis with respect to knowledge, that would mean that the mathematics in its entirety is the result of chance and only afterwards selected. In other words, anyone's first reflections in the domain of mathematics, or if you like Greek mathematics at its beginning, would be down to chance: what works has been retained and what does not work eliminated. Now to subordinate science to chance would be to destroy scientific truth.

Q23 Voyat
Taking that into account, what do you call phenocopy?

Piaget
I would still like to say that biology today is in deep crisis and when some of my claims run into objection, the counter-claims of neo-darwinians, these biological arguments can be expected to be rather flimsy and liable to be contradicted in the sequel. There is very nice example in comparing Monod's fine book on chance and necessity with work that came later. In Monod's book, you find him saying: the action of RNA on DNA is not only impossible but unthinkable in that what can legitimately conceived is solely the action of DNA on RNA and not the reverse. As Grassé said, the ink with which Monod had written that had scarcely dried when a few days later Temin published his findings showing the action of RNA on DNA with these relations the other way round. Exactly the opposite. There we have Monod's absolutely dogmatic assertion that appeared fully justified until the work of Temin. A fortnight later, it was demolished by new discoveries. I believe that biology and all biologists are in agreement in being very far from thinking that they have found the key to evolution.

Q24 Voyat
From your perspective, evolution is neither neo-darwinian nor lamarckian? What is your position with regard to embryogenesis?
Piaget
I think that between Darwinism and Lamarckism there are phenomena related to internal selection, selection at the organism's interior. Thus the organism, modified by a phenocopy and so the exterior action of the environment in Lamarck's sense, in that event is slightly modified as to its internal structure. Now this modification may be weak and in that case without hereditary fixation, or instead it may give rise to a profound disequilibrium that continues step by step. That is not a message, but rather an action of successive disequilibria. These continue right up to regulator genes that are then going to produce largely random mutations, but not a random characteristic of a large number of mutations, rather mutations that will be selected by the new internal environment, namely the one specific to the new phenocopy that has just emerged from the environment. This selection by the internal environment can produce the hereditary fixation of a new characteristic.

Q25 Voyat
In other words, the phenocopy is really a replacement by exogenous pressure of an endogenous environment. It is the replacement of structures with an exogenous origin that become endogenous.

Piaget
Replacement, but not fixation. Biologists a few years ago, such as the great Chodat, the well known botanist, spoke of fixation. Chodat used to say that the mystery of evolution is that in new self-producing phenotypes, there are some that become fixed, though how is not known. The major problem is fixation. For me, it is not fixation, but replacement.

Q26 Voyat
Your position on this point of view is fully compatible with Waddington's, who established the phenomenon at the biological level.

Piaget
I think that what I call phenocopy is equivalent to what Waddington called genetic assimilation. Waddington gave me pleasure in devoting a whole chapter to my Limnaea and to my interpretation of the occurrence of new lacustrine breeds, stating that it was the best example that he knew of genetic assimilation, and so a phenocopy, in nature itself. In the laboratory, you can create whatever you want, whereas the creation of my Limnaea seemed convincing to him.

Q27 Voyat
Have you evidence about anything other than *Limnaea*?

Piaget
I find the same thing in *Sedum* which I am currently studying. For example, *Sedum* called *Sedum album*, which is the most common variety with us, goes up to 2000 metres with its appearance then much reduced. Its leaves become quite small, etc. If you transplant one of these *Sedum* back down, it returns to its normal size, whereas in certain parts of Savoy, near the summit of Le Môme, and at Tenneverge, where it had been observed earlier, the small form remains hereditary on its transplant back down.  

Q28 Voyat
When you say that the order of stage succession is self-evident, this can be understood in two ways, one arising from an internal feature of your system, the other due to the facts. Could you say something more about this?

Piaget
I would first of all like to say when you talk of my system that I have no system. I have never constructed a system in the abstract so as to try later to verify it factually. What is called the system are the serial interpretations that I have given to new facts that we have discovered in my research.

<[Asked whether that will do, Voyat restated Q28]>

The order of succession is self-evident because you always see at any given level what is being prepared for the following level and especially because the order of succession is independent of the contribution made by a subject's age. When you compare subjects from different environments, as Bärbel Inhelder and her collaborators have done with Baule children in Africa, something well worth doing, the same stages are encountered in a quite different civilisation, but not always at the same ages. That's to say, the stage which is attained by certain subjects in cultured backgrounds towards 7 years may be attained only toward 11-12 year in illiterate backgrounds, which thereby means that age differs with background but in the same order — whether later or earlier, you always find conservation after stages of non-conservation, and so on. Stage constancy in all environments where it has been studied — African environments, your work on North American Indians and a psychologist whose name I no longer know in Shanghai comparing Chinese and Europeans, in Iran comparing urban and rural children, etc. — stages are always encountered. This was for me very a source of great comfort and I will even say surprise, because I was expecting some exceptions. An exception was detected by one of Seagrim's students in
Australia: in young children, she found that weight conservation preceded quantity conservation, contrary to what we have found everywhere else. This finding was then re-investigated by Dasen who noticed that the good lady had questioned only school children and not children without schooling, and had questioned them in English because she had neglected to learn the language of these small children. Then Dasen, after taking these necessary precautions — children without schooling and in their own language — found the usual sequence.\[^{39}\]

Q29 Voyat
From your perspective, a question of really fundamental importance in the United States at the cultural level is this — what are the relations between, on the one hand, intelligence with innateness and culture, the influence of cultural factors on genetic factors in the development of intelligence?\[^{40}\]

Piaget
I believe that cultural factors advance or delay, but do not modify, structures. I also believe that structures always have a biological point of departure.

Q30 Voyat
That amounts to saying that IQ is hereditary.

Piaget
No, not at all.

Q31 Voyat
It could be said in reply, of course, that since you have an order of succession independent of culture and other sociological factors, etc., that reflects at the subject's level an interior genetic organisation. What's your answer to that?

Piaget
I do not believe that IQ is interesting. Secondly, an analysis with a direct reliance on the heredity of IQ is much too cursory. I am not well informed on the laws of heredity in biology, it is necessary to be careful.

Q32 Voyat
How do you distinguish dialectic as the implicative aspect of behaviour and causality as the explicative aspect?

Piaget
Dialectic as the implicative aspect of behaviour, all behaviour is dialectical and implications at the basis of dialectic are implications of considerable importance. Although no attention has been paid to them, these are implications between action, not between statements: an action implies another action which amounts to saying that the meaning of this action is inter-linked with the meaning of other actions. Dialectic is inherent in behaviour. An isolated action is not a possibility, there is no such thing as a isolated meaning, they are all bound by implications.\textsuperscript{41} If you now move to the causality in phenomena, that causality is known only by constructing a model and that model is deductive. The model is what you compare with experimental facts.\textsuperscript{42}

Q33 Voyat
There are relations between dialectical causality and equilibration, because dialectic is new process and equilibration is also a process, as you pointed out at the beginning of this interview.

Piaget
Equilibration is always dialectical. Equilibration — and this really should be made clear, my critics often forget this distinction — it should be made clear that after a phase of disequilibrium, simple equilibration consists simply in the return to a previous state, as opposed to the equilibration that I call optimising where there is an advance over the previous state. In any such advance, you have dialectic and optimising equilibration at the same time.\textsuperscript{7}

Q34 Voyat
In other words, dialectic is a complementary aspect of equilibration or its contrary?

Piaget
They are inseparable.

Q35 Voyat
And so all cases are such that optimising equilibration is necessarily accompanied by a dialectic?

Piaget
In all cases, if the dialectic is a real and creative, that means it leads to advances over the previous states, and too where there is such an advance, there is optimising equilibration.\textsuperscript{43}

Voyat
Thank you.
Appendix

The first column identifies text in the typescript marked in my translation thus. The second column shows my emendation.

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Endnotes

1. **February** The date in the typescript is given as *Février* [February] 1980, the date shown in English in the DVD's credits as March 1980. The original recording was a video-tape (presumably later copied to DVD) for use in anglophone United States. The difference in date is likely due to the extra time required to add an over-dubbed English translation since Piaget spoke in French, and to make it suitable for public use by the addition of opening and closing credits.


3. **Introduction** Voyat spoke in fluent English with a distinctive accent that taxed my comprehension in a couple of places in this paragraph.

4. **Centre** This is the English name (International Centre for Genetic Epistemology) of Piaget's research unit at the University of Geneva. For its annual projects over the decade 1968-1980, see Piaget (1980/2006).

5. **70th birthday** The reference may be to a book of which — as Inhelder wryly noted — Piaget was "not the author" (Inhelder, 1966, p. xi).

6. **In press** The reference is to Piaget's annual research projects on causality during the 1960s, and so to six texts subsequently published as Volumes 25-30 in French in the series *Etudes d'Epistémologie Génétique* [Studies in Genetic Epistemology] arising from Piaget's Centre in note 4 (Archives Piaget, 1989). Also on causality is Volume 26 available in English (Piaget, 1971/1974).

7. **Groupings** The reference is to Piaget's logical models (1942; see also 1949). These models were initially used to interpret the empirical findings concurrently gained during the 1940s (Piaget & Szeminska, 1941/1952; Piaget & Inhelder, 1941/1974). Commentary on and refinements to these models were subsequently made (Bradmetz, 2008; Grize, 1987; Papert, 1963; Mays, 1953; Wittman, 1973). See also note 14.


11. **Infinite** The reference is to Piaget (1981/1987, ch. 1).

12. **Voyat** Bärbel Inhelder also assisted in this interview conducted by Gilbert Voyat who was well placed to do so in view of his own contributions to Genevan work (Cellérier, Papert & Voyat, 1968; Piaget & Voyat, 1968, Piaget & Voyat, 1976/1979; Rieber, 1983; Voyat, 1981, 1983; Voyat, Silk & Twiss, 1983).

13. **Q1** I have numbered each exchange (question-answer) for ease of reference; actually, some are statement-answers. In a couple of cases, more than one response is made.

14. **Operatory** In Piaget's epistemology, any cognitive act (action, activity) had two properties. [i] Any act had a structure whose own organisation varied, poorly organised at one pole, well-organised at the other. [ii] Each subsequent act changed the organisation (structure) of a previous act, whether minimally as augmentation (new content), or maximally as amelioration (new form). A paradigm example of [i] is a scheme: action schemes in infancy (1936/1953), operational schemes in adolescence (Inhelder & Piaget, 1955/1958). The properties of a scheme were logico-mathematical and so normative, where these properties changed in each of its uses in line with [iii], i.e. its properties were operatory. Although all schemes were operatory, non-operational schemes were used in early childhood, namely conceptual schemes. Piaget's argument was that operational schemes emerged in mid-childhood onwards. An operational scheme had an organisation isomorphic to a grouping or group — see note 7. And whereas the operatory scheme used in a successful act did not require conscious recognition of its organisation by its agent, an operational act required some acknowledgement of its organisation in some appropriate way, thereby enabling its agent to gain a fuller conscious knowledge in the sequel. See also commentary on the normative character of Piagetian schemes (Smith, 2006b, 2009a,b), and on the operatory-operational distinction (Furth (1981, pp. 55-58).

15. **Displacement at all** This example nicely illustrates two things. One is the point made in Voyat's Introduction about Piaget's interest in finding and analysing a structure (e.g. displacement group) with both an origin and a constitution on twin tracks, childhood (Piaget, 1936/1953) and the history of science (Poincaré, 1905). See also Piaget's answer to Q14. The other
concerns advances in universalisation. In his first book, Piaget repeatedly asked the question "is universality knowable?" (1918, p. 46). His answer was a qualified Yes. In this example, advances start from a displacement group fully mastered in particular contexts to its unrestricted universalisation "free from its dependence on the initial hic et nunc" (Piaget, 1947/1950, p. 9).

16. **Intermediaries** In Piaget's epistemology, there are always "intermediaries" (1967/1971, p. 244*), that is, transitional levels "between the innate and that which is acquired from outside" (p. 190). That is why "the initial problem of knowledge will therefore be the construction of such intermediaries" (1970/1972, p. 20). On the location of structures, see Piaget (1968/1971, p.138); and their thematisation, see Piaget (1977/2001, pp. 303-05; cf. Campbell (2001, p. 31, note 7).


18. **Ratio cognoscendi, ratio essendi** One of the meanings of the Latin term ratio is reason — compare English rationale and French raison d'être. Roughly speaking, the contrast is between the reason for knowing something as a necessity and the reason why something has to be what it is. So here in the same sentence, Piaget's gloss seems to be incomplete. Amends are made in the next sentence with its reference to different types of reason (1980/2006, pp. 7-8), an interpretation in Piaget's hands owing something to Leibniz: "no fact can ever be true or existent, no statement correct, unless it has a sufficient reason it is thus and not otherwise, even though in most cases we cannot know these reasons" (1957, Monadology, 32*). See also notes 19 and 20.

19. **Inferences** Reading afférences [English afferents] in the typescript as inférences [English inferences] based on a French recording of the interview (Ducret, 2011). Piaget was mindful of the distinction between two positions One: knowing has causal antecedents and logical implications: "neurophysiology is exclusively causal whilst psychology takes stock of the implicatory function" (Piaget, 1961/1969, p. xxiii*). Two: causality is intelligible only in terms of a logic of reasons: "no objective or causal spatio-temporal structure is possible without logico-mathematical deduction" (1936/1953, p. 12*). Any such logic included three varieties of reason: anticipatory, consequential, and over-arching (1980/2006, p. 9). Piaget's argument was that a logic of reasons was required because afferent neurons
as causal antecedents of colour detection were indeterminate about consequential actions. For example, "red" in "a red sky tonight" and in "a red traffic light ahead". Causal antecedents are necessary, but insufficient, in the formation of distinct norms, such as permissions (you may want to be outdoors tomorrow to enjoy the fine weather) and prohibitions (you must stop). On the difference between causality and normativity, see Smith (2006a, 2009a). See also note 18.

20. A property of a circle and not the reason for it Piaget was likely inspired by Spinoza. "If a circle be defined as a figure, such that all straight lines drawn from the center to the circumference are equal, every one can see that such a definition does not in the least explain the essence of a circle, but solely one of its properties .... a circle should, according to this rule, be defined as follows: the figure described by any line whereof one end is fixed and the other free" (Treatise on the Emendation of the Intellect, 95-96 in Spinoza, 1994, p. 52). In one of his final letters, Spinoza added: "if I consider only the circumference of a circle, I will not be able to infer anything except that it is everywhere like itself, or uniform, by which property, indeed, it differs essentially from all other curves. Nor will I ever be able to deduce any other properties. But if I relate it to other things, such as the radii drawn from the center, or two lines intersecting [within the circle], or also to other lines, I shall certainly be able to deduce more properties from this" (Letter 82 to Tschirnhau in Spinoza 1994, p. 275). See also note 18.

21. English Inhelder here used the English knowing how, knowing that, knowing why. In Q5, she expressed her position in French. See also Inhelder and Piaget (1979/1980).

22. Cybernetic models On cybernetic models in genevan research, see Cellérier, Papert and Voyat (1968) and Piaget (1967/1971, p. 61). Yet cybernetic models were interpreted in a manner contrary to logical models. Inhelder and Cellérier argued that the logical models used in Piaget's analysis of psychological structures were insufficient for the analysis of procedures in psychological functioning. They saw a way forward in cybernetics with its models of artificial intelligence [AI]. But they also saw two alternatives: "(a) is AI, as implemented by computer programs, in itself sufficient to constitute a theory of psychological functioning, or (b) must not instead psychology see AI essentially as a tool, thereby preserving the specificity of psychological functioning and of its particular models? (Inhelder & Cellérier, 1992, p. 49). Regarding (a) as an incipient version of reductionism, their commitment was to (b). Yet with regard to logical models of psychological structures, Inhelder and Piaget made the alternative commitment. They had
raised the question of whether structures characterised through logical models (a*) existed in the child or (b*) existed merely as the products of the models articulated by adult researchers. Assuming that structures are organs comparable to stomachs and lungs, their commitment was to (a*). This was because (b*) amounted to "stating that even though children are aware of eating and breathing, their stomachs and lungs only exist in the minds of physiologists" (1979/1980, p. 23).

23. **Necessity** The typescript refers to the *Harvard Educational Review* without a date; the DVD refers to the same journal "four years ago". Voyat was well placed to ask this question since he had recently translated one of Piaget's papers on necessity (Piaget & Voyat, 1976/1979; cf. Piaget 1977/1986, 1981/1987, 1983/1987). But it is not clear which paper in the *Harvard Educational Review* he was referring to: during this period there were several dealing with Piaget's position, but none dealing with necessity in line with Q17. The point in this question may have been inspired by two papers published elsewhere some four years earlier. One included a conclusion about that "the interesting possibility that some nonconservers truly felt their nonconservation conclusion was as necessary as the conservers felt their conservation conclusions were" (Murray & Armstrong, 1976, p. 484). The other accepted deductive logic as a normative discipline for researchers to use in the study of critical thinking, but its objection was that Piaget's position about children's propositional reasoning was flawed: it included "both normative and descriptive dimensions. [Yet] I have suggested that the normative dimension of Piaget's claim (that is, Piaget's logic) is mistaken" (Ennis, 1975, p.38).

24. **Square, it's a double triangle** The text in angle brackets is from the DVD. The reference is to Piaget and Inhelder (1948/1956, ch. 12) or to Sinclair and Piaget (1968).

25. **Once you know** This child was called Stion aged 5\(\frac{3}{4}\) and took part in their study of reasoning by recurrence, i.e. mathematical induction (Inhelder & Piaget, 1963, p. 66; quoted in Smith, 2002, p. 25). Piaget was fond of Stion's remark (1970/1972, p. 72; 1971, p. 5; 1972, p. 223; see also Inhelder & Piaget 1979/1980, p. 23).

26. **In the subject's head** Piaget was aware of the problem of "experimenter effects", arguing that they could be excluded if five criteria were met (1926/1929, p. 32). These were later augmented by a further criterion of his "critical method", that an experimenter should be "restricted to introducing questions and discussions only after, or during, manipulations directed on objects producing an action by the subject" (1947, p. 7; cf.
Smith, 2002, ch. 5). He rejected the criticism made by Phillips (1969) that his studies were in fact vulnerable to "experimenter effects" (Piaget, 1973/1981). For discussion of Piaget's position in the context of the classic Hawthorne Study, see Hsueh (2002).

27. **Book on philosophy** Piaget's position on philosophy was that there is "a kind of intellectual dishonesty in making assertions in a domain concerned with facts, without a publicly verifiable method of testing, and in formal domains without a logistic one" (1968/1972, p. 12). With regard to the philosopher's aim as "the search for truth" (p. 21), Piaget's counter-argument was that an adequate criterion of truth was available only in the empirical or formal sciences. But even though neo-darwinian biology was an empirical science, it was precluded from providing adequate evidence because "biology has not yet solved its main problems [and so is still] at a stage comparable to that of physics before Newton" (pp. 177-78).

28. **Monod** There is a significant error in both the typescript and the overdubbed translation which I have corrected in my translation. Recall that the so-called central dogman in neo-darwinian genetics states that

- [i] all sequences are DNA-to-RNA and are irreversible
- [ii] some sequences are RNA-to-DNA.

In the interview, the error is as follows.
(a) The typescript reads: "l'action de l'adn sur l'arn n'est pas seulement impossible, elle est impensable et on ne peut penser légitimement qu'à des actions de l'arn sur l'adn et pas l'inverse." In English this reads: "the action of DNA on RNA is not only impossible but unthinkable; what can legitimately be conceived is solely the action of RNA on DNA, not the reverse". A comparable translation is used in the DVD translation. Thus both the French typescript and the DVD translation state the sequence in [i] the wrong way round. Therefore, either Piaget made an error, or the error was in the audio-transcription.
(b) It is impossible to hear the French words spoken by Piaget due to the overdubbed English translation (i.e. Voyat, 1980). But in the French-only version, what Piaget said is correctly reported in the typescript (Ducret, 2011). Evidently, there was a slip of the tongue since in this context Piaget was actually invoking the central dogma in neo-darwinian genetics. He was referring to Monod's book with its explicit commitment to [i]: genetic information transfer in the sequence DNA-to-RNA is "strictly irreversible" (Monod, 1970, p. 124; cf. Monod's complementary position that this ordering "neither should nor could be revised" p. 127). In his books on biology, Piaget invariably referred to [i] as the standard position in neo-darwinism — for example: "genetic information passes from DNA to RNA to
control the initial selection of amino acids from which proteins are synthesized" (Piaget, 1974/1980, p. 22; see also 1967/1971, pp. 165-168 and 1976/1978, pp. 68, 125). Crucially in this exchange, Piaget's point in Q23 was that Monod's commitment to [i] was invalidated because of new evidence for [ii] available shortly afterwards. Therefore, the error lay in the audio-transcription.

(c) A footnote was added to the English translation of Monod's book. Its intention was dispute the interpretation of the recent evidence: Temin's "important observation actually in no way violates the principle that the translation of sequential information from DNA (or from RNA) to protein is irreversible" (Monod, 1971, p. 110; see also Beljanski, 1972). Under Piaget's interpretation, some biological sequences are reversible compatible with [ii], and so incompatible with [i]. Referring approvingly to Temin's work on "inverse transcriptase" he added that "the advantage of this concept is rather that it opens up the possibility of the constitution of new genes according to the sequence DNA —> RNA —> DNA, which gives rise to 'protoviruses' " (1976/1978, p. 124; see also 1967/1971, p. 288-89 and 1974/1980, p. 65). On Piaget's biology, see Bickhard (1988) and Messerly (2009). See also note 29.

29. Temin Awarded a Nobel Prize for Physiology in 1975, Temin later summarised his position: "genes for reverse transcriptase have been found in most kinds of eukaryotes (animals, plants, and fungi) ....The common mode of information transfer in biological systems is DNA to RNA to protein — the famous 'central dogma of biology'. Almost 20 years ago it was established that certain viruses use information transfer from RNA to DNA catalysed by an enzyme called reverse transcriptase; as a result these viruses were designated retroviruses" (1989, p. 254). Piaget's reference was to Grassé (1972) who reviewed evidence of transfer from RNA to DNA, notably by Temin, and too by Baltimore (1970; Temin and Mizutani, 1970). See also note 28.

30. Demolished The typescript reads: foutu en l'air.

31. Successive disequilibria The typescript reads: "une action successive de deux équilibres" whose English translation is "an action of two equilibria in succession", confirmed in the DVD translation. But this is problematic. It is arbitrary: why only two?. And in context, it is contrary to the gradualism ("step by step") required in the previous sentence and to the randomness required in the next. Recall that the typescript was gained by audio-transcription, and so an alternative version of what was said might be: "une action successive de désequilibres"; in English, "an action of successive disequilibria". This leaves open the number of equilibria and is in conformity
with the complexity implied by the sequence in note 28c, i.e. a range of actions on the environment back to regulatory genes that could not be restricted to "two equilibria".


34. **Le Môle, Tenneverge** In the Haute-Savoie [Upper Savoy], Le Môle (1863m) is a mountain near the French town of Bonneville, Pic de Tenneverge (2989m) is near Sixt-Fer-A-Cheval. For his review of *Sedum*, see Piaget (1967/1971, pp. 198-201; 1974/1980, p. 31ff).

35. **No system** "To the extent to which one would be able to speak of 'Piaget's system', this would be a conclusive proof of my failure" (1968/1972, p. 29). See also Piaget's remark that he was the "chief revisionist of 'Piaget's theory' " (1970/1983, p. 103), whose principal source was an earlier paper that he entitled "Le point de vue de Piaget" (Piaget, 1968b).

36. **Age** Piaget's two principal stage criteria were constant order of succession and a general structure, i.e. the stable organisation of a knowing framework matching a structure in the history of science, whilst chronological age was not a criterion at all (Piaget, 1960, pp. 13-14; 1971, pp. 13-15).

37. **Baule children** The reference is to Ivory Coast children studied by Dasen, Inhelder, Lavallée and Retschitzki (1978).

38. **North American Indians** The reference is to indigenous Americans at the Pine Ridge Indian Reservation in South Dakota studied by Voyat, Silk and Twiss (1983).

39. **Australia** The reference is to Aboriginal children studied by Dasen (1972).

40. **Genetic** The adjective [French, *génétique*] is ambiguous. In Q29, it means *innate*, in Q31 as too in the title of this interview it means *developmental*, a significant difference (Smith, 2009a, p. 64).

41. **Isolated** The point at issue here was explicit in the definition of an
operation as "reversible" and "never isolated" (Piaget & Inhelder, 1966/1969, p. 96) and thereby the reason why "human knowledge is essentially collective" (Piaget, 1977/1995, p. 30). Effectively, Piaget is here issuing the reminder that his epistemology was incompatible with the notion of a "solitary knower" (Smith, 1993, p. 125ff).

42. Model In Piaget's epistemology, a model was variously characterised as a system, structure, level of organisation, framework [cadre]. Its importance was threefold. One: from birth, and so “from the beginning and even among our youngest subjects, a physical fact is recorded only within a logico-mathematical framework, however elementary it may be” (Piaget, 1977/2001, p. 320). Two: even though models or structures have normative properties, their discovery is factual and so establishing which "structures exist is, therefore, for the investigator to ascertain and to analyse" (1970/1973, p. 46*). Three: the unit of analysis in any evaluation of Piaget's evidence is, or at least should be, the level of organisation in a a child's or adult's model. Typically in Piagetian research, this third requirement has been violated rather than respected.

42. Dialectic and equilibration Piaget's point can be explained through examples. Mammals are such that 'creature with a heart' and 'creature with a kidney' refer to co-extensive properties, i.e. each in fact correlated with the other (Quine, 1961, ch. 2). Euclidean triangles are such that 'interior angles' and 'two right-angles' refer to co-intensive properties, i.e. each implies the other (Leibniz, 1990, IV-i-1). But in neither case does either property mean the same as the other. Similarly, for Piaget (1980), creative dialectic and optimising equilibration are co-extensive and co-intensive, but non-identical aspects of the formation of knowledge. On dialectic and equilibration, see Boom (2009) and Campbell (2009).
References


