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Back to the future of scientific epistemology? Jean Piaget on science and epistemology

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Abstract The sciences achieved consensus amongst their practitioners through emancipation from philosophy. In the first half of the 20th century, philosophers began to align themselves with science, and most contemporary philosophers call themselves naturalists. Epistemology was still largely considered a philosophical prerogative until Quine's paper "*Epistemology naturalized*" (1969). Opinion is now divided. Ironically, the prodigious work that secured Jean Piaget's reputation as a cognitive developmental psychologist was actually carried out largely in service of epistemology. Disillusioned with philosophical speculation and with a background in empirical science (Piaget trained as a biologist), Piaget conceived a method based on psychological and historical evidence to investigate epistemological questions scientifically. In this paper, I outline his genetic-epistemological method and locate it in the discourse on naturalism. I conclude by classifying genetic epistemology according to Goldman's classification of naturalistic epistemologies and by assessing it in the light of criticism typically levelled at naturalistic epistemologies, before highlighting some salient points for a future scientific epistemology.
KEYWORDS: Epistemology; Naturalism; Psychologism; Genetic Epistemology; Jean Piaget

Riassunto *Ritorno al futuro dell'epistemologia scientifica? Jean Piaget su scienza ed epistemologia* – Le scienze hanno acquisito credito tra gli addetti ai lavori emancipandosi dalla filosofia. Nella prima metà del XX secolo i filosofi hanno iniziato ad allinearsi alla scienza e molti filosofi si definiscono oggi naturalisti. L'epistemologia è stata considerata materia filosofica fino alla "*Epistemologia naturalizzata*" di Quine (1969). Qui le opinioni si dividono. Per ironia della sorte il poderoso lavoro che ha consegnato a Jean Piaget reputazione di psicologo cognitivo dello sviluppo è stato di fatto svolto largamente al servizio dell'epistemologia. Deluso dalla speculazione filosofica e formatosi nell'ambito delle scienze empiriche Piaget (che era un biologo di formazione) ha elaborato un metodo basato sull'evidenza storica e psicologica per dare risposte scientifiche a problemi epistemologici. In questo lavoro intendo illustrare il suo metodo epistemologico-genetico, collocandolo all'interno del discorso sul naturalismo. Concluderò discutendo l'epistemologia genetica in base alla classificazione delle epistemologie naturaliste proposta da Goldman e valutandola alla luce delle critiche tipicamente rivolte alle epistemologie naturaliste, prima di illustrare alcuni punti salienti per una futura epistemologia scientifica.
PAROLE CHIAVE: Epistemologia; Naturalismo; Psicologismo; Epistemologia genetica; Jean Piaget

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Introduction

THE CRITIQUE OF PSYCHOLOGISM INITIATED by Gottlob Frege and championed by Edmund Husserl after his conversion was a watershed for naturalistic philosophy. Before their critique, naturalism looked back on a long and distinguished tradition, in which thinkers drew uncritically on psychological insights in the workings of the human mind to shed light on epistemological issues. It is testimony to the power of Frege's and Husserl's critique that the accusation of psychologism remained sufficiently intimidating to dissuade naturalistic inclinations in epistemology for almost 100 years.[1]

During this period, epistemology was essentially foundational in spirit, and the following bullet points summarise its salient characteristics: (a) Epistemological theorizing is a priori. Knowledge, justification, evidence etc. are epistemic notions and an accurate understanding of them can be gained by philosophical reflection rather than empirical investigation; (b) Epistemology is autonomous. The sciences depend upon epistemological reflection but epistemology has its own subject matter and method and does not dependent on the findings of the sciences; (c) Epistemology is not purely descriptive; since it is concerned with evaluation and prescription, it is normative; (d) Epistemology's main task is to formulate a plausible defence of knowledge against scepticism.[2]

The term "naturalism" was coined during the first half of the 20th century in US philosophical discourse, but it does not have a precise meaning. It derives from the conviction that philosophy should be more closely aligned with science, and, broadly speaking, involves two commitments: reality is exhausted by nature, and it should be investigated by scientific method. In modern philosophical circles, naturalism is positively connotated, and few contemporary philosophers would reject naturalistic commitments.[3]

Ironically, the floodgates holding back an inundation of naturalistic epistemologies were opened by a member of the same ilk as the founder of modern logic. In *Epistemology naturalized*, Quine dismisses the Cartesian quest for certainty in empirical knowledge as «a lost cause»[4] and advocated instead «[e]pistemology, or something like it, [...] as a chapter of psychology and hence of natural science».[5] By arguing that psychological investigation of the actual construction of scientific knowledge from sensory stimuli should completely replace futile endeavours to deduce the former from the latter, Quine rejects foundational epistemology outright.[6] Published amid anti-psychologistic sentiment and being uncompromisingly radical, *Epistemology naturalized* did not fail to provoke a storm of criticism. The main thrust of the criticism is summarized in the following five points:

1. A naturalized epistemology does not necessarily follow from a rejection of Cartesian-style epistemology. In fact, Quine argued against the strong foundational styles of traditional epistemology, but they had already been abandoned for an analytic programme by the time he wrote *Epistemology naturalised*.
2. It is considered to be the task of epistemology to legitimate empirical science as a source of knowledge, yet Quine advocates the liberal use of empirical science, especially psychology, to establish the possibility of empirical knowledge. By founding legitimation on what has to be legitimated, Quine commits epistemology to a vicious circle.
3. Quine's response to scepticism is considered to be inadequate. Scepticism challenges the very possibility of knowledge, but Quine only considers it to be a form of scientific doubt.
4. Justification is the cardinal concern of epistemology, yet psychology is a descriptive science. By making epistemology a part of psychology, Quine thus redacts normativity from epistemology.
5. Finally, Quine's naturalization of epistemology has been accused of being self-defeating. By arguing the case for a naturalization of epistemology and leaving the reader to assess the arguments in the light of epistemic intuitions, Quine appeals to standard philosophical practice. Since naturalism rejects armchair philosophizing, Quine is attempting to justify naturalism by means of a method whose validity is in question.

«Naturalism in philosophy has a long and distinguished heritage»,[7] and, before the antipsychologistic intermezzo, the pertinence of the workings of the mind for epistemology was not in question. Fuelled in part by cognitive science,[8] the naturalization of epistemology since *Epistemology naturalized* is again gaining momentum. Whilst there is agreement that philosophical investigation of knowledge, justification, rationality, etc. and empirical science work closely together in a naturalised epistemology, there is division in the details of their collaboration: «whether and to what extent [naturalistic epistemologists] advocate use of empirical *methods*, or insist upon the relevance of the *results* of certain areas of empirical study, or invoke certain recognized "natural" *properties, relations*, and so on, in their accounts of certain central epistemic phenomena». Divisions also extend to the science(s) considered relevant for a naturalized epistemology: «psychology and/or cognitive science, ethology, cultural studies, evolutionary theory, social theory, or some other area of empirical investigation».[9]

Alvin Goldman has classified naturalistic epistemologies into meta-epistemic, substantive epistemic and methodological naturalism.[10] Meta-epistemic naturalism constitutes a denial of the

autonomy of epistemology (b) by requiring that epistemic properties be related in some way to natural properties, and reduction or supervenience are commonly thought to be the appropriate ways to relate them. By accounting for epistemology in terms of natural properties or relations, substantive naturalizations of epistemology also amount to a denial of the autonomy of epistemology's subject matter (b). Finally, methodological naturalizations also deny the autonomy of epistemology (b); however, not because of the subject matter but the method that consists in or is at least informed in some way by empirical science. By regarding epistemology as a chapter of psychology, Quine advocated replacing epistemology completely by science. In contrast to "replacement naturalism", "moderate" or "cooperative naturalism" denote less radical versions of methodological naturalism in which epistemology is informed by or beholden in some way to science.[11]

Goldman's taxonomy reflects the ontological and methodological aspects of naturalism. Whereas meta-epistemology and substantive epistemology are primarily concerned with ontological matters, methodological naturalizations are concerned with the role science plays in epistemology. Concerning the latter, Quine regarded the explanation of the formation of scientific knowledge, not its legitimation, as the purpose of epistemology; however, by replacing traditional epistemology by science, he is accused, despite his protests, of jettisoning normativity. Not all methodological naturalisations are as radical as Quine's, and they can be differentiated according to the relative weights given to the normative dimensions of epistemology and the role of science. In some methodological naturalisations, for example, normative methodologies such as mathematics, logic, probability theory, etc. prescribe proper cognitive conduct, and empirical science investigates human ability to conform with these norms. Alternatively, a non-scientific methodology may discern the goals and values of cognition or the criteria of proper cognitive conduct while science determines the processes that promote these goals or satisfy the criteria. Finally, science may also help determine the goals, values or general criteria associated with epistemic norms.[12]

In the *Preface* to the 1st edition of *Introduction à l'épistémologie génétique*, written in 1949, Jean Piaget expressed his own motivation for a naturalized epistemology as follows:

> While studying zoology, two interests – one in problems of biological variation and adaptation, the other in logical and epistemological questions – made me dream of constructing a biological epistemology founded exclusively on the notion of development. Recourse to positive psychology seemed to be essential and, above all, to what could be called "the embryology of reason", namely, the study of children's intelligence.[13]

Introduction à l'épistémologie génétique was published in 1950 and represents the culmination of almost 30 years of empirical research and reflection. Like Quine, psychology is also essential for Piaget's biological epistemology (abbreviated GE for genetic epistemology[14]); in contrast to Quine, however, it is not the only science of relevance. Besides cognitive developmental psychology, Piaget attributed significant roles to evolutionary biology, sociology, and the history of science as well. Like cognitive science, then, GE is interdisciplinary; unlike modern cognitive science, however, the sciences Piaget considered relevant for epistemology are less numerous and determined by development.

Piaget actively pursued his dream from his teens until his death in 1980, and, as with any research programme productively pursued over a long period, GE evolved.[15] Since adequately representing almost six decades of evolving research encompassing more than 50 books, 500 papers and 37 volumes in *Etudes d'épistémologie génétique*[16] in a single paper verges on impossibility, I will simply focus on the object and method of GE in this paper, which was set out in the *Introduction* to *Introduction à l'épistémologie génétique* and formed the methodological foundation of his research programme.

Ironically, the prodigious psychological research that secured Piaget's reputation as a developmental psychologist was carried out largely in service of his epistemological interests, but the epistemological aspect of his work has never received much recognition in the Anglophone world.[17] A potential source of common misconceptions surrounding Piaget's work lies in the translations into English that are selective and not rarely of dubious quality;[18] it is perhaps also symptomatic of the skewed reception in the Anglophone world that *Introduction à l'épistémologie génétique* has not yet been translated into English.[19] Since addressing this deficit is part of the motivation behind the present paper, I begin by adumbrating the object and method of GE. Perhaps more significantly, however, *Introduction à l'épistémologie génétique* was published almost two decades before Quine's pivotal paper and coincided with the beginnings of the cognitive revolution, an intellectual movement that ushered in cognitive science.[20] The situation reminds me of Biopace technology developed by Shimano. Based on extensive research and computer aided design, the chainwheels on bikes were shaped to optimise cyclists' leg-power; however, it was a solution to a problem nobody really had, and it never caught on. Analogously, Piaget also proposed a solution to a problem nobody seemed to have at the time. With renewed interest in naturalised epistemologies and the role of science in epistemology[21] times are

changing. Another part of the motivation is therefore to locate GE within current discourse on scientific epistemology.

To this end, I classify GE according to Goldman's taxonomy of naturalistic epistemologies introduced above. Finally, current philosophical debate revolves around the normativity of epistemology and the self-defeating nature of philosophical justifications of naturalism (points 4 and 5);[22] however, circularity and scepticism (points 2 and 3) still pose unresolved challenges. Naturalism being the natural consequence of the failure of the quest for Cartesian certainty (critique point 1) is, by contrast, specific to *Epistemology naturalized*. On a more liberal interpretation, Quine motivated the naturalization of epistemology through the failure of the pursuit of infallibility. Although the five critique points directed at Quine's naturalization of epistemology are thus still relevant for naturalizations of epistemology, I nevertheless assess GE only in light of the critique points 2-5 typically levelled at naturalistic epistemologies only since they can still be regarded as a litmus test for naturalizations of epistemology. I wrap up by briefly highlighting some salient points for scientific epistemologies.

2 Genetic epistemology

2.1 Science and philosophy in contrast

Piaget was interested in the acquisition of knowledge. Like Kant,[23] Piaget contrasted, with growing dissatisfaction, the few in-roads philosophy has made during the past 2½ millennia with the success of the sciences and desired the same success for questions concerning human knowledge. Again, like Kant,[24] he also saw the solution in an orientation on the sciences. Piaget drew attention to the success of the sciences, starting with mathematics, logic and astronomy in Antiquity, through physics, chemistry and biology in the wake of the Scientific Revolution, to the behavioural sciences in more recent times, going hand-in-hand with an emancipation from philosophy. Moreover, he considered the success of the sciences to be the source of renewals in philosophy, not vice versa.[25] Unlike Kant,[26] however, he did not believe that a Copernican Revolution would put philosophy on the same road to success as the sciences.[27]

Piaget measures the success of the sciences in terms of the consensus they achieve among their practitioners. Consensus in philosophy is rare, as the numerous conflicting schools of thought clearly demonstrate. For Piaget, the lack of consensus is due to the subject matter and method of philosophy. Philosophy tries to grasp reality as a whole. Since this reality encompasses the world of objects, the human mind and the relationship between them, each philosophy presupposes an epistemology.[28] The only cognitive tool general enough for the task is reflective analysis, but reflective analysis allows values to intrude into the systems philosophers construct, and the disparate values give rise to opposing philosophical positions. Disagreement is, therefore, inevitable in an investigation whose scope and generality are so great. The sciences, in contrast, are imbued with a different spirit. Instead of attempting to grasp reality as a whole, they abstract a limited number of problems from the whole nexus of problems, thus isolating a delimited field of research. Through the quest for answers to specific questions, each science then develops methods that allow it to collect, interpret and coordinate facts within the confines of a delimited research field. Moreover, the more a science is able to find answers to the specific questions it poses and the more precisely the methods employed are defined, the greater the consensus it will achieve among its practitioners. In short, the sciences, in contrast to philosophy, achieve consensus, and the secret of their success measured in terms of consensus lies in their modesty.[29]

In light of these preliminary considerations, a scientific epistemology is a conundrum. On the one hand, epistemology is part of philosophy, but philosophy being directed at reality as a whole cannot achieve consensus. Science, on the other hand, can achieve consensus but at a price – modesty. Science and philosophy thus pull in opposite directions, and for epistemology to become scientific it has to abandon the philosophical ambition for a modest few questions on which inquiry can achieve consensus.

2.2 The subject matter of scientific epistemology

Not without reason, epistemology is traditionally considered to be the prerogative of philosophy. On the one hand, an epistemology is part of any philosophy; on the other hand, any general theory of knowledge connects mind and matter and therefore presupposes a philosophy of mind, matter and their connection. An immediate challenge for a scientific epistemology is therefore the mutual dependency of epistemology and philosophy. Piaget concedes this point but only for epistemology approached in all generality. The sciences, in contrast, never tackle the big issues head on; they approach them obliquely, dividing and conquering. The big issues are divided into small manageable questions that can be tackled incrementally. Analogously, Piaget proposes an indirect route to a theory of knowledge which circumvents prior dependency on philosophy.[30]

To approach epistemology scientifically, Piaget has to demarcate a part of epistemology from philosophy. The fact that we speak of the different sciences generically as "science" suggests that they have properties in common; however, by drawing attention to the many different scientific disci-

plines, their subject matters and methods, Piaget considers it to be utopian to imagine agreement on any common characteristics of scientific knowledge. Although there are no predetermined lines along which science can be demarcated from philosophy, Piaget maintains that sufficient convergence of minds can nevertheless be achieved in answers to the following question for psychogenetic or historiogenetic analyses of precisely circumscribed discoveries or well-defined notions:

> How did the scientific knowledge at stake in the cases considered (and considered with a definite delimitation) proceed from one state of knowledge to another judged to be higher?[31]

By investigating the growth of knowledge, that is, by investigating how knowledge develops from lower to higher states, Piaget abstracts specific questions from the totality of epistemological questions, thereby delineating a field of epistemological enquiry from epistemology in general. The field of enquiry is modest enough to make consensus possible, and a discipline can be founded that, through progressive differentiation, strives to become scientific by analysing the growth of knowledge empirically in historical and psychological case studies and combining the results to form theories on the mechanisms responsible for the growth of knowledge.[32]

2.3 Method of a scientific epistemology

2.3.1 Special genetic epistemology

Having isolated the growth of knowledge as the subject matter of a scientific epistemology, Piaget developed an appropriate methodology. The goal is to determine how knowledge grows; knowledge is therefore considered from a diachronic perspective. The development of knowledge is thereby regarded in a continuum, in which each stage in the development of knowledge can be considered relative to precursor and future stages.[33]

Organisms grow, and the growth process can be investigated from a structural and physiological point of view. In analogy to organic growth, Piaget discerns a structural and functional aspect to the growth of knowledge; by functional, however, he does not mean the purpose of a particular structure but the mechanisms causing transformations. States of knowledge can therefore be compared via their inherent structures, and the mechanisms transforming one structure into the next. From a practical point of view, sequences in the transformation of structures are first established before the mechanisms mediating the sequential changes are discerned.[34]

Piaget understands the immediate task in the investigation of the growth of knowledge in analogy to comparative anatomy in biology. By considering the development of the concepts used in a particular science in the course of its history, it is possible to establish lineages of concepts by means of their direct continuity and conceptual connectivity within a system of knowledge as it develops over time. The first method of a scientific epistemology is thus established, and Piaget believes that the historico-critical method, when suitably refined, is adequate to this task. However, the historico-critical method alone can only investigate concepts in systems of scientific knowledge, concepts, that is, that scientists already in possession of mature cognitive faculties construct. Whilst such lineages shed light on and partly explain the development of complex concepts and their connections from more elementary ones, they cannot shed light on the emergence of the most elementary concepts themselves that have long been formed in the mature cognitive faculties of the scientists. For Piaget, the historico-critical method therefore has to be supplemented by a psychogenetic method that investigates the origin of the most elementary concepts.

In a scientific epistemology, then, the psychogenetic method investigates the ontogenesis of elementary concepts whilst a refined historico-critical method investigates the development of complex concepts from more elementary ones in the systems of scientific knowledge. Piaget envisages the two methods working together in analogy with the way embryology complements comparative anatomy in biology.[35] Moreover, he distinguished the science they constitute from a general theory of knowledge, and denoted it "special genetic epistemology", in contrast to "general genetic epistemology", which is the expression he uses for the latter.[36]

2.3.2 General genetic epistemology

A philosophy of the cognizing subject, the known object and the relationship between them is inherent in epistemologies; however, there is no consensus within philosophy on these issues. Piaget advocates an indirect route to a general theory of knowledge, but it appears to lead astray. While the psychogenesis and historiogenesis of selected contents of knowledge is interesting in its own right, the goal is a general theory of knowledge rather than theories of the growth of particular aspects of knowledge. Piaget therefore has to show that the indirect route is not just an interesting diversion but still leads to the desired destination.

Piaget classified epistemologies according to two criteria (see *Table 1*): development or preformation of truth, on the one hand, and the dependency of these truths on the cognising subject, the known object, or both inseparably. In this way, he discerned six philosophical positions, which he then

treats as hypotheses for a general theory of knowledge. Furthermore, he argues that the hypotheses can be verified or falsified on the basis of empirical evidence derived from psychogenetic and historiogenetic studies of the growth of knowledge. In essence, evidence of actual rather than pseudo construction of truth, falsify hypotheses maintaining preformed truths existing in the object, subject or both; whereas evidence of the emergence of preformed, timeless truths in the subject, object or both falsify developmental solutions.[37]

Table 1. *Classification of philosophical schools of thought* (cf. J. PIAGET, *Introduction à l'épistémologie génétique, vol. I: La pensée mathématique*, p. 31, table 1). Two criteria are used to classify the philosophical schools of thought in this table: Preformation or development of truth are used in vertical columns 2 and 3, respectively; whereas, rows 2, 3 and 4 counted from top to bottom represent the roles, respectively, of the known object, knowing subject or both inseparably play in the manifestation of truth.

	Non-developmental Solutions	Developmental Solutions
Primacy of Object	Realism	Empiricism
Primacy of Subject	Apriorism	Pragmatism/ Conventionalism
Inseparable Object and Subject	Phenomenology	Relativism

Piaget's classification of philosophies raises several issues. From the point of view of the primacy of subject, object or both together, the main concern is whether the hypotheses are exhaustive; in other words, whether there are epistemologies implying a philosophy that cannot be classified according to subject and object. Piaget argues that the subject-object relation is fundamental in epistemology and both subject and object are inherent even in the most extreme idealistic and realistic epistemologies.[38]

Another concern is that the genetic-epistemological method appears to favour developmental over non-developmental theories of knowledge since growth of knowledge is presumed in the investigations designed to come to a decision on the general theory of knowledge. Piaget was at pains to show that no such bias exists and disperses concerns by distinguishing between the individual or collective roads to truth and truth itself. While individual and collective knowledge grows and develops, the truth discovered at the end of the personal or collective journeys along these roads can still be preformed in external reality, the subject, or a combination of both. The development of knowledge would then be a pseudo construction of truth, and analysis would reveal its subjective nature.[39]

A further, though less obvious, potential source of bias also needs to be addressed. Science, particularly the deductive sciences, are replete with necessary truths. These truths do not simply describe how we in fact think but prescribe how we should think; they therefore have a regulative function on rational thought. In other words, they are not just facts but norms that express an obligation to think in a particular way. However, norms can only be founded on other norms since what should be the case cannot be derived from what is the case. The deductive sciences especially are replete with such norms, and in order to avoid bias against developmental theories construction of such norms must be made plausible. Piaget's task is then to show how it is possible to conceive the construction of timeless truths over time.

The construction of a stone arch is an example of an effective coordination of actions either on the part of an individual or of individuals working together. For Piaget, actions have two complementary aspects. Moving a stone, for example, has a real aspect since it produces a physical displacement of the stone. Since the displacement of the stone opens new possibilities for further actions while making those present prior to the displacement now impossible, it also has virtual aspects. In the arch, setting a stone in the foundation, for example, allows further stones to build on it but simultaneously excludes it for other uses.

Piaget distinguishes two distinct types of possibility in these virtual actions: the action can be reproduced so that properties inherent in the action can be investigated, or it can be combined with other actions, including itself, which are made possible by the real or virtual performance of the original action.[40]

At first, virtual actions are contingent on real actions, modelling them mentally and augmenting them with possibilities; in the course of time, however, they complement and complete real actions to such an extent that real actions become embedded in a web of virtual actions. Piaget draws attention to their importance in explanations when reality is sufficiently well embedded in a web of virtual actions. The stability of the arch, for example, is explained physically by means of virtual work. The work done by a virtual displacement of the keystone falling under the influence of gravity is compensated by the vertical components of the virtual work done by the supporting pillars while the horizontal components of virtual work balance each other out. A reversal of roles thus takes place since virtual actions now prescribe the conditions that must obtain for a physical system such as the stone arch to be in static equilibrium.[41]

While physical actions are subject to causal and temporal constraints, virtual actions are not. They are implicational in nature, but compositions of virtual actions derived from the physical systems they explain impose constraints on thinking about the physical systems in much the same way as timeless

truths of deductive thought impose constraints on rational thought. With respect to timelessness and prescriptivity, then, the virtual actions embedding physical systems are not unlike the truths of deductive sciences; however, the timeless truths of deductive sciences are not contingent on any particular physical system, yet they apply to all physical reality. The problem is therefore to explain the construction of intrinsic constraints in the compositions of actions, constraints, that is, that do not derive from the content of physical systems external to the actions themselves.

Equilibrium and reversibility are the keys to Piaget's explanation of the construction of the necessary truths of the deductive sciences. In analogy to the stone arch, virtual actions develop in conjunction with real actions, augmenting them, at first, but eventually complementing them with a web of virtual actions. Real and virtual actions then become mutually dependent on each other, and they form an equilibrium when real actions are sufficiently well embedded in virtual actions. The significance of the equilibrium lies in the fact that real actions are constrained by causal-temporal laws alone. In equilibrium, however, real actions are performed with an awareness of the accompanying virtual actions and are therefore subject not just to causal-temporal laws but also to the additional constraints of the accompanying virtual actions in much the same way as the net virtual work being zero imposes constraints on the organisation of real stones in a free-standing arch.[42]

Deductive sciences are replete with necessary truths, and logicians analysing inferences from the perspective of validity, for example, have discovered necessary truths of logic. Furthermore, the necessary truths of logic, among others, are constraints on a thinking that aspires to be logical. Whereas the constraint originates in the equilibrium generated by real and virtual actions; the necessity, according to Piaget, is due specifically to the reversibility arising within the equilibrium.

Actions actually performed, being causal-temporal, are sequential in time; necessary truths, in contrast, are timeless. A collection of red wooden beads added to another of blue wooden beads, for example, results in a collection of red and blue wooden beads, and removing the red ones from the collection of both results in a collection of blue beads or vice versa. Experiments show that children do not hold the whole, the wooden beads, to be greater than its parts, the red or blue ones, let alone necessarily so, when the virtual actions accompanying the real actions are not sufficiently well developed. Once sufficiently developed, however, real actions are embedded in virtual actions, and the latter allow the former to be reversed so that the original collections of blue and red beads can be retrieved mentally while the physical outcome of unifying them into a collection of wooden beads remains in sight. By virtue of the virtual actions, awareness of the original collections of blue or red wooden beads is thus preserved in the outcome of their merger: they are now perceived as parts of the whole collection of wooden beads, and the whole is thus held to be necessarily greater than its parts. By virtue of the reversibility arising in real and virtual actions in equilibrium, the causal-temporal nature of real actions is, thus, overcome and necessity realised. For Piaget, reversible actions are operations, and they are the source of the necessary truths of deductive science. They have causal-temporal as well as implicational aspects, and in equilibrium they form fully reversible systems of transformations with laws of composition and conservation whose structures can be modelled using the formal tools of deductive science.[43]

2.3.4 Transition from special to general genetic epistemology

Piaget's goal was a general theory of knowledge; however, a general theory of knowledge presupposes a philosophy of mind, matter and their interaction. He considered special GE to be an indirect route to this goal, which avoids philosophical speculation over these matters. Based on empirical evidence derived from the psycho- and historiogenetic analyses of the growth of knowledge, he wished to substantiate one or more of the hypotheses set out in *Table 1*. Specifically, the hypotheses represent limits, on which the development of knowledge as a whole converges, and he wished to substantiate one or more of them by means of developmental trends in special-genetic-epistemological analyses.[44]

However, two major hurdles stand in the way of the transition from psychogenetic and historico-critical case studies to a general theory of knowledge. Both arise because there is no privileged vantage point outside of knowledge for an observer to investigate knowledge, and one is due to knowledge being in a state of development.[45] Each particular case study analyses an area of knowledge as it progresses from one state to the next. The analyses are based on the cognitive tools at the disposal of the psychologists and historians, but neither the logico-mathematical tools nor currently accepted scientific knowledge provide an absolute frame of reference. From a truly historical point of view, the frame of reference itself is also mobile: it is a state of scientific knowledge that has superseded previous states and, being *in statu nascendi*, will likely also be superseded in the course of time. This would not be critical if our perception and understanding of mind, matter and their interaction remained unaffected by such changes; however, evidence suggests that they are. In particular, perception of the growth of knowledge changes in the light of changes in the frame

of reference employed by psychologists and historians. The other hurdle is erected by methodological constraints inherent in particular psychogenetic and historico-critical case studies.[46] By means of the frame of reference constituted by the knowledge currently accepted in the sciences, particular case studies can chart the growth in specific fields of knowledge up to the limits set by this frame of reference. However, the limits of the growth of knowledge as a whole is beyond their reach because they cannot account for the undetermined movement in the scientific knowledge presupposed in the frame of reference. In other words, general GE has to do without the absolute frame of reference assumed in special GE.

2.3.5 Generalisation of genetic epistemology

Piaget's approach has two parts, corresponding roughly to the historization and generalization. Starting with the latter,[47] it is clear from the previous section that an inductive generalisation of special GE cannot account for scientific knowledge as a whole because the individual analyses always presuppose the current state of scientific knowledge as the fixed frame of reference. The fixed frame of reference is therefore the hurdle a generalisation of GE has to negotiate.

The first solution that comes to mind is to do without the frame of reference. However, a subject gets to know an object via interaction with it, and, complementary to the knowledge acquired over the object, it gains knowledge of itself. In other words, knowledge of an object is acquired via the interaction of a subject and knowledge of the subject, via the interaction with its object. An epistemology that strives to be scientific is no exception. In order to investigate the interaction between subject and object in any particular field of knowledge, an observer makes subject-object relationships inherent in it into the object of investigation. However, a vantage point outside of the subject-object dialectic does not exist: the epistemologist is still a subject studying an object, namely, the newly created object constituted by the subject-object relationships in the particular field of knowledge under investigation.

Moreover, the epistemologist studies the subject-object relationship in the newly created object with the help of the cognitive tools at his/her disposal. The latter is his/her frame of reference, and it is limited by the current state of scientific knowledge. The frame of reference is thus an integral part of knowledge acquisition; a generalisation of special GE must therefore find a way of coping with this hurdle.

For Piaget, the solution to the problem of generalisation lies in the circularity inherent in the interaction of subject and object in the development of knowledge. Although Piaget acknowledges the epistemological circle of subject and object to be a fundamental structure of science, he does not opine the impossibility of scientific knowledge. Using the development of time, he illustrates how confidence in scientific knowledge can grow despite circularity. Clocks measure time, but their construction relies on the isochronal movements as units, which clocks themselves help to determine. Since clocks and isochronal movements are mutually dependent on each other the circle is unavoidable; nevertheless, the circle is not necessarily vicious: if the movements are truly isochronal, then clocks based on them are accurate, and if clocks are truly accurate, isochronal movements can be determined as units.

Unfortunately, however, neither one is known with absolute certainty; they can only be assessed in light of each other. Although the circle is inescapable, a web of connections between clocks and isochronal movements can be spun, and, as the spreading web of connections converge in logical coherence, reassurance that the circle is not vicious grows. Although scientific knowledge is circular, the circle may be virtuous, and belief in any body of scientific knowledge is warranted by a web of connections converging in logical coherence. The criterion for scientific knowledge not being vicious is therefore convergence in logical coherence of a web of connections spun between scientific findings during the expansion of the inherent epistemological circle. In analogy to the other sciences, Piaget advocates expanding the circle inherent in special-genetic-epistemological studies of the growth of knowledge, and, through the expansion, he expects the web of connections to converge in an inner logical coherence unobtainable in epistemology pursued purely philosophically.

Since the virtuosity of the epistemological circle cannot be assessed without the evidence of scientific research, scientists have to take a leap of faith. They are forced to start investigating without knowing whether their efforts will be rewarded with success. However, a leap of faith means that not all beliefs are questioned at once. When investigating specific problems, scientists make preliminary assumptions, knowing full well they will have to account for them later. This is particularly apparent for genetic epistemologists who rely on a frame of reference provided by currently accepted scientific knowledge in the analyses of the growth of particular aspects of knowledge.

For the genetic epistemologist, the knowledge presupposed in a frame of reference is no different from the knowledge under investigation. It does not have any special status; it is simply assumed in any particular study but can equally well become the object of investigation. Beginning in the midst of knowledge with analyses of particular subject-object relationships in the growth of knowledge, then, assumptions concerning the subject, object

and their relationship constitute a frame of reference for these analyses; however, being knowledge like any other knowledge, these assumptions can be accounted for later.

Expanding special GE analyses has two effects: on the one hand, it begins to repay its debt by successively accounting for the assumptions any particular investigation is forced to make at the outset; on the other hand, it will inspire confidence in the circularity not being vicious as the spreading web of connections progressively converge in logical coherence. Aiming to maximise confidence, the scope of the analyses can be successively increased, and a maximum is reached as the scope approaches the current state of scientific knowledge. As the scope of special GE converges with the limit set by the current state of scientific knowledge, the methodological limitations of special GE will also be overcome since there is in this limit no knowl-edge presupposed in a frame of reference left unaccounted for. In contrast to a simple inductive generalisation of special GE, this generalisation thus makes good on its promise to account for the frame of reference assumed in its particular investigations because all scientific knowledge is now encompassed.

The generalisation hinges on the circularity of scientific knowledge. However, scientific knowledge is not typically represented by a circle; it is frequently represented linearly with logic and mathematics at its base and physics, chemistry, biology, psychology and sociology building successive storeys of the edifice. The linear representation is often motivated by foundational considerations, whereby mathematics or logic form the solid foundation on which the other sciences build.

In this representation, logic or mathematics and psychology or sociology occupy the ends of a hierarchical sequence. Being at the top of the edifice, psychology and sociology do not play any role in the foundation of other sciences. Piaget does not doubt that logical and mathematical truths have an axiomatic foundation. However, he draws attention to the fact that the axioms constituting the foundation still have to be taken to be true; in other words, the axioms have to be understood and acknowledged collectively. Inexorably, a system of axioms therefore leads to psychological and sociological considerations. On the other hand, psychosociological studies have explained how logical and mathematical operations such as space, number, order, etc. evolve. For Piaget, then, the ends of the foundational linear hierarchy of scientific disciplines turn toward each other and meet.

Although scientists searching for explanations of phenomena do not usually venture outside of the narrow confines of their disciplines, scientific explanation does not stop at the boarders of scientific disciplines. Sooner or later psychological and sociological explanations of the subject-object relations will also need to refer to the biological subject. Likewise, biological organisms are also chemico-physical systems; explanation, therefore, does not stop with biology but draws sooner or later on chemistry and physics.

All sciences, but especially chemistry and physics, rely on the tools of mathematics and logic. Chemico-physical explanations therefore lead to considerations of mathematics and logic. Finally, the necessary truths of mathematics and logic lead to psychology and sociology sooner or later because they are not only true but also have to be taken to be true individually and collectively. In contrast to the linear hierarchical representation, a circle, thus, represents explanatory dependencies rather than the foundational connections of scientific knowledge according to Piaget.

In the circle, opposing trends in scientific explanation are discernible. On the one hand, the material world is assimilated to the logical, mathematical and psychological structures of the cognizing subject; on the other hand, the cognizing subject is assimilated by biological, chemical and physical processes. From a philosophical point of view, the circle therefore has idealistic and realistic tendencies. Whereas special GE investigates the growth of knowledge using the fixed frame of reference provided by the current state of scientific knowledge, the circle of scientific knowledge with its opposing tendencies toward realistic and idealistic explanations becomes the object of investigation as the scope of special GE investigations expands towards the limit set by current scientific knowledge.

From the point of view of special GE, the current state of scientific knowledge provides a stable frame of reference. The poles of idealism and realism are therefore fixed and the growth of knowledge in any particular field of knowledge can be assessed in relation to them. However, the poles cannot be likened to the fixed poles of a magnet from the general point of view. Scientific knowledge continues to develop; trends toward realism or idealism can therefore shift as either the subjective provenience of purportedly objective realities or the causal mechanisms governing supposedly subjective processes are discovered. Thus the poles themselves move as the sciences continue to develop over time.

Although the circle achieves the generalisation of special GE a simple inductive generalisation could not, changes in the poles within the circle as scientific knowledge continues to develop also need to be taken into account.

2.3.6 Historization of genetic epistemology

The methodological hurdle inherent in generalising special GE is overcome by expanding the epistemological circle inherent in special GE. As it converges with the limit set by the current state of scientific knowledge, it not only maximises the ev-

idence for the virtuosity of the circle but also accounts for the frame of reference assumed in each special study of GE. As this limit is approached the nature of the subject, object and their relationship would emerge if the sciences were not also *in statu nascendi*. Development in some branches of knowledge follow discoveries and progress in others; rather than being fixed, as it is for the special studies, the circle of scientific knowledge is therefore in flux from a historical perspective: the connections between the branches of scientific knowledge within the circle shift and change over time and future development remains open. Since a circle is a closed geometrical figure but the development of scientific knowledge as a whole never fully closes from a historical point of view, Piaget prefers to imagine its development as a spiral or cyclical process over time.[48]

The cross-section through a spiral approximates to a circle while remaining open. It is therefore a helpful metaphor for representing the circle of scientific knowledge forming the frame of reference for special GE at a particular point in time. As the scope of the analyses of different aspects of the growth of knowledge approach the circle, general trends in the development of scientific knowledge can be discerned. However general these trends may be, they are nevertheless only valid up to the point in time under consideration. In order to discern general trends over time in the development of scientific knowledge as a whole, comparisons of different cross-sections of the spiral are needed. An overall trend towards realism or idealism in the growth of scientific knowledge as a whole over time, for example, is thus revealed by the comparison of tendencies to reduce the subject to objective reality or, respectively, objective reality to the subject in different cross-sections of the spiral. In the historization of the generalisation of special GE, then, the comparison of a historically prior state of knowledge with the current state of knowledge serving as an absolute frame of reference is replaced by a comparison of general developmental trends in an earlier state of the totality of scientific knowledge with those in a later one. For Piaget, discerning direction in the development of scientific knowledge as a whole by comparison of an earlier ring in the spiral with a later one is the historization that remains faithful to the genetic method of special GE.[49]

In summary, a theory of knowledge is implied in any philosophy of the world and everything in it, but theorizing about knowledge in all generality requires a philosophy of mind, matter and their connection. Special GE analyses the growth of particular aspects of knowledge, and Piaget classifies the philosophical schools of thought so that they can be assessed in the light of such analyses.

However, the findings of special-genetic-epistemological analyses do not apply to knowledge as a whole due to the requirement that currently accepted scientific knowledge be used as a frame of reference. Piaget overcomes these methodological limitations through generalisation and historization. Through generalisation, the fundamental circle of subject and object inherent in the acquisition of knowledge converges with the circle formed by scientific knowledge, and Piaget discerns two tendencies within the totality of scientific knowledge – one toward a reduction of the subject to objective reality, realism, and the other toward a reduction of objective reality to the subject, idealism.

Since the future development of scientific knowledge remains open, the cross section through a spiral is a better representation than a closed geometrical form such as a circle, and trends toward realism or idealism over time can be discerned through the comparison of earlier and later cross sections. In general GE, then, empirical and historical investigation of the growth of knowledge inform a theory of knowledge. However, some care is still needed. As long as the future development of the sciences remains open, insight into the directed-development of scientific knowl-edge as a whole only has retrospective import. In other words, a general theory of knowledge can only find provisional support.[50]

Having outlined the object and method of GE, I will situate Piaget's approach within the discourse on naturalism and assess it in light of criticism commonly levelled at naturalised epistemologies.

3 Conclusion

The growth of knowledge is the subject matter of GE. For special GE, the validity of currently accepted scientific knowledge is not called into questioned. On the contrary, it serves as the frame of reference against which the growth of particular aspects of knowledge can be assessed; in particular, it sets the developmental goals and provides the cognitive tools for psychogenetic and historiogenetic investigation of the growth of particular aspects of knowledge.

Unlike traditional epistemologies, then, special GE is not limited to a priori, theoretical reflection on knowledge, justification, evidence, etc. (a). Since it has its own subject matter, it is autonomous; however, it is not autonomous in the traditional-epistemological sense. On the one hand, it is itself an empirical science since it investigates the growth of knowledge as a phenomenon using the techniques that genetic epistemologists develop and refined in the course of psychogenetic and historiogenetic case studies; on the other hand, it depends on science for the frame of reference that permits investigation to take place (b). As a science, it generates knowledge over the growth of particular aspects of knowledge, and the knowledge it generates is descriptive (c). Whether it also

has evaluative and prescriptive aspects will be deferred to the more general discussion of the normativity of knowledge. Finally, as an empirical science, it is not infallible and critical reflection on the methods and findings will raise doubts; however, the doubts in question occur within a framework of accepted scientific knowledge. The doubts are therefore symptomatic of a critical attitude rather than scepticism that denies the possibility of knowledge altogether (d). Since at least (a), (b), and (d) are not characteristics of special GE, it is not epistemology in the traditional sense.

General GE, on the other hand, has to take into account the frame of reference special GE takes for granted. By including the frame of reference in the historical process, the subject matter is generalised from the growth of particular parts of knowledge to the growth of scientific knowledge as a whole. In analogy with the method employed in special GE, trends in the development of scientific knowledge as a whole are discerned by comparing earlier with later states. The purpose of these comparisons is to inform judgement on the philosophical epistemologies serving as hypotheses. In contrast to special GE, general GE therefore has two sources: hypotheses on the subject, object and relationship between them originating in philosophical reflection; verification and falsification, on the other hand, are based on empirical evidence derived from the development of scientific knowledge. Since philosophical reflection is the source the hypotheses, epistemological theorizing in general GE is a priori (a). However, it is a priori only in the context of formulating hypotheses; in the context of justification, empirical evidence plays the decisive role. In other words, epistemology is not autonomous of empirical science (b). Discussion of characteristics (c) and (d) are differed till the of critique of naturalized epistemologies; nevertheless, it is already clear from (b) that special and general GE are not traditional epistemologies.

Naturalism has ontological and methodological components. Although the *Introduction à l'épistémologie génétique* synthesizes 30 years of research, the purview of the current paper is restricted to the object and method of GE rather than its findings; in other words, the ontological component is beyond the scope of this paper. From the methodological point of view alone, special GE is an empirical science with its own object, the growth of knowledge, and methods that are tailored to the analysis of the psychogenesis and sociogenesis of knowledge. The aim of special GE is to explain the growth of knowledge and is indeed, in Quine's words, a chapter of psychology for the embryology of particular concepts, and a chapter of history for the development of scientific concepts and theories. Specifically, special GE is therefore not only an instance of methodological naturalism but of replacement naturalism. For general GE, on the other hand, philosophical reflection is the source of the hypotheses ultimately justifying claims to knowledge. Scientific knowledge therefore depends on philosophy for its legitimation; however, science presides over the hypotheses. Although the ultimate decision on the hypotheses can only be made on the basis of scientific knowledge that has ceased to develop, trends discernible in the development of scientific knowledge as a whole inform provisional judgements until such time. General GE is therefore dependent on empirical evidence to corroborate hypotheses. Since the context of discovery, philosophical reflection, and the context of justification, empirical evidence derived from the growth of knowledge as a whole, are different yet mutually dependent sources, cooperative or moderate naturalism appears to be the more accurate characterization of general GE than replacement naturalism.

In summary, special and general GE are not traditional epistemologies but instances of methodological naturalism. Being a chapter of psychology and history, replacement naturalism adequately characterizes special GE; general GE, on the other hand, has empirical as well as philosophical components; it is therefore more accurately characterized by moderate/cooperative methodological naturalism.[51] Having partially situate GE in the discourse on naturalism, I now review it in light of criticism typically levelled at naturalistic epistemo-logies.

3.1 Circularity

According to Piaget, circularity is inherent in science, and GE being a science is no exception. The source of the circularity is the mutual dependency of the knowing subject on the known object and vice versa in cognition. For Piaget, the circularity of GE is therefore not per se a cause for concern but whether the circle is vicious. This is not known prior to embarking on scientific inquiry but it can be assessed retrospectively. By spinning an ever-finer web of connections between its findings, evidence for the virtuosity rather than the viciousness of the circle is revealed by the converging coherence of the findings. Just like other sciences, then, special GE warrants belief in its own findings. General GE, on the other hand, has philosophical and empirical components. Whilst empirical science receives its legitimation from the philosophical component, alternative theories comprise the latter, but philosophy does not have any impartial means for assessing these alternatives. For general GE, the theories are hypotheses, which are assessed on the basis of empirical evidence. Since the legitimation of empirical science relies on the very theory being legitimised, the circle critics of Quine's naturalism of epistemology bemoan is manifest in general GE. Again, however, the important question is whether the circle is vicious. Piaget argues that belief in a

theory of knowledge is based on the evidence of empirical science, and the evidence of empirical science is justified by a commitment to the theory in question. An epistemic circle is therefore at the heart of Piaget's argument, and such circles have attracted the attention of philosophers more recently.[52]

In essence, epistemic circles form around sources of beliefs – perception, intuitive reason, introspection, memory, reasoning – since arguments for the reliability of these sources are premised on instances of the source being reliable. Clearly a commitment to the conclusion justifies belief in the premisses, and the premisses justify the conclusion of the argument. However, such arguments do not constitute logical circles since the conclusion does not appear in the premisses. Although not without problems of its own, epistemic circularity, in contrast to logical circularity, does not therefore appear to be vicious.[53]

3.2 Scepticism

Turning to scepticism, Descartes used doubt strategically in his quest to find solid foundations on which to erect an edifice of certain knowledge. Quine also sees doubt as the source of epistemological endeavours; however, he considers Cartesian certainty to be a lost cause and consequently Cartesian doubt to be the wrong approach to epistemology. Instead, he draws attention to the central role illusions play in sceptical arguments and argues that a backdrop of scientific facts is a prerequisite to discerning illusions. In using illusion as a tool, sceptics thus assume some areas of knowledge to cast doubt on others. From this point of view, scepticism is not opposed to scientific knowledge but part and parcel of the critical attitude cultivated in the sciences, which Quine laconically expresses as «sceptical doubts are scientific doubts».[54]

Scepticism does not appear explicitly in Piaget's taxonomy of philosophies, nor, to my knowledge, does Piaget refer to scepticism except in a historical context. With respect to the historical school of thought, he points out that sceptics invariably draw attention to the involvement of a subject in knowledge acquisition but use this insight destructively by highlighting the subject's fallibility or its deformation of objective reality.[55] Illusions, according to Quine the main instrument in the sceptical toolkit, can be seen from this perspective. The illusion of a straight rod appearing bent when partially submerged in water, for example, is explained by distinguishing between observed reality and the observing subject and attributing the appearance to the perceiving subject rather than the object. Clearly, the explanation plays into the hands of sceptics, who readily interpret the illusion as yet another illustration of the way the subject deforms objective reality.

Piaget sides with the sceptics on the activity of a subject in knowledge acquisition, but he does not accept that deformation and error are an inevitable outcome; for him, the challenge lies in discovering the actual role the subject plays in the construction of knowledge.[56] As already mentioned, scepticism does not appear explicitly in Piaget's taxonomy of philosophies; nevertheless, it could be allocated a role in GE's method. Pyrrhonian sceptics, for example, constructed equally strong arguments for opposing opinions using what was known at the time in order to acquiesce in an inability to decide. Knowledge rather than agnosticism was Piaget's goal, and, to this end, he classified the different philosophies according to the role subject and object play in the acquisition of knowledge. By emphasising the involvement of the subject in knowledge acquisition, a Pyrrhonianesque scepticism would provide an idealist counterweight to realist inclinations and thus help prevent premature judgments concerning the taxonomy of philosophies by restoring the balance between both tendencies in the development of scientific knowledge. Be that as it may, although Quine emphasizes illusions and Piaget the challenge of integrating the subject into the scientific description of reality, sceptical doubts are arguably also scientific doubts for Piaget. However, Quine's response to scepticism is considered to be inadequate, and a similar fate probably awaits my suggested integration of scepticism into GE.

3.3 Epistemic justification

Changing tack, epistemology is traditionally concerned with the constitution of knowledge, yet epistemic justification is beyond the scope of descriptive sciences such as psychology and history. The critique that Quine redacts normativity from epistemology by making epistemology a chapter of psychology, therefore, appears to be equally applicable to GE. (i) Norm-denial, e.g., behaviourism; (ii) norm as average or typical, e.g. psychometrics; (iii) norm as social regularity or compliance, e.g., social psychology; and (iv) norms as norm-laden are different positions on norms discernible in 20th-century psychology.[57] Despite his protests, Quine is accused of advocating that the chapter of psychology be written from the (i)-perspective.[58]

GE on the other hand investigates the growth of knowledge and given that the sciences not only describe what is the case but also maintain that their descriptions are true, GE also has to explain the emergence and development of the descriptive and normative aspects of knowledge. As a chapter of psychology, it must therefore be written from the perspective iv). For GE, actions are not just physical occurrences; they also have implicational aspects; i.e., they are intentional, meaningful and normative.[59] However, psychologists are not privileged to the first-person perspective of others; as observers,

they are confined to the third-person perspective. Nevertheless, observable behaviour is the manifestation of agents, and observation allows insight, albeit indirect, into the mental life of these agents. Since norms regulate agents' actions, they express themselves in patterns of behaviour and are accessible to observation. These are normative facts, and GE describes and explains their construction. In other words, the chapter on psychology in the book of GE is written from the perspective of normative facts.[60]

How Piaget explains the construction of norms in deductive sciences was set out under *General Genetic Epistemology*. However, there are two kinds of norms in play in GE: from the first-person perspective, the norms are instrumental in regulating behaviour; from the third-person perspective, on the other hand, the norms form the frame of reference used by observers. The former, being valid for the agents under investigation, are subjective; the latter, in contrast, are considered to be objective. As a chapter of psychology, special GE investigates the development of the former in light of the latter; whereby the validity of the latter is not in question.

The frame of reference used by observers is the current state of accepted scientific knowledge. While it is the benchmark for assessing the growth of knowledge in special GE, it does not have a privileged position for general GE – it is a norm like any other and will likely suffer the same fate as those it has superseded. The historicity of currently accepted scientific norms would be eliminated by knowledge of what really constitutes knowledge, and, using reflective analysis, the only tool with enough generality to deal with these matters adequately, philosophers have formulated possible constitutions of knowledge. However, the sheer scale of the project and the lack of control instances in reflective analysis means that the epistemological intuitions are laden with disparate values. Philosophical reflection is therefore the source of theories of knowledge, but it is impotent when it comes to achieving a consensus on vying hypotheses. Realistically, a systemization of contenders is all that reflective analysis can achieve, and Piaget classified them according to preformation and construction, on the one hand, and primacy of subject or object, on the other. Nevertheless, the ultimate epistemic justification of scientific knowledge lies in the hypotheses originating in the philosophical intuition. Hence, «psychology makes a necessary, but not a sufficient, contribution to [GE]»[61] and «epistemology makes a necessary, but not sufficient, contribution to [GE]».[62] In other words, the book of general GE includes chapters on psychology and philosophy. And, since normative facts and epistemic justification are part of the contents of these chapters, normativity is not redacted from the book of general GE. Nevertheless, with one chapter descriptive-explanatory the other is prescriptive, the question is how GE combines them into a single narrative.

GE aims to discover the constitution of knowledge by investigating the growth of knowledge; instances of knowledge are thereby being investigated scientifically. Since the object and method of investigation are considered to be sources of knowledge, they are assumed to have what constitutes knowledge. For GE, a commitment to the constitution of knowledge is therefore inherent in the discovery of the constitution of knowledge; however, its contitution is not yet known. Practically, theories of the constitution of knowledge can be conjectured, and philosophy has given rise to several contenders; however, preferences for particular hypotheses remain unwarranted without empirical evidence. Investigation of the growth of scientific knowledge is the only means of deriving empirical support for a particular hypothesis. Developmental trends toward idealism or realism can be discerned in the growth of scientific knowledge as a whole, and preferences for particular hypotheses can be formed on the basis of these trends. However, preferences are provisional in nature and remain fallible as long as the constitution of knowledge is not known, and this remains the case as long as scientific knowledge continues to grow.

According to Piaget, a circle is inherent in all sciences, yet it is not cause for concern unless the circle is vicious. Although it is not possible to know in advance whether or not the circle is in fact vicious, evidence can be gathered *a posteriori* by enlarging and assessing the convergence in logical coherence of the findings. Thus, GE as a science proceeds in analogy with the other sciences by enlarging the circle incorporating preferred hypotheses together with the developmental trends indicated by findings of genetic-epistemological investigations, and convergence in logical coherence serves as the criterion for assessing the viciousness of the circle. In other words, a particular hypothesis is warranted by the virtuosity of the circle it forms with the findings.

Piaget uses "accord" to refer to the agreement of thought with itself and with things.[63] As long as coherence is understood as incorporating both types of accord, Piaget thus appears to advocate what Rysiew calls "warrant-emergent coherentism".[64] In it, «warrant for each proposition in a web of mutually supporting, probability enhancing propositions arises in virtue of their mutual relationships [...] Coherence itself is the property in virtue of which each member of the set of propositions has warrant. Warrant emerges all at once, so to speak, from the web-like structure of the set of propositions. The coherentist can then argue that the fact that the propositions cohere provides each of them with some *prima facie* credibility».[65] Warrant-emergent coherentism connects facts and norms by deriving warrant from coherence. It

is not without advocates among philosophers,[66] and, in the book of GE, it combines the philosophical and psychological chapters into a single narrative, thus bridging the gap between norms and normative facts. In summary, as a chapter of psychology, GE investigates norms as facts; as a chapter of philosophy, it analyses reflectively possible constitutions of knowledge; and as a science, its knowledge is warranted by the coherence emerging in the narrative uniting the factual and constitutional chapters. Far from redacting normativity from epistemology, GE investigates and constitutes norms scientifically.

3.4 Naturalization of epistemology

Finally, Quine's arguments for a naturalization of epistemology have been accused of being self-defeating. By arguing the case for a naturalization of epistemology and leaving the reader to assess his arguments in the light of epistemic intuitions, Quine appeals to standard philosophical practice. Since naturalism rejects armchair philosophizing, Quine is trying to justify naturalism using the very method naturalists reject. Limited to the philosophical chapter, this critique would be equally applicable to GE. Using reflective analysis, philosophers formulate arguments for their epistemological convictions and judge the epistemologies of others on the basis of their own convictions. For GE, however, empirical evidence complements philosophical speculation and plays the decisive role. Despite appeals to philosophical intuitions and convictions in the generation of hypotheses, empirical evidence rather than arm-chair philosophising arbitrates between these hypotheses. GE is therefore immune to the accusation of being self-defeating since arm-chair philosophising is necessary but not sufficient.

In summary, GE represents a methodological naturalisation of epistemology; specifically, replacement naturalism classifies special and moderate/cooperative naturalism, general GE. GE was conceived by Piaget as a science almost two decades before Quine's pivotal paper, yet provisional considerations suggest GE weathers the storm of criticism whipped up by naturalisations of epistemology. However, GE appears to have been a solution to a problem no-one had at the time. Considering the naturalistic convictions of many philosophers today and renewed interest in scientific epistemology, I believe GE certainly deserves more attention than it has so far received. I will therefore wrap up by briefly highlighting some salient points for scientific epistemologies.

Like Kornblith,[67] Piaget regarded knowledge as a phenomenon that can become the object of scientific investigation, and, as Kornblith points out, our understanding of the phenomenon investigated is deepened by the investigations carried out. As already mentioned, *Introduction à l'épistémologie génétique* represents the culmination of 30 years of scientific research, and, based on the three decades of reflection, Piaget recognized that the subject-object relation is fundamental in knowledge acquisition. Interestingly, Quine[68] envisioned a naturalised epistemology in analogy to a philosophy of science that investigates the relation between theory and evidence but psychologically; Quine's intuition therefore corresponds to the subject-object interaction Piaget considered fundamental to knowledge acquisition. Like Goldman,[69] philosophical intuitions also have an important role to play in GE. Rather than *a priori* sources of knowledge for concept analysis, however, philosophical intuitions are the source of hypotheses on the foundation of knowledge for Piaget, and he instrumentalised them for empirical purposes by classifying them according to preformation and development on the one hand and the role subject and object play in knowledge acquisition on the other.

Piaget, Kornblith, Goldman and Quine all recognise the value of some if not all of the cognitive sciences for a scientific epistemology. However, experimental designs in cognitive science typically employ epistemic norms. Reasoning experiments, for example, are based on classical logic, probability theory, etc. as benchmarks for gauging the performance of test persons at cognitive tasks.[70] Such norms constitute frames of reference in the experimental design; however, they are also forms of knowledge. In such experiments, one form of knowledge is therefore being assessed on the basis of another. To get off the ground, a scientific epistemology may provisionally take knowledge like that constituting the frames of reference for granted, but it will never encompass all knowledge as long as this knowledge is not also taken into account. A scientific epistemology based on the cognitive sciences yet with pretensions to encompass all knowledge thus seems to be faced with the same issues as those arising from the transition from special to general GE.

Again, based on 30 years of scientific research, Piaget conferred a seminal role to development. It is one of Piaget's enduring legacies that he did not dismiss the mistakes children make in reasoning simply as errors but attempted to discover the reasons for these divergences. As an embryology of reason, special GE investigates the development of concepts from their primitive origins to their forms in the normative framework; however, the normative framework is constituted by the accepted scientific knowledge, which is also in flux.

From a historical perspective, then, even the concepts constituting the normative framework develop, or at least appear to, over time. Both the historiogenesis of concepts in the scientific worldview as well as the psychogenesis of concepts in the embryology of reason are therefore methodo-

logical pillars of general GE. By contrast, development is not typically a concern of the cognitive sciences. Test persons in reasoning experiments, for example, are typically adults, and the history of science does not as a rule feature in lists of the cognitive sciences, although its value for the philosophy of science has long been acknowledged.

Notes

[1] Cf. D. JACQUETTE, *Introduction: Psychologism the philosophical shibboleth*; M. KUSCH, *Psychologism and sociologism in early twentieth-century German-speaking philosophy*; M. KUSCH, *Psychologism, history of*; M. KUSCH, *Psychologism*; P. RYSIEW, *Naturalism in epistemology*, section 1.1
[2] Cf. P. RYSIEW, *Naturalism in epistemology*, section 1.3.
[3] Cf. D. PAPINEAU, *Naturalism*.
[4] Cf. W.V.O. QUINE, *Epistemology naturalized*, p. 74.
[5] *Ibid*., p. 82.
[6] P. RYSIEW, *Naturalism in epistemology*, section 2.
[7] H. KORNBLITH, *In defence of a naturalized epistemology*, p. 158.
[8] Cf., e.g., A.I. GOLDMAN, *Epistemology and cognition*; H. KORNBLITH, *A naturalistic epistemology*; A.I. GOLDMAN, *Philosophical applications of cognitive science*.
[9] Cf. P. RYSIEW, *Naturalism in epistemology*.
[10] A.I. GOLDMAN, *Naturalistic epistemology and reliabilism*, pp. 301-306.
[11] P. RYSIEW, *Naturalism in epistemology*, section 1.2
[12] A.I. GOLDMAN, *Naturalistic epistemology and reliabilism*, pp. 305-309.
[13] J. PIAGET, *Introduction à l'épistémologie génétique. vol. I: La pensée mathématique*, p. 5.
[14] "*Genetic*" has two meanings: one relating to genes or heredity; the other, to origins. In modern usage, the former sense dominates; however, Piaget uses *génétique* in *épistémologie génétique* in the sense of genesis. As the translation of *génétique*, "genetic" should therefore be understood in the latter sense in this paper (L. SMITH, *Piaget's developmental epistemology*).
[15] Cf. B. INHELDER, *Foreword*, pp. vii-xi.
[16] Cf. Jean Piaget Society, About Piaget 2020.
[17] Cf. J. MONTANGERO, *The various aspects of horizontal décalage*; Y. HSUEH, *Piaget in the United States, 1925-1971*; L. SMITH, U. MÜLLER, J.I. M. CARPENDALE, *Introduction*, pp. 1-10.
[18] Cf. L. SMITH, *Introduction III. Reading Piaget in English*, pp. 28-44.
[19] Cf. JEAN PIAGET ARCHIVES FOUNDATION, *The Jean Piaget Bibliography*; L. SMITH, *Introduction III. Reading Piaget in English*, p. 30, table 1.4.
[20] Cf. B.J. BAARS, *The cognitive revolution in psychology*; H.E. GARDNER, *The mind's new science: A history of the cognitive revolution*.
[21] Cf. A.I. GOLDMAN, *Epistemic folkways and scientific epistemology*, pp. 95-116; H. KORNBLITH, *In defence of a naturalized epistemology*; H. KORNBLITH, *A naturalistic epistemology: Selected papers*; A.I. GOLDMAN, M. MCGRATH, *Epistemology. A contemporary introduction*; A.I GOLDMAN, *Philosophical applications of cognitive science*, chap. 1; H. KORNBLITH, *Scientific epistemology*.
[22] P. RYSIEW, *Naturalism in epistemology*, section 3.2.
[23] I. KANT, *Kritik der reinen Vernunft*, BXIV-XV.
[24] *Ibid.*, BXVI
[25] J. PIAGET, *Introduction à l'épistémologie génétique. vol. I*, p. 1.
[26] I. KANT, *Kritik der reinen Vernunft*, BXVI-XVIII
[27] J. PIAGET, *Vorwort*, p. 6.
[28] Piaget's *Foreword* to the 1972 German edition suggests that he had the philosophical systems of continental not analytic philosophy in mind when referring to philosophy (Cf. J. PIAGET, *Vorwort*, p. 8.)
[29] J. PIAGET, *Introduction à l'épistémologie génétique. vol. I*, p. 1.
[30] *Ibidem*.
[31] *Ibid.*, p. 18 - my translation.
[32] *Ibid.*, p. 1.
[33] *Ibid.*, p. 2.
[34] *Ibidem*.
[35] *Ibidem*.
[36] *Ibid.*, pp. 49-50.
[37] *Ibid.*, p. 4. The classification of philosophical schools of thought does not appear to be carved in stone; at a later point in time Piaget discerned nine philosophical positions instead of the six above. (Cf. L. SMITH, *Piaget's developmental epistemology*, p. 67).
[38] *Ibid.*, pp. 6-7.
[39] *Ibid.*, p. 4.
[40] *Ibid.*, p. 5.
[41] *Ibidem*.
[42] *Ibidem*.
[43] *Ibid.*, p. 5.
[44] *Ibid.*, p. 6.
[45] *Ibid.*, p. 7.
[46] *Ibid.*, p. 6.
[47] Cf. *ibid.*, p. 6. Unless otherwise mentioned, this is the text referred to in this section.
[48] *Ibid.*, p. 51.
[49] *Ibid.*, p. 7.
[50] *Ibidem*.
[51] Kitchener concurs that genetic epistemology is a naturalized epistemology (cf. R.F. KITCHENER, *Genetic epistemology*). However, his conclusion is based on the content of GE. In particular, he focuses on the genetic-epistemological analysis of the emergence of the normative aspect in the social interactions constitutive of knowledge. Accordingly, genetic epistemology is, in his opinion, a meta-epistemic naturalization of epistemology since norms supervene on facts. From the methodological point of view pursued in this paper, however, meta-epistemic naturalism should be integrated in the classification of epistemological hypotheses and as long as scientific knowledge continues to develop, only provisional judgements can be entertained.
[52] Cf. P.W. ALSTON, *Epistemic circularity*; K. KAPPEL, *Naturalistic epistemology*; M. LAMMENRANTA, *Epistemic circularity*.
[53] Cf. M. LAMMENRANTA, *Epistemic circularity*.
[54] W.V.O. QUINE, *The nature of natural knowledge*, p. 258.
[55] J. PIAGET, *Introduction à l'épistémologie génétique, vol. I*, chapter 3.
[56] My argument is based on J. PIAGET, *Introduction à l'épistémologie génétique. vol. I : La pensée mathématique*, chap. III, sec. 1 A. In it, Piaget examines the meteoric rise and eventual stagnation of mathematics in ancient Greece through the subject-object lens. He argues that the process of becoming conscious has a natural propensity to overlook the subjective activity involved in the construction of mathematical objects and focus on the constructed object, which is responsi-

ble for the contemplative nature of ancient-Greek mathematics and its static sterility.

[57] Cf. L. SMITH, *Norms in human development: Introduction*, sections 3.1-3.2; L. SMITH, *Piaget's developmental epistemology*, p. 75.

[58] A.I. GOLDMAN, *Naturalistic epistemology and reliabilism*, pp. 305-306.

[59] L. SMITH, *Piaget's developmental epistemology*, p. 74.

[60] J. PIAGET, *Introduction à l'épistémologie génétique, vol. I*, pp. 34-35; cf. also L. SMITH, *From epistemology to psychology in the development of knowledge*; L. SMITH, *Norms and normative facts in human development*; L. SMITH, *Piaget's developmental epistemology*).

[61] Cf. also L. SMITH, *Norms and normative facts in human development*; L. SMITH, *Piaget's developmental epistemology*, p. 65.

[62] L. SMITH, *Piaget's developmental epistemology*, p. 70; L. SMITH, *Norms in human development: Introduction*.

[63] Cf. L. SMITH, *Piaget's developmental epistemology*, p. 80

[64] Cf. P. RYSIEW, *Naturalism in epistemology*.

[65] For Kitchener, the key to explaining the emergence and development of norms lies in Piaget's social theory (cf. R.F. KITCHENER, *Genetic epistemology: Naturalistic epistemology vs. normative epistemology*). From the methodological perspective of this paper, warrant-emergent coherence simply bridges the gap between the factual and the normative. However, a social theory appears to have an important though not exclusive role to play in bridging this gap since intersubjective interactions seem necessary to ensure the agreement of thought with object and thought with itself.

[66] Cf., e.g., L. BONJOUR, *The coherence theory of empirical knowledge*; W.V.O. QUINE, J.S. ULLIAN, *The web of belief*.

[67] H. KORNBLITH, *Scientific epistemology: An introduction*, chapter 2.

[68] Cf. W.V.O. QUINE, *Naturalized epistemology*, p. 83

[69] Cf. A.I. GOLDMAN, *Epistemology and cognition*; A.I. GOLDMAN, *Epistemic folkways and scientific epistemology*.

[70] Cf. e.g., A. TVERSKY, D. KAHNEMAN, *Extensional versus intuitive reasoning*; P.C. WASON, *Reasoning about a rule*.

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