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Play, Between Understanding
and Praxis: René Thom's Catastrophes

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When, while recollecting his encounter with René Thom, Francis Crick reports his impression that Thom ‘understood very little about how science was done’ (Crick 1988: 144), he is, ironically, pointing towards a very profound interpretation of the consequences of Thom’s work. On the one hand, the question of Thom’s dislike towards ‘Anglo-Saxon’ modes of scientific practice is quite pertinent to the shift of paradigms effected by his work: from the earlier focus on the study of continuity by the means of calculus, to his own development of the study of discontinuity under the heading of ‘catastrophe theory’. On the other hand, rather more importantly, Crick’s remark pinpoints the dichotomy between science¹ and praxis at the centre of catastrophe theory’s concern. In his article ‘At the Boundaries of Man’s Power: Play’, beginning with the question of the relation between the scientific understanding of the world and man’s power to act on the world, Thom outlines an ethics of scientific practice through an exposition of the concept of play.

Man’s power: Noise and paradoxical determinism

In order to embark upon an elaboration of Thom’s exposition of play, I claim here that it is first necessary to look at it through the spectrum of a more general problem lying at the core of post-Newtonian scientific enquiry. Classical mechanics, as well as all the scientific research projects springing from it, are grounded on the core assumption that universal laws determine all natural relations of cause and effect, known as the philosophical position of determinism. Even today, at a time when the most recent advances in physics indicate that at a microscopic level it is apparent that indeterminism holds, determinism is the current model for the explanation of everything at the macroscopic level. As Thom himself puts it, if one were to depart from the assumption of determinism towards the realm of pure chance, then this would imply taking up the position that there are *a priori* unknowable aspects of nature, since ‘a random process is one which cannot be simulated by any mechanism, nor described by any formalism’ (Thom 1983, 11).

Thom proceeds to explain how epistemologists such as Jacques Monod, Ilya Prigogine and Isabelle Stengers, Michel Serres and others, who hold in one way or another the position that there is chance in nature, seem to attempt to solve a problem which is philosophical in nature, i.e. unsolvable. By adopting such principles as, for example, the accidental mutations of DNA, ‘dissipative structures’ or the atomists’ *clinamen*, these theorists may be adopting viable philosophical positions², but these positions seem to preclude a study of areas which might turn out to be intelligible by a scientist whose interrogation of phenomena has not already assumed that they are unintelligible.

In other words, Thom is making the pragmatist claim that although certain positions are philosophically sufficient, grounded on the knowledge that the problems they respond to have been, at least up to the present, unsolvable, their hindering effect on potential scientific research should be deferred as long as the possibility of an optimistic approach on behalf of the scientist to the problem is viable.³

¹ The term ‘science’ here, as in the rest of the paper, refers not only to the so-called ‘exact’ sciences, but rather to the broader spectrum of scientific knowledge, including the ‘soft’ sciences, the arts and the humanities. It is, in this way, closer to the German term ‘Wissenschaft’, involving a view of scientific knowledge transcending disciplinary boundaries, than the contemporary use in English of the term science to connote the ‘Anglo-Saxon’ conception of the ‘hard’ sciences. This does not necessarily correspond to Thom’s use of the term or to a more general French understanding of the term scientific knowledge at the time, but is an attempt to expand Thom’s use of the term towards a wider range of applications.

² Thom seems to be unfair in his characterization of such positions as appropriate for ‘writers of literary formation’ (Thom 1983, 11) and not for ‘scientists’.

³ Of course this faces the same problems that Karl Popper’s criterion of falsifiability has been facing, especially since Hempel’s paradox: there seems to be little one can do to finally determine the non-viability of a scientific solution to a problem. Thom’s scholarly criterion of optimism seems to have no

The problems that surround the recent philosophico-scientific tendency towards adopting what Thom calls 'noise' as a fundamental concept in scientific enquiry can be traced back to a paradox at the foundation of classical mechanics itself. This paradox is one which precisely forms itself in the gap between scientific understanding and praxis. Although modern science, following classical mechanics, postulates determinism at the heart of its understanding of the world, it does so in order to intervene in the world, in order to predict future events, to prevent potential catastrophes. Determinism, then, has to give way to a very paradoxical compatibilism⁴, in which it is the condition for acts of 'free will', for the emancipation of humanity from its slavery to the natural world. It is only through the spectrum of determinism that humans can see nature's tyrannical imposition of laws on the human trait of free will and, in understanding what has become apparent, break free from them. It is only by discovering laws governing causal chains that man can postulate her own freedom from this causality and thus set up an image of mankind as being somehow capable of transcending these laws – a transcendence which in its turn justifies the attempted position of mastery over every other subject of these laws.

How are we, then, to understand the paradox that occurs between the understanding of determination and the act according to free will? This question of man's power is inextricably linked with the question of the ethics of scientific practice. It is, of course, clear that any approach to the question in theoretical terms is one that immediately contains within it, and effects, certain implications in terms of praxis. Whether one holds that the universe is a being which is rationally structured, or that it is a chaotic perpetual flux (the second of which is entirely inconceivable by Thom, who repeatedly claims that 'it is indisputable that our universe is not chaos' (Thom 1999, 1)) determines, to a certain extent, how one goes about acting in the world. One's ontology cannot but determine, in one way or another, one's ethics.

Stoicism and Play

Thom cites as an example the ancient stoic Epictetus, a philosopher who seems to bring the ethical implications of determinism to their most radical conclusion. For the Epictetus whom Thom construes, rational behavior is equivalent to acting on those things which fall under one's control (*ta eph emein*, i.e. that which one can determine) and refraining from acting on those things which fail to fall under one's control (*ta ouk eph emein*). In other words, according to Thom, an Epictetian stoic should act only in those conditions where one can predetermine the outcome of one's actions, thus precluding any rational action with an unpredictable outcome. Thom rejects this construal of stoicism as a 'moralist's fatalism' (Thom 1979, 12), as he puts it, as too simple. Even in a completely deterministic system, like that postulated by the stoics, it is improbable that one may continuously predict the effect of one's intervention in the world.

Of course, as John Sellars points out in his study of Epictetus' account of *phantasia kataleptike* (Sellars 2006, 1), the matter of *ta eph emein* is rather more complex than a matter of refraining from unpredictable actions. Rather, the Epictetian's task is to refrain from choosing to assent to value-judgments attached (whether consciously or unconsciously, although the latter is primarily at stake in most cases) to certain impressions. Thus, if emphasis is put on the input (and processing thereof) which determines understanding rather than the determination of action through an imposition of abrupt barriers by the understanding, one may reach an entirely different stoic model of the relation between understanding and praxis, one which, as we shall see later on, is not as opposed to Thom's conception of play as his construal of stoicism seems to be.

a priori reason for its inapplicability to, for example, Aristotelian 'flat-earth' theories. His own reintroduction of the Aristotelian conception of quality into mathematical theories seems to be as optimistic about modern science as Serres' reappraisal of the 'clinamen'.

⁴ By compatibilism here I mean the philosophical position which holds that the existence of free will is compatible with determinism.

The alternative Thom offers to the construed stoic prohibition of unpredictable action entails a preliminary understanding of action in terms of catastrophe theory. He proposes a cybernetic understanding of action in terms of a black box with an input and an output. The black box's input can be modified in various ways, which in effect will produce an output which is not related in any immediately straight-forward way to the input. The black box here contains what in Thom's topological jargon is termed a catastrophe. To put it simply, a catastrophe is, within an input-output system, the point at which a minute variation of the input will produce a large fluctuation of the output. According to Thom, the black box is to be understood as containing that invisible point which introduces discontinuity between the input and the output. Thom's revolution consists in the introduction of the study of discontinuity to mathematics.

This immediately seems to offer us a model for understanding the paradox of the relation between scientific understanding and praxis, between determinism and free will. Although Thom fails to mention this directly, man's imposition of her 'free will' onto nature through the discovery of deterministic laws seems to be precisely a case of the occurrence of a catastrophe. Similarly, the opposite, i.e. the production of determinism from man's attempt to impose her free will onto nature seems to be precisely another case in which a practical input undergoes a catastrophic transition towards its theoretical output. More generally, the transition from scientific understanding to praxis and vice versa seems to be clearly intelligible when understood as catastrophic, as a morphogenesis.

Of course Thom's black box does not dictate a specific method of approach to the catastrophe it contains. What it necessitates for its exposition is a stance toward it that can be described as what in Thom's words we might call play. Play entails the fact that 'there is always something to be done' (Thom 1979, 12). In other words, it denies fatalism based on the optimistic premise that the universe is intelligible⁵ (or at least it becomes so once one assumes this optimism). It involves a certain element of risk taking as well as risk evaluation and management. It requires an entry into "'no man's land", the boundary of human action, ... the domain of the player' (Thom 1979, 12).

The idea here is that abstention from playing with the unpredictable black box will disable one from formulating any intelligible description of its mechanisms. In order to understand the content of the box, one will have to take a certain amount of risk – without the risk, without the possibility of catastrophe, there can paradoxically be no way of mastering the catastrophe.

Analysis and hermeneutics

Thom pinpoints two strategic models through which the player can approach the black box. The one, which he calls the 'analytic-reductionist' (Thom 1979, 13) method, consists in breaking down the boxes into identifiably stable parts, which are then studied as separate parts and as interacting with the other parts. The other, which he calls the 'hermeneutic' (Thom 1979, 13) method, relies on a qualitative study of either tendencies or (in case that fails) of a psychic force or "spirit" controlling the system. These two models of approach to the exposition of black boxes seem to correlate directly to Thom's models of social structure, the military and the fluid. In military societies, 'each individual occupies a specified position and regulates his own movement so that the global form of the society is preserved, as well as his position within the society' (Thom 1999, 318), whereas in fluid societies 'stability is assured in catastrophe by a barrier causing discontinuity in behaviour' (Thom 1999, 319). Thus the 'analytic-reductionist' player seeks to break-down and stratify a system in order to preserve the whole

⁵ In attempting to explain the kind of intelligence which the ethics of play requires, Thom opposes the philosophical conception of *logos*, central to the Stoic understanding of the universe, to that of *metis*, cunning, derived from ancient Greek myth. Perhaps another word from Homer might be more suitable in conveying Thom's sense: when describing Odysseus, Homer uses the word *polymechanos* as synonymous to *polymetis*. The kind of intelligence implied by this word, associated with the multifarious machinations of non-linear approaches to a problem, seems to resonate closely with Thom's account. The association of the word with the multiplicity of machines (input, black box and output) as methods of problem solving seems, as we shall see later, to relate directly to Thom's use of local models.

of the system as a pattern of interactions between stable elements identical to themselves, while the 'hermeneutical' player attempts to think the discontinuity in the behavior of a system qualitatively, in terms of controlling tendencies.

The first kind of approach to play, focusing on quantitative properties, seems to come with a certain implication of the limitations of its applicability. If one were to imagine the field of scientific understanding as consisting of knowledge of discrete, stable and thus identifiable disciplines, then that would imply that there should be no one-to-one correspondence between, for example, a mathematical theory and an understanding of types of society. Rather, the interaction between the two should come through a hierarchy, in which, for example, a mathematical understanding would come to explain a social structure. The paradox here is that one has already to create the break-down, to assume an understanding of discrete entities, in order to then claim that there can be no one-to-one correspondence between the entities. In other words, one must conceal or become oblivious to the creation of a break-down in order to claim that the entities are broken down – but the creation of the break-down itself implies that the set from which the entities were made discrete was not itself discontinuous with regard to those entities.

The second kind of approach to play is traced back by Thom to the pre-Socratics, and particularly to Heraclitus and Anaximander. For Thom, the rejection of the pre-Socratics based on their anthropomorphism relies on a misunderstanding of what that anthropomorphism implies. The claim Thom makes is that the pre-Socratics understood that 'the dynamical situations governing the evolution of natural phenomena are basically the same as those governing the evolution of man and societies' (Thom 1999, 323). In other words, there are certain qualitatively describable controlling tendencies which can explain discontinuity in the behavior of a system.

One can construe these tendencies anthropomorphically, as the 'spirit' of a black box playing a game with the observing player. Spariosu interprets the sameness of the dynamical situations governing nature and society as Thom's proposal to undermine scientific objectivity by proclaiming 'the unity of interpreter and object interpreted, or more broadly, the unity of culture and nature' (Spariosu 1989, 234). But looking into Thom's use of game theory in his account of the relation between the observer and the 'spirit' reveals a much more complex and dynamic structure of play than a simple unification of the players through it. Of course, Spariosu is right in pinpointing here that one of the fundamental problems for Thom revolves around the relation between nature and culture and his anthropomorphizing of mathematical entities – after all, we have gone a long way in demonstrating the ways in which catastrophe can relate scientific understanding (i.e. culture) to praxis (i.e. nature). What Thom saw in the pre-Socratics, then, can be understood in terms of a dynamic relation (a black box) with, for example, culture as its input and nature as its output, or vice versa. (This understanding of Heraclitus, might provide a profound insight into his account of the catastrophic way in which *logos* becomes a gathering of *physis*.)

Playing and preying

In order to understand the issue at hand, namely the exposition of the different possible applications of play in Thom's approaches to scientific observation, one has to go back to his evolutionary formulation of the concept of play in his book *Structural Stability and Morphogenesis*. Here we clearly see the ways in which two possible approaches to play are formed: (a) the play of animals, and particularly the predatory practice of feeding and (b) the play of humans, or combinatorial rule-following games.

Thom gives an account of the 'predatory loop' in terms of a morphogenesis between predator and prey, which are modelled in terms of conflicting attractors. The process revolves around two states of the system, on loop, which are transformed from one to the other through a kind of catastrophe Thom calls the perception catastrophe.

There is a catastrophe at *J*, the *perception* catastrophe. If the predator is its prey before *J*, this means that the mind of the predator is dominated, alienated by the image of its prey. In some sense, the nervous system is an organ that allows an animal to be something other than itself, an *organ of alienation*. As soon as the external prey *p* is perceived and recognised by the predator, it becomes itself again, and it jumps from the surface corresponding to the prey to its own surface in an instantaneous *cogito*. At this moment, the chreod of capturing the prey is triggered, this chreod having several modalities according to the behavior of the prey (fight, flight, etc);... (Thom 1999, 299)

This implies that there is a certain disruptive pattern of self-identification in animals which is determined by the predatory loop. Thom elaborates on this by exposing the relation between animal territoriality and impermanent ego formation. His claim is that a territory, for animals, consists of 'an aggregate of local charts, each associated with a well-defined motor or psychological activity (areas for hunting, congregating, sleeping, etc.)' (Thom 1999, 303), associated with specific sensory marks (colours, smells, etc). This fragmentation of space coincides with the partiality of the animal ego, which does not consist of some permanent identity but rather refers to a multiplicity of ways in which the animal copes with the particular tasks of specific territories.

Play comes in at this point precisely as the element of control over this partiality of the animal ego, as a remedy to this fragmentation. In this function, it is coupled by dreaming, which allows for the continuation of consciousness during sleep⁶; sleep being, in turn, temporally regulated by the predatory loop (the animal sleeps during those times of the circadian circle by which it would have normally fed its hunger). Play, contrary to dreams which act as a form of deception, functions, for Thom, as a way in which the predator learns to differentiate itself from its prey. By playing with a make-believe⁷ prey, the predator can differentiate between itself and the prey, as well as differentiate between types of objects (e.g. edible and inedible prey). In effect, play achieves a kind of catharsis through mimesis. The perception catastrophe is reproduced outside the predatory loop; the catharsis takes place without ingestion. Mimesis in play allows for the prey to appear as an object separable from its predator.⁸

⁶ Thom characterises sleep as 'one of the most evident manifestations of this impermanence of ego, still clearly apparent in man' (Thom 1999, 304).

⁷ The concept of make-believe I am using here is derived from Walton's elaboration on the way in which fiction is founded on make-believe, especially through the use of the example of make-believe in children's play, found in (Walton 1978).

⁸ A summary comment on a certain limitation in this account is necessary here. Despite the description of play in terms of predatory antagonism given by Thom, not all play is reducible to conflict. Not all predatory acts are antagonistic. There are specific symbiotic situations, which take place on the basis of predatory activity, but are irreducible to pure antagonism. In their book *A Thousand Plateaus*, Deleuze and Guattari develop the notoriously obscure concept of 'becoming-animal', which we will examine here in its relation to predatory play. Although it is beyond the scope of this paper to clarify the opaque musings of Deleuze and Guattari, there seems to be a *prima-facie* relation between their account of becoming, structured around the model of symbiosis, and Thom's account of play, structured around the model of polemics. The predatory model of play becomes, in Deleuze and Guattari, 'deterritorialized' from its polemic territory. Notice here the resonance with Thom's model of play: play functions, in a way, as what Deleuze and Guattari call deterritorialization, i.e. as the abstraction of a task, of a partial ego, or (as we shall see later) a local model from its original 'territory'. This deterritorialized play becomes, in turn, reterritorialised to the model of symbiosis, under which the predatory act consists of partial ingestion, of a conjunction between strife with the 'prey' and parasitic dependence on it. Play here does not take place in absolute terms – the perception catastrophe is both perpetuated and perpetually deferred. What matters, rather, are degrees of contagion, rather than absolute edibility – everything is edible in degree. 'Bands, human or animal, proliferate by contagion, epidemics, battlefields and catastrophes' (Deleuze & Guattari 1987, 266). But of course the battlefield here takes place between two attractors which are contaminating each other, rather than as a morphogenetic process from one to the other. 'Becoming can and should be qualified as becoming-animal even in the absence of a term that would be the animal become' (Deleuze & Guattari 1987, 262). In other words, in the same way that predatory play relies on the imagination of an inedible prey for the imaginary construction of an impartial ego, symbiotic play (or becoming) goes beyond imagination in its indifference to the extent of the reality of the parasite's prey. What matters, rather, is the

Thom links this up to a certain attitude of wakefulness, occurring in man as well as other animals, which he identifies as predatory. He remarks that, etymologically, "...*percipere* is "to seize the object continually in its entirety"" (Thom 1999, 305).

This primal, animal form of playfulness, especially its relation to the continuous seizing of the entirety of an object, seems to relate to what Thom has termed the 'hermeneutic' approach to play. To play with the make-believe 'spirit' in a black box seems to be very much in parallel with the formation of the predator's ego through its disassociation from the prey – the 'spirit' is what remains of this erased mode of identification, a kind of mimetic remnant of the process of enculturation. To play with one's fictitious prey through a rule that dictates playing *as if* it was real, one must always combine it with a meta-rule of knowing that this is just a game (the spirit must remain in the binding magic circle formed by the quotation marks). The make-believe 'spirit' brings about a kind of interpretation which the 'analytical-reductive' method prohibits. In fact, as Thom claims, the latter method, by breaking down the black box into 'simple' black boxes, effectively destroys the possibility of imagining such an interpretation, which would rely on the complexity of the box before it was broken. Far from being mere make-believe, though, the result of playing with this imagined prey can be expressed in rigorous mathematics. The claim is not that there is, in fact, a spirit in the black box, but that the methodological assumption of the ghost in the machine yields an explanation for results which are more transparent and permeable through it, rather than broken down into simpler parts which might be more opaque and impermeable.

Having given a general account of animal play, Thom proceeds to give an account of human play in particular. What Thom calls 'human play' is 'an eminently combinatorial activity' (Thom 1999, 317) which results from the following of rules. These rules can determine to a small or large extent the outcome of the game, depending on the possible ways of evaluating them. Human play fundamentally differs from animal play in the fact that its rules remain explicit throughout the game, as well as conscious in the mind of the player⁹. Nevertheless, this play does not prohibit creativity – it only engenders the boundaries within which spontaneity and creativity can emerge. This play can thus stand behind both the 'hermeneutical' and the 'analytic-reductive' accounts of play. Although, Spariosu, through the scope of his book, calls this 'rational' play, in opposition to the 'irrational' animal play, it could perhaps be seen as one possible expression of natural play – one of its many possible extensions.

Local models and play beyond territories

In his 'Playstations. Or, playing in earnest', Steven Connor traces the history of the phenomenon of the serious study of play. This phenomenon, as Connor shows, is exclusively a modern one. He points out that 'play has always

indispensability of the 'prey' to the becoming. Ego-formation is a parasitic side-effect of the symbiosis which, in being a relation of interdependence, resists it.

⁹ Of course, this raises the issue: what does it mean for a rule to be present in a player's consciousness? This issue is thoroughly questioned by Saul Kripke in his 'sceptical problem' regarding the mathematical rule of addition presented in *Wittgenstein On Rules and Private Language*. Briefly put, the sceptical problem lies in the fact that it is impossible to determine whether the rule we use in addition is what we have always assumed is 'plus', or the special rule 'quus', made up by Kripke. 'Quus' is the rule which states that in all cases of addition, our regular rule of addition holds only where the sum is less than a number x and after x all addition results in 5. The number x could be larger than any sum ever calculated in the history of addition, or larger than any sum to be calculated in the future. This in turn implies that there is no way of knowing whether the rule followed, for example in adding, is the rule one is conscious of following, or, for example, a much more complex one that is nevertheless being followed.

The 'sceptical solution' offered by 'Kripkenstein' (a term denoting Kripke's reading of Wittgenstein) offers an alternate account of rule-following as belonging to a community which approves of kinds of behaviours as indicating that one is following such and such a rule. This might prove to illuminate an account of 'human play' and the kind of rationality involved in such an activity. A Kripkensteinian human play and its corresponding rationality should relate to Thom's account of 'military' and 'fluid' societies in terms of topological distribution. The instance of the rule followed in human play is not traceable back to an individual act participating in a global 'law'.

functioned as excess, exception or anomaly' (Connor 2005, 10), This can further be construed either as an excess which defines man as 'the kind of creature whose essence it is to play' (Connor 2005, 9) or, as for example with Lorenz, a defining characteristic of all existence, of existence as exceptionally playful. Connor goes on to question this, calling for a study of play as a norm. This dimension of play seems to correspond to a world apparently structured around and 'governed by the production of play and the consumption of leisure and pleasure' (Connor 2005, 10).

The question which Connor leads us to here is whether we can read into Thom's account of play something beyond the exceptional, excessive status accounted to play by its modern construal. When Lyotard famously groups Thom together with Mandelbrot under the ironic heading of 'post-modern science', he focuses on Thom's account of local models or 'describable islands' (Thom 1983, 12). The locality of these models implies that we cannot *a priori* hope to integrate them into global systems. Lyotard claims that 'Catastrophic antagonism is literally the rule: there are rules for the general agonistics of series, determined by the number of variables in play' (Lyotard 1984, 59).

Of course we see here how Lyotard appears to twist Thom's account into fitting his own 'grand narrative' of postmodernism. For Thom there are local models (black boxes) which are simple enough to be deterministic, and local models which can be broken down into deterministic components. Of course there are local models containing catastrophes. These, in many cases, constrict us to a qualitative account, but, 'in the best cases' (Thom 1999, 7) account quantitatively for the model's behaviour.

These 'islands' or local models seem to correspond to Thom's account of territories – of fragments of space which are identified with specific forms of behaviour (or with partial animal egos). As outlined before, play relates to these territories as a mode of reparation of their partiality. This is perhaps the locus of Thom's 'post-modernity' – his account of play is not one which can be precisely qualified in terms of exception. It does retain the element of exception and excess, in that it seems to be formed as a parasite to this partiality, as an exceptional product of the norm of territorial locality. Play, in contrast to dreaming as a mode of producing impartiality, although necessarily takes place at a specific territory (the area of play, the territory of the relation between the predator and its make-believe prey, etc), cannot be reduced to it since it effects the whole of territorial existence. It in fact effects existence in the Heideggerian sense of ex-stasis, standing back, of being able to differentiate an impartial ego from partial coping with particular activities. It is in this sense that play begins in Thom to find an early serious study as norm, without completely evading its state as exception.

Lyotard is right in pointing out the centrality of agonism in Thom's work. This preoccupation with conflict seems to determine the way in which Thom describes play and thus limits his account to cases in which the players are antagonistic. It is important here to stress how play is, even in its function in describing the workings of territoriality, itself only partial, only a local model. The globalization of a local model could come with catastrophic effects. Take, as an example close to the antagonistic theme in Thom, the case of the assumption of self-interestedness in modern day economic theory. By assuming individual, self-interested players, game theory has constructed models of behavior that account only for partial aspects of the players (i.e. those situations in which they are in fact agonistic).¹⁰ After these models were applied, though, to a wide range of local cases, they seem to have effected a globalization of their assumptions, an impartial establishment of the partiality under study. This, in turn, may give rise to a more global situation of a conversion of altruistic players to self-interested individualists. In other words, acting on a specific, local understanding is catastrophic – its effects on the global scale can in many cases remain unpredicted.

¹⁰ Of course, this situation may be seen as arising out of what Thom had proposed as a 'stoic' attitude, one opposed to play. For example, in prisoner's dilemma, what is at stake becomes too crucial for a 'rational' player to experiment or play with – the self-interested approach is a case of having more certainty in the face of uncertainty, 'pragmatism' rather than optimism.

Taking into account these limitations, play may have a positive role to play in our understanding and practice of science. Whereas, for example, education has hitherto revolved around the presentation of knowledge as certainty, the development of an attitude of play in educational practice might be beneficial in a world where scientific advances continually render older certainties redundant.

Additionally, an understanding of the ethical issues involved in the complex practical effects of knowledge is becoming increasingly necessary. From the nuclear catastrophes brought about by discoveries in physics (and, more generally, the military-technological advances produced by advances in knowledge) to the effects of evolutionary biology on religious policy, academia has constantly failed to link up its understanding to the effects it might produce. A playful attitude is paradoxically in this case an attitude of responsibility. It cannot preclude the imperative of there being always something more to be understood. At the same time the development of risk management strategies follows as a necessary consequence of the process of play. In a time where the Epictetian *eph emein* of the production of knowledge is necessarily out of reach, there is perhaps no other conceivable choice than for the scientist to play.

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