Why Children and Young Animals Play

A New Theory of Play and Its Role in Problem Solving

By ARNE FRIEMUTH PETERSEN

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To and from my Children

Abstract

Behavioural science has shown that only homeothermic animals play, and neurophysiology has located the principal driver of animal play to the limbic system. In this monograph a thesis on play's function as feed-forward and error selection is proposed, and the role of play *qua* improvisation in problem solving and learning is explored. It is argued that animal and human play was "invented" to enable young individuals rehearsing species-typical behavioural solutions to problems, often before they are in need of solving them, as well as helping the players to hit upon new solutions to problems while "playing away" old ones which no longer work. To understand this dual function of play, and its many effects, an action-selection principle of learning is outlined according to which repetitious forms of play belong to the selection part of the learning process – thereby rendering an explanation of play which cannot be glimpsed from the avenues of traditional learning theory.

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Contents

In describing the life of different animal species students of behaviour have, time and again, pointed out that those animals whose infancy lasts the longest play the most – or, as it was already put by Karl Groos in 1896, "... animals do not play because they are young, but they have their youth because they must play".[1] Comparative psychologists now hold that a capacity for imaginative problem solving, as well as inventiveness, can only evolve in animal species whose young remain *immature* for a sufficiently long period of their life – immature in the sense that, without the care of their parents, they would be unable to survive and live normally. As we shall see, immaturity, however important, is not enough for these faculties to evolve.

A prolonged infancy appears favourable not only for the survival of the species but also for the ontogeny of individual members of a species. This may be so because play has a *liberating effect* on the player regarding the

I wish to thank Professor Mario von Cranach (Bern) for a thorough and fruitful discussion, in 1980, of the topic presented here and for encouragement to put down my ideas on play behaviour in writing. I am specially indebted to Sir Karl Popper (Kenley),whose thoughts do not only pervade anything written here, but who also spent hours with me explaining his "philosophy of organisms". For helpful and stimulating discussions of play and related issues over the years, I also wish to record my thanks to Drs. Niels Bolwig (Cheltenham), Alexander Brownlee (Midlothian), Konrad Lorenz (Altenberg), Anne Rasa (Johannesburg), Iven Reventlow (Copenhagen), John Richer (Oxford), Wulf Schiefenhövel (Seewiesen), Fini Schulsinger (Copenhagen), Esther Thelen (Missouri), Niko Tinbergen (Oxford), and Ralph Vollstedt (Copenhagen). Special thanks go to Mr. Guilhem de Roquefeuil (Montpellier) for a careful scrutiny of the first sections of this monograph and to Professor Marc Blancheteau (Montpellier) for constructive criticism of the ideas on stereotypic behaviour put forward in the last sections. I am most grateful to Miss Barbara Boyle (Paris) and Mrs. Jo Baïssus (Castelnau-Le-Lez) for their expedient and competent help with the translation. Thanks are also due to Dr. Clemence Heller, Maison des Sciences de l'Homme (Paris) who, at the instance of Dr. Pierre Garrigues (Montpellier), awarded me a travel grant in 1981-82, and to "Inge Lehmann's Legat af 1983" (Copenhagen), the grant of which I held while completing this work.

1 K. Groos, *The Play of Animals,* D. Appleton, New York. Quoted here from J. S. Bruner *et al, Play – Its Role in Development and Evolution,* Penguin, New York 1976, p. 67. (Hereafter quoted as *Play.*) The first paragraph of the present monograph also alludes to the opening chapter of the volume edited by Bruner and colleagues.

various possibilities of behaviour and action in given situations (which, under favourable conditions, may even lead to new behavioural trends, ritualisations, or traditions within the species). However, behavioural stagnation or regression may also occur and the cases of children who, when small, have not had much opportunity to play for one reason or another and who, later in life, are seen to have various behaviour problems such as stereotypes, phobias, learning disabilities etc., may be examples of this. There are, at present, sufficient indications to assume that the study of play in animals and man will contribute to a better and more profound understanding of both the evolutionary history of animal species and ontogenetic development of individual living beings.

What characterizes play behaviour in young animals and children is a typical *alternation between repetition and improvisation.* By thus implying improvisation play may enable the individual to solve problems which have not been solved before, although they may be old and well-known problems to the species; thereby the individual may come to discover or recognize something which no-one has discovered or recognized before. In this sense play can be said to be potentially *creative,* and this is probably one of the evolutionary significances of play which contributes to its obvious survival value.

1. A New Thesis of Play: Feed-Forward and Error Selection

The main thesis of this monograph is that play – much like exploration – helps the individual to solve vital problems by *developing behavioural regularities vis-à-vis* his physical and social environment: Play allows the young individual to make his first attempts at problem solving in relatively detached situations, where the elimination of errors can happen in a less dangerous and more efficient way than in serious situations later in life.

I thus conjecture that the central function of play is twofold: (1) *to unlock the behavioural repertoire of the individual,*[2] often before there is a real need to perform the different modes of behaviour; such repertoires will, for the greater part in animals, be executed in a manner peculiar to the species and it is these behavioural traits which the young individual rehearses in play with increasing precision and skill. (This *release function* of play seems to be particularly developed in higher animal species whose behaviour is not primarily monitored by "sign stimuli" – which in lower species is known to release species-typical behaviour patterns automatically.[3]) – (2) *to perfect solutions to problems* – for example motor problems and problems of movement – *through a selective error-elimination process*, which only lets those parts of a given solution "survive" that turn out to be "to the point" with respect to the way in which the individual attempts to solve the problem in hand. (The accompanying *effect of play* seems to be to fascilitate a *progressive simplification* of the activities involved in problem-solving processes – which, in effect, implies simplifications of the innervation patterns of the nervous system.[4])

The survival value of this kind of automatization, economization, or progressive simplification – which also occur over time in the individual's behavioural repertoire, thus becoming particularly conspicuous during the development of skilled movement – may, in the course of evolution, have led to that peculiarly organized state called "playfulness", during which nearly any form of activity may be tried out and practised in a more efficient and speedy way than any serious situation would permit. It seems logical that nature had to equip higher animal species with some such mechanism that could allow the young to simulate adult behaviour, and thus to boost the performance of species-typical behaviours and the acquisitions of skills, and it seems plausible that play is such a "device". The frequent repetitions of movements that occur during play may therefore be conjectured to have the function of adapting the required muscular innervation patterns fitted to a given problem situation by eliminating inappropriate and non-economic patterns of movement – in such a way that, in tempo with the "automatization" of the muscular innervations, brain capacity may be liberated for new, more demanding, performances.

It is tempting to compare the simulation- or anticipation-aspect of play

2 Activities which will later relate to the satisfaction of specific needs can take a rudimentary form the first time they are performed during play where, for developmental reasons, young individuals cannot be dominated by the corresponding needs. The "unlocking" effect of play proposed here suggests that during the ludic state certain types of behaviour peculiar to the species – as with certain other activities of a more individual nature – can be "triggered" and thereby *tried out*.

3 Although in higher animals the "unlocking" of activities during play can resemble the triggering effect of sign stimuli, the processes implied appear entirely different.

4 This idea of behavioural selectionism is an application of a conjecture first put forward by K. R. Popper in *Die beiden Grundprobleme der Erkenntnistheorie* (1930-33), J. C. B. Mohr (K. Siebeck), Tübingen 1979, pp. 24f. (Hereafter abbreviated to *D.b.G.*) For possible precursors to that idea, see note 64, below.

with the functioning of von Holst's "*feed-forward*" mechanism.[5] Since play may facilitate activities that originate with both preprogrammed behaviour patterns and with gradually-acquired patterns of action, it favours the individual's immediate orientations within his environment and helps him to adapt his different activities to it. In pursuing this idea, we may even consider play to be a typical phenomenon of feed-forward with respect to individual ontogenetic development: *By playing, the organism may anticipate and simulate behavioural situations later in life and thus make itself ready for appropriate action thanks to preceeding series of quasi-repeated – and thereby progressively automatized – reactions to such situations.*

One of the reasons why the phenomenon of play has not, until now,[6] been analysed within such a framework, is no doubt that demarcation and definition of the phenomenon itself require a "philosophy of organisms" different from the prevailing one – which students of biology and behaviour currently hold often without realizing to the full its implications for soft-ware phenomena such as play, perception, learning, etc.

E. O. Wilson gives an excellent, though unwittingly reflexive, description of the bankruptcy of the behaviourist point of view when commenting on the question, *What is play?:* "No behavioral concept has proved more ill-defined, elusive, controversial, and even unfashionable",[7] as he seems himself too marked by this very research tradition to be able to put the play phenomenon into genuine biological perspective. However, for some time now, a new and more profound view on the behaviour of organisms has been dawning in various fields of biology and the life sciences, particularly in those where a radical reductionism (such as the one alluded to in note 7, above) has not been the endorsed aim of research. As this new view of living beings has emerged only recently its contours are just now becoming visible – as for instance in a seminar report entitled *Studies in the Philosophy of Biology–Reduction and Related Problems*, 1974.[8]

For this reason my first task here will be to draw up the main lines of an explanatory system for behavioural phenomena like play, based on this new philosophy of organisms. I shall thus be following the advice of Bekoff, who believes that it is advantageous, at the present time, to tackle the problems of play in a "naive way"[9] – which, according to him, is synonymous with a mere speculative and theoretical approach. The aim of the following account will therefore be to *reorganize* a number of aspects pertaining to play, and to *analyse* them in relation to a general theory of action based on a deductive interpretation of problem solving by "trial and error-elimination". The intention is to arrive at the formulation of hypotheses on the functions of play valid for the ontogony of higher animals and Man – hypotheses, which may be testable at least by means of situational analysis.

2. Life Considered as Problem Solving

Now, what is the biological basis of the above thesis of play or, what is the relationship between this thesis of play and the announced "new philosophy of organisms"? – In order to answer this type of question, it will be necessary to try to dig a bit deeper to root our inquiry more firmly.

In his discussion of Schrödinger's famous book, *What is Life?*, which is centered around the differences between organic and inorganic matter, Sir Karl Popper suggests that the origin of *life* coincided with the first appearance of *problems*.[10] In other words: life has got problems to solve,

5 The basic ideas of *feed-forward* and *feed-back* descend from the work of Erich von Holst on relative coordination. See his major exposé "Das Reafferenzprincip" in *Gesammelte Abhandlungen,* R. Piper & Co. Verlag, Munich 1969, Bd. I, pp. 135-66. (Hereafter cited *G. A.*) The notions used here are adapted from Karl H. Pribram, *Languages of the Brain,* Prentice-Hall, Englewood Cliffs, New Jersey 1971, pp. 88-96. (Hereafter abbreviated *L. O. B.*)

6 Interestingly enough a number of special educators have arrived at principles particularly well suited for teaching children such difficult skills as violin playing (*e.g.* "the Suzuki-method") and skiing (*e.g.* "the Beitostilen snow playground" used in Norway and Sweden) – principles much like the ones derived here in an analytical manner. To my knowledge existing learning psychology has not offered any explanation as to why educational methods using play situations can show such good results. The present monograph tries to do that.

7 E. O. Wilson, *Sociobiology – The New Synthesis,* The Belknap Press of Harvard University Press, Cambridge, Mass., 1975, p. 164. Following this brisk contestation, which any behaviourist is liable to applaud, Wilson gives a then up-to-date, though brief, summary of the research on play.

8 F. J. Ayala et al. *Studies in the Philosophy of Biology: Reduction and Related Problems,* Macmillan, London 1974. See especially the articles of Francisco Ayala, Donald T. Campbell, Theodosius Dobzhansky, Peter Medawar, Jacques Monod, Karl Popper, and William Thorpe.

9 M. Bekoff, "Animal Play: Problems and Perspectives", in P. P. G. Bateson *et al, Perspectives in Ethology,* Plenum, New York 1976, vol. 2, p. 167: "... a naive approach appears to be a good way both to review a field replete with qualitative studies and to suggest ideas for further research."

10 K. R. Popper, *Unended Quest,* Fontana/Collins, Glasgow 1976, pp. 135-38. (Hereafter cited as *U. Q.*)

while this cannot be said to be the case of inanimate matter. The idea that living beings will be constantly involved in problem solving seems compatible with their established capacity for adaptation: this implies that living beings are no more capable of living in a vacuum than in a chaos, and that they are linked up by their entire organism to a world characterized by processes that occur with "suitable speed" and where the objects around are relatively stable over time. Moreover, as Popper realized, all solutions to problems have to follow, for reasons of logic, the principle of "*trial and error-elimination*" and that life is an unending series of problems, since for each problem solved there will arise other problems[11] which normally, however, will be of less biological and psychological urgency than the problem which the organism has just solved.

If we consider living beings, and in particular higher animals, more *active* and *creative* than passive and reactive in their relationship with the environment,[12] then activities such as play and exploration take on a vital importance with regard to individual problem solving. In the course of ontogenetic development each individual solves innumerable problems, for the most part automatically and often without conscious cognitive control. Individual development – and even the formation of personality, which is particularly functional in higher animals and Man – may be considered, along with Karl Duncker,[13] as a sort of final feed-back product of a myriad of singular attempts at solving problems.

How, then, does problem solving take place, and how does play come into this domain? To answer these questions I shall propose a distinction between two principal strategies which allow organisms to solve problems:

(A) *Indirect problem solving* (species adaptation) goes on within the gene-pool from generation to generation through transfers of information subjected to *natural selection*. This kind of problem solving consists of mutations and recombinations of genetic material forming new properties ("*genetic trials*") in a given population, after which natural selection weeds out the carriers of the unfavourable characteristics while favouring individuals endowed with more advantageous ones. Thus, it is supposed that animal species gradually adapt to their environment and to living conditions thereby "inventing" solutions to problems facing them. Or, as it is expressed in the current terminology, *adaptation of animal species* results from *variation* and *selection*. Such "collective" solutions are, of course, very slow and take place over vast periods of time. This does not mean, however, that the behaviour of individuals – the phenotypes – does not play a role as traditional biology would have it. In fact, behaviour genetics and ethology have shown that the species-typical behaviour in a number of species – for instance the activities involved in the so-called behavioural "*isolation mechanisms*" – has a decisive influence on which genes of the gene pool become accentuated or selected in future generations.[14] It is in this way we may understand how species-typical behaviour and systems of preferences can come to function as *the spearhead of evolution.*[15]

(B) *Direct problem solving* (individual adaptation) takes place at the level of the individual organism which, during its life, develops behaviours and skills suitable for solving the immediate problems at hand. This kind of problem solving, which proceeds by variations in the method of trial and error-elimination already mentioned, commences as soon as the animal starts life. Thus in the different *life projects*[16] of animal species we find various combinations of solutions to problems, which allow even "marginal individuals" of a species (*i.e.* those individuals which have problems other than species-typical ones) to adapt to environments where they – like their more "normal" species-members – may function with a minimum of metobolism and energy expenditure. This is seen, for example, in those individuals of migratory species which happen to be capable of adapting to "non-traditional" biotops, as well as those individuals of a species which "choose" to eat new kinds of food[17] or live in unusual kinds

11 K. R. Popper, *Objective Knowledge – An Evolutionary Approach,* Oxford University Press, 1972, p. 243. (Hereafter abbreviated to *O. K.*)

12 K. H. Pribram, *L.O.B.*, pp. 95-96.

13 K. Duncker, "On Problem-Solving", *Psychological Monographs,* vol. 58, 1945, p. 13: "Life is of course, among other things, a sum total of solution-processes which refer to innumerable problems, great and small. It goes without saying that of these only a small fraction emerge into consciousness. Character, so far as it is shaped by living, is of the type of a resultant solution."

14 E. Mayr, *Animal Species and Evolution,* Harvard University Press, Mass. 1963, pp. 89f.

15 K. R. Popper, *U.Q.*, note 287.

16 J. Monod, *Le hasard et la nécessité,* Seuil, Paris 1970, p. 22. The "project" of a species comprizes a certain number of indispensable activities – "performances" in Monod's terminology – preprogrammed to solve vital problems, which arise as a consequence of the lifestyle of the species, its ecology, and so on.

17 Such a case has been described particularly clearly in certain sub-populations of great tits in England which, some forty years ago, had found out how to open delivered milk bottles in order to eat the cream on the top. (See J. Fischer *et al,* "The Opening of Milk of shelter – or, again, in the individual achievements of Homo sapiens, although the problem solving employed here seems more varied and planned than in other species over longer periods of time during work, play, leisure or artistic activity. (As is the case with most genetic mutations, many cases of individual problem solving among free-living animals turn out to be lethal to the individual which undertakes the innovation.) In short we may say that *individual adaptation* is a result of *action* and *selection*.

The moral of all this seems to be that living beings can only solve problems and learn from experience if they are *active* – firstly by having preferences and aims which may eventually give rise to expectations and conscious goals, and secondly by testing these expectations and goals and rejecting them if they do not correspond with a given part of reality.[18] This is a rough outline of problem solving considered as a case of "*applied situational logic*".[19] Apart from being cases of the principle of trial-and-error-elimination, these two types of problem solving follow the same general principle: adaptational changes always take place within "given structures", *i.e.* structures transmitted by *instruction*. On the genetic level replication follows, as it is now known, a "*template-procedure*" – and is therefore, by the very nature of things, an instruction process. On the behavioural level the transmission takes place partly through (young) individuals adopting the behavioural norms and traditions of other (older) individuals, that is, by another type of instruction process. By contrast, new adaptational change on the genetic or behavioural level takes place by means of *selection*, which is always executed by the same type of procedure, namely that of selective pressure on more or less fortuitous variations (*in casu* genetic mutations and new preferences for activities), which eliminates the least favourable ones either instantaneously or gradually.

As we shall see in Section 5, below, activities such as exploration and play do indeed follow this principle of selection to a considerable extent. Thus, contrary to first impressions, in the life of animals and Man instruction is the *conservative* power, while selection is the *evolutionary* (or *revolutionary*) power.[20]

3. On Regulators of Endogenous Acitivity: Systems of Skills, Motivations, and Aims

So far as the above discussion goes living beings may be characterized by their permanent problem-solving activity. This activity differs to some extent from one species to another, and also between individuals of the same species. It always has, however, the same ultimate aim, namely the survival of individuals and of the species.

An organism's level of activity depends on its general state and is characterized by its largely *endogenous regulation*, more or less independent of external initiation according to the situation. This does not mean that *exogenous regulation* is unimportant, but what is emphasized here is the animal's organic and behavioural *readiness:* almost all activity begins with an anticipation on the part of the organism with regard to the state of affairs in which a given activity is to be carried out.

Endogenous regulation may be carried out by various regulatory agents on different levels of organisation within the hierarchy of the nervous system. To simplify, let us suppose that a large bulk of the activities which organisms perform are regulated in three principal ways – namely through:

(a) *systems of preprogrammed skills* (or through *skill-structures*);
(b) *systems of motivations* (or through *motivation-structures*);
(c) *systems of inherited and acquired aims* (or through *aim-structures*).

Ontogenetically, the most simple and fundamental skills, motivations and aims appear more or less ready, also in the early life of higher animals and Man, whereas the more complex ones arise later, partly as a result of inventive interaction with the environment. The idea of *endogenous regulation* is used here in the sense: "*controlled by the organism itself, or, a regulation resident in the organism, not induced from but modifiable by the environment*"; this is to detach the ideas proposed below from the various behaviourist schemes, which usually insist too much on *exogenous regulation* or "control from outside".

Bottles by Birds", *British Birds,* vol. 42, 1948, pp. 347-57.) As a school boy in Denmark I also shared my milk with the tits, but their new ecological niche disappeared when milk cartons were introduced.

18 K. R. Popper *et al, The Self and Its Brain,* Springer International, Berlin-Heidelberg-London-New York, 1977, p. 132. (Hereafter abbreviated to *S.I.B.*)

19 K. R. Popper, *U.Q.*, pp. 168f.

20 K. R. Popper, *S.I.B.*, p. 133.

(a) "*Systems of skills*" refers to a hypothetical control system responsible for the execution – and probably also the formation – of muscular innervations such as those involved in so-called "fixed action patterns"[21] (which are mainly seen in animals), in gestures and facial expressions (which are, indeed, also found in Man) as well as in certain body-synchronization movements executed during speech. We may characterize this kind of behaviour as *spontaneous* in so far as it is executed in the same qualitative way by all members of the species and with a minimum of conscious control and learning involved; it is thought that these relatively simple motor patterns are guided by a *preprogrammed skill-structure,* which is species-typical but may resemble skill-structures of related species. Colwyn Trevarthen has demonstrated that babies within the first months of life already have such motor patterns in their gestures, prehension and mimic, and he considers such patterns as "powerful innate preadaptative regulations" and as "prescribed responses to environmental information" – notably of a social nature.[22] In a similar fashion, Eibl-Eibesfeldt has analysed the repertoire of facial expressions in children born deaf and blind – whereby it may be said that he has also demonstrated *how far in mimic competence* a child may get with the *sole* aid of such a preprogrammed skill-system and with *no* adjustment or synchronisation to the facial expressions of others.[23]

(b) "*Systems of motivations*" refers to another hypothetical system of internal control which manifests itself in activities related to the gratification of fundamental needs. As is well-known, certain needs – particularly *biogenic* ones – can be satisfied only by a specific agent or by only one specific activity (which may then involve preprogrammed skill-structures), whereas other needs – notably *psychogenic* ones – may be satisfied in a variety of ways, which is due partly to the fact that such needs may fluctuate more widely from one individual to another.

A question now arises concerning the relationship between the specific individual activity and the factors motivating it: In brief, why does one individual become active in one way (or direction) while another becomes active in another way (or direction)? Similar questions surround the vital dynamics inherent in the process of *direct problem-solving*. Greatly simplified, one could say that motivation psychology concerns the way in which animals and men utilize time. Now it is easy to realize that different animal species spend their time carrying out different types of activity. Ethology and ecology have shown that this difference is rooted in the manner in which individuals of different species are dominated by specific "motivations" and "interests" related to their specialisations (*adaptation of the species*) which have proved necessary in order to live with different ecological niches. As for motivation, there are therefore *qualitative* differences between species as well as *quantitative* differences between individuals. In other words: all individuals of a given species will normally be dominated by the same motivations, but to a varying degree[24] – as is seen in species-members whose activities may differ when faced with the same situation (*a case of individual adaptation*).

In the field of motivation psychology, one has distinguished between: (i) the motivational force for behaviour or action (the *dynamic* aspect of motivation), and (ii) the *direction* of behaviour or action (the *directional* aspect of motivation).[25] While the individual's impulses to act are considered mainly due to fluctuations within the different motivational systems (needs or drives), the *direction* of the activities, which may follow, is thought of as mainly determined by external circumstances. In this connection it is important to note the fact, often described in ethology, that *a completed activity reduces its own impulse* for a longer or shorter period of time – and the more so if the activity has been adequately directed in relation to the motivational system activated.[26] Activity is said to liberate the biophysical energy which has been stored up in the tissue since a similar activity reduced the energy there. If an adequate object or goal is missing in the environment, the motivation may then be released in another direction, as is seen for example in displacement activity or synonymous

21 Ethologists have described such movements – "*fixed action patterns*" – in numerous animal species. (See N. Tinbergen, *The Animal in Its World*, Allen & Unwin, London 1972, vol. 2.)

22 C. Trevarthen, "Instincts for human understanding and for cultural cooperation: their development in infancy", in M. von Cranach *et al*, *Human Ethology: Claims and Limits of a New Discipline*, Maison des Sciences de l'Homme, Paris, and Cambridge University Press 1979, p. 534.

23 I. Eibl-Eibesfeldt, *Der vorprogrammierte Mensch*, Molden, München 1973, pp. 18-30.

24 R.J. Williams, *Biochemical Individuality – The Basis for the Genetotropic Concept*, John Wiley, New York 1956, pp. 162f.

25 M.H. Marx, *Introduction to Psychology*, Macmillan, New York 1978, p. 418f.

26 N. Tinbergen, *The Study of Instinct*, Oxford University Press 1951, pp. 104-05. It appears that at least one exception to this supposition is to be found in stereotyped behaviour in animals in captivity and in psychotic humans. A theoretical contribution, which could explain the motivational origin and the development of such behaviour, would also lead to a more appropriate theory of motivation than the one held by traditional ethology.

behaviour.[27] (See further Section 4 entitled "The direction of young individuals' activities is mapped out through their search for regularities".)

(c) The "*Systems of inherited and acquired aims*" refers to a level of organisation even higher in the nervous system than those in (a) and (b), as it can be deduced from most intentional activity and voluntary action. Following Popper the notion "*aim-structure*" designates a part of the "*central propensity structure*" of the organism,[28] notably that higher-level part which represents the organism's *expectations*, *preferences*, *intentions* and *goals* – where even in Man some of them will remain unconscious to the individual at any given point in time. This system of aims may be considered the *pilot* of the organism in the sense that this higher-level of control can be assumed to exert a downward causation upon the lower levels of control.[29] Such steering effects are, of course, most obvious in voluntary actions, but they can also be seen in activities where the goals are only partially conscious to the individual. Mario von Cranach and collaborators have described a great variety of such goal-directed actions, in both children and adults, using a similar system of levels of organisation.[30]

One of the main problems for dynamic psychology to explain is how the activity of an organism is channelled in such directions that an activated motivational system may be released and depleted thereby satisfying some of the organism's needs – or solving some of its vital problems. The question is, of course, of great importance not only for behavioural research but also for psychologists and educationists.

In the following sections the discussion will be focused on the question of how activities, guided by the various regulators mentioned above, manifest themselves in play and other endogenous activities of children and young animals.

4. The Direction of Young Individuals' Activities is Mapped out Through Their Search for Regularities

If living beings are considered largely biologically autonomous and characterized by their perpetual preoccupation with decoding the world, discovering its invariants and regularities, by attempts to solve their own vital problems as well as those of their species, then endogenous activities such as exploration and play would seem to be of major importance for our understanding of life processes of higher animals in general – and more particularly, for our understanding of the ontogeny of behavioural forms and actions in young individuals.

When the activities of the young achieve the well-known kaleidoscopic character, which we call "play" or play behaviour, then – in the light of our reflections on the relationship between activity and motivation (*System b*), above – we may consider the phenomenon of play as an evidence that *young individuals do not yet "know" which forms of behaviour to adopt and which actions to perform in order to achieve a certain goal*. In this respect, play is very different from behaviour performed in "serious" situations of life: here sequences of preprogrammed behaviour are seen to lead the young almost automatically to the satisfaction of some motivational urge or need (cf. certain forms of animal behaviour linked to nutrition, retreat, flight, etc.). It is therefore not surprising that in the young of animal species with manifest play – and to a lesser degree also in human children – play behaviour is composed of behavioural segments from the repertoire of "serious" preprogrammed behaviour patterns typical of the species (*System a*); *i.e.* behavioural parts issuing from behaviour patterns, which often require species-specific releasers ("*sign stimuli*") in order to be initiated. (In most cases, behaviour of this kind will be activities endowed with a largely genetically-determined orientation: being of vital importance for the survival of the species "serious" behaviour could not be left to individual trial-and-error experimentation.)

27 Widely studied by ethologists, the phenomenon of "*displacement activity*", or "*vacuum activity*", appears to owe its name to Niko Tinbergen. The idea of "*synonymous activity*" was proposed by Iven Reventlow in his *Studier af komplicerede psykobiologiske fænomener,* Munksgaard, Copenhagen 1970, p. 140. In his classic article, "Play and vacuum activities", in M. Autuori *et al, L'instinct dans le comportement des animaux et de l'homme,* Masson et Cie., Paris 1956, pp. 633-38, Konrad Lorenz puts forward the hypothesis that play has the same origin as "vacuum activities" (and sometimes, too, as "substitute activities"). However, this presupposes that play is generally guided by the same type of *action specific energy,* which is supposed to be hidden behind the vacuum activities, and such a hypothesis, although interesting, seems hard to support – except, perhaps, for certain cases of aggressive play.
28 The idea of "aim-structure", or "hierarchy of aims", has been introduced, apparently independently of one another, by Karl Popper in *O.K.*, pp.274f., and Mario von Cranach in *Zielgerichtetes Handeln,* Hans Huber, Bern 1980, pp. 17f.
29 A review of different forms of downward-causation effects has been attempted by the present author in a paper, "On Downward Causation in Biological and Behavioural Systems", *History and Philosophy of the Life Sciences* (Firenze), vol. 5, no. 1, 1983, pp. 69-86.
30 M. von Cranach, *ibid.,* Chapters 6 and 7.

That play is made up of segments of "serious" behaviour which have, however, not yet found their proper goals, seems to conform to Robert Fagen's demarcation of the phenomenon of play: "Animal play, which may be defined as persistent manipulative or locomotor experimentation with objects, with the environment, with one's own body, and/or with other organisms, includes repeated re-structuring of functioning behavioural procedures, behaviour which appears to maximize inefficiency and instability, prolonged fights in which attack engenders attack though the chance of injury is small, and puzzling variations of hunting, fighting, and escape routines which could never serve to capture prey, to injure or drive off a rival, or to flee from a predator".[31] Thus, it is not the actual play behaviour in itself, with its infinite variations, which is preprogrammed or "innate": play behaviour is a truly *ontogenetic* phenomenon in the sense that any given performance of play shall never be repeated in exactly the same way by other members of the species – although within such sequences of acts (in Fagen's sense) there will be segments of species-typical behaviour. It can therefore be held that such "individual sequences" of play behaviour, which a given member of a species may perform, are not a result of natural selection alone. This can, however, be said about the tendency to play itself – the *propensity* to play – which seems to be a peculiar state of the organism that facilitates the execution of a great variety of activities, which may later prove to be crucial for the individual members of a species in their attempts to solve the problems that life sets for them. From this it follows that the multiple and varied expressions of play behaviour cannot be "*adaptational*" in every case – such as is the case, for example, with the dark fur colour in the young of certain primates, their "lip-smacking" behaviour, and other soothing communications.[32]

It may then be argued that functional similarities in play behaviour of different species can only be found if functional similarities already exist in their preprogrammed behaviour patterns – even though these preprogrammed patterns of behaviour only take on real biological significance during "serious" adult life. Viewed in this way it also becomes understandable why young animals and children tend to be fascinated by dangerous and frightening situations, and why they often throw themselves into activities which are bound to increase, considerably though temporarily, their general level of arousal, whilst being exposed to the danger; because such highly aroused activities invariably are bound to satisfy some of the motivational needs of the young, a correspondence –

an assignment – will develop between these motivating factors and the activities which most effectively exhaust the motivational impulses. (This does not mean, of course, that children *should* be exposed to dangers in order to establish assignments – let alone to play – it only shows that assignments need not work on the basis of a primary *attachment*, and that the question of motivation in problem solving is a most complicated one.)

It is now my hypothesis that the motivational impulses (*System b*), which provoke an activity, will be successively "channelled" in definite directions towards specific means, which the organism finds satisfy its needs, in tempo with the overall ontogenetic development of the behaviour patterns involved. During this process, the biologically-based *search for regularities* is one of the main structuring agents.[33] The affinity for regularities or invariants – this continuous openness towards a world of implicate order – must itself be a genetically-coded disposition of great survival value. That living beings have a biological urge for living in a world of regularities[34] may also be seen from the fact that if they find no regularity sufficiently important and interesting in their immediate environment, they often structure it themselves, either by some quasi-repetitive forms of play or by searching for certain objects which they use in a goal-directed fashion. In conflict situations, on the other hand, with their ambiguous indices of regularity, particularly sensitive individuals may be seen to prefer the regularity of their own stereotyped behaviour rather than a more improvised activity or play based on certain themes. It is, however, impossible to predict *exactly* what regularity or invariant an

31 R. M. Fagen, "Modelling How and Why Play Works", in *Play,* p. 97.

32 The perception of such features as "infantile" by adult members of the species greatly facilitates the social life and survival of the young during the first months of life. (N. Bolwig, *Primaternes verden,* Gad, Copenhagen 1982, pp. 45-49.)

33 This idea appears to have been introduced by Karl Bühler under the term "Regelbewusstsein", in the paper, "Tatsachen und Probleme zu einer Psychologie der Denkvorgänge", *Archiv für die gesamte Psychologie,* Bd. 9, 1907, pp. 334f.

34 This point is made clear in an almost Kantian way by Jacques Paillard in his article "Les déterminants moteurs de l'organisation de l'espèce", *Cahiers de Psychologie,* 1971, vol. 14, no. 4, p. 311: "The organism is immersed by a vast universe of sources of stimulation ... It is therefore necessary to reduce the information to a form which can be manipulated by its internal processing system, and thus make it possible to extract from the primitive chaos of its sensorial impressions, that stable set of useful configurations which it may be able to employ... *The search for invariants and the discovery of stable configurations contributes to the reduction of this complexity and to the ordering of the sensorial world."* (I owe this reference to Mr. Guilhem de Roquefeuil; the translation and the italics, however, are mine.)

individual will form and retain. When a child says: "I want *exactly the same* toy as that one", or complains, "You didn't tell the story now *the same way* you did last night" we are witnessing a spontaneous formation of regularities (on the basis of "identity" and "sameness"), which may be crucial for future expectation, choice and action.

In other words, what is peculiar and important to play is that young individuals here get an opportunity – thanks to their spontaneous choices, and in tempo with their general maturation – to mark out, by a form of trial and error-elimination, in which directions their motivational impulses should be channelled in order to find a satisfactory outlet (*System b*). On a more conscious level, the individual may find solutions to hitherto unsolved species-typical problems (*System c*) by using action and selection procedures such as those seen in playful improvisation.

If play has a role here, as I have tried to argue, one should, however, *not* forget that some of the individual's activities may also come to owe their orientation to adult *instruction*: in this case the young individual does not experiment himself but acquires his experience with regularities from other, more experienced individuals. Such instruction, which in its crude form is seen to be accompanied by a greater or lesser degree of frustration on the part of the instructed individuals, often fails to encourage the young to take interest in problems and their solutions, while merely making them interested in ready-made results. Here, on the human level, education looms large in all its formidable complexity.

5. Some Similarities and Differences between Exploration and Play

Activities like exploration and play are often seen as expressions of "freedom" and "liberation". The idea seems to be that, although men like other animals are born non-free and constrained, by exploring and playing they nevertheless have the possibility of escaping a bit from the imperative and routine-like behaviour necessary only for the satisfaction of species-typical and individual-specific needs. Whether now the premise above pertains to play or not, there are many examples to show that exploration, and especially improvised play, have turned up something new thereby changing the life of individuals and the life-conditions of species.

Viewed in a phylogenetic perspective play has been significant for a number of species since increased play behaviour among the young may have been responsible for the progressive loosening of the close links between appetitive behaviour ("*the intention behaviour element*") and consummatory behaviour ("*the completion behaviour element*") – those special ways of living in a fixed relationship with the milieu, which are so typical for most lower species. Thanks to this evolutionary advance increasingly individual possibilities of orientation within, and exploration of, the environment have become possible in higher species, where play behaviour emerged and proved its survival value. This made it possible for these species to adapt to a wider range of environmental variables – demands originating partly as a result of changes in their aim-structures (*System c*).

Although almost all activities directed towards the outside world can be said to contain an element of exploration, it is however possible to distinguish the phenomenon of exploration from other activities, such as play. Corinne Hutt's elegant experiments with children demonstrate the interconnections, as well as the differences, between exploration and play.[35] Hutt shows how exploration is directed towards changes of the outside world, and that it may serve to familiarize the child with, for example, the properties of a new and unknown object. During this phase the child is visibly tense. When, through exploration, the environment and the object become familiar to the child, and he becomes confident with the object and the whole situation, then play may follow. During the exploration phase, the child acts as if the question was: "What can *this object* do?", whereas, during play, the child acts as if the question was: "What can *I* do with this object?"[36] Play is thus more varied than exploration, just as posture and facial expression are more relaxed in the child at play than in the exploring child. Hutt characterizes play most catchingly as "*nonchalant*", and this appears very well in line with the selective function attributed to play in Section 9, below.

In human activity, perhaps with exception of the most sublime products of artistic and scientific research, exploration appears to adhere to the same principles as in higher animal species. As anticipated in Section 2, it is possible here to distinguish between different forms of exploration, which may finally lead to play:

35 C. Hutt, "Exploration and Play in Children«, *Symposia of the Zoological Society of London*, no. 18, 1966, pp. 61-81. (Quoted from *Play*, pp. 202-15.)

36 C. Hutt, in *Play*, pp. 211-12. See also C. Loizos »Play Behaviour in Higher Primates: A Review", in D. Morris (Ed.) *Primate Ethology*, Weidenfeld and Nicolson, London 1967, pp. 176-218.

(A) *Heterotelic* (non-autonomous) *exploration,* where the individual's interest, governed by different primary needs, is oriented towards certain parts of the surrounding environment – a child searching for his beloved run-away cat, for example; in this case, exploration has a *pragmatic* and *instrumental* function.

(B) *Autotelic* (autonomous) *exploration,* where an active search, directed towards the environment and probably governed by a separate motivational system, constitutes a goal in itself – such as the small child's staring at an unfamiliar person or animal; this type of exploration does not, however, possess an immediate utility which qualifies the search to satisfy primary needs.[37]

These two principal types of exploration may also be observed in animals. Within the exploration here qualified as "autonomous", Hutt makes a further distinction:[38]

(B_1) *Specific exploration:* mainly sensory, this kind of exploration also serves to reduce anxiety and incertitude in an individual following confrontation with something unfamiliar and perhaps complex such as certain prefabricated playthings.

(B_2) *Diversive exploration:* more experimental, this type of exploration often comes near to real *problem-solving activity;* its function is to test the new possibilities the individual discovers when he turns over and over that which is now not unfamiliar or complex any more. In cases where diversive exploration appears at all, it is always preceded by specific exploration and, depending upon the course of events, it may be mistaken for play. It is, however, revealing that the facial expression and bodily posture remain tense during specific exploration, whereas they become more relaxed during diversive exploration.

The ensuing play behaviour seems to be characterized by greater relaxation in the facial expression and posture of the player – a relaxation often accompanied in Man and chimpanzee by the well-known *play face* and an emotional state commonly identified as "amusement" or "delight".

In children, as in the young of higher species, *play* may encompass many different activities, which will generally be repeated for some time. The play behaviour of small children can integrate objects into several forms of repetitive movement. Similarly, in social situations, imitative behaviour between two or several children may be transformed into a social play, where the union surrounding the whole activity seems to stem from the play itself rather than from the orientation or "goal" of the separate activities. We may thus presume that, in ludic behaviour, the central interest is *not so much the result as the activity itself.*[39] Therefore, we may designate an activity by the terms "play" or "exploration", according to whether the player's interest is directed toward the activity *per se* or toward the result of the activity. This is the clearest difference between play and exploration, which we may point to after a preliminary analysis.

As mentioned above, play is often characterized by words like *relaxation, amusement* and *pleasure*. In this context, Liebermann says that in play, amusement ("joy") appears to be the element of the phenomenon of play which most strongly opposes attempts at reductions:[40] the positive feeling of pleasure, which accompanies all play activity, seems to be nature's way of keeping the player playing, thereby facilitating a versatile development. It is not surprising, therefore, that the playing individual often casts aside all sense of danger and all inhibition in an attempt to be in on it while seeming as much at one with the play as with himself.

6. The Behaviour of Living Beings Toward Something New

Every individual is bound to find himself confronted with situations, living beings and objects which he considers new – and this the more so, the younger the individual is.

It is of fundamental interest – not only for psychobiological theory, but also for theories about action and education – to know if young individuals of animal species "*know what to do*" in advance when faced with something new – *i.e.* whether reactions toward novelty may be based on

37 As Hutt points out (*ibid.*, p. 212) play appears "to be relatively low in the motivational hierarchy", since it can easily be inhibited by fear, hunger, curiosity or almost any other need. However, this does not exclude that play *as such* can be motivated – indeed, children's and young animal's propensity to play points to such a possibility – nor is it excluded that play considered as an activity that may lead to improvised solutions to problems can bring the agent into new avenues adequate for the satisfaction of needs.

38 C. Hutt, "Specific and Diversive Exploration", in H. W. Reese et al. *Advances in Child Development and Behaviour,* Academic Press, New York 1970, vol. 5, pp. 120-80. Quoted from S.J. Hutt *et al, Early Human Development,* Oxford University Press 1973, p. 343. (Herafter abbreviated to *E.H.D.*).

39 C. Hutt, in *Play,* p. 210

40 J.N. Liebermann, *Playfulness – Its relationship to imagination and creativity,* Academic Press, New York 1977, p. 18.

"preprogrammed behaviour" – or whether the species "permits" the young to *proceed by trial and error-elimination,* or as specified above by "action and selection". As we know, memory and "habituation", quickly eliminate the novelty aspects of most situations – which is probably necessary for the survival of organisms in a changing world – and, in general, the tendency for individuals to do something new in the same type of situation is seen to diminish over time.

The individual's first encounter with the new and unfamiliar will often leave no more trace than a certain behavioural approach and some tentative movements (except for a certain "atmosphere" or "emotional tone"), partly witnessing what happened the first time the individual had to act in relation to the apparently new. It should be added, however, that such tentative patterns may, by their very performance, block the discovery of other behavioural approaches to problems – which can be both favourable and unfavourable for the individual. Novelty is often a stimulant, but only moderately so even for many adult human individuals.

Animal species have been found to react differently when confronted with new things. In order to describe such differences Desmond Morris has suggested that we distinguish: *neophilia,* the fascination with the new and unfamiliar, and *neophobia,* anxiety in relation to the new and unfamiliar.[41] Predator animals and non-specialised species are generally more neophilic than neophobic, whereas most prey animals and specialised species are more neophobic than neophilic. Moreover, the influence of novelty on the individual will probably also depend on the environmental conditions of the species, on its social organisation and integration of species-members.

Homo sapiens, whose way of life has much in common with that of non-specialised predators, may generally be considered to be one of the most neophilic and curious species; this has no doubt played an important role in the development of tools and techniques which Sir Peter Medawar named "exosomatic evolution".[42] From this one cannot, however, conclude that *all* human beings are curious and impatient for novelty. A study of the frequency of neophilia and neophobia in adults might even show, that the majority of individuals in most human populations is rather neophobic when it comes to *doing something new,* that people feel more at ease with what is well known, and that they hold back or flee from the new and "problematic". It is also most remarkable that infants, as well as children of different age groups, show a marked interest for novelty which may, nevertheless, later disappear completely.

How can we explain the existence of neophobic individuals in an extroverted species such as *Homo Sapiens*? Can a neophobia, which is eventually *induced* in children at an early stage, have consequences for their later life, their problem solving and their mental constitution? – These are only some of the questions which, hopefully, will be answered by the study of play behaviour in animals and children.

Now, the variation in reactions to novelty rather complicates matters. Hutt has proposed to distinguish three types of phenomena, which may give rise to *impressions of novelty* in the young individual: *new objects, new situations* and *new members of the species* (or *new features in the appearances of such members*).[43] This classification is biologically based, since certain forms of novelty often evoke species-typical activities, and because such reactions can be demonstrated in young individuals within specific time periods. Furthermore it may be supposed that the evolutionary significance of different forms of novelty differs from one species to another.

(N_o) *New objects.* Fants and others have demonstrated the existence in the small child of preferences peculiar to our species for certain types of configurations.[44] During the first three months of life round, soft things will typically be preferred to new objects. Bronson says that during the period from the third to the sixth month, the child *prefers new objects* over objects with other preferential values.[45] From the sixth month on, the child is capable of distinguishing more precisely between different types of objects, and we observe *a marked reserve towards new and unfamiliar objects,* as described by Schaffer.[46] Well-known is the description by William James (1890) of his son's changing reactions to a live frog, which was handed to him for the first time when he was six months old and again at 18 months: the first time, the boy immediately stretched out his hands to take the frog, and despite its wriggling movements he held it for some

41 D. Morris, "The response of animals to a restricted environment", *Symposia of the Zoological Society of London,* vol. 13, 1964, pp. 99f.

42 P. Medawar, *The Future of Man,* Methuen, London 1960, pp. 96f.

43 C. Hutt, in *E.H.D.*, pp. 331f.

44 R. L. Fantz, "The origin of form perception", *Scientific American,* vol. 204, 1961, pp. 66-72. Most surprising here was the preference in newborns for looking at the human face.

45 G. W. Bronson, "Development of fear in man and other animals", *Child Development,* vol. 39, 1968, pp. 409-32. (Quoted here from *E.H.D.*, p. 312.)

46 H. R. Schaffer *et al,* "Perceptual-motor behaviour in infancy as a function of age and stimulus familiarity", *British Journal of Psychology,* vol. 60, 1969, pp. 1-10. (Graphs 1 and 2) time, he even went so far as to put the frog's head in his mouth, after which he let it hop all over his body without the slightest sign of fear; when he was offered the frog a second time twelve months later, he showed a marked aversion – even though, according to James, he had seen and heard nothing of frogs in the interim.[47] More recent and systematic studies show that the tendency of the second period, mentioned above, to accept any object, is followed in the second year of life by a *higher selectivity in willingness to approach and touch a wider range of objects.* Further, Rabinowitz *et al* have shown that pre-school children *explore and play with new toys almost as much as with familiar toys,* and boys even more so than girls.[48] More specifically, Hutt has demonstrated *a general reduction in the attraction to new and unfamiliar objects in autistic children,* often accompanied by an increase in stereotypic behaviour – apparently regardless of age.[49]

(N_s) *New situations.* Studies of early ontogenesis have shown that the probability that a given situation will induce the individual to explore or withdraw from it depends on the degree of emotional attachment to other individuals. The famous studies by Harlow on the development of young monkeys living in isolation showed that a young monkey will only start to explore the outside world if he has established a "security base" with at least one other species-member. Without such a base the young will react with fear and hide itself. Something similar will happen more promptly if an isolated monkey is put into a new situation, and its reactions become even more conspicuous if, in this new situation, there are strange objects or unknown species-members. Harlow found that the development of fearful behaviour may be avoided if the young monkey either stays with his own mother from birth or stays for company with some other known member of the species – or even with a wire doll wrapped up in *a towel.* Everything points to this attachment developing before the fourth month.[50] Observations of children who have grown up under deprived life conditions tend to show that a relation exists between this lack of emotional attachment and fear or anxiety in new and unfamiliar situations. (Sections 11 and 12 will elaborate this question further in connection with the specific problems of autism.) Rheingold reported a series of observations concerning 10-months-old children which show that a strange environment inhibits exploration and causes fear if the child first finds himself there alone – even if only temporarily.[51] It was seen, furthermore, that the child shall remain affected by the situation also after the mother has appeared in it. But if the mother accompanies the child into a strange environment from the start – or if she is just present on a television screen, as *Adams et al* have shown with 3-year-olds[52] – then the situation seems to change from "foreign" to "new" in such a way that the child begins to examine the place, and may even continue exploring, and perhaps playing, if the mother's presence is interrupted.

(N_m) *New members of the species*. Young individuals' interest in new objects does not extend to new members of the species, or at least not in the same way; in fact, in this domaine there seem to be periods in early life when the presence of new species-members produces different effects. The observations on sound preferences in the baby made by Friedlander[53] and by Sackett on species-recognition in monkeys[54] show that young individuals begin life by showing a stimulus preference for members of their own species. Then, as Bronson has shown, from about the fifth month on they will distinguish familiar members from strange ones and will prefer to be with familiar ones.[55] Logically, such recognition of the *familiar* is necessary in order for the fear of the *strange and unfamiliar* to develop. Bronson identifies fear as merely "*an aversive reaction to new visual configurations*", but there are obviously other types of stimuli which can also evoke fear. Carpenter *et al* have shown that babies only a few weeks old can recognize faces and can also connect facial features and voices, to the

47 W. James, *The Principles of Psychology,* 1890; Dover Publications, New York 1950, vol. 2, p. 417.

48 F. M. Rabinowitz, "The Effects of Toy Novelty and Social Interaction on the Exploratory Behaviour of Preschool Children", *Child Development,* vol. 46, 1975, pp. 286-89.

49 C. Hutt *el al,* "Stereotypes and their Relation to Arousal: A Study of Austistic Children", in S.J. Hutt *et al, Behaviour Studies in Psychiatry,* Pergamon Press, Oxford 1970, pp. 175-99.

50 H. F. Harlow *et al,* "The affectional systems", in A. M. Schrier *et.al., Behavior of Nonhuman Primates,* Academic Press, New York 1965, vol. 2, pp. 287-334.

51 H. L. Rheingold, "The effect of a strange environment on the behaviour of infants", in B. M. Foss, *Determinants of Infant Behaviour,* Methuen, London 1969, vol. 4, pp. 137-66. (Taken here from *E.H.D.,* pp. 351-60)

52 R. E. Adams, "Effects of visual and auditory aspects of mothers and strangers on the play and exploration of children", *Developmental Psychology,* vol. 15, 1979, pp. 269-74.

53 B. Z. Friedlander, "Receptive language development in infancy: Issues and problems", *Merrill-Palmer Quarterly,* vol. 16, 1970, pp. 7-51.

54 G. P. Sackett, "Monkeys reared in isolation with pictures as visual input", *Science,* vol. 154, 1966, pp. 1468-73.

55 G. W. Bronson, in *E.H.D.,* pp. 309-10.

extent that they will show signs of discomfort and fear when suddenly, by some technical device, a strange person seems to speak with their mother's voice.[56] Bronson studied the so-called "*eighth-month-anxiety*" towards strangers, demonstrated by R. A. Spitz, and confirmed that this begins to show at around 7-9 months;[57] it also turned out that the child's reaction varies according to the stranger's behaviour. At 2 years children are seen spontaneously to involve others in their own experience ("sharing"), as shown by Rheingold *et al.*[58] This "act of sharing an experience with others" also includes strangers in everyday situations.

Children's reactions to novelty are thus dependent on both the nature of the stimulation and the age of the child, and in this respect children are not very different from the young of other primates. The changes in this type of reactions, as set out above, could stem from biologically based changes in the sensitivity to specific triggers ("sign stimuli"). Apart from those, in principle, predictable reactions to the unfamilar of different environmental entities, we do not seem to find similar species-typical behaviour patterns in humans later in life. What we find, however, are more individualized attitudes to novelty, undoubtedly shaped by differences in experiences and in reactions to experience with different parts of the world. Phrased in another way one could say that children display more *behaviour* than adults, or that adults perform more *actions* than children – actions being *intentional* and voluntary activities which may be based on deliberate and conscious *choice. This freedom with respect to the possibilities of action* – an apparent late development in phylogeny – must have been an enormous evolutionary advantage for *Homo sapiens*. However, this freedom is double-edged. To simplify, it may be said that a price is paid each time a child is frightened – because of an accident or a slip on the part of adults during one of the sensitive periods mentioned above – by something that spontaneously attracted it. One possible consequence of such a mishap is that the child will avoid this kind of object, situation or kin for the rest of his life.

Thanks to studies of free-living primates and to observations of children in their actual environments, we know that young individuals *learn to fear* what the closest species-members or kin have *induced them to fear* and perhaps fear themselves – such as spiders, wasps, snakes, dogs, apart from inanimate things and situations. Although sensitivity and anxiety can be regarded as innate, this disposition has no precise orientation at birth. Because of its genetic origin, the *degree of* sensitivity and anxiety varies from one individual to another. *What* the sensitivity and the anxiety *will be directed against* is, however, determined by experience with the environment early in life – and perhaps more particularly, during sensitive periods of fixed duration.

This being so, we may deduce that it is "decided" at early stages in life whether a child becomes *neophilic* or *neophobic*. In other words, the question is whether the child will develop a *marked taste for problems and problem solving* – in which case it will perhaps even "*seek*" out new problems – or whether it will be *uneasy with problems and try to avoid them* as much as possible. (Cf. Section 11.)

7. The Role of "Repetition" in Problem Solving

The reaction of a young animal or child when encountering the new and unfamiliar may thus be determined by both preprogrammed visio-motor patterns and by learning through trial and error-elimination. This means that a given reaction to novelty may be the result of a solution found by either the *species* or by the *individual*. The two cases illustrate *applied situational logic* as outlined in Section 2, above.

How can we describe, in terms of this logic, what happens in species adaptation and individual adaptation to novelty in real life? As we shall see, one of the important consequences of such a logic can be shown to be that *the first reactions to novelty of either the gene-pool or the individual* – as they come out in "variations" and "actions" respectively – *are decisive in terms of their later relation to the phenomenon in question, which is thus no longer "new" for the species or for the individual after the first encounter.*

(A') The case of *adaptation of the species* easily shows that this is so. As already mentioned, the solution consists of two parts: *1°* – The gene-pool of the species produces first *variations* made up of re-combinations of genes and genetical mutations; *2°* – This variation is then subjected to

56 G. C. Carpenter *et al*, "Differential visual behaviour to human and humanoid faces in early infancy", *Merrill-Palmer Quarterly*, vol. 16, 1970, pp. 91-108.
57 G. W. Bronson, in *E.H.D.*, p. 310.
58 H. L. Rheingold *et al*, "Sharing in the Second Year of Life", *Child Development*, 1976, vol. 47, pp. 1148-58.

selection which lets individuals with favourable combinations of characters pass and eliminates from the population those individuals with unfavourable combinations of characters. The terms "favourable" and "unfavourable" are clearly relative, specifying the relationships between the population and the set of environmental factors, which may influence the population's way of life. These relationships become particularly critical for the population (whose individuals are, in fact, the phenotypical realisations of the gene-pool of the population) when they undergo changes – either because of changes in the individual's way of life (food choice, choice of habitat, changes in social structures, etc.) or because of changes in the environment (climatic, geological, ecological a.o. changes). Here, the term "new situation" refers to such changes which often occur simultaneously and in combinations.

Problem solving which follows the principle of natural selection is thus *deductive* in nature and allows *no possibility of repetition*. Mutations and recombinations are never repeated in any strict sense, and what they may contribute to the solution of vital new problems does not appear as a result of repetition and it appears only once. If successful, however, the solution to problems arrived at by this type of genetic changes *will be repeated* as long as the solution works in that field of combinations which is constituted by the species and its environment. As with direct problem solving indirect problem solving by *genetic variation* and *natural selection* will always carry a time-index and remain temporary.

(B') This deductive logic seems at first sight less obvious in the case of *individual problem solving,* where living beings are confronted with something new. But *individual adaptation* by this kind of direct problem solving can in fact be seen everywhere. A now classic ethological description of it, given by Konrad Lorenz concerns the spontaneous reaction of his famous goose "Martina" to a new situation – a reaction which is gradually transformed into a ritualised behaviour pattern without changing its function. Lorenz writes: "In our house in Altenberg the bottom part of the staircase, viewed from the front door, stands out into the middle of the right-hand side of the hall. It ascends by a right-angled turn to the left, leading up to the gallery on the first floor. Opposite the front door is a very large window. As Martina, following obediently at my heels, walked into the hall, the unaccustomed situation suddenly filled her with terror and she strove, as frightened birds always do, towards the light. She ran from the door straight towards the window, passing me where I now stood on the bottom stair. At the window, she waited a few moments to calm down, then obedient once more, she came to me on the step and followed me up to my bedroom. This procedure was repeated in the same way next evening, except that this time her detour to the window was a little shorter and she did not remain there so long. In the following days there were further developments: her pause at the window was discontinued and she no longer gave the impression of being frightened. The detour acquired more and more the character of a habit, and it was funny to see how she ran resolutely to the window and, having arrived there, turned without pausing and ran just as resolutely back to the stairs which she then mounted. The habitual detour to the window became shorter and shorter, the 180° turn became an acute angle, and after a year there remained of the whole path habit only a rightangled turn where the goose, instead of mounting the bottom stair at its right-hand end, nearest the door, ran along the stair to its left and mounted it at rightangles."[59]

Now, surprisingly enough, this gradual *behavioural change* is explained by Lorenz as a result of *habit formation* – *i.e.* the new behavioural ritual is assumed to be the result of *repeated behaviour* – in fact the same type of explanation as behaviourists apply to learning phenomena and to questions of behavioural organization, where any kind of activity is considered a result of repeated reinforcement of innervation patterns of the nervous system. However, the term "habit" explains less than it covers up, and behavioural scientists seem to accept this state of affairs as easily as we seem to accept every-day phrases like "Habit is second nature", or "Repetition is the master of all knowledge".

It is therefore most fortunate that we can point to another explanation of the same phenomena which rests on a sound logical basis. This interpretation of problem solving and learning, *based on situational logic,* has been developed by Popper who was inspired by analyses made by psychologists of the "Würzburg school". Following this type of explanation Martina's behavioural development may then be summarized this way (see *Fig. 1*):

59 K. Z. Lorenz, *On Aggression,* Methuen & Co. Ltd., London 1966; repr. 1967 & 69, pp. 57-58.

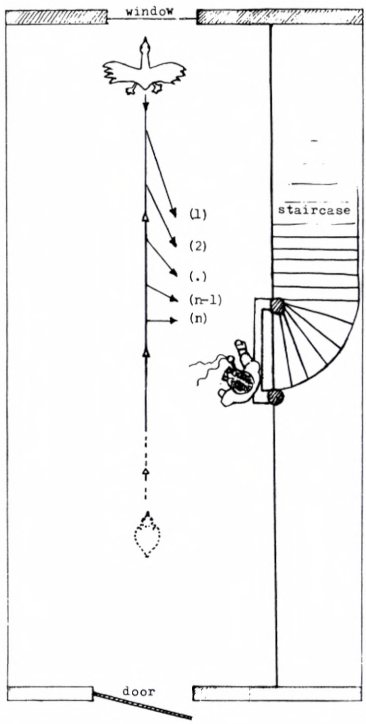

Fig. 1.
Schematic representation of progressive simplification, or ritualisation, of a fear reaction in the greylag goose, sketched on location and in accordance with the passage in Konrad Lorenz, 1966, quoted in the text.

As Lorenz' meticulous description clearly shows, it is precisely *not* due to any strict repetition that the calming behavioural detour becomes established, but rather that a *progressive shortening* of the original detour takes place each time the bird prepares herself to climb the stairs. This kind of progressive simplification of an original behavioural trial is called by Popper *Ablaufsverkürzung*[60] and may, in effect, be the same process as ethologists refer to as *ritualisation.* In other words: learning situations like the one described above seem to be governed by a logic different from the illogical assumptions of traditional learning theory. Accordingly, the decisive action of an animal in some such situation is *not* established by repetition – it appears right from the beginning with the animal's first reaction to the unfamiliar: the increasing promptness of the behaviour should therefore not be mistaken for its gradual creation, since *living beings do not induce conclusions – they rather jump to them* (*natura facit saltus*).

Thus "habit" does not create any new behaviour; the effect of "habit" is rather to eliminate useless and superfluous elements of a given activity. Or more precisely, paraphrasing Popper: *Nothing new can appear by repetition: "repetition" can only cause something – usually unuseful – to disappear.*[61] The apparent "repetition" of a given activity carried out in response to a problem serves the biological function of transforming the adequate part of the activity into a non-problematic routine[62] – probably in order to liberate and prepare the higher cortical functions for new problem solving. Children's love for recurring events and stories told again and again supports intuitively such an analysis.

A given behaviour or action will only remain in an individual's repertoire of activities – as in the case of Martina – if it really contributes to the solution of a problem. As mentioned in Section 2, such a *deductively* working procedure is by nature *selective* when it comes to testing potential solutions to problems. When a tentative solution is proved wrong or inadequate, the behaviour employed is seen gradually to disappear.

According to the interpretation of Lorenz' description given here, it appears that problem solving and learning presupposes, from their inception, that the organism is active.[63] After the organism has carried out the

60 K. R. Popper, *D.b.G.*, p. 25.

61 K. R. Popper, *ibid.*, p. 28.

62 K. R. Popper, *S.I.B.*, p. 134. – Popper and Lorenz have discussed and corresponded on these and related issues for years, but as late as in 1976 when, in his house in Altenberg, Lorenz himself vividly described to me the development in behaviour of his favourite goose, Martina, and repeated *his* explanation of the phenomena, no agreement on the matter had apparently been reached between the two. In a letter to me, dated January 28th, 1975, Popper outlines his position at some length. At one place he writes: "The central point is that all learning is *adaptive modification* – sometimes complication, sometimes simplification – of previously existing *highly complex* adaptive skills ... It does not put together simple elements, but it modifies existing complex structures. These complexes may, in their turn, perhaps consist of elements such as neurons and synapses; but the idea that an association corresponds to a thickened synapse is totally mistaken; even a slight modification of a skill would probably correspond (*assuming* the synapses are modifiable physical elements) to a *modification of a thousand* (*or more*) *synapses,* of a whole network. Even lower animals which are not yet capable of learning (of modification) have highly complex behaviour; and it is such complex behaviour which is the antecedent of all learning processes."

63 One cannot even decide on the nature of Tolman's "latent learning" before the animal has had a chance to carry out the appropriate act, for which information has been incorporated at a given moment into a corresponding control system, memory or "search model". We may say that the notion of "latent learning" has its origin *not* in the animal as such but rather in *our* ignorance about the "search models" in question.

initial activity, selection will determine – either instantaneously or after repeated testing – whether the action undertaken is adequate for solving the problem at hand or not. This alternation between *action and selection,* which can be said to be a generalization of the method of trial and error-elimination, is here considered a governing principle of all problem solving.

8. Learning Through Action and Selection

As mentioned in Section 4, the affinity which living beings have with regularity is a biological condition for survival both on the individual level and on the level of the species. In higher animals and Man, where the relationship between organism and environment is not fixed upon species-specific models (*i.e.* "sign stimuli" and their corresponding reactions) as is the case with lower animals, the possibility of creating new regularities will be of the utmost importance to their whole way of life.

Traditional learning psychology presumes mistakenly that the individual organism learns by establishing, *inductively,* the regularities of the world by repeatedly associating and generalizing received impressions from the environment. A different conception is proposed here, which conjectures that living beings actively invent and set forth regularities *deductively* through their activities (be it preprogrammed behaviour patterns or improvised actions) thereby trying out hypotheses, anticipations, prejudices, or theories about different parts of the world. Only those hypotheses are then retained, for a longer or shorter period of time, which resist the selection pressure that comes with the testing of them in the world of realities (and that happens, of course, whether the animal is conscious of it or not).

It may seem curious that the main features of this process were discovered in connection with studies of the behaviour of rhizopodes and other unicellular organisms. However, in his pioneer investigations of the reactions of protozoa to different types of stimuli, Herbert Spencer Jennings described a phenomenon, which he named "exploratory movements":[64] amoebae brought into contact with a toxic fluid were seen to run through their whole repertoire until a behaviour pattern proved *adequate* in ridding the animal of the painful stimulus. When the experiment was repeated, the whole repertoire was run through again, and even after several "repeated" experiments, no change could be seen in the way in which the repertoire of behaviour was run through – except that *the length of time taken to execute the whole repertoire became shorter and shorter, i.e.* the "adequate" reaction was mobilized more promptly.

As in the case of Martina, we may say that a necessary condition for problem solving and learning to take place is that a *tentative assignment* is established between an effective behavioural trail and the stimuli present in the problem situation. This is how behaviour acquires its anticipatory character: living beings do indeed make the first step in learning and problem solving by jumping to conclusions[65] – *i.e.* by assigning certain stimuli to already existing behaviour. (In both cases above, the very first activity of the protozoa and of the goose was a preprogrammed behaviour pattern; this will often be the case in Man too, although the first reaction to a new situation may also be an acquired behaviour which the agent, for some reason or other, takes to be applicable also in a given new situation.) The *assigned* relationship thus established will, however, only be maintained insofar as the anticipatory behaviour is *biologically functional.* If the content of the problem situation is changed, then the initially adequate behaviour will gradually disappear and be replaced by another behaviour, which is more to the *new* point. It is easily seen that such a continual *selection by elimination* of pre-formed anticipations, and of expectations and hypotheses formed as a result of such experience, has much in common with evolution by natural selection.

The *assignment process,* which seems akin to a semi-irreversible form of "imprinting", may be considered a *dynamic expression of the affinity of organisms for seeking out regularities of the world.* This idea, which was first introduced by Karl Popper and named *"Gesetzerlebnis"*,[66] may perhaps best be translated like this: "Living beings experience the world in a lawful way". The concept of assignment explains in a more fundamentally biological

64 H. S. Jennings, *The Behaviour of the Lower Organisms* (1906), Indiana University Press 1962, p. 22. As an explanation of his observations, Jennings adopts (pp. 289f.) the "*law of dynamogenesis*" formulated by James M. Baldwin, which he restates as follows (p. 291): "*The resolution of one physiological state into another becomes easier and more rapid after it has taken place a number of times* ... The operations of this law are, of course, seen on a vast scale in higher organisms, in the phenomena which we commonly call memory, association, habit formation, and learning."

65 K. R. Popper, *O.K.*, p. 21f.

66 K. R. Popper, *'Gewohnheit' und 'Gesetzerlebnis' in der Erziehung – Eine pädagogisch-strukturpsychologische Monographie,* Pädagogische Institut, Wien 1927, pp. 3f and p. 17. (I wish to thank Sir Karl for kindly premitting me to quote from this unpublished work.)

way what the "laws of association" of traditional learning theory were supposed to explain ever since Aristotle.

Such assignment processes may be due to the existence, as much in the control system of unicellular animals as in the nervous system of multicellular animals, of a functional differentiation between an afferent side and an efferent side (*i.e.* between *reception* and *reaction*), and especially because the efferent side is normally more autonomous than the afferent side. It is thus characteristic that the effect of incoming stimuli depends to a large degree on the reacting apparatus itself: the stimulus, which triggers the reaction, can be considered only as its *material condition* (since it determines the moment of the appearance of the reaction and certain quantitative aspects of it), while it is the efferent apparatus which constitutes the *formal condition* of the reaction (since this will determine the whole character of the reaction – a consequence of the law of the specificities of sensorial energies).

It is interesting to note that some recent developments in neurobiological theory, such as Karl Pribram's model of "test-operate-test-exit" (TOTE), were aimed at explaining precisely this type of central control of receptive mechanisms: "... perception is in essence a 'motor' phenomenon ... perception per se is more a reflection of the response patterns instigated in the brain by an input than it is a resultant of the input patterns".[67]

Thus, for logical reasons, no *direct* assignment can occur between the sensations (derived from "repeated perceptions"), as has been assumed by traditional learning theory. The sensations must first be assigned within the register of pre-existing reactions, before – via this pre-formed "carrier system" – *indirect* assignments can be established between the sensations themselves (those very links which have been wrongly named "associations").

Deductive as it is, the assignment process may be taken to be a key-feature in the individual's functioning towards the environment. We only have to think of the early formation in mammals of a so-called *attachment* link between the young and their caregivers in order to see the generality of this sort of process. A similar kind of attachment has been found in the human infant, and we may conjecture that the phenomenon of love in Man (and animals) will be of the same type of process. At any rate their logic of functioning seems much alike. Such links between species-members may thus be considered a *semi-irreversible assignment process,* where genetic preferences can also play a role (as can be seen from the auditory and visual *engrams* of the newborn). This disposition to form *attachment to other members of the species* is limited in time to the early stages of life (to the so-called "sensitive" or "critical periods"), while *emotional attachment* may recur at different stages of life. As mentioned earlier, species-attachment has been found to be a necessary condition for exploration to occur; likewise, emotional attachment has been demonstrated to be a necessary ingredient of human well-being and normal functioning, and John Bowlby has specified the acute symptomatology which can develop from early childhood on, if this kind of attachment is disturbed.[68]

At this point in the analysis, it is worthy of note that a good number of different forms of motor learning, cognitive learning and problem solving also seem to imply assignment phenomena like those described here. Indeed, this can be shown to be the case for the types of learning which the classical learning curve maps out. This curve acquires its characteristically terraced shape precisely because the experimental subjects jump to conclusions with regard to what methods to use and which movements to perform.[69] That is clearly shown by the existence of the so-called "plateaux" in this curve: in learning, say, telegraphic signalling, a given "plateau" of the curve indicates that the person in question has changed to a new, or just slightly different, signalling method, and that the ensuing part of the curve – down to the next "plateau", so to speak – reports on the effect of the *progressive simplification* of the implied patterns of movement (for instance measured by the number of mistakes made per unit of time). A new "plateau" is reached when the possibilities of the hitherto utilized signalling method are exhausted – *i.e.* when the method can no longer increase the speed or precision of signalling. The canonical explanation of these forms of learning in humans is of course, quite different and probably false; for, in contradistinction to the explanatory principles drawn upon here, these traditional explanations start out from an idea of repetition which is untenable, both theoretically and empirically.

67 K. H. Pribram, *L.O.B.*, p. 91.

68 J. Bowlby, *Attachment and Loss*, vol. 1-3, The Hogarth Press, London 1974-80.

69 R. S. Woodworth *et al*, *Experimental Psychology*, Methuen & Co., London 1961, pp. 537-38. In fact, the classical learning curve mixes up two learning processes: *the assignment process*, which in Man may be linked to insight, and *the process of progressive simplification.* Analyzed more correctly, the learning curve ought to be drawn out for each new assignment, *i.e.* for each new method employed or insight gained.

When set theory appeared at the beginning of this century, it was thought, also in psychology – as often is the case on the occasion of some such discovery – that the new tool could solve a lot of old problems in this and other fields. Viewed in presentday perspective it may be, however, that the generalization made by Schlick of Dedekin's notion of *assignment* ("*Zuordnung*") – "*In thinking, there is basically no other function than that of assignment*"[70] – when used properly, can help to bring learning theory out of its present inductivist impasse by contributing to our understanding of the logical foundation of problem solving.

9. On Play as Nature's Short Cut to Problem Solving: Fundamental Functions and Effects of Play

Since Wolfgang Köhler's studies of problem solving in chimpanzees, primatologists have been able to demonstrate that problem solving depends on much more than a re-structuration of the visual field.[71] Paul H. Schiller thus pointed out that play and exploration facilitate future problem solving in chimpanzees living in captivity,[72] and Jane Goodall observed that early experience with straws and sticks made during play helped freeliving chimpanzees in their later hunt for termites;[73] furthermore, Itani and his colleagues showed that the young of wild Japanese monkeys could only transmit behavioural innovations – such as the cleaning of dirty food – to other members of the group, if their mother held a dominant social position there.[74]

Such results could indicate that play is a kind of *preparatory exercise for adult life*. This conception of play, first advanced by Karl Groos, attaches to play an important biological function. Influenced by Darwin's doctrine of evolution by natural selection, Groos shows, via a number of examples, the importance of play in the fight for survival of higher animals, and he argues that it would be fatal for individuals of such species if the various instinctive forms of behaviour did only appear when fully developed and biologically required. The infancy period may thus be seen as a time span which allows them to practise these behavioural forms, and in the young of these animals training takes place mainly through play: "Hitherto we have been in the habit of referring to the period of growth as a matter of fact only important at all because some instincts of biological significance appear then. *Now we see that youth probably exists for the sake of play.* Animals cannot be said to play because they are young and frolicsome, but rather they have a period of youth in order to play; for only by so doing can they supplement the insufficient hereditary endowment with individual experience, in view of the coming tasks of life... The play of young animals has its origin in the fact that certain very important instincts appear at a time when the animal does not seriously need them."[75]

Alexander Brownlee, who is inspired by Groos, advanced another *exercise-theory of play* half a century later, according to which play is not to be seen as a preparatory exercise of certain behaviours for later use, but rather as an activity – typically a motor activity – which allows young individuals to train their muscles, tendons, bones etc. in order to secure their adequate functioning in adult life. This allround training is important since the young rarely need to use such bodily apparatus which goes into catching prey, fleeing, fighting and copulating. Brownlee maintains that an animal which has not trained these muscles etc. in infancy, either in play or for real, would probably run the risk of these organs not developing properly. It is known that when the growth rate slows down, as the animal gets older, training is less effective and consequently requires more time and energy. Also, the training of certain muscular functions seems impossible in adult life. Brownlee specifies *the survival value of play* as follows: "(1) It exercises and strengthens the muscles, tendons, ligaments, bones and joints involved in play; in the immature animal these organs are thereby trained and are then ready for use in those corresponding serious activities which play behaviour outwardly resembles. (2) By playing the young animal becomes acquainted, from

70 M. Schlick, *Allgemeine Erkenntnislehre,* J. Springer, Berlin 1925, p. 351. (Translated here from K. R. Popper, *Zur Methodenfrage der Denkpsychologie,* Dissertation, Universität Wien 1928, p. 61; in the English edition of Schlick's *General Theory of Knowledge,* Open Court Publishing Co., La Salle, Ill. 1985, p. 383, the term "function" is translated by "relation".)

71 W. Köhler, *Intelligenzprüfungen an Menschenaffen,* J. Springer, Berlin 1921.

72 P. H. Schiller, "Innate Motor Action as a Basis of Learning: Manipulative Problems in the Chimpanzee", in C. H. Schiller, *Instinctive Behaviour,* Methuen, London 1957. (Here quoted from *Play,* pp. 232-38.)

73 J. Goodall, "Early Tool Using in Wild Chimpanzees", *Animal Behaviour Monographs,* vol. 1, 1968. (Quoted here from *Play,* pp. 222-25.)

74 J. Itani, "On the acquisition and propagation of a new food habit in the natural group of the Japanese monkey at Takasakiyama", *Primates,* no. 1, 1958, pp. 84-89.

75 K. Groos, in *Play,* pp. 66-67. A century later, neurobiologists – *e.g.* P. D. MacLean – have provided experimental evidence to support the view "that youth exists for the sake of play".

impressions received from its kinaesthetic sense organs, with properties of its environment and thereby can attack or escape with confidence in its knowledge of its terrain and the experience gained by play fighting with inanimate objects and friendly congeners will be valuable when attacking alien congeners and also predators."[76]

Following this line of thought Robert Fagen has more recently developed a theory of play, in which *physical training* is considered one of the most important *functions* of play. The theory is supported by physiological and neurobiological measurements of muscular work, its effects on the muscular apparatus itself, and its influence on long-term development of muscles, skeleton and circulation.[77] Moreover, it is supposed that great physical effort during play may facilitate the development of the nervous system. In his impressive work, *Animal Play Behavior* (1981), Fagen states his thesis of play as follows: "*play is a mechanism by which animals can influence their developmental rate, brain weight, and the flexibility of their behavior as well as certain aspects of learning ability.*"[78] Fagen carefully points out that his theory of physical training does not explain all forms of play – nor all aspects of *manipulatory play* and *social play* – and that the function of play specified by him cannot be the only one: "Possible functions of manipulative play, including motor practice, [may be] development of tool use and problem-solving strategies, experimentation on the environment, and discovery or facilitation of novel behavior patterns ..."[79] He rejects previous explanations of *social play* (for example, its alleged function of linking individuals) and claims that social play is a result of population density, group size, birth rate, interval between births, etc. – a hypothesis which in his view conforms to the supposition that there are critical periods for socialisation: "Individual tendencies to engage in social play as a function of population density of potential playmates can themselves be affected by experience. Natural selection may produce experiential modifiability of an individual's tendencies to play with others in preference to playing alone."[80]

Fagen proposes that one of the *effects* of play is the integration of ontogenetic experiences gained during a certain period, the length of which is determined by natural selection. In each individual happy experiences as well as trauma and stress will manifest themselves by the *frequency* and *quality of play* – say, in the sensitivity to invitation, willingness to accept a certain play role, intensity and length of play, probability of expressing pain and vocalizing, etc.

Precise, exhaustive, and stimulating as Fagen's account of play is I think it possible, however, to arrive at a common function of play which would come into force in all the forms mentioned up to now. As outlined in Section 1, I conjecture that the main function of play is, *firstly,* to facilitate the individual's "first steps" in life, at a time when mistakes in problem solving are less dangerous than later in adult life, and, *secondly,* to automatize any problem-solving attempt that comes to grips with some such recurrent problem – be it ways of movement, manipulation of objects, or managing social relations. This dual function of play, which is here compared to "feed-forward" mechanisms of the nervous system, does not contradict the functions analysed by Fagen – it appears to be a necessary prerequisite and antecedent for them.

It becomes plausible when we consider the importance of play in *the development of skills.* Fagen compares this with the acquisition of an aptitude for writing computer programmes. This skill, which, it appears, can become routine for some people, consists of drawing up a series of operations which, executed in the right order, solve a given calculation problem. Here Fagen analyses those rational errors (so-called "bugs"), which often crop up when the different parts of a programme are synchronized, thereby linking up the different operations (or "subroutines"). These irregularities in the programme, which strongly resemble the ungainly, clumsy movements of a young animal learning a whole new practice, must be eliminated by better attuning ("debugging") the various operations and their parts. The importance of play in the development of such capacities may also be formulated by this question: In the process of synchronising the parts of an operation, does there – and should there – exist combinations of behaviour which do not enter into the refined end-product? – If so, would play function as a kind of catalyst in this connection? Fagen sees clearly that in order to answer such questions, we would be in need of *a deductive theory of (optimal) learning by trial and error.*[81]

As suggested in Section 8, above, it is possible to arrive at such a

76 A. Brownlee, "Play in Domestic Cattle in Britain: An Analysis of its Nature", *The British Veterinary Journal,* vol. 110, 1954, pp. 61-62.

77 R. Fagen, "Exercise, Play and Physical Training in Animals", in P. P. G. Bateson *et.al. Perspectives in Ethology,* Plenum Press, New York 1976, vol. 2, pp. 210-11.

78 R. Fagen, *Animal Play Behavior,* Oxford University Press 1981, p. 476. (Hereafter abbreviated to A.P.B.)

79 R. Fagen, *op.cit.,* p. 308.

80 R. Fagen, *op.cit.,* p. 349.

81 R. Fagen, *op.cit.,* p. 320.

theory by starting off with the principle of *action and selection.* What Fagen describes so aptly as "*debugging almost correct plans*" seems to me to refer essentially to the same effect, which must be at work in the progressive simplification of patterns of movement throughout the acquisition of a given motor skill. The thesis proposed here as an explanation of this effect assumes, as implied in Section 7, above, that individuals in a population who developed a form of learning, where incorrect and superfluous patterns of muscular innervation became eliminated through "repeated" performance – thereby freeing those individuals from being fixed in stereotyped interactions with the environment – have in the long run been favoured by natural selection.

Such a conception seems to conform to recent neurophysiological theory, which – without using terms like "*debugging*" or "*progressive simplification*" – describes the progression observed in learning as the result of a gradual transfer of control from one part of the brain to another. According to David Marr, to whom Fagen also refers, the "automatization" of a skill is brought about by *an interplay between the cortex and the cerebellum,* through which information about the innervation pattern of a given movement will be stored in the cerebellum thereby making it possible to execute the movement *without continuous, cortical control.* It is supposed that the gradually-refined programmes of movement thus established in the "unconscious" cerebellum liberate the cortex little by little, so that its "higher" parts may take care of more complex problems: "... cerebellum becomes an organ in which the cerebrum can set up a sophisticated and interpretive buffer language between itself and the muscles."[82]

Pursuing Fagen's idea, we may say that *play facilitates the liberating effect upon the higher centres of the brain,* since play provokes better than most other activities a progressive simplification of patterns of movement which go to make up the various skills of the individual. Such "liberating effects" can be demonstrated not merely for motor cortex but also for other parts of the cortex; thus the *effect* of playfulness in problem solving (*e.g.* "improvising on a given trial") could be that of making way for the break-through of a good idea–*i.e.* the phenomenon alluded to by words like "*Gestalt-switch*", "*Aha-Erlebnis*", or "Incubation Effect in Creative Thought".[83] As far as movements are concerned, we may assume that play helps the animal "to get unstuck"[84] from different types of blockings, rigid sub-routines and stereotypes. However, this does not happen, as Fagen supposes, via a new *generalisation* in the new context of action, but rather through the new situation putting the innervation pattern to a new test. The result is either another simplification of the pattern or a more or less deliberate "leap" by the animal towards a new variant of the behaviour, which implies new constellations of muscular innervations.

As Fagen stresses, neurophysiologists have also observed that the context in which a skill is first attempted is of the utmost importance for the future development of that skill.[85] Contrary to the behaviourist conception, which more or less explicitely supposes that any form of behaviour may start any time (because behaviour is supposed to be the result of repeated reactions to repeated stimuli), the conception defended here implies that in real life there is no strict repetition of behaviour, and that there are phases of development which are critical for different types of behaviours. From animal studies it is known that exceptional and disturbing situations influence behaviour, change problem solving and repress play. As with the case of Martina, exposed in Section 7, strange behavioural sequences easily occur in such situations which, upon closer analysis, turn out to be reminiscences of earlier attempts at solving similar problems in other contexts.

Since, in the course of evolution, *homeothermic* animals have gradually become less dependent on behavioural releasers, something other than "sign stimuli" has become necessary to facilitate a whole sequence of activities. So during their gradually prolonged ontogenetic development these animals have become capable of a more diversified adaptation to their surroundings, mainly thanks to the higher degree of freedom their activities gain through exploration and play. *Poikilothermic* animals did not evolve the same way; this perhaps explains why they were not in need of "inventing" play, since their way of life continued to be monitored by sign stimuli. We may therefore propose the thesis that for the young of homeothermic animals play became the "non-serious" way of running through, testing, and perfecting the typical behavioural repertoire of the species: *play thus renders the first attempts at problem-solving behaviour less fatal than if it had to be executed for the first time in serious adult life.* This is why the various "excercise"-theories, mentioned above, only partly explain play:

82 D. Marr, "A theory of cerebellar cortex", *Journal of Physiology* (London) vol. 202, 1969, p. 468.

83 A. F. Petersen, "On the incubation effect in creative thought", in Hans A. Krebs *et.al. The Creative Process in Science and Medicine,* Excerpta Medica, Amsterdam 1975, pp. 50-51.

84 R. Fagen, *A.P.B.*, pp. 321-22.

85 R. Fagen, *op.cit.*, p. 322.

a fundamental characteristic of play is that it functions as a "*feed-forward*" *mechanism* for most species-typical behaviour. This way of releasing species-typical behaviour in non-functional and "non-serious" settings allows the young individuals of higher species to accomplish a whole series of activites which remain inaccessible to young individuals of lower species, since the latter continue to live in fixed "serious" relationships with their surroundings without much possibility of variation. Slow ontogenetic development, as well as infantile immaturity, has proved to have a "survival value", since under such circumstances young individuals may, with the help of play, integrate individually acquired experiences into their behavioural repertoire before their adult life begins.

The idea of play as a "feed-forward" mechanism opens up the possibility of *improvisation* and *inventiveness* in the life of higher animal species. They are not just blindly aggressive machines which have to be push-started with the aid of ludic behaviour, as Symons resolutely maintains.[86] Fagen notes that individuals playing with objects and with members of their species have often been seen to develop their phenotypical qualities in directions exceptional for their own species. This leads one to believe that *ludic activity depends more on improvisation than on play defined as a game with fixed rules;* should living beings therefore have a game to play, then the rules of it are not determinist but indeterminist. On this point even Darwin seems, at times, to have conceded too much to the world view of classical mechanics.[87]

As ludic activity most often consists of spontaneous concatenations of species-typical behaviour patterns, the individual player may happen to produce new combinations, *i.e.* genuine innovations, new behaviour sequences and patterns of interaction which are ultimately also new, compared with what normally occurs in the species. Why this constant simplification, with its subsequent increased chance of improvisation, does not more often lead to durable new creations for the player, and thereby for the species, is perhaps due to one or more out of several factors: (i) The player must *discover* the moment when something new he is doing happens to be a solution to some felt or known problem (living beings may solve problems without knowing or remembering them); (ii) A discovery must have a *motivational significance* for the player or for others present (it must give a kind of reward by solving a problem); (iii) The invention must be *assimilable* in already existing schemes (problem solving happens through an interaction between instruction and selection); (iv) For a new solution to develop as *a tradition* in a population, the individual who makes the discovery must belong to a *high-status* part of the population (ironically "status", which is often founded in power relations is also, in Man, confused with "authority" with regard to experience and knowledge).

Kathy Sylva and her colleagues showed that children's play with objects, which later had to be used in a real problem, facilitated the discovery of the solution to this problem.[88] The functions and effects of play, mentioned above, seem to comply very well with the instructive characteristics of play given by these authors (although they did not allow sufficient time in their experiment for a normal progressive simplification to occur in the children's mastering of their attempted solutions to the problem): play is regulated *autonomously* and is of a *voluntary nature;* by shifting the interest from the *result* of an activity to the *activity itself,* play diminishes the risk of failure and frustration; play makes possible the integration of behaviour patterns into uncommon sequences as well as the formation of new constellations of objects; by virtue of its repetitious and improvisatory character, play is a most efficient means of arriving at innovation and problem solving.

10. Play as a Phenomenon of Feed-Forward or Anticipation

We have seen how play occurs solely in relaxed situations where the individual is freed from major external and internal constraints and fears. This is also why play does not seem to be an activity which can be controlled by simpler feed-back mechanisms, as is the case of food and liquid intake, temperature regulation, and the like. Play rather supposes such needs as having already been satisfied. We are then led to the assumption that play belongs to a higher control system (*System c*) at

86 D. Symons, *Play and Aggression: A Study of Rhesus Monkeys,* Columbia University Press, New York 1978, p. 200.

87 D. Symons (*op.cit.*, p. 199) quotes Michael T. Ghiselin for rightly saying, it seems to me, that "Darwin may be considered the Newton of biology"; however, Symons thereby intends to attribute to Darwin a determinist point of view, which Darwin – albeit influenced by the success of classical mechanics – never held.

88 K. Sylva *et al*, "The Role of Play in the Problem-Solving of Children 3-5 Years Old", in *Play*, pp. 244-57.

which level feed-back control is less important than feed-forward or anticipatory control.

By analysing "the means-end relationship" in behaviour and its paradoxical reversal, Karl Pribram was able to show – although only indirectly – which types of behaviour are controlled by a feed-back process and which are controlled by an anticipatory process. In quoting an example borrowed from George Mace, he asks the following question: How does a man or an animal pass his (or its) time when all, or nearly all, of his (or its) basic needs are provided for almost before they announce themselves? – In answering this question, the case of the domestic cat is first considered: "We might expect that having taken its food in a perfunctory way it would curl up on its cushion and sleep ... But no, it does not just sleep. It prowls the garden and the woods killing young birds and mice. It *enjoys* life in its own way ... *This is the reversal of the means-end relation in behavior.* In the state of nature the cat must kill to live. In the state of affluence it lives to kill."[89] A similar reversal of the "means-end relationship" in the life of modern Man is also seen to lead to "ludic" activites: "When men have no need to work for a living there are broadly only two things left to them to do. They can 'play' and they can cultivate the arts. These are their two ways of enjoying life ... 'Play' is characteristically an activity which is engaged in for its own sake ... In play the activity is often directed to attaining a pointless objective in a difficult way, as [in the case of] a golfer ..."[90] As may be easily seen in the normal life of animals and Man, affluence is not a necessary requirement for play to occur, but does facilitate it. What *is* necessary is rather "a relaxed field" around the individual, as described by Hutt[91] – this implies, of course, that most of the basic needs of the player are satisfied, which is often the case of the young during infancy.

From this imagined case it appears that play cannot be explained by a mere feed-back mechanism as with the satisfaction of primary needs. When performed, play functions rather as a means of ready *anticipation* of future changes, for which it prepares the individual, so that he can *adjust* according to a certain *programme of action* or *aim-structure* (*System c*). This type of mechanism is known in technology as a "*feed-forward mechanism*", and a simple example of this would be a temperature regulator which causes the temperature to rise in a room when the temperature *outside* has been dropping for a *certain length of time*.

The feed-forward concept has also been applied only quite recently to organic systems.[92] Thus, in Pribram's view, feed-forward is considered to be a mechanism which exercises a neural control on the sensory input and efferent output of organisms. Moreover, feed-forward control is held responsible for the "bias" (Pribram's terminology) with which individuals approach a problem cast in real life.[93] As in von Holst's account of the interaction between the central nervous system and the peripheral organs, the assumption is that higher-level *feed-forward* anticipates change in the field of operations, whereas lower-level *feed-back* is responsible for the execution of skills necessary for attaining the overall objective. In von Holst's terminology, this may result in either (1) *re-afference,* which indicates the smooth accomplishment of an action which cancels out its own impulse, or (2) *ex-afference,* which is the case where the action executed leads to an unexpected perception requiring the pursuit of new action.[94]

Following these suggestions it now seems possible to gain new insight into the structure and dynamics of activities which are of interest in the

89 K. H. Pribram, *L.O.B.*, pp. 294-95. In the example quoted by Pribram, Mace makes the following allusion to one of the evolutionary significances of play: "The fact that life can be enjoyed, and is most enjoyed, by many living beings in the state of affluence ... draws attention to the dramatic change that occurs in the working of the organic machinery at a certain stage of the evolutionary process."

90 K. H. Pribram, *op.cit.*, 295. Together with Mace, Pribram admits that many people work because they take pleasure in it, but then work has already become a sort of "play". However, contrary to these authors I do not hold *play* and *game* to be one and the same thing, although games sometimes *are* carried out like play; in fact, sufficient evidence supports the view that play may lead to something new, which is rarely, if ever, the case for games with fixed rules.

91 C. Hutt, in *Play,* p. 204.

92 See, for example, A. J. Vander *et al, Human Physiology – The Mechanisms of Body Function,* McGraw Hill, New York 1980, pp. 130-31. – By applying this idea to the analysis of different controls in motor systems, Masao Ito ("The Control Mechanisms of Cerebellar Motor Systems", in F. O. Schmidt, *The Neurosciences – Third Study Program,* M.I.T. Press, Cambridge, Mass. 1974, p. 296) characterises the feed-forward mechanism this way: "Compared with the feedback control, the feedforward control is much more sensitive to external disturbances and changes in parameters." (Cf. note 37, above, where Hutt argues for the special motivational status of play without, however, considering play as a feed-forward phenomenon.)

93 K. H. Pribram, *L.O.B.*, pp. 90-91, mentions certain "*intention patterns*" in visual cortex which occur *prior to* the onset of a response. Such a feed-forward control can even take into account certain images and illusions which, according to Pribram (*op.cit.*, pp. 91-93), nearly always occur in relation to the execution of movements. (This should satisfy those who maintain that play implies fantasy and thus, for this reason, claim that only humans can be said to possess play in the true sense of the word.)

94 E. von Holst, *G.A.*, pp. 144-46.

present context. Thus, feed-forward could lead the individual to either (1') *repetitive behaviour* (*i.e.* non-cooperation), if he is incapable of facing up to complexity and novelty, or (2') *improvised behaviour,* if he is able to cope with them. It is thus the *programme of action* with which the individual is equipped which is decisively important here; this *aim-structure* (or "bias") determines the type of action (repetition or improvisation) that an individual may produce in a situation inviting or instigating action. (See further the Addendum, below.)

This proposal appears to be in agreement with the ideas advanced by John Szentágothai on feed-forward and feed-back,[95] according to whom the function of *feed-forward is to bring the agent into the right "field of operation"*, after which simple *feed-back* can be brought into function to begin, or continue, correcting the mistakes which the given type of feed-forward has brought with it. I assume that such sharing of responsibility in the control of movements is present in our second case of improvised behaviour – namely in activities such as exploration and play.

When feed-forward is applied to a situation which, for one reason or another, is too complex for the individual, it can "bias" his approach differently. Thus, he may try to reduce the complexity of the situation by opting for a more reduced field of operations, after which the feed-back mechanisms employed lead to a kind of behaviour which can be controlled by a set of uniform strategies (Szentágothai speaks of a feed-forward which disguises a complex system). In my view, this kind of restrictive control resembles the behavioural "*stop phenomenon*" seen in various forms of *stereotyped reactions* in psychotic subjects.[96]

The question now is this: Why will feed-forward be used by certain individuals to anticipate complexity and to obtain *ex-afference,* and by others with the aim of reducing complexity and obtaining *re-afference?* – Or in other words, why do some children develop an aim-structure which makes them explore and play, while others stay with a very simple aim-structure which almost prevents them from interacting or from exploring the environment – and, *a fortiori,* from playing?

11. Neophilia and Play versus *Neophobia and Stereotypy?*

Recent studies on social interaction between the baby and the adult world have shown that from quite early on the infant displays a number of dispositions for nonverbal communication and cooperation with others. There are even degrees of that, and Colwyn Trevarthen has pointed to two types of predispositions, which he has boldly named *primary* and *secondary intersubjectivity* indicating how they steer bio-social interaction differently.[97]

It is, however, not because these skill-structures and motivation-structures (*Systems a and b*) in the human infant are preprogrammed that nothing may go wrong in their functioning. We may be able to explain why this can happen to the developing individual, when we come to understand how such structures unfold themselves in the course of ontogeny. The following (abridged) description by the linguist Noam Chomsky on the unfolding of *language capacities* in the small child is particulary useful and clear for understanding some of the logic behind such "unfolding processes": "There is a close connection between the scope and limits of readily attainable knowledge... The point is, if we really were plastic organisms, without an extensive preprogramming, then the states our minds achieved would simply be a reflection of the individual's environment, and would therefore be extraordinarily impoverished. Fortunately for us, we are preprogrammed with rich systems that are part of our biological endowment. Because of that, and only because of that, a small amount of rather degenerate experience allows us to make a great leap to a rich cognitive system which is essentially uniform in a community and, in fact, roughly uniform for the species... In particular, our innate language faculty, because of its highly restrictive and quite specific properties, makes possible the growth and maturation of a grammar in our minds – what is called 'language learning'. The system that develops in the mind is comparable to what has developed in other minds, also on the basis of very limited experience. We can then say anything we want over an infinite range. Other people will understand what we say, though they have heard nothing like it before. These achievements are possible

95 J. Szentágothai *et al*, "Conceptual Models of Neural Organisation", *Neurosciences Research Program Bulletin*, vol. 12, 1974, no. 3, pp. 346-48.

96 J. Richer, "Human Ethology and Mental Handicap", in F. E. James *et al*, *Psychiatric Illness and Mental Handicap*, Glaskell, London 1979, pp. 103-13.

97 C. Trevarthen, "Communication and Cooperation in Early Infancy: A Description of Primary Intersubjectivity", in M. Bulowa (Ed.) *Before Speech – The Beginning of Interpersonal Communication*, Cambridge University Press 1979, pp. 340-43; and "Secondary Intersubjectivity: Confidence, Confiding and Acts of Meaning in the First Year", in A. Lock (Ed.) *Action, Gesture and Symbol*, Academic Press, London 1978, p. 184.

for us precisely because of our rigid programming. Short of that, we would not be able to accomplish anything of the sort."[98]

I conjecture that what one may call normal, species-typical social behaviour unfolds itself in the course of a similar interaction process: the child must be *surrounded and stimulated* by other human beings in the manner of our species in order to *develop* his preprogrammed structures of basic skills and motivations for social intereaction and comprehension. If this does not happen, the structures in question may *cease functioning* – perhaps even "atrophy" – and the child may become a case of *psychogenic psychosis* such as those diagnosed under the label of autism.

What the autistic child possibly lacks, I suggest, is a fully-developed control system capable of guiding his social behaviour and thus of establishing a *basic emotional confidence vis-à-vis* the world (a "security base") which eventually will allow him to act upon the world using a feed-forward control that permits plastic adaptation to change. Such a system does not seem to develop in children with severe autism, which may be the reason why these children abhor change and are incapable of most play and problem solving.

One of the really important facts about Harlow's baby monkeys was that, having been deprived of the company of other members of the species to spur on the development of their preprogrammed aim-structures, they proved unable to acquire normal social behaviour later. In its place, an extreme *neophobia* installed itself making all future learning practically impossible; these isolates never became masters of their actions in relation to any kind of surrounding. Instead of exploration of and interaction with the environment, these deprived young showed different forms of stereotyped behaviour, characterized by a high degree of invariance in certain apparently aimless movements.

Such animal and human stereotypes may be considered as behavioural reminiscences of previous stages of development, during which a repeated testing of the movements in question normally has the function of spurring on the control of the body's position and movement.[99] For reasons still unknown, which may be connected to the *effects of deprivation* mentioned above, psychotic individuals often continue performing these movements after having gone through their corresponding stage of development. Contrary to normal motor and skill development – in which we witness an automatization of body control and a progressive simplification of movements – in behavioural stereoptypes there is no "diminishing" in the behaviour patterns after they have been shaped by the first trials. A hypothesis shared by students of animal stereotypes is that the initial act or behaviour is fixed by some biochemical mechanism – not yet known – which, according to the views set forth above, prevents progressive simplification and eventually the total elimination of these apparently aimless stereotyped movements.

It would thus appear that a necessary condition for the development of neophilia is that the individual is able to start off from a "security base" located among other members of his species. From here on, it may be sufficient for maintaining this openness toward the world that the developing individual gradually loosens his emotional attachment to his caregiver in tempo with his own explorations of the environment. Such an exchange or "give-and-take" process seems to be the pretext for nature's invention of feed-forward control in exploration and play.

12. Concluding Remarks on Changes in Feed-Forward Control during Biphasic Approach and Withdrawal

"Nature's phantasies outrun those of Man", Hans Christian Andersen remarked in his novel *The Improvisatore,* and what he had noticed was undoubtedly the great many variations nature produces out of her endless improvisations on a much smaller number of ingenious themes.

With this warning in mind the present monograph searches for such themes in animal's and child's play and problem solving using Popper's situational logic as a means of analysis. By way of criticism it is argued that play cannot be understood on the basis of traditional psychologies of learning – not because nobody knows what play is, this somehow we all do – but because learning theories have so far only used simple, inductive models for behavioural phenomena employing false conceptions of repetition, reflex, conditioning, association just to mention a few.

An explanatory system is proposed which suggests that certain modes of behaviour of organisms are *endogenously controlled* by a set of skill-structures, motivation-structures, and aim-structures which appear largely

98 "The Ideas of Chomsky – Dialogue with Noam Chomsky", in B. Magee, *Men of Ideas – Some Creators of Contemporary Philosophy,* British Broadcasting Corporation, London 1978, pp. 213-14.

99 E. Thelen, "Rhythmical Stereotypes in Normal Human Infants", *Animal Behaviour,* vol. 27, 1979, pp. 699-715.

"inborn" and functionally autonomous. Animal and child play is viewed as a feed-forward phenomenon, which helps the developing individual to progress faster in solving life's avenues of problems by applying progressive error-elimination to attempted solutions in the course of repeated testing – much like the way in which babies develop their body and limb control through the so-called "rhythmical stereotypes" just alluded to. Thus play ensures that species-typical behaviour is released and repeated sufficiently often so as to be thoroughly tested, changed and automatized – ready for later use in solving similar and different sets of problems, in combination with learned and higher-level activities.

With regard to the child's *attitude* to problems and problem solving, there will be many degrees between the extremes of *being attracted by problems* on the one hand and of *fearing problems* on the other. Simplifying matters, it is suggested that this attitude development be considered a special case of how preprogrammed aim-structures – aim-structures guiding early behaviour with respect to basic approach and withdrawal reactions to other living beings, to things and situations – become biased by experience in either of the two directions. As reviewed above recent psychobiological research has demonstrated that the small child is equipped with behavioural "mechanisms", which seem to function according to Schneirla's theory of *biphasic approach and withdrawal processes.*[100] In short the theory says, that for organisms in the early ontogenetic stage *low intensity stimulation* tends to evoke *approach reactions* while *high intensity stimulation* tends to evoke *withdrawal* reactions with reference to the source.

Such systems of preferences with regard to low and high intensities of environmental stimulation are undoubtedly of importance for the establishment of a basic emotional orientation toward congeners – the "basic trust" – which is indispensable for further developments of normal species-typical behaviour. Deprivation experiments with primates have demonstrated that a disturbance of the normal unfolding of these biphasic reactions towards living beings and inanimate objects invariably disturbs the functioning of other aim-structures normally activated later in life. In children with infantile autism it even appears as if the aim-structures controlling species-typical social interactions have "atrophied".

As outlined above, it is suggested that the predominant approach – or "set" – of a child toward persons, objects, and situations arises as a result of the formation of a *feed-forward system,* which will vary according to how "smooth" or "difficult" the unfolding of the aim-structures has been which guide the various approach and withdrawal reactions. In most normal children we see that, although the child may be scared from time to time of new and complex situations that demand his action he will eventually come round to doing what is needed of him in order to solve problems at hand: we may say that feed-forward *anticipates complexity* enabling the child to make an approach. In the case of the autistic child, however, his way of functioning will bias his whole approach to life differently: here feed-forward will *reduce environmental complexity* leading the child to cut himself off repeatedly from situations demanding his reaction or intervention.

Viewed in this way feed-forward functions may simulate the biphasic processes of approach and withdrawal. The next question will then be: given a certain level of sensitivity on the part of the child, what kind of high intensity stimuli – or, perhaps, lack of low intensity stimuli – may facilitate the withdrawn attitude of the autistic child? If such answers can be found we may hold the key to an understanding of this problem and to a possible prevention of a group of psychogen psychoses from arising.

100 T. C. Schneirla, "An Evolutionary and Developmental Theory of Biphasic Processes Underlying Approach and Withdrawal", *Nebraska Symposium on Motivation*, vol. 7, 1959, pp. 1-42.

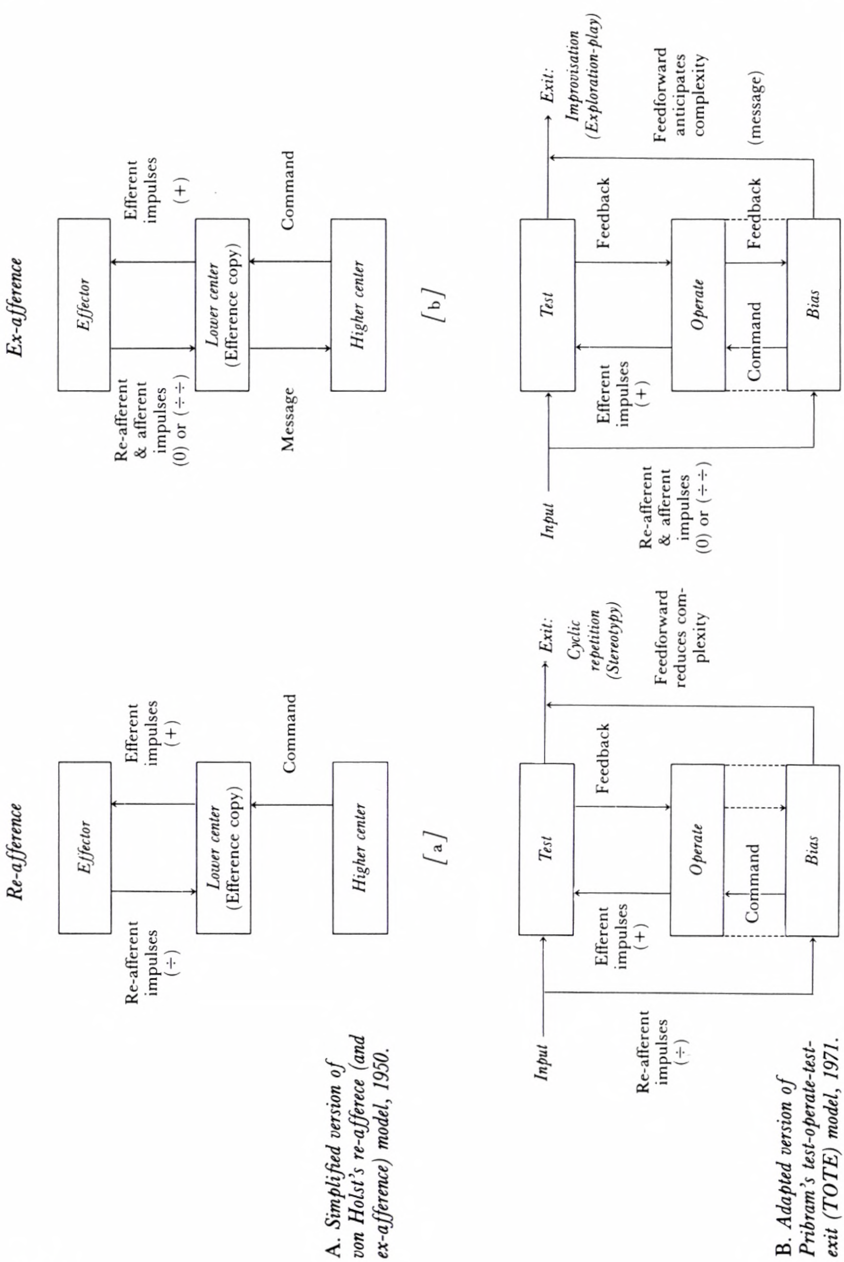

Fig. 2.

Outline of von Holst's and Pribram's models for re-afference and ex-afference effects of different behaviour. (Explanation in text.)

Addendum: Some Remarks about Feed-forward Control during Improvisation and Cyclic Repetition

In an attempt to understand how either improvised or stereotyped behaviour may come to dominate the individual's reaction to the world, I propose to apply Erich von Holst's *principle of re-afference* (*and ex-afference*) much in the same way as it has been used by neuropsychologists in recent years to account for certain aspects in motor development. By doing so it seems possible to gain some insight into the structure and dynamics of certain behavioural traits, the control of which it has been, and still is, difficult to explain. (In the following, reference is made to *Fig. 2.*)

A. *von Holst's re-afference model.* This model was originally designed to account for various interaction phenomena between the central nervous system and the peripheral organs, and the basic working principles of the model may be summarised as follows (see *Fig. 2a & b*): A motor impulse, *a "command"*, from *a higher center* causes a specific activation in *a lower center,* which gives rise to a stream of *efferent impulses* (a so-called "*efference*") directed towards *the effector* (*i.e.* a muscle, a joint, or a whole limb). During this initial process *an "image" of the efference* (a so-called "*efference copy*") is stored in the lower center. The effector, thus stimulated by efferent impulses, produces a train of *re-afferent impulses* (a *re-afference*), which returns to the lower center where it nullifies the "*efference copy*" by superposition (like the negative of a photograph superimposed on its print).[1] As the action of the two components are complementary, the whole *efferent* part of this process can arbitrarily be designed as *plus* (+) and the afferent part as *minus* (÷). When the "efference copy" and the "re-afference" exactly compensate one another (as illustrated in *Fig. 2a*), nothing further happens. This is the *re-afference process* at work. When, however (as shown in *Fig. 2b*), the total afference is small or lacking (0), then a *(+)-difference* will remain in the lower center and exert an influence on the movement in question; when the total afference is too great (÷÷), then a *(÷)-difference* will arise in the lower center and ascend to a part of the higher center as *a message* which will normally produce a perception that gives information about a discrepancy between the perceived world

1 E. von Holst, "Relations Between the Central Nervous System and the Peripheral Organs", *The British Journal of Animal Behaviour,* vol. 2, 1954, p. 91.

at rest and in motion. This is the *ex-afference process* at work. (Changes in afference can, of course, also come from external sources, which are fed through the senses into the lower center from where they ascend to the higher center as messages about a (+)- or (÷)-difference in this lower center.[2])

B. *Pribram's test-operate-test-exit model.* This model was devised in order to account for the central control of receptor mechanisms, a question which "reflexiology" had left unanswered. In the model, which is here adapted to the present context (see *Fig. 2c & d*), it is assumed that some kind of *test* is always carried out on the *input* which reaches the organism. After this initial test the resulting information is *fed back* into the *operational level,* where it may meet with a motor *command* exerted from the higher level – here named *bias*. Together with a train of *efferent impulses* toward the *test-unit* (the effector) this resulting information is then *tested again* (taking into account the total internal and external situation), after which the movement (*exit*) can occur. As in von Holst's model, one may herafter assume that a stream of *re-afferent impulses* directed towards the higher level (*bias*), and a *feed-back* toward the lower *operational level,* cancel out the initial command and efference. This process may continue in different ways according to the kind of *feed-forward* control that descends from the higher level.[3]

Following these ideas of von Holst and Pribram the *feed-forward mechanism* is thought typically to *anticipate immediate or future changes* in the organism's environment. It is a mechanism by means of which an organism may establish a pre-adaptation to an expected change in the environment – analogous to a temperature regulator which increases the temperature in a room provided the temperature *outside* the room has been on a descending curve for a given period of time. With respect to our problems of explaining behaviour, I assume that feed-forward control can lead either to *improvised behaviour* (as indicated in *Fig. 2d*), if the individual is able to cope with environmental complexity (*ex-afference*), or to some sort of *repetitive behaviour* (as indicated in *Fig. 2c*), if the individual is unable to cope with environmental complexity (and thus prefers *re-afference*).

This interpretation seems to agree with the views on feed-forward and feed-back put forward by Szentágothai, where the function of feed-forwards is said to be to bring the agent into the right "ball park", or field of operation, after which simpler feed-back loops can be brought in to carry out standard operations and correct errors. In the case of a cat preparing to pounce, feed-forward makes a gradual adjustment of the whole operation: the "orientation part" controls the position of head and body as well as the tension of the muscles, while the "execution part" controls the release and continuous correction of the direction of the movements, and when the cat finally has landed on the mouse, the synchronisation of the consumatory movements will be controlled more or less automatically by feed-back control.[4] This is clearly a situation where the same theme is played through with variations each time – mainly in the feed-forward part of the catch.

When feed-forward is applied to situations which, for some reason, are too complex for the agent to handle, feed-forward may bias the approach of the agent differently – *i.e.* the complexity of controls can be reduced if the agent "chooses" a more limited field of operation. The then employed feed-back mechanisms will often correspond in simplicity to such a situation where the agent has limited his own operational field. The executed behaviour will thus conform to some simple model of the situation which can be controlled by a set of uniform strategies monitored by feed-back chains.[5] With reference to the present context, this kind of restricted control resembles the behavioural "*stop-phenomenon*" seen in various forms of stereotyped reactions of psychotic individuals.

2 *Ibid.*

3 Karl H. Pribram, *Languages of the Brain,* Prentice-Hall, Englewood Cliff, New Jersey, 1971, pp. 83-96.

4 J. Szentágothai et.al., "Conceptual Models of Neural Organization", *Neurosciences Research Program Bulletin,* vol. 12, 1974, no. 3, pp. 346-47.

5 *Op.cit.,* p. 348.

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