VERHANDELINGEN DER KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN, AFD. NATUURKUNDE

EERSTE REEKS, DEEL 30

A SOLUTION OF THE PROBLEM OF MIND AND MATTER

by

J.H. GREIDANUS

NORTH-HOLLAND PUBLISHING COMPANY – AMSTERDAM, OXFORD, NEW YORK – 1981

ISBN 0 4448 5527 0

AANGEBODEN IN DE VERGADERING
VAN 27 SEPTEMBER 1980

CONTENTS

SUMMARY*

The proposed solution starts from the assumption that the subjective experience of a human mind is continuously becoming recorded in material "coding" symbols in the associated nervous system. The recording is to occur decentralized over all cells of the system and to physically concern their discharges and inhibitions. The symbols used are to be microphysical, e.g., small (nucleotide-base?) molecules. The recording events then become physically predictable (with respect to timing and exact identity) in terms of quantummechanical probability only. These probabilities lead in the recording aggregates to a symbol statistics which has to agree with a coding symbol correlation statistics of information theory as originally recognized in printed messages. The interrelation problem of mind and brain is in effect solved by reinterpreting quantummechanics as the a priori basis of probabilities which are information–theoretical in nature. This implies reinterpretation of microphysical randomness as "lack of encoded semantics" or "coding potentials of microphysical symbols involved not used". The limitation of predictability to probabilities becomes due to the requirement (of information theory) that predictions shall be "objective", that is disregard the encoded semantics. The sustained coherence of the recording nervous processes is recognized as being due to the emotion, advance effect of the future, inherent in their mental complement. It resides in consciousness and not in physical space-time. The relation of mind and matter so defined appears to agree with complementarity as defined by Niels Bohr, a concept effectively providing the general solution of the problem. The quantummechanical complementarity of particles and waves can be argued to be equally due to the basic polarity of past and future. In addition to particularly solving the problem of the human (and animal) mind, generalized psycho-physical comple-

* See also the list of propositions at the end of the paper.

mentarity seems to assign semantic complements to the physical process in the universe and to the process of the evolution of life on the crust of the earth. Both would thereby become fundamentally purposive. The standard ''quantummechanical'' neuron which responds to perturbations of synapses by arriving spike signals is ideally matched to abstraction-type and instruction-type brain circuits. Accepting a variant moreover capable of spontaneous discharge to back up psychological initiative, it also perfectly fits into the serially operative circuitry of the high brain. The construction permits simple interpretations of many elementary properties of the mind, ranging from perception and memory to the classical Freudian sexual neurosis, and (even) telepathic phenomena.

1. INTRODUCTION

The solution presented hereafter of specifically the problem of the relation of the human mind to its material substratum, primarily the brain, and more generally: of "the psycho-physical problem", has evolved from intuitions born in its author's mind when he was, in the mid-thirties, a young student of theoretical physics in the university of Amsterdam. Throughout the next 45 years they gradually grew out to what is believed to be an essentially complete theory. The development was slow and difficult since it had to occur parallel with a professional carreer in aeronautical engineering chosen soon after graduation in 1937 (and ending in 1976 with retirement at the age of 65). Several attempts were made, in the course of time, to bring the work to the attention of others, but none of them was successful. Publications concerned were possibly all premature and too intransparent. Still, they helped to break up a certain initial isolation. With the present paper, which inevitably (as all earlier ones) has more the character of an essay than of a scholarly scientific work, the author is making a final attempt to present his ideas, in an again improved and very carefully worded form, to the world community of scientists.

Doubtless, the spreading of the ideas implied in the proposed "solution" has also been hampered by the circumstance that they have their origin in the physical sciences. The implied logic, modes of abstraction and assessments of relational opportunities are comparable to those characterizing the fundamental theories of physics, particularly quantummechanics. From neurophysiology, the natural science of the nervous processes, not more than bare fundamentals are needed. Just so for psychology. This is held to be quite natural, for it is physics which controls the existing (highly sophisticated) insights in the nature of the stuff at the one side of the borderline: matter and energy. The greatest and constant obstacle blocking the way to a solution of the interrelation problem was, as a matter of fact, the apparent complete lack of opportunity to integrate the entirely

unphysical aspects of "mind" with the firmly established properties of matter, an integration to be performed without in any way hurting the beautiful consistency and very elaborate verifications of physical theory. The subjective processes in a human mind indeed can only be approximated by aid of the categories of psychology: memory, will, perception, learning, initiative, thought, etc.

The theory developed refutes the probably rather common view, that the mind/brain relation utilizes some still unrecognized natural degree of freedom of "hypercomplexity", of conditions implying such countless numbers of variations that a proper assessment of opportunities implied is still failing. This "feeling" vaguely puts all hopes on the (current) pursuit of ever finer detail in neurophysiology and molecular biology. The solution actually has the highly attractive type of (relative) simplicity characterizing the fundamental theories of physics, quantummechanics and relativity theory. It can only be understood when the capability and willingness to follow corresponding ways of deduction and reasoning are available. Naturally, the biological and psychological sciences will in the end have to supply the (not yet disclosed) precise organization of the relation.

2. THE PROBLEM OF THE HUMAN MIND

The proposed solution of the problem of the human mind starts from the view, accepted as a working hypothesis, that the overwhelming memory features of almost anything mental leave no doubt that the process backing up the mind in the brain must basically be a *recording* process. This idea is, of course, not foreign to other considerations of the mind/brain problem, but the experimental analysis of the functional processes in the nervous system has still not revealed with any clarity how such recording is organized and this has left the proposition vague and effectively unexplored. As ever, most of the work remains concentrated on those features of the nervous processes which are with some clarity associated with the processing of information. This has shown that the subjective processes in a human mind are in some way *encoded* into a vast system of elementary events per cellular unit of the nervous system, per "neuron". The events are *excitation* by pulse signals ("spikes") arriving at synaptic receiver stations at the cell's surface through fibres coming from other neurons, followed by *responses* in any of two forms, *discharge* or *inhibition* as soon as stresses generated (assumed to be additive in time and space over the synaptic system) have become "sufficient". The one response leads to new spike signals travelling through the cell's ramifying offshoot, its "axon", to other cells, and the other achieves silent restabilization. Both alternate "as the case requires". The addition property of synaptic excitations should be a possibly quite complex "weighted" addition in line with the fact that the distribution of synapses over the cell's surface, the intricate dendritic extensions included, unmistakably implies a high degree of organization. It is, further, important to know that discharge responses are frequently compound in this respect, that they lead to one, two, three, or even a "volley" of spikes, obviously providing additional information encoding opportunities.

Since any new proposition has to be compatible with this experi-

mentally well-founded functional picture of the individual nerve cell, recording as postulated can only occur decentralized over the entire nervous system and physically concern the neurophysiological events mentioned, in particular the discharge/inhibition response alternative. This is (possibly against current views in neurophysiology) assumed to be *strictly systematic,* any excitation which arrives at the cell's synapses sooner or later provoking any of these two (restabilizing) "decisions". Consequently, any neuron's cumulative record will, at least as far as the cell participates in the processing of variable information, naturally exhibit highly significant *aperiodicity* reflecting the utterly irregularly alternating decisions. The process is, even disregarding all the natural complexity of its physiology, doubtless also complex from a functional point of view. It is, thus, not really amenable to speculative reconstruction. For one thing, it cannot easily be expected to leave alone the excitation patterns provoking the response decisions (firmly accepted main objects of the recording). The solution might imply additional decentralization (within one cell). The point, however, is that all such detail and precision is in a way irrelevant, the mere idea of recording with only minimal specifications (soon to follow) on its own appearing to be powerful enough.

The decentralization, practically inescapable implication of any straight recording proposition, can at once be foreseen to lead to an equally radical and seemingly hopeless reintegration problem if it is really to back up memory. Probably, this is the true reason why such propositions have never received serious attention. The difficulty will prove to have been seriously misunderstood (because of the "exclusion of randomness", see later).

The next question concerns the material symbols in which the recording can be supposed to occur. Obviously, (at least) one, an "*n*" symbol, is needed for inhibition, while discharge probably requires more than one "*y*" symbol to cover possibly implied spike multiplicities. Further, more than one discharge symbol may be needed to discriminate between (classes of) associated activation patterns. Again, a definite answer is impossible without experimental guidance. Surely, however, symbols used have to be *microphysical,* that is no larger than small individual molecules. It is quite plausible that the four small nucleotide-base molecules known from the chromosome (DNA) codification of the life processes again find use

in this new coding requirement. Then, to each molecule, a common (deoxy)ribose-phosphoricacid carrier chain element has to be, or become, attached to maintain order in the accumulating record.

The small size of the symbols employed, effectively the smallest one physically possible in the conditions encountered, should firstly make it understandable why the recording has still escaped the grip of the experimenter. It resides in the still only superficially explored, exceedingly complex molecular background of the gross neurophysiological processes. Secondly, only with such small units can a life-long accumulation ever find a place in the space of a cell. But imperative is the monomolecular size because it is absolutely essential that the recording process escapes the objective causality of macrophysical processes. This is necessary since the reintegration problem mentioned above is unsolvable on a causal basis. The proposition, finally, attractively refers the heart of the nervous process back to the same physical category to which the coded control processes of life are *known* to belong. Conceiving the human mind as the ultimate development of life in general, the idea that its material basis would be simpler is unrealistic.

Assuming that the recording does use the nucleotide-base symbols, it will, obviously, yield novel, original DNA (single stranded, perhaps) and cannot have anything to do with the common copying processes of existing DNA in growing and dividing cells. Much more might it be comparable to the (DNA) mutation processes known to have recorded (!) organic novelty during the evolution of life. It shares with them the rather particular constant choice opportunity of the symbol required.

Recording as proposed makes, in any neuron concerned, provisions necessary (i) to convert the stress generated by spikes arriving at synapses into a perturbation effective at the microphysical decision level, and (ii) to amplify the microphysical discharge choice back to spike strength. The inhibition choice may simply fail to trigger this amplifier process. Further, uncommitted symbols are continuously to be kept ready for use in a suitably organized reserve.

The elementary events achieving the recording per neuron are the additions of "next" symbols at the shifting endpoint of the accumulated aggregate (the "matrix" of the neuron), or of one of them if they exist in plural. The physical theory to be applied is quantum-mechanics, the advanced general theory of microphysical processes. It

resolves these processes into sequences of sudden events, "transitions" between "states" of the system considered. The states are characterized by (1) geometrical equilibrium configurations of atomic particles involved, (2) particle vibrations about the equilibrium positions and (3) orbital properties of participating electrons. Properties (1) and (3) determine the internal state energy and vibrations (2) (together with a small electron motion share) the heat motion energy, that is the temperature if the system is embedded in a wider environment. The most dramatic issue of the theory is that transitions to occur can be predicted in terms of probability only. Sharper predictions are deemed *impossible* "because microphysical events actually happening are just *random* within the frame of probabilities imposed". The theory contains rules to determine the set of probabilities mentioned and the set of "possible" states. On this basis, classical causal physics can be reconstructed because physical matter normally consists of numerous microphysical (sub)systems in much the same condition. Then, the laws of great numbers of classical probability theory state that (future) events will, with overwhelming probability (that is with practical certainty) occur with relative frequencies very close to the predicted probabilities. Residual random fluctuations will disappear with the inverse square root of the number of subsystems as a factor. Since probabilities per subsystem are quantummechanically well-determined, the same holds for resulting relative frequencies which, thus, become (e.g., as intensities) indistinguishable from causal issues of prevailing conditions.

Erwin Schroedinger was actually the first (in his little book "What is Life?", ref. 5) to apply quantummechanics to aperiodic molecular aggregates, the chromosome control centres of living cells. It appeared that the *mutations* now and then touching these structures are just transitions between configurational states, any possible one having its own in principle well-determined probability of showing up in the prevailing conditions (e.g., at the prevailing temperature) in the next interval of time. Again, improvement of this prediction was held to be impossible. There is extensive evidence (particularly from experimental work with "artificial" mutations) supporting Schroedinger's conclusions. Now, for the aperiodic recording aggregates of neurons, the additions of next symbols, each time either n or some type of y, were proposed to be events provoked by spikes which arrived at the surface of the cell since the last decision. The nearest

quantummechanical description of this case is that of configurational transitions triggered by an environmental (probably chemical) *perturbation*, the prevailing "stress" E_c. The probabilities for the addition, in the next interval of time Δt, of an n or any y (y_1, y_2, etc.) symbol can be written as

$$n(S, T, E_c, a, b, \ldots)\,\Delta t \quad \text{and} \quad y_k(S, T, E_c, a, b, \ldots)\,\Delta t \qquad (F)$$

with S denoting local physical structure, T the temperature, E_c the prevailing stress and $a, b, \ldots$ possible additional chemical factors in the environment. The stress E_c is definitely a compound condition; it sums up synaptic excitations which are neurophysiologically known to (at least) fall apart into groups "provoking discharge" and "provoking inhibition". The chance that nothing happens during the interval Δt is $1-(n+\Sigma_k\, y_k)\,\Delta t$. This allows for further signals to arrive. Any such signal will modify the stress level and, hence, the applicable probabilities. The specifications imply that the expectations for n or y_k, irrespective of the timing, are for a given condition E_c,

$$\frac{n}{n+\Sigma_k\, y_k} \quad \text{and} \quad \frac{y_k}{n+\Sigma_k\, y_k}$$

respectively. It is worth noting, that there are no signs that the relation between stresses E_c and the spikes touching the individual synapses would anywhere leave the *macrophysical* process level. The synapses processes are known to be minutely organized, but they always seem to involve specific molecular materials in at least a thousand or tenthousand fold. The relation is thus essentially causal.

At this point, it becomes of interest to note, that there exists another theory, again a purely statistical one, which in principle can be applied to processes of the kind considered. This is information theory (Shannon, ref. 4). Subject matter of this theory are "messages", entities with two aspects: (i) a *semantic* one determining the value of the message, its "sense" to an "assimilating" subject, and (ii) a *material* one, an ordered row of "encoding" physical symbols, e.g., printed letters. The second aspect serves the conservation, transfer and possibly multiplication of the message. It is found that, *largely independent of whatever semantics messages may convey,* encoding symbols show up an "objective" feature of order which is *statistical* in nature. Each single symbol

("monogram") appears to occur with a rather typical relative frequency, and so do the pairs of successive symbols ("digrams"), etc. Word space and punctuation marks are counted as additional (equivalent) symbols. The whole statistics, clearly a *correlation statistics,* can be determined numerically by counting out symbol polygrams in a large set ("library") of available messages. This appears easy for monograms (single letters) and progressively more laborious for the larger combinations. Beyond letter tetragrams, e.g., things become pretty unfeasible. The same analysis can also be carried out for the class of "higher" symbols represented by "words". It is, then, already very difficult to proceed beyond digrams. The usefulness of the exercise lies in resulting opportunities to automatically, that is machinewise, reduce the number of errors in messages which have become spoiled by "noise" in the course of transmission. Now, returning to the mind/brain process, the subjective, mental aspect can quite reasonably be identified as "the semantics of the messages" and the physical, nervous one as "the encoding material process". Then, the correlation statistics of the material symbols, counted out, e.g., in a long *record*(!) of past experience, also yields, for the next symbol to appear at the momentary end of the record, a prediction in terms of probability which is independent of whatever the mind might subjectively contain at that moment. This reveals a unique opportunity to solve the interrelation problem of mind and brain: the two statistical approaches shall be *equivalent*. The one, that of quantummechanics, shall a priori yield the a posteriori defined issues of the other, information theory. This makes the relation of mind and brain similar to that of semantics and encoding symbols in information theory. The identification shall imply that the claim of quantummechanics asserting that microphysical (coding) events are *random* within the statistical frame supplied by the theory, is replaced by the statement of information theory, that improvement on the predictions in terms of probability is (for processes of the kind considered) impossible because they are desired to be "objective", that is to *disregard* the semantic aspect. In this rewording, the restriction "for processes of the kind considered" can, remarkably enough, safely be cancelled if the reference to the semantic aspect of the process is extended by the simple clause "if any", and if randomness is *defined* as "absence of encoded semantics, that is of encoded sense, intention or purpose". This, unexpectedly, *for the first time*

furnishes a definition of the concept of randomness which, in spite of its liberal use by physicists, had never received an adequate definition. The one just established fills this gap and shows that the difficulty was due to the fact that the concept is fundamentally *psychological* in nature. With this revision, the concept of randomness *logically* becomes *inapplicable* to all mental processes, their material codifications included. These processes, hence, satisfy a "principle of exclusion of randomness". This, by the way, looks conspicuously similar to Pauli's exclusion principle in quantummechanics which forbids, for arbitrary physical processes, any two electrons to occupy the same quantum orbit.

The identification of the statistics of quantummechanics as a symbol correlation statistics in the sense of information theory is supported by the equivalence of the associated source references. The probabilities of quantummechanics are specifically determined by physical structure (S in (F)) around the spot where the transition is to occur, and those of information theory by symbol correlations counted out in a sufficiently long record of the type of experience in question. Now, "surrounding physical structure" exactly provides such a source for through the recording it does represent experience accumulated to date!

The correlation statistics resting in the recording aggregates of the nervous system is *stable* in this respect that it is becoming *imposed* on additional experience which, becoming recorded, will thus confirm its basis. This observation, however, at once suggests an intriguing modulation; "compliance with statistical requirements", namely, can never be an *exact* condition. Short sequences of events, e.g., cannot themselves exhibit a clear statistics at all. If *mental effort* could be assumed to use this freedom to try *improvement* on past achievements, then resulting successes, becoming inserted in the basis, will slowly change the inherent statistics in the new direction. This, then, will open up opportunities for further improvement through persistent effort and exercise. This seems a very simple additional explanation of the capabibility *to learn* which all psychophysical agents possess. Additional, because another type of learning is known to exist which is based on the development, again on a sustained exercise basis, of synapse selectivities and efficiencies. It leads to accelerated "desirable" responses. This mechanism is, at least for a large part, bulk chemical in nature.

There is a completely independent reason why microphysical recording processes leading to large aperiodical molecular aggregates do not easily fit into existing physical theory. Conventionally, the formal definition of the probability concept is both in physics and in classical probability theory constructed by aid of relative frequencies of events occurring in large ensembles of identical specimens of the system considered. When, e.g., the disintegration of radioactive atoms is said to be controlled by probability, the chance that a particular atom will disintegrate in the next interval of time Δt being $\lambda\Delta t$, then this is to mean only that the number of atoms by counting found to disintegrate (that is the change $-\Delta N$ of the number of intact atoms) will be practically equal to

$$(-\Delta N =)\ N\,\lambda\Delta t.$$

This yields by integration the well-known law of radioactive decay

$$N = N(0)\ e^{-\lambda t}.$$

When it is desired to demonstrate that this well-determined result is nevertheless due to chance phenomena, the *large* set of N atoms is divided into many *small* subsets (of N_{sub} atoms each). If, then, the disintegrations in the time Δt are counted for all subsets separately, results are obtained randomly fluctuating from the one subset to the other and only on the average yielding $N_{sub}\ \lambda\Delta t$. The relative fluctuations decline with $N_{sub}^{-1/2}$. Now, human experience is so exceedingly variable that any of its aperiodic records, taken over a significant time, necessarily becomes *unique*, which leaves no opportunity at all to ever produce experimentally "large ensembles of identical specimen". The formal definition of physical probability thus breaks down in this case. The difficulty undermines the formalizations (*F*) which were supposed to control the recording processes (in their two aspects, the timing of the recording events and their identity). Now, the ensemble requirement looks exaggerated indeed for processes of the kind considered since there are already at least two opportunities to define probabilities by counting: firstly the spike system in the whole brain. Spikes are relatively strong and in their rates and origins not escaping detailed investigation and counting. Corresponding registrations, the electro-encephalograms, tend to confirm the stochastic irregularity of neuron discharges in the brain and quite directly support approximations of the type (*F*). Presently rather of an

overall nature, they could imaginably become perfected to experimental documents permitting verification of specific discharge probability claims. Secondly, the records themselves, which keep track of virtually all transitions, in principle provide opportunities for counting specific frequencies. Suchlike procedures, obviously, perfectly match the proposed revision, extension, of quantummechanical theory.

Countings as considered, which will generally tend to be useful only in conjunction with precise knowledge of structural details of the entire nervous system (particularly of its wiring), might, by the way, though in principle possible, invariably meet quite narrow *feasibility* limitations, even to a point where the distinction of the impossible against the unfeasible becomes unreal. Nature seems to oppose (particularly in the complexity of the nervous system) analytical proceedings aimed at "objectively" resolving questions which have already a direct answer in the subjectivity of the mind. Breaking of the psycho-physical code may forever remain *unfeasible.*

The proposed generalization of quantummechanics still leaves unexplained how the psycho-physical mind/brain process forges the established objective trend of the physical component to extend the records of the past some "statistically compliant" steps into the future, to *coherence* lasting indefinitely. On its own, the physical process is inevitably to degenerate into randomness irrespective of how clever probabilities implied would have been tuned to the requirements of a subjective counterpart. The responsible factor (exactly the one excluding randomness) must lie in the very nature of subjective semantics. It is conceived as *"emotion"*, that is as advanced effect of the future complementary to the after effects of the past as conserved in terms of facts recorded or acutely noticed in the surrounding material world. This rests on the insight, that the strong affections commonly identified as "unambiguously emotional" result from the intense bright or dark colours which the inductions of the future now and then assume as reflections of positive perspectives or unassailable constraints (by facts accomplished). Along a descending scale they attenuate via joy and grievance, wish, regret, hope and fear, to never failing elementary sense and valuation. Emotions, accordingly *have no* description in physical terms. Their

seat is *consciousness.* Their descriptive concepts are purely *psychological* in nature (as used in the comments presented above). These descriptions are invariably resting on memorized experience, on affections locked up in the recorded past as reflections of the original colours in which the ever shifting present appeared. It is possible to disregard the affective aspects of emotion and to concentrate on the *operational* one which results from their bearing on the future-induced *will.* This reduces emotions to volitions, intentions and purposes, generally satisfactory representations in rationalizing considerations.

With the nature and role of emotion recognized, the fundamental principles taken to control the psycho-psychical relation are complete. Developed with emphasis on the unit building element of the nervous system, the neuron, they can rather easily be shown to provide a degree of basic understanding of the functioning of the whole brain. As a last preperation to this point, the standard "quantum-mechanical" neuron, which either refuses to respond to signals arriving at its synapses or transduces them into a code symbol of its own, one or a small train of spikes sent away through its axon, may be argued to have at least two straight derivatives. The one is a *mechanical* device missing the choice faculty. It always responds in one and the same way as soon as excitations received surpass a certain threshold. Consequently, one and the same response symbol is again and again becoming added to its record, which, thus, becomes an ordinary crystal. This, in confirmation, is well-known to invariably invite extension with its constituent material unit. Such mechanical neurons create nor store significant information. They eminently suit the *automatic* functions residing in the nervous system (as there are many). They have no direct relation to consciousness. The other derivative is a standard neuron destabilized to such an extent that probably always existing, but negligible, *spontaneous* response probabilities become significant. This gives them the capability to *initiate* spike processes in the nervous system, eminently suiting the psychological faculty of *initiative.* Their existence can scarcely be doubted. They should carefully be distinguished from neurons which develop *small* inhibition and discharge tendencies in reply to (initially) weak synaptic activations. This, namely, implies long (average) delay of the

decision which, when occurring, might easily become misinterpreted as an initiative. Such strongly hesitant neurons doubtless exist also. The millions of neurons in the brain capable of spontaneous discharge are responsible for the emphatic *restlessness* characterizing the mind. They make it *impossible* to halt mental process for any significant time by off-loading the sensory channels and *willfully* imposing complete silence. The subversive initiatives which break up such attempts are particularly well-known to people suffering of sleeplessness. They are due to the circumstance that millionfold finite probabilities *must* lead to corresponding relative frequencies of events or the laws of physics are void.

With respect to the brain's wiring, the developed picture of the neuron cellular units very straightaway yields three types of circuitry so narrowly suiting three very basic and elementary nervous functions that they can scarcely fail to be true. The first is almost directly represented by the standard neuron, which is capable of replacing a whole pattern of spikes – firings of other neurons – by its own code symbol, a new spike or small train of spikes. If all such positive neuron responses are really encoding some semantic element, then this replacement is psychologically equivalent to defining one new element on the basis of a set of "lower" ones. This is a process of ("integrating") *abstraction.* The selectivity of the replacement is due to the compound nature of signals received and the filtering properties of the synaptic-dendritic systems. The interpretation suggests that abstractions will generally be carried by whole neurons, a suggestion certainly not strange to current experimental work. Secondly, the same device obviously permits the generation of time sequences of discharge responses in "horizontal" systems of interconnected neurons. The process might progress through the system from the one neuron to the other by distributing the one's response signal to perhaps many others, all but one of which – the "right" one – answering with inhibition. With each neuron accepted to represent a semantic element, this psychologically reproduces the serial processes of thought. In contrast to abstraction processes which start from material offered in parallel, the processes of thought are as a matter of fact naturally singular time-ordered evolutions on the scene of consciousness. It is natural to expect initiative in the neuron systems concerned. With the semantics carried by the linear sequence of events, one should (again) expect a

liberal use of compound response signals (spike trains) and selective synaptic filtering in the process as is necessary to simulate running purely on a correlation statistics of neuron responses when the semantics is disregarded. Further, inhibition would, in the high brain, become much more common than discharge. Thirdly, again the same standard neuron, sending its response signals through branches of its axon to a horizontal set of "next" neurons, is perfectly suited to activate a whole system of neurons capable of translating the activation on the basis of additional interconnections within the set into very precise timings and new spike patterns. Psychologically, this is a process of minutely controlled *differentiation* of one original *instruction.*

Given these simple wiring principles, we may expect to find, embedded in the immense complexity of the brain, ascending circuitry trees which start from the receptor cell systems of the various sense organs and which insert in the fluctuating detail intercepted from the surrounding world, probably in a few steps, the interpreting abstractions which make the world familiar to us in terms of objects and agents resting or moving about in a three-dimensional spatial frame. The integrating abstractions continuously appear on the scene of consciousness dressed in all the detail which the receptors have been able to pick up. It is this simultaneity in the conscious picture which makes it difficult to recognize how and in how many steps the final interpretations were developed. At their top ends, the sensory abstraction trees should merge with type 2 circuitry of the "high" brain. This is to decide about the ways and modes in which the "self", as one agent among fellows, (within constraints) shall participate in the external game. This requires the purely abstract conceptual processes of thought, consideration, extended evaluation, imagination and fantasy to which the type 2 circuitry supplies the encoding and recording provisions. Finally, conclusions are to become converted into *action* in the external world. This requires differentiation, doubtless again in several steps, of the *instructions* into (through sustained exercise) precisely organized, timed and coordinated activations of millions of muscular cells. This is done in type 3 circuitry, which, thus, must grow out of the brain "at the other end" as trees descending to all cells of the muscular system.

This simple picture is flexible enough to accomodate many additional provisions, e.g., short-cuts and feed-back channels

(additional to the powerful feed-back which runs through the external world from action to perception). All-important is the existence, in the human brain, of an auxiliary nervous subsystem mapping all high abstractions into a set of *verbal* symbols coupled to an action mode not directly tuned to intervention but to *communication* with fellows.

If, in the end, we ask for the most fundamental conditions allowing the wonderful nervous instrument considered to function as a faithful servant of the mind, then molecular aperiodicity and quantummechanical control rank high in the list. The aperiodicity (which is to be free from whatever trace of randomness) normally represents the variability of recorded human experience. Now, the instrument is known to start functioning at a quite definite *moment of birth.* At that moment, personal experience is zero, but yet the youthful agent clearly is conscious and capable of adequately organizing elementary life-supporting action. So, the cells of the nervous system must even at this early moment contain some conditioning aperiodicity. This cannot have its origin in experience and must, hence, be *innate.* It encodes *the instincts,* endowments of life in general to the mind of the individual. The aggregates concerned could straightaway be parts of chromosomal DNA. This would imply continuity of the code from the origins of life up to the case of the mind of man.

The theory presented is powerful enough to explain a great many elementary properties of the human mind. A résumé is given in part 4 of this paper, except for one highly important case still to receive attention hereunder. This concerns the mind's all-important reconstruction faculty from memory. Generally, two modes of this faculty are distinguished: (1) recognition (identification) memory and (2) recall memory. The first is, in a way, rather trivial. It hinges on the selective coding values which the neurons of the abstraction circuits have obtained on a recorded assignment basis. Current experience is processed through these circuits and invites neurons to deny or announce their semantic reapplicability. In contrast, recall is a complex, difficult and active mental process aimed at conscious revival of possibly complex sequences of data or events (hypothetically) presumed to have been witnessed in the past. Difficulties, imperfections

and limitations frequently encountered are invariably due to the radical decentralization of all recording. This might at first sight even seem to make the reviving repetition exercise totally hopeless. The number of possible random recombinations of any length, of symbols resting in available old records just is tremendous beyond all measures. Fortunately, however, randomness *is excluded* in psychophysical processes. This reduces the number of *possible* recombinations to a very small fraction of the one just contemplated. It implies that the "true" recombination is only to be discriminated against *fantasy*. Now, if the revival pursued is of low abstraction level, the original records will, still, linger amidst numerous very comparable notes all missing much semantic character. This makes the search operation still *unfeasible,* unless the original events were relatively very recent. Then their recording symbols are laying close enough to the momentary endpoints of the linear aggregates to make themselves felt in conditioning of extensions. This makes the events reconstructable. Or the original process has implied purposive memorizing through learning exercises involving repeated, essentially identical recording. Then, the exceptional multiplicity of established notes should even for trivial data facilitate retrieval. If, on the other hand, the revival desired contains highly abstract elements, which normally are semantically very characteristic and selective in their possible recombination-relationships, then this property should strongly facilitate the reconstruction, even after considerable time. The discrimination against fantasy is in this case (and similarly in other cases) to occur by trying to extend the revival in time and detail, checking for inconsistencies indicating error. Very helpful are written notes relying on conservation by bulk physical materials.

The low-level case seems to adequately cover "short time memory" as recognized by the experts, and the high-level case long time memory. It is only so, that we now understand why the one is short and the other long.

Given that recalls necessarily start from initiative and use further initiatives in the searches involved, the possible implication of lowly-abstract data shows that the sensory abstraction channels must contain, in addition to the ascending main circuitry, nerve fibres descending from the high brain into almost the sensory peripheries.

Memories from times very long ago, from rather early youth, are probably possible only because events concerned have, for some

reason or another, been (tentatively) reconstructed frequently in the course of time. Every reconstruction has been rerecording, and exactly this may keep the events accessible. Chances are, of course, that none of the returns to the old times has really been fully accurate. Repeated return may enhance this. So, dear old memories might, at old age, gradually have become more legend than truth.

3. PSYCHO-PHYSICAL COMPLEMENTARITY

The principles explained in the preceding section in an attempt to solve the problem of the relation of the human mind to its material substratum, primarily the brain, characterize these two processes as *complementary*, that is as aspects of one integrated psycho-physical process which cannot be reduced to each other and which, hence, unconditionally are both to receive consideration if the combined process is to be properly understood. They have scenes which, consequently, have also to be conceived as complementary: consciousness and space-time. The mutual relation was one of *coding*, the physical brain processes recording, writing out, the semantic experience of the mind. Symbols used taken to be microphysical, the continuation of the process became, at any moment, physically undetermined except for certain quantummechanical probabilities. These would soon lead to randomness and chaos if the emotion residing in the mental complement did not take over control, imposing *coherence* to the brain process, lasting compliance with the subjective semantics. This characterized emotion as an advanced effect of the future, as fascination by the possible or oppression by the impossible (given the realized-as-recorded), as pre-emanation of freedom and constraint.

The physical brain processes thus became, fundamentally, noncausal. The motivating affection of emotion, however, activating the will and determining intentions and purposes, inserts in psychophysical processes a kind of psychological causality; the question "why so?" generally has a quite clear answer. As a result, mental processes can definitely be investigated scientifically. Emotions, once properly recognized, may well permit very far-reaching and reliable predictions securely permitting verification. The corresponding science is psychology. It is applicable to the semantics of the mind as far as it manifests itself in communication and behaviour. There are ample opportunities for experimental approaches. Thus, psychology and physics (physiology) become scientific disciplines which, applied

to organisms with a mind and a brain, permit insights and predictions which, again, are in some way complementary and which, in all fairness, must be considered as of equal value. This means that psychology is to be rated as a science equally fundamental as physics.

It is striking to find that the idea of complementarity has earlier been used, as a matter of fact been invented, by Niels Bohr to clarify the curious relation which, in quantummechanics, exists between particles and waves (refs. 6 and 7). At the end of a rather difficult analysis, he arrived at the conclusion (i) that it was impossible to reduce the one pictorial approach to the microphysical world to the other, (ii) that specifically either the one or the other had to be used depending on the kind of question or problem submitted, (iii) that with proper care conflict would never arise in this way, and (iv) that the opportunity, and, even, necessity of the typical dual approach to reality was to be attributed to the break-down of causality in the microphysical world. This, in effect, puts psycho-physical and quantummechanical complementarity in exactly the same logical category. The correspondence, however, is extremely narrow indeed, as the following small consideration may show.

Starting with the quantummechanical case, particles are the interacting compact agents in which the material world has been resolved. They are groupwise characterized by specific values of typical interaction parameters: mass, electric charge, spin, etc. They determine the ponderable properties of matter by sheer addition of masses, and, potentially free to move about in space, the dynamic properties by interaction stresses and motion energies. The whole range of specific material properties is determined by (equilibrium) configurations of the heavy ones and orbital distributions of the electrons. They reflect the balance of order and chaos in the physical world. The waves, in contradistinction, are abstract derivatives of the particle picture void of physical quality. In them, nothing physical really oscillates. They represent the prediction algorithm of the theory. They determine the stability of particle configurations and orbital electron distributions – that is of the "states" in which the system can exist – and in terms of probability the transitions of the one state into the other, the sudden events in which the change of the system has become resolved. Hence, they straightaway *refer to the future.* Transitions which, by the way, keep the energy balance level by converting any excess into a messenger package ready to report elsewhere about the

event; in many purely physical cases a ghostly particle racing out at the speed of light, conserving its message if need be over eons, crossing any distance, until somewhere absorbed in interaction with matter, a pigment molecule, perhaps, in some living retinal receptor cell.

Thus, it appears natural to conceive the particle representation of the physical world as the conserving registration of whatever anywhere is going on, as carrying the essence of what ever happened, as summary issue of the past, and the waves as a kind of primordial emotion lingering in the physical world, scouting the future, the possible against the realized. Rationally determined by the prevailing state of the particle system, they (still) belong to the past, but the *freedom* implied in resulting probabilities associated with opportunities to change, to evolve, clearly refers to the future and contains an irreducible element of emotion. In the human psycho-physical system these probabilities in effect smoothly connect up with the genuine emotion which leads the process into the future, indefinitely assuring its coherence.

Still, an entirely general mutual identification of quantum-mechanical and psycho-physical complementarity remains difficult because of the lack of any clear mental factor in conventional physical processes. In these cases, the microphysical change probabilities leading from past to future are known to discharge in randomness. This was, exactly for the reason mentioned, explained as "lack of encoded intention, coding potentials of material symbols involved unused". Now, could the difficulty perhaps be solved by assuming that this condition, randomness, chaos, lack of specific semantic complement, is *in itself* intentional, an organization *potential* purposively created in behalf of agents descending from some original psychic factor residing in the whole cosmos? The physical processes of the cosmos would, then, become conservations in matter in bulk to a universal semantic complement containing the intentional point mentioned. The human sciences investigating those processes would turn into attempts to transcode this semantics to the molecular symbols of the human brain. This operation would apparently with ingenuity and sustained effort bit by bit be achievable by proper interrogation of processes concerned. Obviously, such a consideration tends to leave the solid grounds of natural science, even inclusive psychology. It would not seem to allow proper verifi-

cation, although consistency to purpose could well be a suggestion indismissible for truly *understanding* the large-scale processes considered.

Another implication of the complementarity theory of semantics and coding symbols is the recognition of the evolution of life on the crust of the earth as a probably psycho-physical process. This process quite obviously uses the individual microphysical constituents of the material world as basic coding symbols, much the same as the human mind does. A discussion of this case, to the extent possible, is outside the scope of this monograph. Again, the sole straight consequence would be that the process becomes consistently purposive. This would resolve the existing confusion about this since long recognized property of the process.

The philosophical perspectives which the proposed theory of the human mind discloses because its subject is not only central to science but also to much traditional philosophy have been submitted to a first discussion in ref. 3.

4. ELEMENTARY PROPERTIES OF THE HUMAN MIND

The theory developed, with minor extensions, makes it possible to explain in very simple ways many elementary properties of the human mind.

a. Consider the proposed neurological basis of initiative: neurons capable of spontaneous discharge. They naturally are at home (as mentioned in section 2) in the seat of the serial processes, the high brain. They, as a matter of fact, are misplaced in abstraction circuitry since that has to report faithfully about the external world and so to exclusively respond to receptor signals, and also in instruction circuitry designed to execute high commands. Now, response transitions of standard-type neurons provoked by stress are generally also possible spontaneously, be it with very small (negligible) probability. If such neurons, however, could become significantly destabilized, then these residual probabilities could make themselves felt. Such destabilization, however, is physically known to invariably result from rise of temperature, that is from fever. Further, certain chemicals introduced into the internal environment of a cell may have such effects, e.g., alcohol and certain drugs. Spontaneous discharges unintentionally provoked in such ways in abstraction circuits will initiate nervous processes which have nothing to do with receptor signals but which, still, inevitably have a perception character. They could easily become misinterpreted as true perceptions. Actually, they are *hallucinations*, involuntary sensations caused by inordinate initiatives occurring in perception channels. In action channels, similar inordinate events should cause essentially uncontrollable muscular contractions. They are known as *convulsions* and *spasms.*

b. The agreement of the (y_k/n) response transition statistics of neurons determined by quantummechanics with a polygram symbol statistics of the semantics processed, psychologically represents an

anticipation property of the mind. The adaptation of the brain to the processing of experience is so well-organized, that "the unexpected scarcely can happen". However, the adaptation can never be perfect: sometimes the totally unexpected *does* happen. In such a case the brain is naturally compelled to hold on for a while: the appropriate interpreting abstraction has to be "constructed". Such a presumably somewhat panicky stop of the nervous process clearly corresponds with the *fright* which the totally unexpected invariably causes. It fades away as soon as the course of events has become properly assimilated. Since the anticipations have for a large part been developed under the pressure of experience, very young children are much more easily frightened than adults.

c. Common frightful experiences are the accidents, forms of unexpected possibly damaging violence or mishap. In cases of really serious damage, the sensitive brain processes may get out of order and immediate *loss of consciousness* may occur. If the damage has remained repairable, a fortunately not uncommon condition, consciousness will be regained as soon as sufficient good order has become restored. It can be predicted, that the victim will in this case in vain search for what has happened. The fright initially triggered simply prevented the halted perception process to reach the high brain before consciousness was lost. Hence, no initiative will succeed in picking up the course of events; corresponding notes are just failing in the high brain. *This explains the memory gap commonly found to cover serious personal accidents.* Conceivably, the gap could in favorable cases become eliminated later on. The organic recovery, namely, might become good enough to restore the whole condition which existed before the conscious black-out in the abstraction channels. Then, many neurons will return to the unresolved excitation condition existing when consciousness became lost and resume trying to relieve their stresses in fundamentally normal ways. The report may, hence, as yet reach the high brain. This will cancel the memory defect.

d. The recording process in the cells of the nervous system which supports mental activity is, again and again, to add a new y_k or n symbol to the existing record. These symbols must in some way have been taken from a symbol reserve which is either well-organized as a

part of the material provisions securing the recording or which still has the chaotic features of the watery solutions of the cell. This second case, however, is scarcely acceptable since it would leave the supreme nervous processes handicapped by annoying search operations. The watery solution, though, is doubtless the ultimate source from wich any organized reserve has to be replenished. The existence of such a reserve can only have pushed the search and sorting operations one step further away. The condition leads to a strictly organized and hence if need be swift consumption process supplemented by an inherently probably rather slow replenishment process. So, brain processes will inevitably now and then have to decelerate or at least certain reserves will become completely exhausted. Now, such deceleration is achievable for the sensory abstraction channels and for the instruction circuits, but, as explained in section 2, not for the high brain. This is inherently restless due to the many cells capable of spontaneous discharge. Hence, there must exist a seperate, specifically organized, process periodically silencing the high brain. Obviously, this must be *sleep*. All conscious organisms need it. It is a complex process.

e. There might exist at least two (mutually not totally exclusive) "methods" to inactivate the high brain. The first would use narcotic hormones carried to the otherwise restless centres by the organic fluid systems, just the same way as narcotic drugs must be supposed to have used to reach these centres. The second would make use of the natural inhibition faculty which all neurons, also those equipped with initiative, possess. It might be possible to keep the high brain inactivated for prolonged times by transferring a slowly-periodic "inhibition" pulse signal to an "unconditionally inhibitory" synapse of every neuron possessing initiative. The continuity of the inhibition would arise on the basis of natural refractory inactivation. The pulse system, being periodic, should have its source in a "sleep centre" consisting of mechanical neurons functioning beyond conscious participation.

Whatever is being proposed, complications soon appear to arise, proving that sleep cannot be a simple process. Obviously, this is in line with whatever is empirically known about sleep. With the first method, it is rather natural to assume that the manufacturing area of the narcotic hormones in the brain is in the sleep-centre, a neurologic

subsystem definitely known to exist and exert some form of control over sleep. Any centralized manufacturing (like this), however, must leave the distribution to the naturally unselective fluid systems. This is awkward for a measure to apply to the centres of initiative only. Experimentally, chemicals of the kind of narcotic hormones seem to have been detected in the brain, but not in quantities and with distributions which the experts would believe to be necessary for primary control of the process (ref. 9). A similar selectivity problem of course does not exist in the second case: the distribution of the sleep pulses is determined by the wiring which is to run from the sleep-centre to exactly the appropriate (diffuse) neuron system. Admittedly, no such wiring system is experimentally known to exist, but the wiring of the brain is anyhow a chapter of neurology crowded with unknowns. The more serious difficulties arise in the neurons affected. The periodic inhibiting responses of the cells to the periodic signals received cannot easily be assumed to be entirely common inhibitions since this would lead, in the cumulative records, to symbol strings which (i) have no semantic counterpart and which (ii) are periodic over such length that they would tend to *unlearn* more constructive responses. Against this it does not help that, in the high brain, relatively long inhibition symbol strings must be common (see earlier) and that the probabilities associated with spontaneous discharge are, per neuron, naturally very small only (or initiatives would become so frequent and crowded that their adaptation to serial semantic control would cancel away). A next serious objection against method II is that it would seem to imply massive use of inhibition recording symbols (n), a queer property of a provision aimed at replenishment of recording symbol reserves. Thus, the inhibition will, per neuron, probably have to be achieved by aid of auxiliary provisions separated from the main functional system and activated from "their own" synapse. They should prevent the useless recording of each arriving pulse. One would guess that the relation between the auxiliary and the main functional system of the cell would still involve, strictly within the boundaries of the cell, stabilizing narcotic chemical agents. Further guessing is improspective.

The "exotic" sleep-pulse inhibition proposition might not be taken really serious if it were not strongly supported by the following three additional arguments. Firstly, it should have a large "evolutionary" advantage over method I in that it leaves all brain com-

ponents with the exclusive exception of the centres housing initiative in perfect working order. In particular, sensory receptors and the whole associated abstraction circuitry remain in principle capable of picking up and interpreting signals from the external world and, hence, to detect alarm signals. They could not be accepted by the high brain, but some short-circuit to the sleep centre might stop it producing pulses at once. This would with similar speed cancel the inhibition of the high brain and restore normal working order. This would nearly immediately upon the alarm permit the organization of appropriate emergency action (given that the action circuits have ever remained ready to accept instructions). All this would, in swiftness, seem far superior to any unselective fluid-born narcotic inactivation process with its inevitably long restoration times upon the stopping of hormone production. Secondly, a slowly-periodic (6 cycles p. second) pulse system is empirically *known* to pervade the brain during deep sleep. It is indicated in the electro-encephalogram by the so-called δ-wave. Thirdly, the whole proposition is in line with a firm conclusion of one of the most famous experts in the scientific field concerned, I.P. Pavlov; "sleep is irradiation of inhibition into the active brain" (quoted from Scientific Monthly 17, 1928, I.P. Pavlov: The Identity of Inhibition with Sleep and Hypnosis). So, proposition II reasonably cannot fail to be part of the truth.

f. A sleep centre has long been known to exist in the brain, but how it did exert control was less clear. The developments just described characterize it as the source of the inhibiting sleep pulse system. They, however, do not clarify how it is controlled (except for its quick response to alarm signals). Obviously, artificial activation of the sleep centre would be the ideal way to induce sleep. None of the existing narcotic drugs seems to be so directed. Engineers believing in resonance might suggest that some relatively weak 6 cycles per second electrical signal focussed to the area might achieve it.

g. Accepting that sleep is essentially – that is disregarding complications doubtless existing – a condition in which initiative in the high brain is inactivated while all other nervous circuits are fundamentally in normal working order, it is at once clear that not all nervous activity need fail during sleep. Such "residual" activity should explain the old mystery of dreaming. The explanation is

doubtless effective, as the following list of experimentally confirmed elementary observations shows. Firstly, (i), sleep following deep exhaustion should be, and is, dreamless. In this condition almost all neurons should have used up their reserves and be unable to remain active. Conversely, light sleep should normally involve dreaming. Secondly, (ii), a normal source of residual activity in the abstraction channels is formed by residual excitations of sensory receptors by noises and sounds, flickering lights, discomfortable bodily conditions, etc., They, in effect, are known to provoke dreams. Thirdly, (iii), all neurons which have become activated by signals reaching their synapses but which are still hesitating with their decisions are in a condition of latent stress which may hold on till after the moment of falling asleep. They will try to get rid of their stresses, generally readily, and (in addition to perhaps many inhibitions) cause discharges in the abstraction channels shortly after the onset of sleep. Such discharges necessarily belong to dreams. Fourthly, (iv), it is the high brain, inactivated during sleep, which normally controls the top logic of all semantic proceedings. This type of logic must, hence, fail in dreams. Their semantics is left to the association logic which rests in the lower brain circuitry. So, dreams will normally jump erratically from subject to subject, image to image, without persisting consistency. There is really no mystery at all in this well-known typical property of dreams. Fifthly, (v), particularly strange dreams might follow upon long hours of intense worrying about nasty or nearly insoluble problems. This will engage the neurons at the top ends of the abstraction channels in restless dense activity, and provoke hesitation and residual stresses in abundance. With the high brain finally relieved by sleep, these stresses will seek ways through still operative circuits. The applicable association logic will permit them to step aside to least exhausted ones which, semantically, means to subjects and images foreign to those so restlessly explored in the preceding wakeful process. Similar strange dreams might, for much the same reasons, follow upon an exhausting day's search for the solution of, say, a scientific problem. Sixthly, (vi), dreams should be, and are, empirically difficult recall items. The reason is obvious: they cannot be picked up by initiative except at the tail end possibly penetrating into the high brain immediately after waking up. So, anyone desiring to write up his dreams should do so immediately after waking up. Seventhly, (vii), dreams should not normally involve (muscular)

action, for the inactivated high brain is exactly the station where accomplished perception is converted into action. Occasionally, dreams suddenly call for immediate action and meet. . . a condition of paralysis!

h. In order to halt the restless brain, initiative is the only function to be pertinently suppressed. Now, located in the high brain , do *all* cells of that region possess this spontaneity? Such questions are not easy to answer. However, as long as we stick to the very simple brain model developed, the best answer to this one seems to be *no*. Part of the cells of the high brain should be free of initiative. Firstly, this is indicated by the fact that heavy forms of dreaming exist which succeed in crossing the perception to action barrier, e.g., sleep-walking. This phenomenon even requires an operative action to perception feed-back. Secondly, the phenomena of *hypnosis,* which is doubtless closely related to sleep, remain to be explained. Both cases suggest that an "underground" perception to action channel remains passable in the nominally inactivated high brain. In hypnosis, the hypnotist would by mere suggestion succeed in switching on the sleep centre, thus cancelling all initiative. Next, he uses the operative sense and action channels and their passive underground interconnection in his victim's brain to pass on instructions and assertions, which are without opposition accepted and executed. This seems to confirm, that it is indeed exclusively initiative, the elementary prerequisite of independence, which has become suppressed. The fact that no recall of hypnotic "experience" is possible after waking up also confirms this. A recall *instruction* at the end of the exercise in hypnosis may make recall possible because it pushes the hypnotic process just over the border of the awaking mind, just as seems to occur at the end of dreams. Further, it is to be noted that the suppression of initiative really prevents even the vaguest distraction from the instructions of the hypnotist. This circumstance may also explain why *pain* can be suppressed hypnotically. It is only felt *when attended to,* which normally occurs because pain signals naturally insist upon attention and reject distraction. Attention, however, implies selective participation of initiative. The obtrusiveness of pain signals should thus cancel out during hypnosis. Finally, an awkward instruction passed on during hypnosis may fail to become accepted because it does not comply with the anticipation resting in the

nervous system. This means that it causes a fright, a sudden stop in the nervous process sufficient to break up the hypnotic condition.

It may be doubtful if such simple explanations can claim to be full truth, but they certainly are suitable to underline the all-important significance of the initiating faculties of the mind.

i. The two learning faculties of the mind, (i) slow evolution of the predisposing symbol statistics resting in the recording aggregates under the pressure of repeated exercise and mental effort, and (ii) evolutions in the synaptic/dendritic filtering provisions of neurons by "acetylcholine discharge quantification" or "calcium ion current quantification", again under pressure of sustained exercise, have already been discussed in section 2. It is perhaps useful to point out that the first can only be associated with neurons possessing aperiodic matrices, while the second can also reside in mechanical neurons. It is believed, that the preponderance of the second mode in the neurophysiological literature is due to the fact that most of the experimentation has exactly been performed with such relatively simple neurons and neuron systems.

j. The straight "identification" mode of the memory faculty (with its slightly hesitating "recognition" variant) undoubtedly arises (as explained in section 2) from the continuous processing of perceptional information through the sensory abstraction channels, where the objects and actors, properties and relations, sounds, smells and colours have their recorded representations. As carriers complete neurons or, perhaps, neuron clusters come into consideration: their interconnections and discriminating response tendencies are to control the semantic definitions involved. The semantic/symbolic allocations must have their origin in the personal past, but since continuously new useful elements are being encountered, new shapes and forms, new objects, new people, new names, the allocation process has to go on continuously. This implies that the brain must always contain virgin neurons and circuits to accept corresponding responsibilities. Accordingly no human being can be supposed to ever use up his whole brain. It is, of course, plausible that with rising age the still virgin areas of the brain will get ever closer to the periphery of the network, and it is also plausible that this not only holds with respect to circuitry, but also with respect to the blood

supply. Consequently, deterioration of the blood supply to the brain, as almost inevitably seems to occur through arteriosclerosis with rising age, has a parallel in progressive trouble with latest novelty, latest encounters, latest names. This is so clearly confirmed by experience, that the proposed nervous construction may also count as confirmed. It follows that, with natural death at last approaching, people will mentally withdraw to ever earlier periods of their life, to middle age, marriage, first love, childhood, just to ultimately retire through the gates of instinct to the relative immortal totality of life in general from which they were born.

k. *Imagination* is a mental faculty quite obviously controlled by initiative. It may be a highly abstract process, but it may also involve constructions of fundamentally perceptional nature filled in almost to the bottom with specific lowly-abstract detail (without ever running into confusion with true perception, as in hallucinations). The process is practized for the sake of the compound semantic novelty which it creates on the basis of the arsenal of elementary semantics stored in the nervous system. It may for inspection, stabilization or communication purposes call in supporting action, possibly generating recording notes or sketches rigidly conserved on paper. The faculty confirms the existence of descending fibres in the sensory abstraction channels permitting initiatives to activate lowly-abstract materials.

l. The reconstructing recall mode of memory seems with certain people to have an uncommon variant, an ability to generate so-called *eidetic* images of past perceptions, images which with respect to quality and detail effectively repeat the original perception. The case may possibly be explained by assuming an exceptional ability to record a visual image *in multiple* in one act of perception, e.g., by some exercise of "immobile staring and assimilating twice or thrice". This would at very superficial level lead to a very exceptional duplicate or triplicate record, exactly a condition making retrieval imaginably possible at this level.

m. The human mind lodges one instinct which has the particular property of becoming fully developed only at the age of puberty, some 12 years after birth. Once awake, it inspects experience on

opportunities for sexual encounters and enhances corresponding behaviour on a hormonal basis. The instinct is complex, endowed with initiative and residing in the high brain. Its rather late awaking confronts it with a considerable amount of recorded earlier experience, exactly referring to a period during which the youthful mind has to, and naturally will, accept educational guidance. It has later on to live with the conventional characteristics of the cultural environment in which it was born. Remarkably enough, the educational instruction may, at least in certain environments, have tried to establish in advance strong restrictions on the purposes which the sexual instinct serves. Now, normally, instincts are very powerful and cannot be easily restrained. However, the educational "rejection" may also employ powerful instincts, e.g., the religious one. It may, moreover, use highly authorative interdictions and refined forms of punishment. For girls there is (or in old times was) in addition the annoying and educationally exploitable fear of becoming pregnant when yielding to the instinct. Such circumstances may, finally, in unfortunate cases provoke very frightful experience in first sexually oriented encounters.

It appears, that such convergent deterring influences can generate very severe fear against any further sexual exploration. This will induce the victim to invariably reject every instinctive preamble on sexual engagements. In the language of the psycho-physical theory developed, this means that the peripheral neurons of the neurologic area in the brain housing the instinct will upon every signal reaching their synapses, in spite of the natural variability of their responses and (thus) with initially tremendous effort systematically select inhibition. Once done with some significant repetition, the learning faculty will make continuation easier. Ultimately, this will push away the natural aperiodicity of the instinctive (innate) bases of neurons involved by establishing *inhibition periodicity.* From that moment on, the habit will become mechanical, effortless and (almost) unbreakable. The conscious burden originally experienced has disappeared and a new equilibrium apparently achieved. Unfortunately, however, the centre housing the instinct is equipped with initiative and cannot be permanently silenced by cutting the afferent flow of signals at the periphery. So, nervous processes will (continue to) arise spontaneously in the centre and signals will be emitted with correspondingly oriented imagination and action values along unimpeded

efferent lines to the surrounding brain. They will be received as signals with a *foreign* origin conveying a totally incomprehensible message. The semantic agent residing in the centre has become *expelled* and forced to unintegrated interference of a truly *demoniac* nature. The victim thus finds herself confronted with the new problem of finding some relieving interpretation for the interferences experienced, in particular for the awkward behaviour features, visible to anyone, which the action component generates: the *psycho-pathological symptoms* of the condition. The interpreting fantasies will inevitably disguise the true origin. They will have to find silly, innocent interpretations for naturally sexually oriented impulses and action elements. They are, ever since Freud, called "symbolic diversions". To the expert psychologist, their true nature is easily recognizable. They belong to a standard "sexual neurosis".

n. Clearly, there is only one way to truly cure a sexual neurosis: eliminate the screening inhibition periodicity and restore the normal role of the instinct in the affected mind. This should not be impossible, for the inactivated neurons still contain beneath the crystalline inhibition symbol strings the original aperiodic codifications of the instinct. So, the response probabilities $y_k(S, E_c, \ldots)\ \Delta t$ should not have vanished completely, but merely become negligible. The still existing residual chances may be exploited by (i) purposively directing conscious experience again and again to the screen, counting that small probabilities may still make themselves felt when multiplied by numerous occasions, and (ii) have the patient spend greatest possible effort on detecting and understanding whatever "unusual" she finds occurring in her mind. One would expect that even a single penetration would manifest itself in confusion in the mind of the patient and vigorous (though probably still disguised) response of the instinct. The psychiatrist should watch for such signs and urge sustained effort to understand. Perspectives should rapidly improve with every next successful penetration, for the corresponding new records will spoil and ultimately destroy the inhibition periodicity. A kind of avalanche progress with the reintegration of the instinct may well be achievable. Recidivism should be prevented by not stopping too soon. Since the sexual instinct is naturally aiming at relations with someone of the other sex, one should not be astonished if a successful cure would leave the (female) patient in love with her

male psychiatrist. This may burden him with the additional task of carefully shifting the restored instinct to acceptable targets.

All this quite reasonably agrees with the characteristics of psychoanalytical treatment as designed by Sigmund Freud. The essentially simple considerations of this and the preceding paragraph bring about a wonderful confirmation of his genius. For one thing they make plain why his investigations of female neuroses so frequently led him to the sexual area.

o. One may wonder if no other cases could exist of extorted inhibition periodicity and if no other human instinct could become hurt. Taking the second question first, it is to be observed that no other instinct is known to exist maturing with such a long delay time as the sexual instinct. So, mishandling would, with the other instincts, have to start in very early youth and even then the instinct would not at all be found particularly pliable. The observation, however, does underline the importance of this early time of life. Worst of all would seem to be disruption of a baby's strong instinctive ties with the mother. This will lead to destruction of corresponding anticipation patterns, probably to the detriment of all later mental development. Such considerations, however, are essentially common psychology. With respect to inhibition periodicity, a feeling exists that this is a rather common "mutilation". If no instinct is directly involved, response trends of neurons of the high brain should be rather "neutral", ready to accept whatever relationally defined abstractions might usefully be taken over from experience, educational suggestions inclusive. So, inhibition periodicity might also "if useful" develop rather easily. Now, all human beings have the instinct of maximizing their understanding of the world they find themselves living in. This instinct is probably the most powerful driving force behind human culture. It has led to the development, by sustained talented cooperative effort during many generations, of cultural systems of high truth, religious, political, (scientific-)philosophical. Inhibition periodicity would seem to offer stabilizing protection to such systems in the individual mind by narrowing down the semantic field of the high brain, simplifying wide integration. It might develop almost unperceived by intially tentative, but in the end systematic rejection of refractory associations.

p. The concept of the "subconscious", introduced into psychology by people like Freud, obtains a strikingly sober representation in the psycho-physical theory developed. It is definable as the totality of recorded information in the nervous system inclusive the instincts and *minus* the readily accessible parts. The (superficially) mysterious aspect is exactly this reduced, erratic, difficult accessibility. It is now known to largely result from the radical decentralization of the recording process in the nervous system. This makes, as discussed in section 2, recalls dependent of a recording reintegration exercise which is easy only when events concerned are recent. Only then are original records still close to the momentary endpoints of recording aggregates, giving them a chance of making themselves physically felt to the endpoint transitions. Later on they become deeply buried and loose their individual physical influence except of their contribution to the correlation statistics which determines prevailing general transition tendencies. Access to the store backing up the subconscious part of the mind is, hence, rather a feasibility problem and less a matter of principle. The sensitivity of the recall faculty can probably be enhanced in several ways, in particular by suppressing distractions. Very helpful is doubtless a certain multiplicity of recording fragments concerned, established either under the influence of original concernedness, interest and attention, and/or through rerecording of earlier returns to the experience. The impossibility of resolving the base records of the instincts in separate events (from the history of the sort?) and the inaccessibility of baby-age experience might, as a matter of fact, be due to absence of rerecording interest in the past during this early time of life.

q. Finally, it is of interest to point out, that the theory developed does not exclude the transient existence of certain *singular* mental conditions and processes. They don't have their origin in some inordinate (e.g., defective) condition of the nervous instrument, but in a general property of consciousness. They would manifest themselves in conditions where the wakeful, restless, mind is left without emotional guidance, the supervising ego stubbornly refusing, or at least in complete passivity abstaining from control. This condition is critical because two "solutions" are impossible: (i) the process cannot stop, and (ii) it cannot make way to randomness. The physical instrument, the brain, could hence possibly become "singularly sensitive"

in such a condition. The difficulty of finding out what could happen arises from the circumstance that consciousness and the inherent emotion do not exist in physical space and cannot be properly rationalized. Conceivably the fundamentally open mind could "lock on" to "foreign" emotional process. One thing, however, is sure: whatever experience is to fill the control gap, it has to run in abstractions and (superficial) anticipations solidly residing in the brain, that is in terms of actors and objects, images, sensations, properties, relations belonging to the mental property of the normally supervising ego.

In looking for empirical indications about what might occur, that is for reported experience possibly associated with the singular condition mentioned, the "conventionally paranormal" comes to mind. This at once leads the attention to the class of phenomena called "telepathic". They do witness of disrespect for (wide) spatial separation and they are semantical in nature, that is involving emotion. The case most common both in the literature and in popular experience concerns the establishment of awareness, in the intimate subjectivity of the mind, of the death of some close relative. Such a case might reasonably be accepted to have the following characteristics: (i) very strong emotion at the "emitter" person's end, (ii) highly resonant mental property (as e.g., resulting from mutual love) at the receiver's end and (iii) use of an occasion of (at least) mental passivity at the receiver end (e.g., sleep). This suggests, that a condition of clear hypersensitivity is not required in this case. Against this, the existence of the resonance mentioned should be very helpful. This opens a vague opportunity for some telepathy of a more general nature on the basis of hypersensitivity of the receiver mind against a more trivial nature of the "message". Pertinently, however, it is only the *emotion* involved which can ever be transferable, that is some bit of "guidance" becoming accepted in the receiver's mind.

For the rest, the insights developed are only enhancing the scepticism of science with respect to the paranormal. The possibility of "telekinesis", e.g., can be flatly denied. With respect to all "extrasensory" guesswork on randomized data (card-guessing, etc.) complete scepticism remains prevalent. Towards medium-mediated messages – a large class of the paranormal – the theory also tends to remain dismissive since the "trance" condition, which never seems to fail, is very probably auto-hypnotic in nature implying initiative silenced and hypersensitivity (hence) excluded.

June 1980

5. REFERENCES

1. Greidanus, J.H., A Theory of Mind and Matter, Transact. Royal Neth. Academy of Arts and Sciences, 1st series, *XXIII,* no. 4 (1966).
2. Same author, Psycho-Physical Theory (improved), Proc. Royal Neth. Academy of Arts and Sciences, series B, *78* (1975).
3. Same author, The Psycho-Physical Nature of Reality, Transact. Royal Neth. Academy of Arts and Sciences, 1st series, *XXVI,* no. 4 (1972).
4. Shannon, C., The Mathematical Theory of Communication, Univ. of Illinois Press (1949).
5. Schroedinger, E., What is Life?, Cambr. Univ. Press (1945).
6. Bohr, N., Atomic Theory and the Description of Nature, Cambr. Univ. Press (1934).
7. Bohr, N., On the Notions of Complementarity and Causality, Science p. 51, jan. 1958.
8.* Gerard, R.W., Neurophysiology, an Integration, Handbook of Physiology, section 1, Neurophysiology, Am. Physiol. S. (1960).
9.* Scientific American, vol. 241, no. 3, sept. 1979, 11 papers on Mind and Brain.

* used for general information and final checks.

LIST OF PROPOSITIONS

The problem of the relation between the human mind and its material substratum, (primarily) the brain, is attacked by aid of thc following propositions (which in the end will appear to reach beyond the human case): (i) the relation involves *recording* (lasting "for life") of the subjective experience of the mind into material symbols of the nervous system, (ii) this recording occurs decentralized over all cells of the system and directly concerns their discharges and inhibitions, (iii) these functional events are to be strictly systematic cellular response alternatives to perturbations by spike signals arriving at synapses; taken together they shall represent a complete coding account of the semantics of the mind, (iv) the material symbols used in the recording shall be *microphysical,* that is no larger than small individual molecules, *possibly* again the four nucleotide-base molecules of the chromosome (DNA) code script, (v) the separate coding events, additions of next symbols to the stored aggregates, fall under the jurisdiction of quantummechanics and are with respect to timing and choice from alternatives (as e.g. inevitably associated with the discharge/inhibition alternative) predictable from physical data in terms of probability only, (vi) these probabilities result in the accumulating aggregates in a symbol statistics which is to agree with the symbol correlation statistics to encoded semantics from information theory as originally recognized in printed messages (Shannon), (vii) a corresponding reinterpretation of quantummechanics as basis a priori of probabilities which effectively are information-theoretical in nature fundamentally solves the interrelation problem of mind and brain, (viii) the reinterpretation is to imply replacement of the auxiliary condition enforcing the limitation of predictions to probabilities, the fundamental *randomness* of microphysical processes, by the condition (with the same effect) of information theory "that semantics possibly encoded shall be disregarded", (ix) this condition leaves the formalism applicable to conventional physical processes

unchanged by defining randomness (appropriately eliminating an existing deficiency) as "absence of encoded semantics" or "coding potentials of microphysical symbols involved *not used*", (x) this definition appropriately underlines that randomness does not (cannot) exist in psycho-physical processes which, hence, satisfy an "exclusion principle of randomness", (xi) quantummechanically relatively improbable continuations of psycho-physical (recording) processes tend to slow down the process and witness of "proportional" *mental effort,* (xii) the factor maintaining coherence (consistent compliance of semantics and symbols) in psycho-physical processes is pin-pointed as *emotion*, an a-physical, (consciously) purposive aspect of the process induced by the future, (xiii) the mental and neurophysiological aspects of psycho-physical processes comply with *complementarity* as defined by Niels Bohr (as a quantummechanical concept), (xiv) the complementarity of quantummechanical particles and waves can indeed also be conceived as being due to the polarity of time, the particles registering whatever happens (inclusive the dispatch of messages) and the waves scouting the future, annunciating future change (possibly in response to messages accepted) in terms of probability, prerequisite of emotion, (xv) postulated complementarity of semantics and the encoding symbolic process is to represent the general solution of the psycho-physical relation; it implies complementarity of the respective frames, consciousness and space-time, (xvi) the process of the evolution of life on the crust of the earth with its aperiodic DNA record administration and mutational change (extension) modes, and the cosmic process in the universe seemingly relying on coding in bulk materials (leaving microphysical backgrounds intentionally random) are indicated as very probably also psycho-physical, that is purposive. The essence of cosmical semantics is apparently by proper effort and interrogation bit by bit *transcodable* to the symbols of the human mind.

The application of these propositions starts with the observation that the standard "quantummechanical" neuron is perfectly matched to three types of brain circuitry: (1) integrating abstraction circuitry, (2) high serial processing circuitry, and (3) differentiating instruction circuitry. Together with a final hypothetical assumption relating psychological initiative to neurons capable of spontaneous in addition to triggered discharge, to be found only in the high brain (type (2) circuitry), very simple interpretations appear to be possible

of many elementary properties of the human mind (ranging from perception, learning and memory to Sigmund Freud's classical female neurosis and certain paranormal phenomena). They represent valid verifications of the theory to empirical material from psychology, a science which, in the light of the theory, becomes complementary to and equally fundamental as physics.