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How the Least Effort Principle governs human reasoning and behaviour

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Preface

The present essay (Essay 4) is the first of a number of essays focussed on certain key aspects of the Modular Mental Structure Model (in the following the Model, for short), first described in Essays 3 (October 2015) and again in a restructured and amended Essay 3.1 (November 2016).

Essay 3.1 is recommended to be read as a lead text for the current essay as well as subsequent essays, for reason that readers not accustomed to a physical-science type of reasoning may find Essay 3.1 easier to read and understand than Essay 3.

Furthermore, Essay 3.1 must be read because it contains two important supplements to the Model, viz. the Threshold Hypothesis of Consciousness and the Direct-Access-Storage hypothesis, not mentioned in Essay 3.

The Least Effort Principle [2] is the main theme of the present essay. The contents is similar to that presented to an academic audience at the University of Pretoria

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in April 2016, under the similar heading "How the Least Effort Principle governs human (and physicists') thinking". In the present text, particular attention is drawn to the subject of 'priming', which is a much underestimated, but highly effective, means for directing thinking in particular directions.

In order for readers not to have to refer back too often to Essay 3.1 for aspects of the Model, the core text of Essay 3.1 has, here, been copied into Appendix 1. Also, a separate detailed elaboration of the Least Effort Principle and the Knowledge Priming feature has been copied from Essay 3.1 into Appendix 2.

Introduction

Recently, the weekly news journal Der Spiegel (37/2016) reported on an experiment jointly conducted by Harvard University and the University College of London on the effect which science news has on the opinions held by members of the public; in this particular case the possible threats posed by man-made climate change (something which also the public has an interest in).

The findings of the experiment were that participants in the experiment were highly biased in their choices from the wide menu of science news made available to them. Those believing the possible threats of climate change to be exaggerated went for science news presenting evidence for optimism, whereas those believing threats to be serious went for science news focussed on alarming evidence. Science news about evidence to the contrary of either pre-conceived opinions was ignored by both groups.

The outcome of the experiment was the general conclusion that someone with a preconceived opinion is not interested in facts contrary to this opinion.

This is confirmation of the experience of many of us. And now, with this result in hand, we can be even more certain that the probability of making the same experience again is rather high. But does the outcome of the experiment also *explain* the outcome? The reporting science journalist appears to think so. At least this is what the heading of her report suggests ("Why Man ignores facts"). But she is mistaken. The outcome does not explain the result; it merely turns a

[2] The term "least effort principle" is commonly used in linguistics, as well as in library and information science, and stands for the finding that "information seeking is stopped as soon as minimally acceptable results are found" (Wikipedia). This meaning has been generalised to the postulate, known as Zipf's law, that "people and animals will naturally choose the path of least effort" (Wikipedia). In my Model I have given the term a very different, though not entirely unrelated, meaning.

sporadic observation into a highly probable one. This is what I call a single-level-of-logic argument.

In order to arrive at an explanation, we require a two-levels-of-logic argument, deriving from a hierarchic-architecture-vision of nature. This hierarchic-architecture-vision is briefly described in Appendix 1 (p. 16). In short, the reported phenomenon, where 'opinion beats facts', must be regarded as an emergent property deriving from the formation and interaction of mental modules in the brain (essential for learning), and by the interference of natural selection with certain aspects of the learning process (viz. with the modification of established knowledge modules).

This interference is specified by the Least Effort Principle (also briefly described in Appendix 1, p. 18, and in more detail in Appendix 2, p. 25). In consequence, only if the opinion-beats-facts phenomenon is compliant with the Least Effort Principle can one reasonably speak of an explanation (as one can indeed, as shown farther below).

The areas of brain activity where the Least Effort Principle is of prime importance pertain to a physical-resources-saving type of learning. This embraces formal teaching and thought sharing, but also the, often underestimated, 'priming' of the mind, where priming is to be understood as the seeding of a starting thought for further reasoning. The background to the importance of priming is described in Appendix 2.

Most of the examples referred to below fall into the three categories formal teaching, thought sharing, and priming. These examples are supplemented by discussions of additional aspects of human learning related to the Least Effort Principle.

The Least Effort Principle (LEP) and the opinion-beats-facts phenomenon

First a brief reminder of what the Least Effort Principle (in the following abbreviated as LEP) stands for: Viz. for an "evolutionary predisposition for minimising the consumption of physical resources (materials and energy) for the physical processes behind essential learning", where 'essential learning' can be further specified as survival-furthering learning, embracing both the physical configuration of new knowledge modules and the physical reconfiguration of existing knowledge modules.

For a detailed explanation of the LEP and the associated Knowledge Priming feature, the reader is referred to Appendix 2 (which is a copy of a text in Essay 3.1).

The opinion-beats-facts phenomenon

Applied to the opinion-beats-facts phenomenon described in the Introduction, the explanation of the phenomenon is that it is a consequence of the LEP, viz. in that the LEP discourages brains in either group from giving consideration to new information which is not readily integrated into pre-existing opinions (knowledge modules). If they would, this would consume lots of physical resources for reconfiguring existing knowledge modules.

Another argument in agreement with the LEP is that, according to the Model, the reasoning in brains is governed by a type of knowledge modules referred to as private paradigm modules (or private paradigms, for short), which serve as gatekeepers for their respective areas of knowledge. In the above experiment there are two contradicting private paradigms which help the brains to comply with the Least Effort Principle, viz. the private paradigm "man-made climate change *is not* a catastrophic development", and the contradicting private paradigm "man-made climate change *is* a catastrophic development". These two gatekeepers bar contradictory information from admission to further information processing.

The foregoing two paragraphs *explain* the opinion-beats-facts phenomenon and will be referred to again in the examples treated in the following.

Collateral learning and the LEP

The foregoing example of how human behaviour in guided by the LEP is one of many which can be linked to the LEP, although not necessarily always so directly. In the examples presented below I shall confine myself to the more obvious cases. Prior thereto, I shall discuss the LEP-related concept of collateral learning.

Collateral learning

As pointed out in Essay 3.1, learning in virgin brains is initially and of necessity collateral learning, i.e. side-by-side learning. This is because the virgin brain is confronted with bits and pieces of information which the newborn and baby is unable to piece together into knowledge. At that stage, all learning consists of

collecting information into many elementary information modules which later on serve as sources for the assembly of knowledge modules.

The real learning starts with the first development of a knowledge module (commonly about the mother). As more knowledge modules become assembled by the clustering of seemingly related information, collateral learning becomes the rule, because the majority of knowledge modules are not sufficiently developed for linking them into sets.

As the mind develops further, sets of knowledge modules assemble into centres of knowledge. Also these develop in parallel because a relationship between these centres is not yet apparent. At adulthood most of these centres have been linked and rendered mutually compatible, thus providing a unified world view (e.g. a scientific world view). Centres which remain incompatible with this world view (e.g. a spiritual world view), keep on being developed collaterally.

Examples of the collateral learning of two spiritual world views are found in traditional cultures in Africa and elsewhere, viz. where colonial powers have coerced locals into disavowing their age-old beliefs for the religious preferences of the invaders. With mixed success, because the traditional cultures have applied the strategy of collateral learning for mentally dealing with both, the mismatching new and old beliefs, side by side.

There are also examples of where a unified view of an area of knowledge had to be split into two. An example thereof in physical science is quantum phenomena of nature which mismatch classical phenomena of nature, giving rise to the new knowledge area of 'quantum physics' which now exists side-by-side with the older knowledge area of 'classical physics'. Both continue to be pursued by collateral learning.

To summarise, collateral learning is an important strategy of the brain for satisfying the LEP.

Belief in authorities, and the LEP

Every baby soon learns of the existence of caring and dominant reference persons in its life. This can extrapolate in the "right" environment and over time into a belief in the existence of spirits, gods, and an interfering Almighty. Such spiritual beliefs are so common, that it has been suggested that Man may possess a religious gene. A simpler explanation invokes the LEP.

It is rather obvious that the belief in supernatural entities is a cheap fast-track means of satisfying the LEP, 'cheap' in terms of the consumption of physical resources for configuration of relevant knowledge modules. Even cheaper is it if a Holy Book not only "explains" spiritual aspects of the world, but gives definitive directions for social and cultural behaviour. The enormous saving of physical resources for developing a religiously focussed mind becomes obvious if one looks at the resources required for a physical-science-focussed mind.

Likewise, the saving of resources in learning physical science at university is enormous compared to the resources spent by the millions of researching originators of present-day physical science. Small wonder that a good teacher (of religion or physical science), who contributes so much to satisfy the LEP, leaves a particularly favourable mental impression with students.

Small wonder also that individuals who pretend to be knowledgeable of confusing aspects of life succeed in gathering willing followers of their agendas, be it religious, political, or criminal. These individuals do the thinking for their followers, who, then, save even more resources.

Some of these individuals have become notorious (Hitler, Stalin, Mao), others became famous (Confucius, Jesus, Mohamed), still others became noted as authorities on something.

In all of the above, the general tendency is to stop thinking for oneself if one meets the opinion of an authority. This tendency surfaces also in academic teaching, although critical thinking is held out as preferable. The unfortunate consequence is that any suggestion by such an authority, if ever so outlandish, is eagerly picked up and becomes a primer for research work in the direction indicated by the authority. And the LEP will ensure that followers of the authority are the more unlikely to revise their lines of research, the more physical resources have been invested in the mental development of these lines.

The reliance on authorities has become a problem in many academic disciplines, not only because theories of acknowledged authorities are often learned for an examination rather than understood, but also because often an authority on something is considered to be also an authority on everything else. The benefit for the authority-believing mind is that citation of the authority often exempts this mind from further elaborations; an optimal means of complying with the LEP.

The LEP-driven reliance on authorities turns into an almost blind belief if an authority is regarded as a genius. A discussion of this case is found in the following box.

The misunderstood concept of genius

The Model does not allow for lone outliers of intelligence, which the term genius is associated with, if such outliers cannot be explained in terms of the type of neuronal networking laid on in the species. Rather, the Model puts the occurrence of exceptionally innovative thinking down to learning, learning, and again learning. This is confirmed by investigations into the minds of individuals regarded as geniuses. Let's take physicist Albert Einstein as an example.

Einstein has acquired the status of genius in particular for his general theory of relativity. He has been regarded as being genial ever since, despite the fact that his subsequent work was on a par with that of his average colleagues. Concerning the work which earned him this status, science historian (and expert on Einstein) Juergen Renn put Einstein's feat into perspective in a recent interview (Der Spiegel 48/2015) on the centenary of his first presentation of this theory.

Renn's assessment, in short, is that Einstein's feat can be retraced to his fascination as a child and youth with physical science, inspired and nourished by a set of science books written for juveniles by Aaron Bernstein. These books gave him a wide overview about the physical science of the time and inspired him to think about science questions in a rather uncomplicated way, which resurfaced also in his later research on the photoelectric effect (for which he received a Nobel prize), as well as the theory of special relativity.

Renn emphasises the fact that, although the decisive work was done by Einstein alone, he had very helpful input from a mathematician friend of his (Marcel Grossmann, who taught him the mathematics which he required) and from likeminded former fellow students he met regularly in a discussion circle called the "Akademie Olympia". Renn goes as far as suggesting that the general theory of relativity is the result of a "collective effort" of Einstein and the Akademie Olympia. Renn also emphasises Einstein's patience and perseverance in the face of many setbacks, eventually leading to success after eight years of hard work.

And, not to forget, for some time after publication of the general theory of relativity, Einstein was not aware of the full implication of his theory (thus Renn). It took him 15 years to realise that his theory describes an expanding rather than a stationary universe, and he denied the consequence of black hole formation even longer.

The case of Einstein shows rather convincingly that inspirations are the consequence of hard learning by a mind which is free-ranging not only in

acquiring information, but also in (subconsciously) recombining this information into the inspirations which are considered as genial by others.

The implication is that the alleged genius of a person does not pertain to the person's intellectual power in general, but rather to the area of reasoning which the person is specialising in. Outside this area the person must do with fewer and less opulent knowledge modules, just as any other colleague. At least, this is what the Model predicts. Unfortunately, this is not what the general perception is. The least effort principle tends to favour the assumption that (1) an authority on something is likely to be an authority also on other things, and (2) authorities are not to be questioned. In consequence, any utterance of an authority is taken serious, and authorities on quantum theory or cosmology are questioned only if counterevidence becomes glaringly visible.

An afterthought re. artificial intelligence and feats of intelligence such as Einstein's theory of general relativity: If my foregoing elaborations hold, then there is no reason why a self-learning robot, exposed to the experiences of Einstein's life (including the experience of travelling in trains!), with access to the academic information available to Einstein and programmed for cross-referencing of data, for pattern recognition, for analogue and metaphorical conceptualisation, and for the resolving of contradictions by means of hypotheses, should not come up with a theory of general relativity; and that in a much shorter time than the eight years which it took Einstein.

Self-righteousness of mind and the LEP

As mentioned earlier, the LEP will ensure that followers of an authority are the more unlikely to revise their lines of research, the more physical resources have been invested in the mental development of these lines. Obviously, this reluctance to declare an earlier investment as wasted, pertains also to the authority himself/herself. In consequence, if a revision of an established vision becomes unavoidable, the authority prefers a minor adaptation over any drastic revision.

The mind of such an authority is convinced of the reliability, objectivity, and rationality of its reasoning, although others may see this very differently. To an outsider the phenomenon appears to be a self-righteousness of mind, although it is nothing but a consequence of the entirely natural LEP.

In Essay 1, a major restructuring of knowledge was equated to a serious neurotic crisis, because of the shut-down for repair of major sections of the cognitive part of the brain. Also there, I spoke of the mind - the product of a two decades long

development process - as Man's most precious possession. This is still valid, and explains why neither of two authorities with opposite visions of things can ever submit to substantial aspects of the opponents vision.

In the political arena, such opposing visions can be causes of war between nations or religions, because the fear of having to relinquish one's vision of things (e.g. as a Shiite) for a drastically different vision (e.g. as a Sunnite) is as serious a fear as that for one's physical existence. This mental mechanism has been the reason for many conflicts other than those generated by greed or for power or revenge. For instance, it was this mechanism which was behind many decades of 'cold war' between the Soviet Union and the West, and it is the obvious reason for the widespread scepticism over a peaceful side-by-side of opposing fundamentalists.

Thought sharing and the LEP

In the foregoing, the focus was on teaching as an LEP strategy of the brain. A related LEP strategy is that of thought sharing. To be specific, thought sharing is the most common form of communication, because it is the most direct means of ascertaining the degree of common interest between two or more communicants.

Partnerships are formed if a high degree of common interest exists, at least in certain areas of importance to the partners. One of these areas is sexuality, whence male-female partnering is common. Other areas pertain to hobbies or leisure activities. But most areas pertain to education, viz. learning of skills or learning of facts, where partnering is predominantly of an informal learner-and-teacher type.

In ancient times, partnering of the informal learner-and-teacher type has advanced the rise of Man more than anything else. It has enabled eager learners to participate in the thoughts and inventions of a gifted few. In other words, the resources-saving effect of the LEP is the real reason for Man to form cultural societies via partnering, first on a small scale and than on an ever larger scale.

Interesting is that thought sharing can lead to a similarity of reasoning in specific areas of knowledge, but never to an identity, not even in same-gender twins. In other words, different minds can never develop a common cultural vision. The simple reason for the phenomenon is that even small differences in Man's exposure to the environment, small differences in experiences, small differences in learner-and-teacher relationship, etc., suffice to create rather different minds, on account of minds being complex dynamic systems.

Although the complex-dynamic-system nature of mind is not widely realised, the practical manifestation thereof is a common experience, whence, in formal learning, it is common practice to coerce learners into accepting a prescribed learning content (e.g. by learning by heart) rather than to rely on persuasion. Coercion is also the method of choice in groupthink.

Groupthink: Coercive thought sharing

That the coercive method is applied also in team work was discovered by psychologist Irving Lester Janis (in 1972), when he coined the term "groupthink" for denoting a "mode of thinking that persons engage in when concurrence-seeking becomes so dominant in a cohesive in-group that it tends to override realistic appraisal of alternative causes of action".

According to Janis, groupthink is characterised by four symptoms of in-group pressure for preserving in-group uniformity, viz. by censorship of deviating ideas, illusion of unanimity when staying silent is viewed as agreement, direct pressure on "disloyal" members to conform, and self-appointed "mind guards" who shield the group from dissenting information. Four other symptoms are equally divided between a self-overestimation of the group and the closed-mindedness of its members.

From long experience in academia and industry, I posit that groupthink symptoms are found, in all grades of stringency, in all types of social groups. Hence also in physical science education.

To explain: The LEP causes the conditions for a fast-track development of mind to be optimal in families and in groups of people. It is natural for such groups to develop a leader/followers structure. This leader/followers structure is not always clearly visible; for instance, in groups of physicists. But it is visible to insiders in so-called Schools of two types, viz. in one type which is in the process of forming a leader/followers structure around an innovative leader, and in a second type, focused on perpetuating the published findings of an absent, often long-dead, highly reputed, often mystified, authority (Einstein, Bohr, Heisenberg, and the like), where the followers are shepherded by one or more self-appointed spokespersons of the chosen authority's view. It is in this type of School in particular where Janis' symptoms of groupthink are clearly in evidence.

Where groupthink prevails in academic education it is questionable if graduates can develop an independent critical mind.

Priming and the LEP

Besides formal teaching and thought sharing, there is a third, rather underestimated, LEP-compliant strategy of the brain of wide implication, viz. that of Knowledge Priming of the mind (in the following 'priming', for short), where priming is to be understood as the seeding of a starting paradigm for configuration of a new knowledge module or the seeding of a starting thought for developing an argument. The starting paradigm or starting thought may be self-generated, but is usually - LEP compliant - picked up from external sources. At this stage the reader is advised to read or re-read Appendix 2 in order to fully appreciate the importance of priming.

Priming in spiritual things

One of the earliest primers in the history of Man must have been the concept of a superhuman, respectively supernatural, being. This concept has led to different cultural groups developing as many different visions of a spiritual world (i.e. religions) around this primer. In other words, a single primer has opened the way to a variety of mental structures, each representing a religion, and each able to satisfy the LEP.

Priming in political campaigning

Priming of the electorate is the essence of political campaigning. The success of candidates depends on the starting paradigms or starting thoughts offered for solving problems which the electorate demands solutions for. The intricacies involved in bringing about a promised solution is never discussed at the campaign stage, but is certain to differ from that envisaged by the individual voter. But the priming sticks for a long time, and causes the voter to adhere to the elected politician course, sometimes to a bitter end.

The primer used by Adolf Hitler in his rise to power was the misunderstood Darwinian finding about natural selection, which Hitler interpreted to mean that the strongest had a *right* to power [3]. This primer took hold in the mind of not only his direct helpers, but infected also a majority of ordinary Germans. The priming worked to the very end of the Nazi rule, when the international prosecutor at the Nuremburg trial did not succeed in causing the leading perpetrators of World War 2 crimes to issue a single word of regret.

Collateral priming

[3] In Darwin's words, "Natural selection acts by competition, it adapts and improves the inhabitants of each country only in relation to their co-inhabitants". No word about enforcing natural selection by destroying a competitor.

One of the outstanding characteristic of priming is that once a starting paradigm or starting thought has shown its potential for LEP-compliant reasoning, it is virtually impossible to re-capture the primer, even if a substitute is offered. For instance, the earlier primer 'the Almighty created the world' keeps on holding its ground against the later physical-science-based primer 'the universe emerged in a Big Bang'. The reason is not only that the Almighty primer preceded the Big-Bang primer, but also that any easy-to-follow narrative based on such a primer is also easy to copy into many other minds, in compliance with the LEP. And, indeed, the Almighty narrative is easier to copy than the Big-Bang narrative.

(At this stage, psychologists may claim that they would come to the same result by their single-level-of-logic methodology; a claim certainly in compliance with the LEP. This is unsatisfactory, though, from a physical science perspective, because the psychologists' result would fail to recognise that the phenomenon is a consequence of the physics of the brain rather than the result of a free-will decision - a favoured view of psychologists.)

Daniel Kahneman and priming

The power of priming as a means of establishing a bridge head in the mind, and thereby guiding subsequent reasoning (as just discussed), is demonstrated rather convincingly by the success of the best-selling book "Thinking, fast and slow" by psychologist Daniel Kahneman.

The Kahneman method in short: Kahneman starts with a hypothesis serving as primer, which helps the reader to separate the examples of thinking presented by Kahneman into two categories, one fast and another one slow. Only at the very end does Kahneman reveal that his primer is without any scientific grounding whatsoever, admitting that the primer was merely a hypothesis of convenience, for himself and maybe also for his readers.

Kahneman, as a reputed psychologist, must have known from the start that he was initiating a mass experiment in which the priming message would have taken hold in readers' minds by the time that he would come up with the truth. And right he was. A majority of readers saw no reason for not recommending Kahneman's book as "groundbreaking" in the quest for understanding mind. This may have been contributed to by the fact that Kahneman, as a former Nobel laureate, is considered an authority, and, hence, beyond reproach. The LEP will ensure that this sentiment will persist for a long time to come.

There are plenty of examples where the mind accepts also the most way-out primers as long as it satisfies the LEP in conjunction with the Least Mental Stress Principle.

Priming with an overrated consciousness

One of the most consequential primers in human history, more consequential than the religious primer mentioned earlier, is the one alleging that 'Man is blessed with a consciousness which manages his/her reasoning and behaviour'. Triggered by Man's sensation of having a free will, this primer was later dogmatised by religion (in particular Judaism and Christianity) into a God-nearness of Man. Philosophy played its part by developing a philosophy of humanism. The philosophy of traditional cultures of Africa, which acknowledged a unity of the biological world rather than a division between human and animal, was made down as primitive (a convenient contribution to the LEP).

The alternative primer offered by the Model, which postulates that 'consciousness is an evolution-promoted means of enabling the mind to identify the self in anything in which a person is involved in' (for instance, by ascertaining of who is who in the sensory information received of an event in which the person participates) is just as plausible as the earlier primer. But the new primer is easy to incorporate into the Model, not so the old primer. In particular, the new primer dovetails well with the Threshold Hypothesis of Consciousness, introduced in Essay 3.1 (by opening a window on an integral vision of subconsciousness and consciousness).

Moreover, this new primer acknowledges the early existence of consciousness in the lineage from primitive to advanced forms of life, and obviates the need of having to explain how Man came to his/her alleged type of consciousness. Also, there is no longer a need for understanding consciousness before attempting to understand mind, as is often alleged.

(For some quantum physicists, though, the new primer may be bad news, because it robs them of there belief in an involvement of consciousness in the "measurement problem" of quantum objects which (objects) appear to behave as both particle and wave.)

Priming by fabulating

Inventing explanations of phenomena which one is unable to explain in scientific or other culturally acceptable ways is widely practiced. Why? Because the search for an explanation of an observation is laid on in the human brain, and

the mind keeps on assembling bits and pieces of memorised information in trial-and-error fashion until a self-consistent narrative emerges. The primer for the narrative is a starting assumption, such as "There is a God, and he (!) has instructed me to spread his word". A Holy Book contains the narrative.

Another, less sacred primer is the allegation of a conspiracy, such as that the US government has been behind the 9-11 terror act in New York. Various narratives have been developed around this primer, and were published. The invention of conspiracies is so popular that I have seen them listed in a dictionary of conspiracies of 300 pages. Obviously, conspiracy primers are helpful in satisfying the LEP.

Priming in physical science

Turning now to physical science, the general picture is the same. The LEP governs thinking also here, viz. primers invade and guide the mind towards inventing a primer-compliant narrative on the basis of oftentimes meagre scientific information available in the brain.

The "quantum mind" and "quantum consciousness" primers

For an example lets look at the physical science contribution to the study of mind: After the strangeness of quantum physics caught the attention not only of particle physicists (a century ago) but also of biophysicists and cognitive scientists, the idea soon emerged that the mysteries of mind and consciousness might be resolvable by a quantum physical vision of the brain. The notions of "quantum mind" and "quantum consciousness" became popular.

This idea is still being pursued despite the fact that quantum phenomena in particle physics cannot be (easily or not at all) extrapolated to large objects such as the brain, as evidenced by the fact that a quantum vision of mind and consciousness has not contributed to an understanding of either to this day. Yet, the preoccupation with a quantum physical vision of the brain is such that a Google search for "physics of mind" invariably comes up with this vision and not with any classical vision. I attribute this one-sidedness to a lack of a convenient primer for starting a knowledge module on classical physics of mind.

The 'Copenhagen Interpretation' primer and the von Neumann/Wigner primer

All quantum-mechanical visions of objects, inclusive of biological objects are retraceable to the "Copenhagen Interpretation" of 1927, which according to a poll among participants of a 2011 quantum physics conference "still reigns supreme" (*Wikipedia*).

A key statement of this interpretation is that "the interaction of an observer or apparatus that is external to the quantum system [under investigation] is the cause of wave function collapse". This remains a welcome primer for many theoreticians to this day, although experimental verification seems to be far off.

In the 1930s, the Copenhagen Interpretation spawned the suggestion that the phenomenon of consciousness is of quantum-mechanical nature and thus able to interfere with the measurement of quantum objects. This von Neumann/Wigner postulate is alive and well to this day. For instance, mathematician Roger Penrose and anaesthesiologist Stuart Hameroff have set out to identify a component of neurons of the brain which they propose to be responsible for consciousness and to exhibit quantum properties. The latest contribution from Hameroff is from 2012, published under the title "How quantum brain biology can rescue conscious free will".

The 'fundamental particles' primer

Another example, following the same pattern, concerns the fact that the fundamental entities of nature (such as the electron and the neutrino) continue to be regarded as particles because of an early primer to this effect, and that despite substantial criticism re. the Standard Model of fundamental particle physics [4], as well as the criticism that these "particles" exhibit also wave properties (accepted as particle/wave duality). A more recent alternative primer, proposing that 'the fundamental entities of nature are hyperspherical standing waves in space-time' rather than particles distinct from waves [5] has little chance of becoming part of mainstream physical science anytime soon, although the new primer promises to do away with most, if not all, of the shortcomings of the Standard Model, including the mysterious particle/wave duality.

Again the LEP is in the way. Viz., in the way of starting to question one's earlier certainty about the carefully erected mental structure of particle physics, and in the way of erecting from scratch an alternative mental structure of a new hyperspherical-standing-wave physics of uncertain outcome. This is just one example of many in which the LEP causes physicists to try to salvage an established theory which has come under attack, viz. by following a strategy of making adaptations, if ever so far fetched, and that to the point of entering the realm of metaphysics, rather than discarding the theory.

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[4] The Standard Model of fundamental particle physics is criticised for its "complicated and arbitrary construction" (Alexander Unzicker and Sheilla Jones, *Bankrupting Physics*, Palgrave Macmillan, 2013).

[5] Jan C. A. Boeyens, *The Chemistry of Matter Waves*, Springer, 2014.

The 'String Theory' primer and the 'Big Bang' primer

The LEP explains also the adherence of a large number of theoreticians of fundamental physical science to String Theory despite the theory's obvious failure [6] and its metaphysical consequences.

And it explains also the adherence of cosmologists to the Standard Big-Bang Model of Cosmology, severely criticised as metaphysics rather than physics [7]. The discovery of dark energy and of dark matter has apparently not shaken confidence in this model of cosmology.

Priming of judges of law

Let me end with an example of priming in an area which is generally believed to be unaffected by bias, viz. in the administration of justice. Critical observers of the judicial process have noticed for long that judges seem to have a particular problem with cases which have to be reopened because new important evidence has become available which would have led to a different verdict in the original trial. The problem is that it is rare for judges to revise their original verdict on the grounds of this new evidence, so rare indeed, that critical observers speak of an acquired bias of these judges. In view of the earlier discussion, this suspected bias has to be real because priming leaves these judges no choice.

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Appendix 1

Core Text of Essay 3.1

The Modular Mental Structure Model (the Model for short)

The Model is an artificial representation of mind which has been developed (invented if you wish) by a physicist using a physical-science-typical approach. Selected findings from the evolutionary theory, neuroscience, other cognitive sciences, and physical science are used in the construction of the Model.

Hierarchic architecture of nature

Basic to the Model is a vision of nature as being of hierarchic architecture as

[6] Lee Smolin, *The Trouble with Physics,* Penguin, 2006.
[7] Jan C. A. Boeyens, *Chemical Cosmology,* Springer, 2010.

detailed in Essay 2. In short, the material world (inorganic and organic) consists of components, which consist of components, which again consist of components, etc., down to the most fundamental entities, referred to as fundamental "particles". In other words, every component is constituted of an assembly of components from a next-lower hierarchy level. Every such assembly of components brings forth new properties, referred to as an emergent properties, which are not possessed by the non-assembled lower-level components. For instance, a network of neurons in a brain exhibits emergent properties not possessed by individual neurons, and an assembly of neuronal networks brings forth new emergent properties not possessed by individual networks. The implication of this vision is that an emergent property can be *understood* only by a study of the structure of the assembly of lower-level components.

In the Model, the emergent property of particular interest in a neuronal network is its capability for information storage, and the emergent property of interest in the assembly of all neuronal networks in the brain is the mind.

Post-humanistic complexity

In order to distinguish the Model from unscientific misconceptions nurtured by the philosophical position of humanism, the Model sets off by viewing the entity Man as a complex dynamic system of cooperating anatomical components, where every anatomical component is a system on its own.

Physiology

The anatomical system believed to house the mind and consciousness is the brain. Decades of brain research have shown the brain to consist of networks of neurons (i.e. nerve cells). The neuronal linkages forming the network are not separate "wires", but are neuron-own tentacles joining one another at a linkage point called synapse. Signal transmission from one neuron to another can be controlled (on, off, and regulated) at the synapse.

Every neuron can be interlinked with many other neurons by many of such tentacles (upstream of the synapse referred to as axons, downstream as dendrites) via an equal number of synapses. Control at each of these synapses determines to which other neurons signals are transmitted to and with which intensity.

The number of interlinking tentacles has been found to increase with the learned contents of the mind, suggesting that new growth of tentacles and their synaptic joining is induced by new information intake at the sensory organs.

It appears to be consentient among a large number of neuroscientists that the mental content of a given neuronal network (sometimes referred to as neuronal circuit) is encoded in the "active" configuration of this network, i.e. in the configuration of the networked neurons which are interlinked via synapses in the "on" mode.

Core hypothesis of the Model

It is here where the Model cuts in, viz. by means of the hypothesis that there is a one-to-one relationship between the physical structure of the learning-related parts of the brain and its mental contents. This is the **Core Hypothesis** of the Model.

The idea behind the core hypothesis is that, of necessity, the mind must be a consequence of a physiological, and hence physical, configuration of the brain, and that any such physical configuration must be subject to the laws and principles of physics.

(A message to physicists: From this viewpoint it is plausible to regard the physical storage of sensory information in form of a neuronal network as a conversion of the kinetic energy conveyed by sensory signals into a signal-specific potential energy in the brain.)

An implication of the core hypothesis is that any new mental information necessitates either a new neuronal network to be physically configured or an existing neuronal network to be physically reconfigured, both requiring available material and energy resources to be consumed (where consumption means the conversion of both material and energy into other forms).

Least Effort Principle and knowledge priming

This process is subject to evolutionary constraints, viz. that the development of those brains has been favoured which were able to maximise the economics of realising a learning goal. A detailed analysis shows this evolutionary dictate to give rise to a Principle of Least Effort which can be expressed as an "evolutionary predisposition for minimising the consumption of physical resources (materials and energy) for the physical processes behind essential learning", where 'essential learning' can be further specified as survival-furthering learning, embracing both the physical configuration of new neuronal networks and the physical reconfiguration of existing neuronal networks. This is a principle of highest significance for the understanding of mind.

Part of the Least Effort Principle is a feature referred to as knowledge priming, able to explain the often underestimated importance of mental priming in reasoning and behaviour.

By similar argument, evolution has also favoured fastest possible transmission of signals within neuronal networks as well as between those neuronal networks which encode related information. Therefore, the Least Effort Principle implies that information pertaining to a single object (such as mother) is assembled in closely spaced clusters of dedicated neuronal networks, in the Model referred to as modules.

Modular structure

In consequence of the Core Hypothesis, the term 'module' can be applied both to a physical entity (a physical module) and its mental content (a mental module). In other words, the postulated modular *physical* structure of the learning-related part of the brain gives rise also to a modular *mental* structure of this part of the brain. Hence, the name of the Model, viz. Modular Mental Structure Model.

The Model distinguishes between two types of modules, viz. information modules and knowledge modules. A module which records sensory information is referred to as information module. This information does not suffice for an integrated world view, i.e. one which is suitable for mental analysis of the past and prediction of the future. For this purpose, Man needs knowledge modules, in which information from a number of information modules is combined (by brain-internal processing) into self-consistent visions of things (object, quality, state, event, etc.) and their interrelation. For instance, different sensory information about the thing 'mother', stored in different information modules, are combined in a knowledge module containing knowledge about mother and her interrelations with the child and with the thing 'father'.

The physical and mental structures of knowledge modules are exactly analogue to those of information modules. The only difference is that the input to the knowledge modules comes from information modules rather than from direct sensory input.

Self

Obviously, knowledge modules are not only laid on for external entities (mother, boss, enemy), but also about the self. This becomes possible by the sense of self-awareness, or consciousness, in all situations in which one is involved (observed by the sensory organs or by brain-internal self-monitoring).

The Model distinguishes between two knowledge modules of the self, one pertaining to the self-as-perceived, and another pertaining to the self-as-envisaged.

Consciousness

The function of consciousness as just described, is postulated to be its only function. This function is the identification of self in anything in which a person is involved in. This is a drastic (some would say 'heretical') departure from the general assumption (or rather conviction) that the function of consciousness is to manage a person's reasoning and behaviour. The consequence of this new vision of consciousness is that all brain processes have to be subconscious, and that only relatively few outcomes of these processes become conscious in what is vaguely described as "thinking".

I am now adding two new hypotheses to the Model of Essay 3 which help to give more substance to the new vision of consciousness. One is the Threshold Hypothesis of Consciousness, which states that there exists a threshold value for the intensity of a subconscious mental activity in a set of related modules beyond which (threshold) the outcome of this activity becomes conscious. Mental activities of an intensity below this threshold value remain subconscious. The other one is the Direct-Access-Storage hypothesis, which postulates the existence of temporary information storage modules having a function similar to a Direct Access Storage Device in computers. Both hypotheses are explained in some detail at the bottom of this core text.

Private paradigms

A key aspect of the Model is that knowledge modules within a set covering a particular knowledge area are usually not of equal importance, but are importance-ranked. In consequence, one of these modules rises to a status of dominance within the set, called 'private paradigm module', or 'private paradigm' for short. Examples of private paradigms are dogmas about an Almighty in the religious field, but also the key precondition "No supernatural interference" in the field of physical science. Most widespread and conflict-prone of all is the private paradigm of the I-am-right-and-you-are-wrong type.

The significance of a private paradigm rests in its gatekeeper function: It bars or allows signal admission to the area of knowledge which it belongs to. In this sense, the private paradigm contributes in a significant way to satisfying the Least Effort Principle.

At this stage it must be added that private paradigms do not necessarily have the

last say in human behaviour. Rather, if genetically inherited human needs require to be satisfied, than it is the output of "hard-wired" needs modules who dominate reasoning and behaviour, regardless of what ("flexible-wired") private paradigm modules may propose.

Mind

From the foregoing, it is clear that the Model allocates all mental activity to the modules described above, whence the definition of mind can now be formulated as "Totality of mental contents and mental activities of all physical modules".

Least Mental Stress Principle and Collateral Learning Principle

The Model features a total of three principles, of which the Least Effort Principle is one. The other two are the Least Mental Stress Principle, and the Collateral Learning Principle.

The Least Mental Stress Principle acknowledges the fact that new sensory information, coming in at every moment during the wake state, does not necessarily fit into the existing knowledge modules. In fact, some of this new information is likely to obstruct the fast processing of later incoming challenges. Therefore, evolution has favoured the development of mechanisms for prompt removal of the obstruction without loosing the information. Physical stress is the driver for such prompt removal.

The two ways open are either a separation of the new information from the existing knowledge modules for starting a new, quite different, set of knowledge modules or a modification of existing knowledge until the new information fits.

The former is both an evolutionary predisposition (in early life) and a consequence of the Least Effort Principle (throughout life) and is referred to as the Collateral Learning Principle. (An example is a set of knowledge modules pertaining to physical science in parallel to a set of modules centred on a spiritual belief.)

The alternative to collateral learning, viz. modification of existing knowledge until the new information fits, involves individual modules as well as sets of modules. Modification of an individual module is aimed at re-optimising *self-consistency*, and modification of a set is aimed at re-optimising *mutual compatibility*.

From a physical science point of view, the obstruction caused by non-fitting

information is a physical resistance to the processing of further sensory information, thereby delaying a rapid decision for action to be arrived at in a critical situation. I am positing that the physical resistance is a cause of physical stress within the system, which in turn activates activities for prompt elimination of this resistance.

According to the Core Hypothesis, this physical stress has a mental equivalent which I am calling 'mental stress', whence the duress to eliminate the physical stress is also a duress to eliminate mental stress. In short, the Least Mental Stress Principle is an "evolutionary predisposition for eliminating the incompatibility of new information with existing knowledge"

Complex dynamic systems brain and mind

As mentioned at the beginning, the Model acknowledges the complex dynamic nature of the biological system Man. The study of non-biological complex dynamic systems has shown that such systems are inherently deterministic despite the fact that their behaviour is essentially unpredictable to the point of being seemingly chaotic (whence they are also referred to as chaotic systems). The lifetime of such a system depends on the continuous import of energy from the environment of the system. This given, such a system is self-organising and self-maintaining. In the case of a biological complex dynamic system, the system is also self-reproducing, but also self-destroying after a while (usually after reproducing).

In the Model, the biological system 'healthy adult Man' is regarded as the analogue of a non-biological complex dynamic system, featuring the same properties as the latter. More specifically, Man is regarded as consisting of two mutually interdependent subsystems 'body' and 'brain', which in combination behave analogous to a non-biological complex dynamic system, and which for analytical purposes can be individually treated as complex dynamic subsystems. The Model is, obviously, focussed on the subsystem 'brain'. The Core Hypothesis implies that the status 'complex dynamic subsystem' applies not only to the physical entity brain, but also to the entity mind.

Can learning be undone?

Key aspects of the Model are that, during one's lifetime, mental activity never ceases (also not during sleep or coma), and that brain-deposited and brain-processed information can never be "unlearned" by reverting any part or all of the brain to the original virgin state. What can and does happen regularly is that a module is re-configured, viz. by the growth of additional neuronal tentacles, as well as by deactivating selected synapses. What can also happen is that

certain synaptic linkages in a module "wither" over time due to disuse. Neuroscience expresses this fact in a brief rule stating "Use it, or loose it", where "it" refers to the affected part of a neuronal network. The fate of "withering" may affect a complete knowledge module only if its governing private paradigm module condemns this module to disuse over a long period of time. This does not mean, though, that this module will revert to its original virgin state (i.e. a state when the virgin structure of a module emerges within a sea of neurons with relatively few synaptic linkages).

(The analogy to a configured module is a brick house, which can also not be reconverted into the original bricks and binding materials. In other words, a configured module can be disabled, but not be returned to its virgin state.)

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Model supplements (not in Essay 3)

The Threshold Hypothesis of Consciousness

The new vision of consciousness introduced with the Model appears to be its most difficult aspect to accept for almost everyone, because this vision seems to contradict all experiences with the apparently free-willed recalling of bits of memory into consciousness. Not all memories emerging in consciousness are of this type. Instead these memories emerge spontaneously in consciousness, apparently uncalled for. The Model has to provide explanations for both types, of course.

Basic to the vision put forward in the Model is that information taken in by the human brain is not lying dormant, but that the majority of stored information is subject to subconscious processing whenever required (i.e. when information is assembled into knowledge, and when knowledge has to be adapted to new information). Throughout the wake state, it happens that the outcome of such subconscious processing becomes conscious. My interpretation of this phenomenon is that an outcome becomes conscious if the causative mental activity is of so high an intensity that it exceeds a brain typical threshold value. This is when "uncalled for" memories emerge spontaneously.

The apparently willed recalling of memories is explained in a similar way, except that memories do not pop up into consciousness out of the blue, but as a consequence of a stimulation (name, picture, sound). Assuming that one sees a picture of Table Mountain in Cape Town, then the subconscious mental processing thereof stimulates all memories related to Table Mountain. Of the stimulated mental activities only those release details into consciousness whose

intensities exceed the threshold value.

(It is obvious that the brain, being unaware of the Threshold Hypothesis of Consciousness, interprets conscious memorising as resulting from willed recalling of memory.)

Of particular significance is that the Threshold Hypothesis of Consciousness unifies the hitherto disparate concepts of conscious and unconscious states into a single phenomenon. This is a complete departure from the widespread popular view which regards the unconscious to be an opposite of the conscious.

The Direct-Access-Storage hypothesis

The foregoing vision of consciousness is incomplete without answers to questions such as "What is the purpose of rendering the outcome of subconscious high-intensity mental activity conscious?" and "What enables one to speak and write fluently in a learned language about a subject which has been brain-processed in 'brain language'?" Answers to questions of this type require another supplementary feature of the Model to be postulated, viz. a features which explains how knowledge released from a module in 'brain language' form (i.e. by electro-chemical signalling optimised for communication between neurons) is converted into specific forms dictated by the languages spoken and written by a person.

The basic assumption here is that 'brain language' is common for all humans. And it is posited that knowledge translated for a lecture in English, say, is stored (in English-compatible form) in a temporary information storage module which has a function similar to that of a Direct Access Storage Device in computers (which is "a storage device that can directly read or write to a specific place"). Likewise, knowledge translated for a lecture in Japanese is stored (in Japanese-compatible form) in another temporary information storage module. Storage in speech-compatible and text-compatible form ensures that verbal expressions and blackboard writing are fluently enabled out of these modules (in the following referred to as Direct Access Storage modules). This answers the question re. fluency of speech and writing posed earlier.

It is now posited that the outcome of subconscious high-intensity mental activity exceeding the aforementioned threshold is (temporarily) stored in such modules, and that it is out of these modules that items become conscious, viz. either in English or in Japanese, or in any other language for which a module exists. Again, "What is the advantage of these items becoming conscious?"

The answer is simple if one returns to the alleged function of consciousness,

viz. the identification of self in anything in which a person is involved in. On the one hand, this is the identification of self in the sensory intake of information, e.g. in the sensory intake of a verbal exchange between two disputants (when the auditory reception of one's own uttering would be processed in the exact same way as that of the opponent). On the other hand, consciousness should then also identify the self in anything which the brain contemplates on the basis of what it has learned. This implies that an idea generated by a person's brain should be marked as self-generated by becoming conscious. Once, the idea has become conscious, it can immediately and directly be fed into the normal intake stream of sensory information (i.e. without a detour via voice and ear or via writing and eye) for fast-track participation in further mental processing.

In other words, one's becoming aware of a new emergent item in a Direct Access Storage module is an indication of that, firstly, the brain has identified the self as the originator of this item, and that, secondly, the item is ready for immediate and direct acceptance into the regular learning process.

Hence, consciousness has an important informative functions in brain and mind, but it does neither cause nor manages anything.

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Consequences of the Model

The Model has a number of consequences which challenges Man's vision about himself/herself to the extreme. Key among these are (1) the Core Hypothesis which links mind to the physics and chemistry of neuronal "clustering" in the brain, (2) the relegation of consciousness from the function of managing human reasoning and behaviour to a function focused on the identification of self in all mental information processing, (3) the exclusively subconscious nature of mental information processing, (4) the virtually complete recording of sensory intake in the virgin brain, (5) the essentially collateral recording of sensory intake in the virgin brain, (6) the subconscious self-organisation of recorded information into knowledge, (7) the limited "conscious" access to both, information and knowledge in one's brain, (8) the incessant compatibility-optimising subconscious processing of new and old information, and the sporadic conscious revealing of the outcome of such processing (according to the Threshold Hypothesis of Consciousness and the Direct Access Storage hypothesis), (9) the physical irreversibility of a learning-modified brain to a virgin state, (10) the evolutionary predisposition for minimising the consumption of physical resources (materials and energy) for the physical processes behind mental activities (the Least Effort Principle), (11) the

definition of mind as "Totality of mental contents and mental activities of all physical modules", (12) the inherently physical nature of mind, (13) the brain-internal physical stress deriving from external challenges to the mind, (14) the inherently severe reaction to such challenges, (15) the negation of a free will in the conventional sense, (16) the negation of the existence of a free-will-related motivation (as assumed in the administration of law and elsewhere), and (17) the strong dependence of human reasoning and behaviour on the Least Effort Principle.

Appendix 2

Least Effort Principle and the Knowledge Priming feature (copied from Essay 3.1)

Learning was and is key to the success of humans. Evolution has given them learning-eager brains, and natural selection has favoured the survival of those making the most of learning for the least consumption of physical resources for the learning and thinking processes. The obvious contradiction between learning and saving of resources has given rise to compromise strategies of the brain which have ensured Man's survival in exchange for certain boundary conditions. These boundary conditions require to be known for the Least Effort Principle to be understood.

To start from scratch: The large brain of modern homo sapiens is a consequence of an original per-chance change of DNA of its precursor, as well as of the fact that the new-size brain was fully made use of from the start. The latter follows from an economising property of evolutionary biology, which brings about that an underused or disused part of a biological entity is starved of material and energy resources until it shrinks to a size corresponding to usage or until it "withers" to a state of uselessness. This is expressed by the rule "Use it, or loose it". The loss of a disused feature can become inheritable by a process known as gene switching.

On basis of the use-it-or-loose-it rule, it can be argued that the modern human brain is, on average, fully active within its physical limits.

(In terms of the Model of Essay 3.1) these physical limits are set by the highest possible delivery rate at which physical resources (material and energy) for the construction work of configuration or reconfiguration of physical modules can be made available at the construction sites, as well as by the highest possible rate at which the construction work can be done. Fast delivery is secured by a continuous flow of blood to every part of the brain, which, however, does not

necessarily imply an unlimited availability of resources at the construction sites. I do speculate, though, that it is the construction work which is responsible for most of the activity of the brain. After all, it takes two decades for a virgin brain to reach an autonomous adult state.

Early in life, the construction activity of the brain consists almost entirely of configurations of new knowledge modules, and little of reconfigurations of existing knowledge modules (there just are not that many). This changes with age, until eventually reconfiguration work dominates. The aforementioned compromise with the saving-of-resources dictate of a Stone Age life, was in operation at all times. Viz. in that in the (first) *configuration* of a knowledge module that information was and is favoured which is the most resources-saving for a particular self-consistent piece of knowledge (i.e. the physical basis for Ockham's razor). And, in that the *reconfigurations* of existing knowledge modules were and are reduced. Both together constitute the essence of the Least Effort Principle.

In other words, in the case of a *configuration* of new knowledge modules, the Least Effort Principle favours the "cheapest" self-consistent configuration possible from the in-brain available information. And, in the case of a *reconfiguration* of an existing knowledge module, the Least Effort Principle favours its avoidance or delay, or the option of configuration of an independent new knowledge module for collateral learning (if the collateral configuration is "cheaper" than the reconfiguration of an existing module).

The Least Effort Principle is not the only incentive for avoiding a reconfiguration, but also the being-out-of-service of existing knowledge modules if the reconfiguration is more than minor. This aspect may leave the mind disoriented in critical times.

On basis of the foregoing, the Least Effort Principle can be defined, for instance, as an "evolutionary predisposition for minimising the consumption of physical resources (materials and energy) for the physical processes behind essential learning", where 'essential learning' can be further specified as survival-furthering learning, embracing both the physical configuration of new knowledge modules and the physical reconfiguration of existing knowledge modules.

Now to a point of considerable importance: The concept of private paradigms introduced in the Model, suggests that the Least Effort Principle would favour the configuration of a new knowledge module even more (i.e. more than by favouring the "cheapest" self-consistent configuration possible) if such a paradigm would act as a condensation point for information which can

contribute to the new knowledge. Why? Because this priming by paradigm would save resources by short-cutting the search for compatibly information. In fact, it would provide a flying start for the new knowledge module. I like to introduce the term Knowledge Priming for this even "cheaper" type of learning.

The overall conclusion is that in combination with the mind's reluctance to reconfigure existing knowledge modules, knowledge priming leads to a scenario in which an established set of knowledge primers will govern a mind's reasoning for a long time.

Because physical science is swamped with well established knowledge primers (such as wave/particle duality, Heisenberg uncertainty, Big Bang singularity, and many more), it is evident that physical science requires a critical re-evaluation of the validity of these primers.

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