

Revival of Power in Mental Causation

In contemporary philosophy there is a revival of power in action, and two researchers in Norway have elaborated what they call ‘causes as powers’ and ‘the phenomenal powers view’. Their models are briefly presented and related to my own theories which show remarkable analogy between mental and physical action processes where the latter is represented by chemical and statistical thermodynamics. The same model for causation can be applied for both processes starting with potential energy or power that is converted to work needed to attain the goal.

Specific analogies are related to entropy and information, and a quantitative analogy between information in bits and entropy in calories can be calculated. Moreover, the connection between entropy and energy is clarified and justifies the question: Is real mental energy or power possible? Entropy considerations made it also possible to suggest a novel explanation for mind-brain causation without transfer of any kind of energy.

If there are both mental power and physical energy, do they have any intrinsic and entities in common? The best guess is perhaps a transcendental principle or concept: Change of activity, because activity can be both mental and physical, and: ‘All activity tend towards the lowest possible level while doing work’.

1 Introduction

My concern in this article is the role of power in causation. Power has not been the main focus in philosophy and has not been explicitly and thoroughly studied. Some philosophers, however, have addressed will and force but not elaborated subsequent aspects of causation: E.g. Kant with his causes as power (Leirfall 2019), Leibniz with his constant force, Shopenhauer with his will and representation, Nietsche with his will to power, and Spencer with his fundamental force.

But in the late 19th and beginning of the 20th century both physicians and psychologists delved into the problem of causes and energy. Especially Sigmund Freud (1991a,b), during his work with psychoanalyses, had definite theories related to causation. He observed that repression of an instinctual representative had two aspects: An idea cathected with a definite quota of psychic energy (affect). The latter can undergo vicissitudes such as the creation of anxiety. It should be plausible to call the whole process ‘causation of causal power’.

Freud’s economic (energetic) theory was much discussed in his time, and even the famous scientist Hermann von Helmholtz showed much interest in Freud’s work.

Later in the 20th century Paul Ricoeur (1970) published a brilliant interpretation of the economic theory. He suggested two discourses of mental processes: One related to ideas and meaning subject to interpretation and one related to forces subject to explanation. In other words: The cause consists of a desired goal that is ideational, and a force that is driving the process.

However, there was much criticism even at that time mainly because the various energy quotas could not be measured physically. Freud's theory was even called phlogistic, and lost interest during the decades to come. Nevertheless, it contained some basic elements that survived and led to renewal of interest among contemporary philosophers.

In 1988 W.D.Hart challenged main stream philosophy and published his book 'The engines of the soul' where he analysed psychic energy, belief, desire, quantity, action and causation. He even discussed the conversion of pure wishful thinking to belief and suggested a quantitative law for the process (p.129).

In our time Hedda Hassel Mørch and Anita Leirfall have revitalised the thinking behind power in causes (section 6).

2 Causal or teleological causation?

In 1971 G.H. von Wright published his book *Explanation and Understanding* where he presents the intentional explanation model for action (also called practical inference, PI) based on teleological principles:

- A intends to bring about *p* *Model 1*
- A considers that he cannot bring about *p* unless he does *a*
- Therefore A sets himself to do *a*

This model has a goal or purpose in the future that is decisive for what to do to reach it. This contrasts with the causal model that is used in the natural sciences where a cause pushes towards the future from behind.

Can intention (or will) be similar to a cause in a physical event? Can we 'translate' a teleological explanation of behavior into a causal one? Many philosophers think so and I agree for the following reason:

I contend (Løvland 2019a) that both the second and the third term in model 1 are a result of the cause, the intention to bring about *p*. The intention causes the subject to consider a way to reach the goal, i.e. cognitive work, and then to work mentally or physically to attain it; when this work succeeds, the goal is accomplished. We can express the action as follows:

This model can be applied for both mental and physical causation but the terms are of course different.

In von Wright's teleological model the intention to act may be the result of cognitive reasoning, not necessarily directly by emotions such as desires. But this reasoning may lead to a desire to attain the goal so that the 'cause must have another cause'. Later in this paper I will elaborate on the immediate emotional causes.

3 Power causation

Refer to Appendix A for explanation of terms.

3.1 Potential

When the causation in model 2 above is used for a physical process, mechanical or chemical, the cause can be called potential energy. It is consumed while being converted to work towards the end product, the 'goal'. The amount of potential energy thus being reduced until the process reaches equilibrium (goal), and the potential energy is zero. The total reduction of potential energy in action is the initial amount of free energy minus the final one. Since the initial is the highest potential energy is released. The special mathematics applied in thermodynamics is explained in Appendix A.

Do we have similar relationships in processes with a mental cause? Can a mental cause have potential energy? Freud (1991a,b) definitely thought so. His quota of affects is really meant as a pressure that tends to be converted to 'work', another form of energy.

Generally, introspection gives us the feeling of power that tends to achieve a specific goal. When the goal is achieved the feeling has disappeared, and the subject is calm and relaxed, say that he is in a state of equilibrium at a lower emotional level. Thus the potential mental power is the initial level of feelings and emotions minus the final one analogous to that in thermodynamics. Appendix A.

3.2 Entropy

But a thermodynamical process is not merely based on energy but also on *entropy*. This latter property is actually calorimetric energy expressed in a particular mathematical way according to classical physics. It is related to the change of structural order during the process, say the number of possible microstates in the

components such as atoms and molecules, an *order-disorder change*. When the process leads to less order, the system receives entropy from its surroundings and this energy contributes to the potential energy (e.g. Prigogine 1954). When the order goes up the system loses entropy, and that loss can be compensated by supply of *energy* from the surroundings of the system. (Løvland 2019d)

The question is now: Do we have the same relationships in a mental process? If so it is a crucial indication of the analogy between physical and mental causation. Consciousness consists of many mental representations of various kinds: Images, sounds, words, concepts, memories, logical constellations, etc. A mental process starts with a certain number of those which are activated to carry out a particular task, and may end with the goal consisting of another number of activated representations. This change during the process is an *order-disorder* change of the mental structure. But does it mean that mental *energy* is supplied to or lost from consciousness similar to a chemical process? A preliminary experiment based on Osgood's (1978) 'semantic differential' indicated that it is possible (Appendix B, Løvland 2019a, p11).

3.3 Information

Amount of information is measured as the number of alternatives eliminated in a choice situation where alternatives are the mental representations in consciousness. Fewer alternatives mean more certain information, and vice versa, more alternatives mean more uncertain information. (Attneave 1959, based on Shannon's information theory.)

The amount of statistical entropy is measured as the number of possible microstates in a physical substance: Fewer microstates mean less entropy. A comparison now shows that a lower number of alternatives and therefore less uncertainty correspond to fewer microstates and less entropy. This is expressed mathematically in Appendix C.

We see here that uncertainty and entropy are analogous properties, and it is possible to name uncertainty 'mental entropy' (Appendix C). The analogy is mathematically secured and makes it highly probable that even the *energy* equations in thermodynamics are analogous to something like it in the mind. In thermodynamics the change of free energy is proportional to the negative change of entropy, i.e., less entropy corresponds to more energy. In the mind less mental entropy corresponds to more mental energy (or power), and we have an additional indication of the existence of this kind of energy (Løvland 2019d, Appendix C).

Observe that the mental energy so formed is due to increased order of mental representations in consciousness. We can say that cognitive reactions have created

mental power/energy that consists of feelings (section 4). This corroborates mathematically the experiment described in Appendix B.

3.4 Energy in other disciplines

Since Freud's clinical observations of psychic energy as a cause there has been little interest of power in psychology and philosophy. All the same, in neuroscience researchers (e.g. Carhart-Harris et al, 2010) have studied physical energy changes in the brain and compared them with Freud's theories. They found remarkable similarities between free energy in the former and psychic energy in the latter.

And let us not forget Libet's (1985) famous experiments where he found that a conscious decision to act physically corresponded significantly to the quantitatively measured electrical readiness potential in the brain.

In quantum physics there has also been much interest in mental processes. Thompson (1) has compared quantum and mental causation based on a mental model suggested by Emanuel Swedenborg:

- *Active Energy > Tendency Wave > Actual Outcome *Model 3*
(Hamiltonion)
- *Intention > Possible Plans > Action
(thoughts)

I am neither going to delve into quantum physics nor into Swedenborg's mental model so I merely highlight some relevant features. The top process in the model is the quantum one: According to Thompson Active Energy is the total energy consisting of the kinetic and potential energies of the system, cfr. internal energy in chemistry. It is called the Hamiltonion and is the cause of the process and is likened with intention. The Hamiltonian is an operator that operates on the wave function and changes it. It produces a so called 'tendency wave', which is a form of propensities or tendencies for action, i.e. a probability wave for different actual outcomes. This step in the process is likened with thoughts or cognition work in mental processes which may lead to the goal. In the processes above 'Tendency Wave' is similar to both 'Possible Plans' and 'Action'. It is interesting to note that model 2 is principally suitable for both the above causation processes. Moreover, Thompson (2) has elaborated these ideas in detail in another paper.

4 Motivation

Motivation may consist of both an emotional and a cognitive part. The former may be aroused to different levels or intensities dependent on the significance that the cause of the emotions has for the subject in question. If the subject gets a surprisingly

positive or negative message/experience his emotions and feelings will rise to a higher level than does a dull and normal message/experience. It would be very helpful if we could get a measure of this level or at least a rough impression of it. A proposal for such a measurement is described in Appendix B.

The cognitive part of motivation means that e.g. reasoning has led to feelings that are the real potential mental power and cause of the process as explained for intention in section 2. So, all the different causes in motivation are grounded in affects; a thought in itself has no power. The various causes in motivation are listed as:

- * Intention
 - * Will
 - * Desire
 - * Instinct
- List 1*

These may operate individually or in combination. Moreover, there are phenomenal properties that may cause desires, see later in section 6.

Intention, as von Wright (1971) describes it in model 1, is caused by a cognitive process that leads to a goal. If the goal is wanted, the emotional potential power is used to achieve it. If the goal is not wanted, you just do not intend to bring it about. Nevertheless, if you e.g. get an order from your boss to do it, the emotional irritation that is caused by the order may be enough potential power to do what you do not want to do. Can this emotional power, bad feelings, be called will? Is will the power to attain an unwanted goal which in this setting is wanted?

The causation of desire can be coupled to instinct or need and implies a great amount of emotions coming from the unconscious according to Freud (1991b). But there are also cognitive processes that through reasoning can lead to wish and desire. Moreover, external stimuli such as conscious experiences and bodily reactions can create bad or pleasant feelings resulting in a desire to avoid, keep, or pursue the feelings. Refer to Mørch's (2020) elaboration of these reactions in section 6.

An instinct is an unconscious, inherent motivation to act in a particular way as a response to external stimuli. It may lead to automatic reflexes such as quickly pulling back your fingers from a hot plate, an immediate reaction that resembles conscious mental causation with desire as a cause to avoid bad feelings.

5 Mind-brain relationship

There has been much discussion over many years about this relationship. How can we explain the connection between mental and physical properties? Many

philosophers hold that the mental and physical domains are so different that they can not interact causally. The latter is characterised by space-time coordinates such as extension, bulk, mass, energy, etc which are absent in the former. So, dualism is false!? I deny such a conclusion (Løvland 2019b). I hold that mental causes can affect physical processes in the brain causally. But then one must accept that there is some kind of contact without power or energy between mental entities and neurons: When a subject concentrates to perform a physical task, his mental representations that are relevant for the task are activated, the others are deactivated and there seems to be a more *ordered* mental structure. Presumably the neurons that are relevant for the task are activated, the others are deactivated, and the structure of neurons as well seems to be more *ordered*. In thermodynamics statistical entropy is decreased in a more ordered structure and the system thus needs a supply of physical energy in order to function at a constant temperature. The brain can receive this amount of energy from other parts of the body and thus be able to activate the electrical system that is needed to perform the physical task. Thus the intended or wanted goal is attained without conversion of mental energy to physical activity.

6 Recent Views

In recent years two philosophers in Norway have delved into the problem of power in causes, Hedda Hassel Mørch and Anita Leirfall, both refer to phenomenal power and properties. Mørch has presented ‘The Phenomenal Powers View’ that will be described later in this section. But first to the more general ‘Causes as powers’ as Leirfall (2019) explains it.

The term cause can mean both a physical and a mental cause. The former is well treated within the natural sciences, the latter is still a problem that is not resolved. Leirfall takes as an example a case where both types are combined: Experiences within our bodies give us the sense (feeling) of a required effort, the power needed, for instance to lift a glass of water when you are thirsty. It is obvious that feelings themselves can not lift any physical object. Feelings merely tell us that we should avoid feeling thirsty. Cognitive work and effort must be used to find out how to avoid it, either to lift a glass of water and drink it, or e.g. by drinking directly from the tap. The thirsty subject must have a specific and concrete goal and try to attain it. Leirfall’s sense of a required effort can be part of the following model for a complete process:

1. Physical cause in the body (physical energy) *Model 4*
2. Mental effect in consciousness (bad feeling, qualia, potential power)
3. This effect is a cause with potential power to avoid the mental effect (bad feeling).
4. Cognitive work (reasoning) to find out how to avoid the mental effect (bad feeling).

5. Physical work to attain that goal
6. Attained goal (no potential power, 'equilibrium')

In short:

Model 5

Physical cause > Mental effect/Mental cause >
Mental work > Physical work > Attained goal

We see here that models 4 and 5 are of the same type as model 2: Potential power being converted to work until the goal is attained and the potential power is zero.

The process shown in model 5 has crossed the border between the mental and physical domains two times which is a problem in itself, the well-known mind-body problem. In section 5 I suggested that a mental decision to perform physical work can be effectuated without transfer of energy between the domains. Is the reverse process conceivable?

Mørch (2020) has published an interesting theory called the 'The Phenomenal Powers View' that is grounded on the same principles as described above for 'Causes as Powers'. She contends that phenomenal properties, qualia, have causal powers in virtue of how the subject feels, i.e. in virtue of its phenomenal character. As an example she takes the feeling of pain that has the power to make subjects who experience it try to avoid it in the absence of interferences from other motives. According to Mørch (2020) Harold Langsam has a slightly different view: Conscious states have 'intelligible causal powers' that include pain's power to cause the *desire* to avoid it. So, according to Langsam, Mørch's phenomenal power can not directly be used to avoid the pain, a desire must first be established. This seems to me more plausible, the power of pain probably gives the subject a desired goal.

My main concern relates to the power itself, not to the kind of cause the subject has. I contend that every action is driven by the tendency towards a lower level of energy and power whether the cause is bad or pleasant feelings. The difference of the amount of energy in the final and initial states makes up the driving potential. In a purely physical process this is quantitatively measurable, in a mental process this is difficult but there may be other ways to assess this potential (Appendix B).

As I said about 'causes as powers' there may be cognitive causes, intention and will, that can lead to similar effects, avoidance of bad feelings. But first the intention must have created desire or wish to attain the goal, so that again it is the power of feelings that is the real cause of the action.

List 1, the contents in motivation, will have to be extended with to more causes due to Mørch's and Leirfall's theories:

- * Intention
- * Will
- * Desire
- * Instinct
- * Causes as powers
- * Phenomenal powers

List 2

All these causes consist of feelings with power derived from various sources as explained in section 4.

7 Arguments for the mental-physical analogy

What indications and evidence do we have for the similarity and analogy between mental and physical processes? Below is a summary:

- 1) As explained in section 3.1 introspection gives us the intuition of power to achieve a goal similar to a physical causal process.
- 2) The special effect of structural order-disorder change in consciousness on the intensity and thus potential power of mental causes is indicated in a preliminary experiment (Section 3.2, Appendix B). This is similar to what happens in thermodynamics.
- 3) When a subject concentrates to act, the number of relevant mental representations is normally lower than when he is unconcentrated. We can presume that a similar reduction of the number of active neurons in the brain occurs without energy transfer. Consequently, according to thermodynamics, physical energy is supplied to the brain from other parts of the body. Thus mental-physical causation is possible without energy transfer (Section 5).
- 4) Application of a quantitative mathematical method makes it highly probable that mental energy behaves similarly to physical energy. The method is grounded in Shannon's information theory and Boltzmann's entropy explanation (Appendix C, section 3.3).
- 5) Ian Thompson's comparison of mental and quantum physical causation is a very interesting argument for the analogy between mental and physical processes (Section 3.4).

We have here five indications of the analogy between mental and physical processes, four based on thermodynamics. Are these sufficient to contend that we have real mental energy and not a metaphor? It is hard to believe that similarities of so great and complex details are merely imaginary. Especially the mathematical calculation points to real and reliable similarity; both entropy and information are mathematical and scientific facts that are convincing arguments for real mental energy.

8 Discussion

8.1 Mental power

In this paper I have described mental power coming from four different sources in the ‘macroworld’ plus one in the quantum world. In the macroworld:

Phenomenal power that is feelings, qualia, created by conscious experience, e.g. pain and thirst.

Mental power that is desire and wish that can be coupled to instinct, cognitive processes, or conscious experience.

Mental power that is feelings aroused by cognitive processes in consciousness, e.g. intention and will.

Mental power that is feelings created by cognitive increase of order of mental representations in consciousness, i.e. decrease of ‘mental entropy’ (Appendix C).

We see here four types of (potential) mental power that are all characterised by feelings or emotions. These must not be confused with another type of feelings: Those which are formed as a ‘by-product’ of the work towards the goal, i.e. spontaneous ‘active’ feelings, e.g. joy, happiness, or pleasure if the goal is attained; annoyance, anger, or anxiety if it is not attained. According to irreversible chemical thermodynamics some heat is always formed within the system during a normal process (e.g. Prigogine 1954). This heat can be considered as being analogous to ‘active’ feelings (Løvland 2019a).

8.2 A little metaphysics

The purpose of the present paper is to show that there are several indications or evidence for the existence of some kind of mental energy and power that behave as if they were physical energy. Does that mean that the mental and the physical have a common ground? What are the intrinsic properties? Perhaps the clue lies in intrinsic properties of physical events. There is an old view that is revitalised today that can possibly help to understand such properties, if it is true: Panpsychism.

Panpsychism is the doctrine that mind is a fundamental feature of the world which exists throughout the universe (Stanford Encyclopedia of Philosophy, summer 2005)

So, mind underlies physical causation? Does that mean that mental causes are agents for physical causation? Are mental properties embedded in or fused into physical structure? Does this mean that causal connection between phenomenal power and spatio-temporal physical properties is possible? Or, do we just have moved the border between the mental and the physical domains from the macrolevel to the microlevel? The best interpretation of the panpsychist doctrine may be that mental

and physical properties are identical. They are not fused into each other because they *are the same*. But even this interpretation is controversial. According to Leibniz's law strict identity is governed by the following: 'If x is identical to y , x and y share all their properties in common' (Kim 1998, Løvland 2019c, p.33). Are all mental properties shared with all the physical ones in our case? I cannot see that. How can e.g. phenomenal power be the same and shared with physical potential energy? Moreover, it is hard to see that properties measured in bits are shared with those measured in calories. However, properties that are analogous can share in common the *concept* of these properties which we may call intrinsic and fundamental, a transcendental principle. This principle is applicable for both mental power and physical energy and is observed in the universe as ACTIVITY. Activity ought to be uncontroversial and plausible as a term for both mental power and physical energy. Having such a fundamental activity-principle the analogous mental and physical processes thus become *homologous*, perhaps a more suitable term than is analogous. The activity tends to lower itself until zero is attained. Therefore, it is the *change of activity* that drives the world, but if all processes proceed to zero or equilibrium the world would eventually be dead. Fortunately, it is not so: When the amount of potential energy go down to perform work, this amount is expelled from the system and can increase the energy and activity of another system. Thus the world survives due to an enormous number of such oscillating pendulums.

If the changes of activity are fundamental and intrinsic in both the physical and mental processes we can ask: What are the intrinsic properties of activity?

«It's the energy, stupid!»
The ring is closed.

9 Conclusion

It is highly probable that mental causation is analogous to thermodynamic causal processes with respect to power and energy. Both processes fit into the general model:

Cause > Work/Action > Goal/Effect

This is indicated by introspection of feelings and emotions, by putative analogy between mental and physical entropy, by mathematical dependency of energy on entropy, and by mathematical comparison of information and entropy. Moreover, there is support of Freud's energy model within neuroscience and of the mental-physical analogy within quantum physics. All of these arguments point to the existence of real mental energy or power.

Recently Hedda Hassel Mørch has published 'The Phenomenal Powers View' which is associated with the more general model 'Causes as Powers'. Evidently, some

contemporary philosophers have revitalised the thought that there is power in mental states, a thought that has been sleeping for so long.

The present author proposes to apply the term *activity* for both mental and physical causation. Change of activity level thus being the common ground for mental and physical action:

‘All activity tend towards the lowest possible level while doing work’.

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Appendix A: Explanations of expressions and terms as used in this paper.

Physics and chemistry:

Thermodynamics in this paper is transformation of energy in chemical processes near equilibrium at constant temperature in systems that can exchange energy, but not matter, with its surroundings.

Free energy in thermodynamics is explained for use in this paper as follows: The amount of energy available to perform external work possibly modified by entropy that is either supplied to or lost from the system *during* the process. The initial amount subtracted from the final makes up the potential energy. Since the initial always is the highest in action the potential energy is always negative. The process is described mathematically by Helmholtz:

$$dF = dU - TdS$$

where F is free energy, U is internal energy, S is entropy, and T is a constant (absolute temperature). dF is in action the negative potential energy; it will in this paper be applied without mathematical symbols as a cause of the action except where they are needed for the explanation.

Force is the constituent of and a prerequisite for power.

Power is potential energy consumed per time interval to produce work. The term is not used in thermodynamics.

Work is created by the consumption of potential energy that is converted to the same amount of another form of energy, e.g. mechanical or heat.

Mind:

Observe that ‘mental’ and ‘psychic’ are applied interchangeably; so are ‘emotions’ and ‘feelings’.

Mental power is not clearly defined in philosophy. In our context it is feelings or emotions in motivation. Can be called potential mental power that is consumed while being converted to mental or physical work.

Phenomenal power is mental power caused by a conscious experience.

Phenomenal properties: What it feels like to have a conscious experience, qualia (Stanford Encyclopedia of Philosophy, entry ‘qualia’).

Mental work is the consumption of mental power to create mental or physical action.

Mental energy is contended in this paper to be analogous, but not identical, to physical energy as expressed in thermodynamics.

Appendix B: A preliminary experiment.

The preliminary experiment to measure arousal and intensity caused by the change of mental order in consciousness is based on Osgood’s (1978) ‘Semantic differential’, primarily a psycholinguistic method. Direct from Løvland’s description (2019c, p.44):

‘A subject is shown a picture of concepts (words) that are associated with a set of bipolar adjectives such as weak-strong, soft-hard, and white-black. Each bipolar adjective is evaluated and given a ranking number related to the emotional intensity that it creates. An average ranking number is calculated for the whole picture, a number that represents the motivation or the mental (free) energy created by that picture.’

Løvland (unpublished) carried out a preliminary experiment where a subject was shown two pictures, first one with 6 equal words randomly distributed, quickly afterwards another with only one of the same words. The number of words is thus reduced from 6 to 1. I carefully minimised the influence of affective factors such as the meaning of the words, and evaluated the effect of several such changes of pictures on the average ranking numbers. I found that this number increased some 30% due to reduction of the number of words, which means that the emotional

intensity and the (potential) mental power go up some 30%. This preliminary result corroborates the present hypothesis that lowering the mental entropy raises the mental (free) energy/motivation. The result is the ‘objective’ part of total motivation and of the total mental (free) energy.

In a future experiment it would be interesting to study the relation between mental entropy and cerebral electrical activity.

Appendix C: Information and entropy. Mental energy?

Below it is shown that H , the uncertainty and ‘mental entropy’, is analogous, but not identical, to S , the physical entropy. According to the entropy term in Helmholtz’ free energy equation there is a close connection between entropy and energy. It is contended that the same connection holds for mental entropy and mental energy.

Attneave (1959) published a very informative book about Shannon’s information theory in psychology. It is applicable in our context and I begin with the classical equation for the quantity of information in bits:

$$H = \log_2 m$$

where m is the initial number of equally likely alternatives in a choice situation. Before an alternative is selected, H is the *uncertainty* of the information gaining process. After a choice is made, the information gained, H , is maximum and defined to be equal to the uncertainty eliminated, and both can be measured in bits.

The statistical entropy amount of a physical system is expressed by Boltzmann-Planck’s formula:

$$S = k \ln m_{phys}$$

where m_{phys} is the number of possible microstates, i.e. quantum states related to the number of molecules; k is Boltzmann’s constant which links the number of microstates to calorimetric entropy expressed in energy units, e.g. calories or joules.

We see easily the analogy between H and S , between uncertainty in a choice situation and statistical entropy, between the number of alternative choices and the number of possible microstates. When H goes up, S goes up. It is tempting to name H ‘mental entropy’ designated e.g. H_{th} .

In thermodynamics the amount of free energy is proportional to the amount of negative entropy expressed mathematically in the abbreviated equation:

$$F = - TS$$

Where T is the absolute temperature, a constant. If mental and physical entropy are analogous, why should not mental and physical *energy* also be so? I contend that it is highly probable that they are due to the reasons listed in section 7, especially the mathematical method. It is interesting that the analogy between the energies is indicated in quantum physics as well. All these indications make it justified to conclude:

The amount of potential mental energy in bits is analogous to the amount of physical potential energy in calories.

The amount of mental energy is the ‘objective’ part of the total mental energy and should be added to the energy/power caused by experience or cognitive reasoning, if relevant.

The explanation in this appendix is further elaborated by Løvland (2019d).

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