The Good, the Evil and the 'Entropic Potential of an Event'

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Abstract

The definitions of "good" and "evil" typically belong to the field of ethics. Does physics have a property that can distinguish and group "good" and "evil" events using only its own physical instruments and equations?

Although the physical property "Entropy" as a measure of chaos appears to be the prime candidate for such a grouping, it is in fact unsuitable for a detailed analysis. However, the "Entropic Potential of an Event", which describes the influence of the current event to the *future* change in entropy, perfectly suits this role.

While the second law of thermodynamics dictates the direction of entropy change in an isolated system it does not dictate the *speed* of entropy growth. The speed of entropy growth on Earth is changing in particular due to human-related events, which ethics calls "good" or "evil". Such events, which ethics defines as "good", usually decelerate entropy growth. In contrast, events which ethics defines as "evil", usually accelerate entropy growth.

This article presents the methods of calculating the "Entropic Potential of an Event" for the cases: "A commander receives an order to bombard a city", "A cancer tumor is growing inside a human's body" and other. This article also stresses the importance of the "Time factor" since only for a *sufficiently* large time interval T the "Entropic Potential of an Event" Z(T, A) can be estimated and potentially precisely calculated.

This article also checks on a scale of several centuries if real-life events are averaged in such a way that their entropic potentials become negligible. This analysis shows that prior 1750 the averaged entropic potential of events occurred in human society was negative and had the value of approximately 10^{17} bits (value is an initial approximation). The situation after the industrial revolution is more complicated, as past 1750 human civilization began to utilize non-renewable resources (oil, coal, gas, etc.) for warming, cooling, and transportation with a corresponding entropy growth.

The term "entropy" is applicable to a very wide range of events, from physics and chemistry to art and information. Correspondingly, the significant advantages of the "Entropic Potential of an Event" as a physical foundation of the intuitive terms "good" and "evil" is its measurability, ability to compare events of entirely different natures and its universality.

Keywords: ethics; good; evil; entropic potential of an event; entropy

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1. Introduction

What is common in terms of physics in the following events:

a. A commander receives an order to bombard a city
b. Someone kills a flower during early summer
c. A cancer tumor is growing inside a human's body
d. A salmon was killed on the way to a spawn
e. An obese person eats an unhealthy meal

?

In the field of *ethics*, these events can be grouped and labeled as dramas of various scales. However, can *physics* group all of these events and find commonalities in them as well? In physics the property called "entropy" appears to be the prime feature to group all the unfortunate events listed above. In all cases of destruction or death entropy grows, this makes it the primary candidate to group the (a) - (e) events above. However, in fact, entropy is not completely suitable for this grouping. Yes, in the cases "b", "d" and arguably "c" [1, 2] entropy grows. However, in cases "a" and "e" entropy decreases. In case "e" entropy decreases because the human body converts the low organized nutrients (including water) into higher organized biological tissue and ATP. And even in the case of "a", in accordance with the theory of information, entropy decreases also.

Let us analyze cases "a" and "e" in further detail.

Case "a". Before the order arrives, the commander did not know if they will have to bombard the city or not. The probability of receiving this order was neither 0 nor 100% and instead it was in between. Delivery of the order increased information into this system and made the system more certain than it was before the order's arrival. Therefore, the entropy decreased as soon as the commander read the order. Understandably later when bombardment of the city begins, the growth of entropy will be enormous. But at the moment of the order's arrival, the entropy decreases.

Case "e". The human body converts the sugar and colorants located in the piece of candy into more organized biological molecules in the human body and ATP. As this chemical energy is stored, mainly in the form of ATP, entropy is lowered because this concentrated form of energy has low entropy. Obviously later when this ATP is used for work within the body it creates heat which increases entropy. This heat is then dispersed into the surroundings, increasing the entropy of the surroundings [3]. But all this will happen later after the time of consumption of the candy.

As we see, the physical property "entropy" is not fully suitable to group the cases (a) - (e) as events where entropy grows. On the other hand, we emotionally label all these (a) - (e) events as "bad" since nature, society and people's lives become worse due of them.

If entropy's increase is not suitable to group these unfortunate events, is there anything else that physics can offer for grouping? We can also rephrase this question in another way: *What is good and evil from the point of view of physics*? Can physics offer certain property to describe and to mathematically distinguish good and evil? Perhaps this is impossible?

2. Results

2.1. Analysis

2.1.1. Questions "why" and "when".

Let us begin our analysis with the following question. Why do we call the events (a) - (e) bad and unfortunate? Is it because something bad happens *now*? Or it is because something bad will happen in the *future*?

Obviously, the latter is true. During the moment when the commander received the order nothing bad has happened yet. During the moment when the obese person eats the next piece of candy also nothing bad has happened. They simply enjoy the candy and convert sugars, colorants and artificial flavors into complex biomolecules in their body.

All problems will arise *in the future*, not immediately. The events (a)-(e) simply trigger *future* tragic events.

In the case of (a) part of the city will be destroyed.

In the case of (b) the flower will not grow, will not feed the bees and people will not enjoy its beauty.

In the case of (c) someone will likely die because of the cancer.

In the case of (d) the killed salmon will not spawn children, and this temporarily slows down the growth of salmon population and the overall biomass on Earth until competing fishes will return biomass to equilibrium.

In the case of (e) the obese person will live a shorter lifespan and their contribution to human society will be less than it could have been.

In other words, in all the above cases (a) - (e) entropy will *eventually* grow. But it will grow in the future and not instantly.

2.1.2. Second law of thermodynamic and the speed of entropy growth

On the other hand, in accordance to the second law of thermodynamic the entropy in the described systems will grow anyways. What is the difference then? The difference is in the *speed* of entropy growth. The second law of thermodynamics dictates the direction of entropy change in an isolated system. It can only grow. However, the second law of thermodynamics does not dictate the *speed* of entropy growth. Because of the unfortunate events (a) - (e), entropy in these systems will grow faster than without these events. (This is the reason why we call these events "unfortunate".)

2.1.3. The ‘Entropic Potential of an Event’

Therefore, we have found the commonality in the events above (a) - (e). It is *acceleration* of entropy growth in the future in comparison to the world without these events. It is important to stress that it is not the immediate increase of entropy (which does not happen in the events (a), (c), (e)) but the growth of entropy in the future *due* to these events. Does physics have a property that describes the influence of the current event to the future change of entropy? Indeed, physics has a term for such a property and it is called the ‘*Entropic Potential of an Event*’ [4].

The ‘Entropic potential of an event’ is defined as the difference between the mathematical expectation [5] of the future system’s entropy made before and after the analyzed event. The ‘Entropic potential of an event’ has the simple formula

$$Z(T, A) = \hat{S}_T(T_0+dT) - \hat{S}_T(T_0-dT), \quad (1)$$

where
Z(T, A) is “Entropic potential of an event” for the event A calculated for a future moment T;
T_0 is the moment when event A occurred ($T_0<T$);
$\hat{S}_T(T_0+dT)$ is the mathematical expectation of a system’s entropy for the moment T made immediately after the event A;
$\hat{S}_T(T_0-dT)$ is the mathematical expectation of the system’s entropy at the moment T made immediately before the event A.

The name of the system “R” does not appear in the formula (1) but certainly we will always assume that all considered events occur in the system R.

The ‘Entropic potential of an event is suitable for our analysis because it describes the change of entropy in the system in the future *triggered* by the event A.

The mathematical expectation of entropy for the future moment T is $\hat{S}_T(T_0-dT)$ prior to event A’s occurrence. After event A has occurred the mathematical expectation of entropy for the future moment T is $\hat{S}_T(T_0+dT)$. If $\hat{S}_T(T_0+dT) < \hat{S}_T(T_0-dT)$, this in essence means that event A had decelerated the growth of entropy in the system and protected it from degradation and destruction at least until the moment T. For such cases the entropic potential of event A is negative

$$Z(T, A) = \hat{S}_T(T_0 + dT) – \hat{S}_T(T_0 - dT) < 0 \quad (2)$$

As well as vice versa, if the difference of the mathematical expectations of entropy after and before the event A is positive, i.e. $\hat{S}_T(T_0+dT) > \hat{S}_T(T_0-dT)$, this essentially means that the event A accelerated the growth of entropy in the system and accelerated degradation of this system at least until the moment T. For such cases the entropic potential of event Z(T, A) is positive.

In short, the entropic potentials of events "useful" for the system are negative and (vice versa) entropic potentials of the events "harmful" for system are positive.

2.2. Application of the ‘Entropic potential of an event’ to the cases (a) - (e).

Let us analyze if the signs of the “Entropic potential of an event” in the cases (a)-(e) presented above are negative or positive.

2.2.1. The estimation of the entropic potential of the event “Commander receives an order to bombard the city.”

2.2.1.1. Let us call this as event "A" (and define the analyzed system R as the arrived message, the commander, the cannons and the city that will be bombarded). At the moment of reading the order the (informational) entropy decreases. However as soon as the bombardment begins the buildings in the city are destroyed, people are killed, and entropy greatly increases. Since the probability to receive the order was not equal to 1, the mathematical expectations of future entropy calculated immediately before and after receiving the order are distinct.

2.2.1.2. Few words about the *mathematical expectation*. The “mathematical expectation” of the random variable is defined as “the sum of the products obtained by multiplying each value of the random variable by the corresponding probability” [5]. If in this considered case we denote the entropy growth at the moment T in result of the city bombardment as “S” and denote “p” as the probability that the received message contains the “begin bombardment” order, we obtain the mathematical expectations

$$\hat{S}_T(T_0 + dT) = S,$$

$$\hat{S}_T(T_0 - dT) = S^*p.$$

Indeed, before the arrival of the “begin bombardment” message the probability of bombardment was p and the estimated entropy growth was S*p. However, after the arrival of the message “begin bombardment” the probability of bombardment becomes 1 and the estimated entropy growth becomes S. Correspondingly the entropic potential of the arrival of the message “begin bombardment” is

$$Z(T, A) = \hat{S}_T(T_0 + dT) - \hat{S}_T(T_0 - dT) = S - S*p = S*(1-p) \quad (3).$$

2.2.1.3. Let us consider the meaning of the entropic potential in formula (3).

First, the entropic potential is positive. This is the expected result because entropy grows significantly as a result of the bombardment.

Second, since probability p is located within the [0,1] interval the entropic potential Z(T, A) in this case is between S and 0. Does this make physical sense ? Let us confirm.

Case p=1. If probability p to receive the order "begin bombardment" is equal to 1, then the system is entirely deterministic. Thus, receiving of the "begin bombardment" order is 100% an expected event and its arrival does not alter the growth of entropy. It did not influence the growth of entropy, because the probability of bombardment was and is equal to 100%. Correspondingly, the arrival of the order "begin bombardment" does not influence the future entropy growth and correspondingly the entropic potential of this event is zero, Z(T, A)=0.

Case p=0.5. If the probability p to receive the order "begin bombardment" was equal to 0.5, then in 50% of cases the bombardment is terminated. Correspondingly, the estimated entropy growth before the order's arrival was S*0.5. The arrival of the order "begin bombardment" changed the estimated entropy growth to S. Correspondingly, the entropic potential of this event is

$$Z(T, A) = S - S*0.5 = S*0.5.$$

Case p ~ 0. If probability p to receive the order "begin bombardment" was very low, approximately 0, then the estimated entropy growth calculated *before* the order's arrival was likewise approximately 0 ($\hat{S}_T(T_0 - dT) = S*p \sim 0$). In layman's terms - the people expected that bombardment would not occur and that the situation will be resolved peacefully. The arrival of the order "begin bombardment" changed the estimation of the entropy growth to S. Correspondingly, the entropic potential of this event is positive and is very large

$$Z(T, A) = S - 0 = S \quad (4).$$

In layman's terms – the more unexpected the event is that increases entropy – the greater the entropic potential of this event. Similarly, vice versa, if the event that increases entropy is highly expected - the entropic potential of this event is very low, since this event does not deviate the future entropy from the expected value. As we have confirmed, in all considered cases the entropic potential makes physical meaning.

2.2.1.4. Exploring the time interval T. We must also note that the time interval between the moment T_0 and the moment T for which we calculate the mathematical estimations must be *sufficiently large*. If it is too small (for example just 2 seconds after the moment T_0 when the commander reads the order) the bombardment does not yet begin and $\hat{S}_T(T_0+dT) \sim \hat{S}_T(T_0-dT)$. If it is sufficiently large, the bombardment begins and the estimation is as follows $\hat{S}_T(T_0+dT) \gg \hat{S}_T(T_0-dT)$. We will discuss the time factor in further detail in the part 2.3 "Time factor".

2.2.2 Estimation of the entropic potential of the event "Someone kills a flower during early summer."

2.2.2.1 This event leads to (at least) 3 consequences.

No food for the bees. Since the flower died during the beginning of summer, the bees do not have access to this specific source of food. This slightly decreases their population and correspondingly the Earth's biomass when comparing to the case when flower was not broken.

Loss of beauty to humans. Without discussing at this moment if viewing beautiful items slows-down entropy growth, we must note that people love to surround themself with beautiful objects: bouquets of flowers, paintings, beautiful furniture, artistic dishware, etc. Taking into account that all these objects of nature and art cost greater than plain dishes and/or no objects of art, we see that people have inclinations to surround themself with these beautiful items. Without going into detail, we can agree that beautiful environments complement human life and allows people to live longer and to be more productive in their work. In terms of physics this means that the increased production of highly-organized biomass with a longer lifespan causes the slowing down of entropy growth on Earth. The discussed event "someone kills a flower during early summer" decreases the number of scenes that people view and this effectively increases entropy growth. (The mathematical expectation $\hat{S}_T(T_0 + dT)$ also includes special cases when a flower was picked for a bouquet from which a still life will be painted, or when a flower is presented to a loved one along with a declaration of love. But the probability of such events is small and, accordingly, their contribution to the mathematical expectation $\hat{S}_T(T_0 + dT)$ is also very small.)

This event also decreases the chances that this type of flower will live in the future. In extreme cases this could be the last species of the flower from the IUCN Red List. However, usually in this situation other species of flowers will gain an advantage.

The entropic potential of that event appears to be exactly the same as in formula (3).

$$Z(T, A) = \hat{S}_T(T_0 + dT) - \hat{S}_T(T_0\text{-}dT) = S - S*p = S*(1\text{-}p), \quad (4)$$

where p is the probability of the event “someone kill a flower during early summer” and S is the entropy growth due to reasons described in bullet 2.2.2.1. As we find, $Z(T, A) \geq 0$ depends on the probability p.

Analysis of the physical meaning of formula (4) provides us similar results.

Case p=1. If the system is deterministic and the probability that the flower will be killed is about 100%, then the entropic potential of this event is very low. For example, if the flower grew in the backyard it will be killed anyway during lawn mowing. In this case the entropic potential of this event is $Z(T, A) \sim 0$.

Case p=0.5. Similarly to item 2.2.1.3, the entropic potential of this event is

$$Z(T, A) = S - S*0.5 = S*0.5.$$

Case p ~ 0. Similarly to item 2.2.1.3, the entropic potential of this event

$$Z(T, A) \sim S.$$

This situation can also be demonstrated in the case where the flower grew in a flowerbed in a public park where the probability of its breakage is very low. Correspondingly, someone who kills this flower performs an unexpected event, which lead to the entropy growth equal to S at the moment T. As such, the entropic potential of this event is S.

2.2.2.2 Summary. From the moral point of view of “good” and “bad”, the killing of a flower while mowing a lawn has a very low entropic potential ($Z(T, A) \sim 0$) and is not as bad as killing the same flower grown in a flowerbed in a public park (because $Z(T, A) \sim S$). These results accurately match with concepts of "good" and "bad", though are obtained using physics formulas.

2.2.3 Let us analyze the entropic potential of the following event “Cancer tumor is growing inside a human's body”.

2.2.3.1. For a sufficiently large time interval this event has 2 outcomes. The human with the tumor will either die because of the cancer or will survive. Let us denote the probability of death as p. Correspondingly, the probability of survival is (1-p). The growth of entropy S as a result of the human’s death is essentially the total of entropy growth as a result of the destruction of the human body as a biological object (S_b) and the absence of their input into human advancement and correspondent deceleration of entropy (S_p), which will not occur because of this person’s passing.

In accordance to [6] we can estimate S_b as the loss of $1.3*10^{26}$ bits of information as a result of destruction of the human body as biological object. (In accordance to [7] this estimation is very rough and “could be considered as some “zero” approximation.”).

The deceleration of growth of entropy due to human advancement will be discussed in the section “Averaging” (below). In accordance to this item the deceleration of the growth of entropy (S_p) due to advancement has an average of approximately 1% of S_b for each individual lived before 1750.

Let us calculate the entropic potential of the event “Cancer tumor is growing inside the human's body”. In accordance to formula (1)

$$Z(T, A) = \hat{S}_T(T_0 + dT) - \hat{S}_T(T_0 - dT)$$

The mathematical expectation of entropy $\hat{S}_T(T_0 - dT)$ for the moment T calculated *before* the cancer tumor started to grow is the total of the estimation of $\hat{S}_b$ and $\hat{S}_p$ for the moment T made at the moment $(T_0 - dT)$

$$\hat{S}_T(T_0 - dT) = \hat{S}_{b,T}(T_0 - dT) + \hat{S}_{p,T}(T_0 - dT) \quad (5).$$

The mathematical expectation of entropy $\hat{S}_T(T_0 + dT)$ for the moment T calculated *after* the cancer tumor started to grow is a total of estimations of $\hat{S}_b$ and $\hat{S}_p$ for the moment T made at the moment $T_0 + dT$ (after event A has occurred)

$$\hat{S}_T(T_0 + dT) = \hat{S}_{b,T}(T_0 + dT) + \hat{S}_{p,T}(T_0 + dT) \quad (5a).$$

Correspondingly, the entropic potential of event A is as follows

$$Z(T, A) = \hat{S}_T(T_0 + dT) – \hat{S}_T(T_0 - dT) = \hat{S}_{b,T}(T_0 + dT) + \hat{S}_{p,T}(T_0 + dT) - \hat{S}_{b,T}(T_0 - dT) - \hat{S}_{p,T}(T_0 - dT) =$$

$$[\hat{S}_{b,T}(T_0 + dT) - \hat{S}_{b,T}(T_0 - dT)] + [\hat{S}_{p,T}(T_0 + dT)-\hat{S}_{p,T}(T_0 - dT)], \quad (6)$$

2.2.3.2. Formula (6) shows the importance of the moment T, for which the mathematical estimation is made for.

If T is 200 years, then $\hat{S}_{b,T}(T_0 + dT)= \hat{S}_{b,T}(T_0 - dT)$, because the human dies regardless and the mathematical expectation of biological entropy growth produces the same value.

If T is 10 seconds, then $\hat{S}_{b,T}(T_0 + dT)$ is again equal to $\hat{S}_{b,T}(T_0 - dT)$, because the interval is too short and both mathematical expectations are indistinguishable.

However if T is greater than the life expectancy of the human with this form of cancer but is less than the life expectancy of the same person without cancer then the expectation of the biological entropy growth $\hat{S}_{b,T}(T_0 + dT)$ is about 10^{26} (result of human death) and expectation $\hat{S}_{b,T}(T_0 - dT) =10^{26}*P_{nat}$, where P_{nat} is the probability to die due to natural reasons. Since $P_{nat} \leq 1$, in any case $\hat{S}_{b,T}(T_0 + dT) \geq \hat{S}_{b,T}(T_0 - dT)$. Let us also note that the probability of dying due to natural reasons P_{nat} depends on age. The greater the age - the higher the P_{nat}.(for simplicity we ignore the higher P_{nat} during the first few months of life).

2.2.3.3 Let us consider now the second part of equation (6) $\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)$. It presents the difference in the growth of entropy due to the inability of the person to add their input into the advancement of humankind and the correspondent entropy deceleration in the future. In accordance to the section “Averaging” (below) the deceleration of growth of entropy (S_p) due to progress has an average about 1% of S_b (i.e. ~10^{24}). Since this deceleration will not occur due to the person’s death, then in average $\hat{S}_{p,T}(T_0 + dT) > \hat{S}_{p,T}(T_0 - dT)$ and $\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT) > 0$.

The mathematical expectations $\hat{S}_{p,T}(T_0 - dT)$ and $\hat{S}_{p,T}(T_0 + dT)$ for the specific human also depends on age and the individual qualities of the human. The more talented the analyzed person is, the greater the estimation is of their input into human advancement. Correspondingly, the mathematical expectation $\hat{S}_{p,T}(T_0 - dT)$ calculated for the moment T is smaller and the difference $\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)$ is greater. Similarly, the younger the analyzed person, the greater the estimation of their input into human advancement, the lower the expectation of entropy $\hat{S}_{p,T}(T_0 - dT)$ calculated for the moment T and the greater the difference $\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)$.

What is important for this analysis is the sign of difference $[\hat{S}_{p,T}(T_0 + dT)- \hat{S}_{p,T}(T_0 - dT)]$, which is also a positive similarly to $[\hat{S}_{b,T}(T_0+dT) - \hat{S}_{b,T}(T_0–dT)]$, shown above. Correspondingly, the entropic potential of this analyzed event is positive.

$$Z(T, A) = [\hat{S}_{b,T}(T_0 + dT) - \hat{S}_{b,T}(T_0 - dT)] + [\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)] > 0 \quad (7)$$

2.2.3.4. Let us discuss the physical meaning of formula (7). First, let us stress that we considered the difference $\hat{S}_{p,T}(T_0 + dT)- \hat{S}_{p,T}(T_0 - dT)$ as the *average for a large group* of people (further detail in the section “Averaging” below). For certain individuals the difference $\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)$ can be zero or negative. The following are several examples.

If the person is 100% irreversibly paralyzed or serving a life sentence in prison (with no chance of parole and no contact with the outside world) their input into the advancement of society is none and therefore $\hat{S}_{p,T}(T_0 + dT) = \hat{S}_{p,T}(T_0 - dT)$. The entropic potential of the considered event “Cancer tumor is growing inside the human's body” for such people is nevertheless positive because of the first “biological” component $[\hat{S}_{b,T}(T_0 + dT) - \hat{S}_{b,T}(T_0 - dT)] > 0$.

For the case when a person is an "uncaught serial killer" the difference $\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)$ could be negative. Indeed, the calculation of the mathematical expectation of entropy $\hat{S}_{p,T}(T_0 - dT)$ for a sufficient length of time T includes the entropy growth produced by further human deaths with high enough probabilities. If we denote the probability of the future killing as p_{k1}, p_{k2}, p_{k3} etc. we have

$$\hat{S}p,_T(T_0 - dT) = S_k + p_{k1}*S_b*1.01 + p_{k2}*S_b*1.01 + p_{k3}*S_b*1.01 \text{ etc.,} \quad (8)$$

where S_b is the entropy growth as a result of destruction of the human body as a biological object (~10^{26} bits), S_k is the change in entropy as a result of other activities of this person and 1.01 is the coefficient that includes the 1% input of the killed people into human advancement, which will not occur due to their premature deaths. Since the event “Cancer tumor is growing inside a human's body” reduces the lifespan of this murderer and the number of their victims, the mathematical expectation $\hat{S}_{p,T}(T_0 + dT)$ is less

$$\hat{S}_{p,T}(T_0 + dT) = S_k + p_{k1}*S_b*1.01 + p_{k2}*S_b*1.01 \text{ or even}$$

$$\hat{S}_{p,T}(T_0 + dT) = S_k$$

Correspondingly, the difference of the mathematical expectations is negative

$$\hat{S}_{p,T}(T_0 + dT) - \hat{S}_{p,T}(T_0 - dT)=$$

$$[S_k+p_{k1}*S_b*1.01 +p_{k2}*S_b*1.01] - [S_k+p_{k1}*S_b*1.01+p_{k2}*S_b*1.01+p_{k3}*S_b*1.01...] < 0. \quad (8a)$$

In other words, the entropic potential of the event “Cancer tumor is growing inside a human's body” is *negative* if the considered human is a "uncaught serial killer". This is the expected result, which we formalized using the entropic potential of the event.

2.2.3.5. Summary. In the domain of ethics, we call the death of a person as a “tragedy”, the death of a talented person as a “terrible tragedy” and the death of a serial killer as “fair”. The use of the entropic potential of the event allows us to formalize these terms as well.

2.2.4. The estimation of the entropic potential of the event “A salmon was killed on the way to a spawn”.

2.2.4.1. In this event the killed salmon will not spawn and therefore will decelerate the growth of the salmon's population and overall biomass on Earth. Understandably, this niche will be filled by other salmons because the resources used by the killed salmon become available.

As in other cases, the entropic potential of this event strongly depends on the moment T, for which we calculate the following mathematical estimations.

If the moment T *immediately* follows the moment T_0 when the salmon was killed (i.e. T ~ T_0), the mathematical expectation of entropy $\hat{S}_T(T_0 - dT)=S*p$, where S is entropy growth because of the salmon’s destruction as biological object and p is the probability that the salmon will be killed. For the estimation made at the moment (T_0+dT) the mathematical expectation $\hat{S}_T(T_0+dT)$ of entropy growth is S because no other events have occurred yet at the moment T ~ T_0.

Correspondingly, the entropic potential of this event for T ~ T_0 is

$$Z(T, A) =\hat{S}_T(T_0+dT) - \hat{S}_T(T_0-dT) = S - S*p=S*(1-p) \quad (9).$$

If the moment T is very far from T_0 (for example T=T_0+100 years) then $\hat{S}_T(T_0+dT) = \hat{S}_T(T_0-dT)$, because the killed salmon will be substituted by other salmons, since resources used by the killed salmon become available.

If the moment T is *reasonably* far away from T_0 (e.g. several days/months) then the difference $\hat{S}_T(T_0+dT) - \hat{S}_T(T_0-dT)$ will initially grow, because in addition to the entropy growth due to the salmon’s destruction as a biological object, the population of new salmon will be smaller than it could be if the salmon spawned successfully and after that it will decrease to 0, because the population of salmon will return to normal.

2.2.4.3. In the domain of ethics, we consider the event “A salmon was killed on the way to a spawn” to be worse than the event "Salmon was killed". Does the physical approach reflect this? Yes, because in addition to the growth of entropy due to the salmon’s destruction as a biological object, the population of new salmon and correspondent biomass will be temporary reduced. This implies a greater difference between the mathematical expectations $\hat{S}_T(T_0+dT)$ and $\hat{S}_T(T_0-dT)$ and correspondingly a greater value of the entropic potential $Z(T, A) = \hat{S}_T(T_0+dT) - \hat{S}_T(T_0-dT)$. In the extreme case when the *last* salmon in a local population is killed on the way to spawn, the entropic potential Z(T, A) is even greater due to the much longer time T nature needs to restore the local salmon population and correspondent biomass.

2.2.4.4. Summary. In the domain of ethics, we call the killing of salmon on the way to spawn as "bad", and the killing of the last salmon in population on the way to spawn as "very bad". The use of the entropic potential of the event allows us to formalize these terms as well.

2.2.5 Estimation of entropic potential of the event "An obese person eats an unhealthy meal".

2.2.5.1 Similarly to item 2.2.3.1 and formula (6), we have

$$Z(T, A) = \hat{S}_T(T_0 + dT) – \hat{S}_T(T_0 - dT) = \hat{S}_{b,T}(T_0 + dT) + \hat{S}_{p,T}(T_0 + dT) - \hat{S}_{b,T}(T_0 - dT) - \hat{S}_{p,T}(T_0 - dT) =$$

$$[\hat{S}_{b,T}(T_0 + dT) - \hat{S}_{b,T}(T_0 - dT)] + [\hat{S}_{p,T}(T_0 + dT)-\hat{S}_{p,T}(T_0 - dT)], \quad (10)$$

where S_b is the entropy growth as a result of the destruction of the human body as a biological object and S_p is the absence of their input into advancement of human society and correspondingly the deceleration of entropy (S_p), will not occur because of the shorter lifespan of this obese person.

2.2.5.2 Even if formula (6) from item 2.2.3.1 and (10) look identical, the distribution of probabilities that form the mathematical expectations $\hat{S}_{b,T}$ and $\hat{S}_{p,T}$ are different. Formula (6) describes almost an irreversible process of cancer tumor growth in the human body with a high chance of death and very low chance of survival.

Distributions of probabilities in the mathematical expectations $\hat{S}_{b,T}$ and $\hat{S}_{p,T}$ of formula (10) are different. For example, with sufficient willpower the analyzed human can reduce their weight and return to a regular life expectation. Correspondingly, the numbers of possible events that form the mathematical expectations $\hat{S}_{b,T}$ and $\hat{S}_{p,T}$ are much greater and the system is much less deterministic. However, since we analyze the event "An obese person eats an unhealthy meal" *while* they are yet obese the sign of the entropic potential Z(T, A) in the formula (10) is still positive.

2.3. Time factor

As we saw above in part 2.2, for a *sufficiently* large time T the "Entropic potential of an event" Z(T, A) can be estimated and sometime precisely calculated. We will now clarify what the term "*sufficiently*" indicates.

2.3.1. If the moment of time T, for which we estimate the entropic potential of event A, is very close to T_0, the mathematical expectations $\hat{S}_T(T_0 + dT)$ and $\hat{S}_T(T_0 - dT)$ are very close to each other and correspondingly the entropic potential of an event estimated for that moment T is approximately zero, $Z(T, A) = \hat{S}_T(T_0 + dT) - \hat{S}_T(T_0 - dT) \approx 0$.

2.3.2. If the moment of time T, for which we estimate the entropic potential of event A, is very far from T_0 (for example hundreds of years) the mathematical expectations $\hat{S}_T(T_0 + dT)$ and $\hat{S}_T(T_0 - dT)$ cannot be calculated in indeterministic systems, because the number of events between the moments T_0 and T is too large and the probabilities of these events are unknown in advance. (The fact that the entropic potential of events cannot be calculated does not mean that it cannot be *estimated*; see part "Averaging" below.)

2.3.3. Therefore, we can define the "sufficiently large time interval" ($T - T_0$) as the interval when the mathematical expectations of entropies $\hat{S}_T(T_0 + dT)$ and $\hat{S}_T(T_0 - dT)$ can be calculated (with certain precision) and these mathematical expectations of entropies are significantly different from each other. Depending on event A this "sufficiently large time interval" ($T - T_0$) can have a duration from seconds (for the indeterministic informational system such as Random Number Generators or lottery drums) to hundreds of years for significant events in history or important inventions with a low probability to be repeated.

2.3.4. Let's illustrate the "sufficiently large time interval" term by the following real-life example. Let's consider again the example (a) "*A commander receives an order to bombard a city*". In the first few seconds the system entropy drops because system changes state from uncertain (to bombard city or not) to certain (to bombard). In the following few hours the system's entropy significantly grows because of the destruction and deaths due to the bombardment. The mathematical expectation of entropy in the scale of years depends on who are the people living in this bombarded city. If they are just regular people who are not planning to launch a war or to kill and enslave other people, then the bombardment of their city will significantly accelerate the entropy growth. However, if the city is for example Nazi Berlin in 1939 its bombardment in the long term may significantly decelerate entropy growth because the death of Hitler and his inner circle could lead to the situation where the Second World War never occurs.

Correspondingly the huge destruction and entropy growth due to war never happens, what makes the $\hat{S}_{1945}(T_0 + dT) \ll \hat{S}_{1945}(T_0 - dT)$ and the entropic potential of that event strongly negative $Z(1945, A) \ll 0$, where T=1945 is the year of the end of World War II.

2.3.5. As we can see in the above example, on a scale of a few seconds the entropic potential of the event "*Commander receives order to bombard city*" is negative, on a scale of a few hours it is strongly positive, and on a scale of years it can be greatly negative again. All of this stresses the importance of the time factor in the entropic potential of the event.

Since we are using the entropic potential of an event as a physical measure of good and evil the above example illustrates the weakness of real-life estimations of *good* and *evil* during short time periods. Only after a sufficient time has elapsed (in some cases after decades of years) we can tell if an event was *good* or *bad*, or in terms of physics if the entropic potential of that event was negative or positive.

3. Discussion

3.1. Averaging

3.1.1. Does item 2.3 above imply that on a scale of a several centuries most real-life events are averaged, and their entropic potentials become negligible? Indeed, a few hundred years from now nobody remembers if "someone killed the flower during early summer" or if "someone died from the cancer tumor" or if "salmon was killed at the way to spawn" or if "an obese person lived shorter lifespan than he/she could" etc. Does this mean that the consequences of all these events will be mixed in with billions of consequences of other events and therefore the entropic potentials of these events become incomputable and negligible on scale of several centuries?

No, this is not accurate. It is true that the entropic potentials of most events become incomputable on a scale of a few centuries because their consequences will be indistinguishable, and their probabilities will be incomputable. However, the *averaged* entropic potential does not become negligible. The following will explain why.

3.1.2. Since we are analyzing if the entropic potential of current events will become zero on a century scale, for starters let's consider events that occurred in past, e.g., 200 years ago. Can we infer that the entropic potential of events occurred during the last 200 years is zero? Obviously, we cannot confirm this. The current world is degrees more complex than it was 200 years ago and has many entities that did not exist at that time. The human population is much greater than it was 200 years ago and in addition has a longer lifespan. All these changes are results of events occurring during these 200 years. It means that the *averaged* entropic potential of all events realized in the analyzed 200 years period is not 0. Otherwise, we would live in the same conditions as 200 years ago and would have the same life expectancy as in past.

It also worth to note that these events included not only inventions, agricultural, medical and scientific development, i.e. events that decelerated the entropy growth. They also included enforcement of social theories, 2 world wars, pandemics, genocides, and other events that greatly accelerated entropy growth. Despite this, the *total sum* of all events allowed humans to increase the population and live longer, to create many new advancements in in science, technology and art, i.e. has in average a negative entropic potential. (If we consider not only humanity, but to the entire Earth as an analyzed system R, then we will also have to take into account the growth of entropy due to the active use of non-renewable resources after 1750. We will discuss this below in paragraph 4.5.)

3.1.3. Let's try to calculate the average entropic potential integrated by all events of human history. Although this task seems ambitious, we will still try. In this article we will analyze only the biological component, without considering the new advancements people have contributed in science, technology and art. To begin we will consider the time before 1750, i.e. time preceding the industrial revolution. Before this time people practically did not use non-renewable resources (oil, coal, gas) for warming, cooling, and transportation, which significantly simplifies calculations. In accordance to [8] the world population in 1750 was 795,000,000 and the number of people born before 1750 was approximately 97 billion.

Part of this population growth is due to regular reproduction, similar to the reproduction of other animals and part of this population growth is due to civilization and the presence of intellect in people. Without both intellect and civilization, people would not able to expand their area of life beyond the comfort zone in Africa and the population growth would be similar to other primates living in the same conditions. Per [9] the total number of all primates (minus humans) is currently approximately 4 million. We can therefore assume that without both intellect and civilization the population of human would be no more than 4 million individuals (the total of all primates not including humans). The reason for this estimation is simple. If the comfort niche in Africa where humans originated could support more population then it would have allowed population growth of other primates as well. However, the total number of all primates (not including humans) is only 4 million, less than 1/1000 of the current human population.

This means that at least 790,000,000 people in 1750 were a product of events belonging to civilization and not simple animal-like reproduction. Knowing this and the estimation that the total number of people born before 1750 is 97 billion [8] we gain an increase of biological mass produced by human civilization in 1750 as 790,000,000 * $1.3*10^{26}$ bits ≈ 10^{35} bits. Here $1.3*10^{26}$ bits is the information of what the human body contains in accordance to [6]. (This amount is a rough estimation, which can be corrected through future research, therefore we do not stick to this exact value.)

These 10^{35} bits were produced by events committed by $97*10^9$ of people who were born before 1750 [8]. In another words in average every human lived before 1750 is responsible for the $10^{35}/(97*10^9) = 10^{24}$ bits of biological information in 1750. Without the events produced by these people (or if the average entropic potential of these events was exactly zero) we still only lived in Africa's comfort zone, had short lifespans and had a population of several millions of individuals rather than several billion.

The inquiry about the quantity of events in all human lives is less clear. Firstly, we can disregard all deterministic events (such as eating, breathing, urinating, sleeping, etc.) because deterministic events have zero entropic potential per [4]. The quantity of indeterministic events in a human's life is much less. Therefore, it is safe to assume that people commit no more than one indeterministic deed per minute. This estimation produces 60 events per hour and 60 * 16 hours ~ 1,000 events per a day. This implies ~365,000 events per a year and 365,000 * 30 years ~10^7 events during a human's lifetime, where "30 years" per [10] is the average of a human's longevity estimation prior 1750. Since the average input into the increase biological mass integrated by the lives of all humans lived before 1750 is 10^{24} bits, the average event during human history before 1750 produced 10^{24} / 10^7 = 10^{17} bits.

3.1.4 Obviously, 10^{17} is a highly speculative number and we must not stick to this exact value. Firstly, because the estimation of "one indeterministic deed per a minute during the human life" is just a bottom-line value, the real frequency of indeterministic deeds is likely much less. Even more uncertain is the amount $1.3*10^{26}$ bits as the estimation of information that the human body contains per [6]. This can differ from the actual value in many magnitudes. Paragraph 3.1.3 merely illustrates this method.

3.1.5 The estimation of the average entropic potential integrated by events occurred after 1750 is a much more difficult task. This is due to the utilization of non-renewable resources (oil, coal, gas, etc.) for warming, cooling and transportation that the industrial revolution launched.

Let's start with repeating the calculations performed in section 3.1.3. In accordance to [8] the difference in population between 1750 and 2020 is about 7 billion people (7,772,850,162 - 795,000,000). Correspondingly, the excess of biological mass produced by civilization between 1750 and 2020 is $7*10^9$ *$1.3*10^{26}$ bits ≈ 10^{36} bits. This excess was produced by the collective contribution of 19 billion people who lived between 1750 and 2020 per [8]. Correspondingly, the input of each of human that lived between 1750 and 2020 into 2020's biomass is 10^{36} / $(19*10^9)$ ≈ $5*10^{25}$ bits. (Let's also emphasize that there is a 50 times increase in the input of humans lived after 1750 compared to the input of people before the 1750, which was 10^{24} bit, as calculated in section 3.1.3).

These $5*10^{25}$ bits were produced by 365,000 * 50 years ≈$1.8*10^7$ events during humans' lifetimes where "50 years" is the world's average human longevity estimation between 1750 and 2020 per [10].

Since the average input into the increase of biological mass integrated by lives of all humans born between 1750 and 2020 is $5*10^{25}$ bits, the average event in history between 1750 and 2020 produced $5*10^{25}$ / $(1.8*10^7)$ ≈ $3*10^{18}$ bits of biological information. Let's again notice the 30 times increase in input of the average event into entropy deceleration between 1750 and 2020 compared to the 10^{17} bits during the period before 1750.

Unfortunately, the situation after the industrial revolution is much more complex, because past 1750 civilization utilized non-renewable sources resources (oil, coal, gas, etc.) for warming, cooling, and transportation. If we consider human society as an independent system, then we can ignore the utilization of non-renewable resources. However, if we consider the changes in entropy on planet Earth between 1750 and 2020, we must also account for the entropy growth produced by heating, cooling, transportation, electricity production, and other industries that use non-renewable sources. Therefore, we cannot confirm accurately if there was 30 times increase in biomass production and a correspondent deceleration of entropy growth on Earth between 1750-2020 that compensates for the utilization of non-renewable sources with the corresponding acceleration of entropy growth. Let's leave this for future research.

3.2. Greater scale

As we viewed in section 3.1.5 there is a chance that after 1750 humans on average are accelerating the entropy growth on Earth instead of decelerating it. If future research and calculations confirm this, will this mean that after 1750 humans existence became evil?

3.2.1 As we see in section 2.3 "Time factor", the entropic potential depends on the moment, for which we perform the estimation. Section 2.3.4 illustrates that the same event can have a negative entropic potential in the scale of seconds, positive entropic potential on the scale of hours and again negative entropic potential on the scale of years. Perhaps the most correct method is to consider the entropic potential as the mathematical limit, to which the difference between two mathematical expectations approaches.

$$Z(T, A) = \lim_{T\rightarrow\infty} [\hat{S}_T(T_0+dT) - \hat{S}T(T_0-dT)] \quad (11)$$

The problem is that we often cannot calculate this limit and we are even unable to estimate its sign. Humans however are good exception. The following explains why.

3.2.2 Currently all living organisms on Earth transform basic nutrients into more organized biomass. Not only humans, but every plant, animal, fish, insect, bacteria, etc., continuously converts sugar, water, and other basic nutrients into greater organized proteins, cells, and biological structures. In addition, they also reproduce themselves into more copies, which increases the volume of biomass on Earth. Humans are not an exception from this process. However, currently only humans can expand their area of existence beyond Earth. No plants, no other animals, or fish can do it. (Spores can likely survive in space, but they have no free will and intention to extend their habitat beyond Earth). Only humans have the potential and desire to expand their habitat across the Solar system and further. Of course, for this analysis the importance is not the habitat of human's existence in itself, but the location where the conversion of more primitive matter to more organized biomass occurs in the Universe. Since this area and volume of biomass will expand over time, the sign of the limit in formula (11) becomes negative. The greater the value of time T in formula (11), the greater the area where humans will live, the greater the volume of biomass they will produce and the greater the difference between the mathematical expectations in formula (11).

3.2.3 Warning. The explanations presented in section 3.2.2 will only work if humans will be able to adjust the growth of entropy related to the utilization of non-renewable sources of energy to be less than the deceleration of entropy growth related to our civilization. Otherwise, the situation, which we observe after 1750 (acceleration of entropy growth during the utilization of non-renewable sources of energy is greater than the deceleration of entropy growth due to the production of biomass and other items) will simply be expanded to other planets and beyond. The hypothetical "Dyson sphere" could be one method to solve this and there are likely other methods that exist as well.

5. Conclusions

Use of physics in ethics.

As shown, the physical property 'Entropic Potential of an Event' used within the philosophical domain of ethics allows us to formalize and in certain cases to calculate the values of "Good" and "Evil". This property adds a physical basis to the intuitive terms of "Good" and "Evil" and allows us to compare and sometimes even to calculate with numbers *how good* or *how bad* certain deeds and events are.

Measurability.

The 'Entropic Potential of an Event' gives us the method of how to measure "Good" and "Evil". By using it we can prove with numbers that the killing of a flower in the beginning of summer is worse than killing a flower at the end of summer (see item 2.2.2), to calculate how bad a serial killer is (see items 2.2.3.3 - 2.2.3.5), etc. Clearly the methods presented in this article can be used for the analysis of good and evil in a myriad of other events that we may wish to analyze.

Comparison of events of different natures.

The 'Entropic Potential of an Event' allows us to compare the good and evil of events belonging to significantly different fields. For example, we can calculate how much worse the "killing of a salmon on the way to spawn" is to "killing a flower at the beginning of summer". In most cases we can tell if an event is good or evil ethically. However, we are unable to show with numbers "how good" or "how evil" events are, especially if we compare events of different natures. The 'Entropic Potential of an Event' allows us to do this.

Universality.

The term "entropy" is applicable to a very wide range of events, from physics and chemistry to art and information. Correspondingly the 'Entropic Potential of an Event' is applicable to a very wide range of events as well. Since the 'Entropic Potential of an Event' works as a foundation for our intuitive terms "good" and "evil" we can apply these intuitive terms to a much wider range of events and make them calculable and comparable.

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