

## Tadeusz Sierotowicz\*

Istituto Superiore di Scienze Religiose Italy, Jagiellonian University, IISS Gandhi Italy  
ORCID: 0000-0001-8049-3957

## Tomasz Sierotowicz\*\*

Jagiellonian University  
ORCID: 0000-0002-1462-8267

# MATHEMATICS AS A TOOL FOR LITERARY ANALYSIS. MEASURING HAPPINESS – A CONTRIBUTION TO THE DEFINITION OF HAPPINESS IN STANISŁAW LEM

Background: Happiness and its determinants have been the subject of scientific inquiries as early as in the works of Aristotle. It has appeared in many fields of science. For example, in economics, Frank Knight indicated happiness as one of the three main factors of business success (1921). Nowadays, positive psychology also deals with success. Happiness is therefore an important success factor, not only in business, but also in the real life, career, and development of every human being (Brickman et al. 2016; Seligman 2005).

Aim: The main research problem, as a case study, was to identify a definition of happiness, which would provide the opportunity to formulate a mathematical model, thus making it possible to measure levels of happiness.

Materials and methods: Literature reviews on the definition of happiness were conducted to achieve the main aim. They resulted in identifying the proposals of Stanisław Lem, who in his futuristic works not only offers a definition of happiness but also describes a unit of its measurement and provides a recipe for it. This became the basis for designing a computer simulation of the definition of happiness as a kind of human experience.

Results: A newly designed mathematical model was formulated that describes levels of happiness from a quantitative point of view, including a unit of its measurement.

Conclusion: The designed mathematical model is complete and is the first example of the implementation of the definition of happiness described in literature. It is also the first step in the mathematical approach to happiness becoming the most important factor of human work, development, and success.

Keywords: happiness, philosophy and economics, literature and literary analysis, Stanisław Lem, mathematical models.

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\* Corresponding author: Tadeusz Sierotowicz, Philosophisch-Theologische Hochschule Brixen (Philosophical-Theological Academy Brixen/Bressanone; PTH/STAB), Piazza del Seminario 4, I-39042 Bressanone, Institute for Science of Religion (Istituto Superiore di Scienze Religiose – ISSR), via Alto Adige 28, I-39100 Bolzano; Uniwersytet Jagielloński, Centrum Kopernika Badań Interdyscyplinarnych, ul. Szczepańska 1, 31-011 Kraków; IISS Gandhi, Via Karl Wolf 38, I-39012 Merano BZ, e-mail: sierotowicz@gmail.com.

\*\* Corresponding author: Tomasz Sierotowicz, Uniwersytet Jagielloński, Instytut Ekonomii, Finansów i Zarządzania, Wydział Ekonomii i Innowacji, ul. prof. S. Łojasiewicza 4, 30-348 Kraków, e-mail: tsierotowicz@uj.edu.pl.

*How can a work of fiction which is not and is known not to be true provide any measure of epistemic access to the way things actually are? Is it really possible to find out about the world by making things up? One attractive answer is that works of fiction are thought experiments. Like literary fictions, thought experiments neither are, nor purport, to be physically realized. Nevertheless, they evidently enhance understanding of the phenomena they pertain to.*

Catherine Z. Elgin (Elgin 2014: 221)

## INTRODUCTION

The question of happiness, its causes, and its effects have been dealt with almost continuously throughout the history of human thought. Happiness, its determinants, and factors leading to its occurrence have become a research area in many fields of science. Each field presents its own definitions of happiness and factors that cause it. The topic of happiness and the possibility of its scientific description have particularly been pursued in the field of positive psychology, where happiness is subdivided into various types (Seligman and Csikszentmihalyi 2000). The scientific discussion concentrates on the areas in which the factors considered to be the most important for the occurrence of happiness are identified. The following research areas are specified: age, sex, health and diet, personal finances, education and the level of education, level of intelligence, parenthood, and marriage (Burns et al. 2014; Evenson and Simon 2005; Jha 2008; Lopez and Snyder 2009; Seligman et al. 2005). In turn, on the grounds of behavioural economics, happiness, in addition to entrepreneurial skills and a favourable market situation, is listed as one of the three main factors that determine the achievement of business success (Drucker 2004; Easterlin et al. 2010; Knight 1921). However, happiness in economics is identified as important factor of success but without providing its definitions. Moreover, mainly on business grounds, happiness has financial connotations, as profit is one of the fundamental facets of economic success (Astebro et al. 2014).

In the inquiries about happiness, one cannot ignore philosophical achievements. However, here, as in the case of psychology, happiness is defined in various ways, starting from the description of states of bliss, through to lack of worries, ending with ecstasy. Each described condition is accompanied by specific symptoms like joy, complacency, self-fulfilment, and self-realisation (Barreto and Rolland 2016; Tatarkiewicz 2010). These states are combined in a certain way and are sometimes separated from happiness. At the same time, the demarcation line between what is called happiness and what is not in a given philosophy is different. Most often, its location depends on the adopted criteria and philosophical assumptions (Tatarkiewicz 2010; White 2006). It can therefore be concluded that philosophy does not give one concise definition of happiness but rather its various forms.

The human experience is considered a common denominator of the forms of happiness. Regardless of the form and type of happiness, the subject is a person experiencing happiness. This conclusion implies the need to identify a holistic definition of happiness, the main

issue of which will be human experience. A holistic form of happiness will allow defining a coherent mathematical formula that will describe the core of the experience of happiness and enable the measurement of its levels.

In addition to scientific investigations that are carried out in many different fields, happiness is a topic that is frequently undertaken in the literature of various cultures. One example of the definition of happiness is that put forward by Stanisław Lem, an outstanding representative of science fiction and futuristic literature. What really distinguishes his proposal from many of those found in the literature is that Lem not only put forth a coherent and logically very transparent definition but also described, in a sort of thought experiment, a scenario to measure units of happiness. This description is similar to the application of exact sciences to the phenomenon being studied and its measurement. This is a peculiar description, unheard of in other fields of science and literature trends, and this peculiarity appears precisely in the given scenario and the suggestion of the unit measuring the size of happiness. The above advantages definitely speak for the choice of this concept of happiness, because it opens the possibility of implementing the scenario in a computer simulation.

## THE DESCRIPTION OF HAPPINESS ACCORDING TO STANISŁAW LEM

*The Cyberiad* is a collection of humorous science fiction short stories. ‘Kobyszcze’ is one of them, and it tells the story of a constructor named Trurl, who in order to explore the concept of happiness, builds computational machines of existential dilemmas.

Trurl, the constructor who only Klapaucius was able to match, decided to take on universal happiness. For this purpose, he constructed the Contemplator of the Being, abbreviated as Kobyszcze. The basic problem in the implementation of this machine was the question of the unit of happiness and, as a consequence, its measurability.

### DEFINITION OF HAPPINESS

Physical units like *meter*, *kilogram* and *second* are precisely defined. They can be used to measure something else. Trurl named the unit of happiness the ‘Hedon’, or ‘Hed’ for short. He defined it so that one Hed is ‘the amount of ecstasy you get when you go four miles in a shoe with a nail stuck in it, and then the nail is removed’. Then, Trurl ‘multiplied the distance by time, divided it by the nail’s insistence, brought the coefficient of the painful heel before the parenthesis and this way he managed to translate happiness into the Hedon unit described by: centimetre; gram; second’ (Lem 1972: 438; our translation). A mathematical model of this situation is proposed in the following subsections.

Hence, Stanisław Lem did not report how he made the exact calculations, but he determined that ‘one kiloHed (kHed) is as much as the old men got excited while watching Susanna in the bath, and that aa megaHed (MHed) – the joy of a convicted man who is cut from the noose just in time, and the contemplation of Trurl’s stained apron gave an average of 15.53 Hed’ (Lem 1972: 438). Naturally, it is difficult to compare one form of happiness with another, but

you can ask how many miles and how long the old men would have to walk to experience the same ecstasy that they experienced while watching Susanna (see: the episode known as ‘Susanna and the Elders’, in the *Book of Daniel*, chapter 13) or how many miles and how long the pardoned convicted would have to walk. Or, by reversing the issue and accepting as reference both Stanley Steven’s psycho-physical power law (1957) and the standard of Hed following Stanisław Lem’s easily reproducible mountain situation of the four-mile walk, we could ask: what is the exponent value necessary for the standard walk with a nail in the shoe to become just as ‘intense’ as, for example, the experience of lascivious old men? In this way, it will be possible to bring cases of erotic, self-preserving, and aesthetic happiness – if it will be assumed that Trurl’s apron is comparable to Jackson Pollock’s ‘drip paintings’ (Naifeh and Smith: 1998) – to the same standard situation described by Stanisław Lem. Because the above types of happiness (erotic, self-preservation, and aesthetic) are the basic types of happiness, the proposed approach allows, on the one hand, comparing various ecstasies, and on the other, measuring (or at least estimating) the non-measurable. More mathematical details of these considerations are proposed in subsection 4.2.

#### PRESENCE OF THE PAIN CARRIER

The definition of Hedon refers to the nail in a shoe as a paradigmatic situation that allows creating the definition of an easily reproducible and repetitive pattern of ecstasy. It is an event in which there is a ‘carrier of pain’, and the release from its infliction means the equivalent of the ecstasy that is then experienced. The pain carrier is, in this case, the nail in a shoe. Desiring to mathematise this situation, it is necessary to describe the carrier of ‘pain’ and its impact on people, in other words, to introduce a specific ‘pain factor’ that takes into account the ‘stimulus’ and the specificity of pain. In the case of the nail in a shoe, the pain carrier is the nail, and its stimulus is its poking the foot. In this context, Stanisław Lem writes about the ‘nail’s insistence’. In the case of the ‘nail in a shoe’, the mass of the person marching is not negligible. Although a sharpened nail penetrates the foot and inflicts pain at the point where its surface is almost zero, the higher the mass, the deeper it penetrates into the foot. Naturally, the sensation of pain itself depends on other factors, such as the sensitivity of a given person to pain or the thickness of the skin on the heel.

#### MATERIALS AND METHODS FOR FORMULATING A MATHEMATICAL MODEL OF THE MEASUREMENT OF HAPPINESS

In order to formulate a paradigmatic situation model with a nail, the following variables were defined:

- $m$  – the mass of the walker [grams];
- $t$  – the duration of the event for which we measure the level of happiness [second], e.g. the time of walking with the nail in a shoe;
- $r$  – the distance travelled by the person experiencing ecstasy [cm] (this applies only to walking with the nail in a shoe);

- $s$  – the coefficient of tired heel, i.e. the sensitivity to the carrier of ecstasy (dimensionless individual human characteristic in the range of 0 to 1 changing the value from total insensibility to pain  $s = 0$  to absolute hypersensitivity  $s = 1$ );
- $d$  – how far the nail sticks out from the sole of the shoe (i.e. how many cm the nail protrudes from the sole of the shoe penetrating into the tissue of the sole of the foot);
- $h$  – how far a nail can penetrate into the foot (it was assumed that in practice, the thickness of the tissue dividing the foot surface from the bone is  $h = 1$  cm). In this situation, the interpretation of the variable  $(1 - d/h)$  corresponds to what Stanisław Lem calls the nail's insistence (see comments below);
- $C$  – the calibrating constant that allows expressing one Hed in units specified by Stanisław Lem [cm-gram-second] and ensuring the correct calibration of the mathematical model.

Two comments are necessary here. First, the choice of the variable nail's insistence in the form of  $(1 - d/h)$  is dictated by the fact that in situation  $d = h$  (the nail touches the bone), the pain should be maximum and as such, almost infinite. Second, Lem mentions that he divided the expression by the nail's insistence. Therefore, if  $d = h$ , then the nail's insistence understood as  $(1 - d/h)$ , assumes the value of zero, and the whole expression, if inverted, is aimed at infinity (see below equation 1).

## RESULTS – A MATHEMATICAL MODEL FOR MEASURING LEVELS OF HAPPINESS

Taking into account the description of Stanisław Lem's scenario and the variables identified in the previous chapter, along with their specificity, a model equation for measuring happiness is proposed.

### THE MATHEMATICAL MODEL OF THE DEFINITION OF HAPPINESS

The variable called *Happiness* is a function of several other variables:

$$Happiness = C \cdot s \cdot \left( \frac{r \cdot t \cdot m}{\left(1 - \frac{d}{h}\right)^\alpha} \right) \quad (1)$$

The mathematical formula was created as a result of a simulation carried out in the MatLab computing environment. The detailed results of the simulation are included in Annex 1. It should be noted that equation 1 quotes the nail's insistence as a power expression (power  $\alpha$ ), which is in accordance with the aforementioned Stanley Steven's power law describing the response of senses to sensory stimuli (Knoblauch and Maloney 2012; Stevens 1957). For the

paradigmatic situation described by Stanisław Lem, the value  $\alpha = 1$  is used in the formula above. The value of the calibration variable  $C$  should be chosen so that equation 1 gives a value equal to 1 Hed in the standard situation described by Stanisław Lem, that is in the following situation:

- $m = 60 \text{ kg} = 60\,000 \text{ gram}$ ,
- $r = 4 \text{ miles} = 6.4 \text{ km} = 640\,000 \text{ cm}$ ,
- $t = 1.17 \text{ hour}$  (the average walking speed 5 km/hour for 6.4 km) = 4620 sec,
- $s = 0.5$  (the average sensitivity to pain),
- $d = 0.5 \text{ cm}$  the length of the nail in the foot,
- $h = 1 \text{ cm}$  the total (maximum) depth at which the nail can penetrate the foot.

Simple calculations based on equation 1 give a constant  $C$  of approximately:

$$C = 5.6 \cdot 10^{-15}$$

implementing Stanisław Lem's idea of expressing the unit of happiness [Hed] as a combination of basic units of cm, gram, second.

$$\text{Happiness} = C \cdot s \cdot \left( \frac{r \cdot t \cdot m}{\left(1 - \frac{d}{h}\right)} \right) = 5.6 \cdot 10^{-15} \cdot 0.5 \cdot \left( \frac{640\,000 \cdot 4620 \cdot 60\,000}{\left(1 - \frac{0.5}{1}\right)} \right) = 1 \text{ [Hed]} \quad (2)$$

Thus, the mathematical model that allows calculating the amount of ecstasy in the case of a standard mountain walk with a protruding nail in a shoe is as follows:

$$\text{Happiness} = 5.6 \cdot 10^{-15} \cdot s \cdot \left( \frac{r \cdot t \cdot m}{\left(1 - \frac{d}{h}\right)} \right) \text{ [Hed]} \quad (3)$$

It should be noted that the value of the constant  $C$  is not universal in the sense that it depends on the characteristics of the walking man, that is, on his mass and sensitivity to pain. In the Annex 1 enclosed at the end of this text, a graphic simulation is presented, performed and based on equation 3.

#### THE OLD MEN, HANGMAN, POLLOCK, AND VALUES OF A COEFFICIENT

Stanisław Lem reported that Trurl claimed that the old men watching Susanna experienced ecstasy equal to 1 kHed; the hangman that was cut down in time, 1 MHed; while watching Trurl's apron gave an ecstasy with an average value of 15.53 Hed. Referring to the idea of comparing various types of happiness outlined in the introduction and in subsection II.1, it is possible to estimate the value of the power of  $\alpha$  for these three situations using equation 1 and the values of variables plugged into equation 2. To find this value of  $\alpha$  means to answer

the question of how many times the experience of the hangman that was cut down in time, for example, is more intense than the standard walk with a nail in the shoe as defined in the initial conditions for equation 2 (the standard situation for the definition of 1 Hed which becomes a kind of a ‘least common multiple’ for these different situations).

If so, the problem boils down to the question of the value of power  $\alpha$  in equation 1 that is necessary so that the variable called *Happiness* in these situations would take the values 1 kHed, 1 MHed, and 15.53 Hed, respectively.

With this interpretation in mind, the changing value of power  $\alpha$  reflects the difference between qualitatively different types of stimulus conditions or dissimilar type of ecstasies. By solving equation 1 against the power of  $\alpha$ , the following values are obtained:

- Pollock:  $\alpha \approx 5$ ;
- Old men:  $\alpha \approx 14$ ;
- Hangman:  $\alpha \approx 21$ .

Figuratively speaking, bearing in mind the value of powers and a logarithmic scale of reference, aesthetic happiness would be about five times more intense than the mountain happiness, the erotic more or less three times more intense than the aesthetic, and existential about four times more intense than the aesthetic. Calculation of *Happiness* (= experienced ecstasy) of other situations can be effectively carried out based on the method described above, if it is possible to determine the relationship of a given situation with one of the above cases of ecstasy, e.g. ‘giving a drowning person a float is similar to the situation of cutting down the noose and saving the convict’ or ‘eating a sandwich with ham and butter is similar to walking half a mile in ten minutes’, etc. Another sort of example could be experience of various diseases such as heart attack, where complications make it impossible to use routine therapeutic procedures (Polak 2017). In such cases, the amount of *Happiness* is within the range of 1 kHed to 1 MHed. The exact amount is determined by specific variables of each individual case. To be precise, the story of Stanisław Lem applied in this work includes a philosophical critique of the mathematical model (equation 3) as based solely on the experience of ecstasy in every situation. The above criticisms of Stanisław Lem may be the starting point for further discussion in the field of the model expressed in equation 1.

## DISCUSSION AND CONCLUSION

The reflections presented here are naturally a trinket, a homage to the facetious intuitions of Stanisław Lem. Apart from the ludic aspect of the fragment analysed here, the mathematization of happiness and the attempt to define a unit of ecstasy (of *Happiness*) are part of the current of quantitative research, which in the field of neurophysiology is heading in the same direction. Recent achievements of psychophysics are the confirmation of this (Bruno 2016; Read 2015). Before the final formalisation of the measurement of happiness, it may be worth recalling the adventures of Trurl, who faced this problem. The direct experience of happiness or equivalent experience of a pain carrier belong to the most important aspects of human life. It is related virtually to every aspect of human life. Future research may allow us to describe these experiences in a less elusive and more quantitative way.

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ANNEX:

THE COMPUTER SIMULATION OF STANISŁAW LEM'S DEFINITION AND MEASUREMENT OF HAPPINESS

Assumptions: the diagrams refer to the situation in which  $d$  is also changed (Table 1). The specifics of the painful drama with a nail, described by Stanisław Lem as a model situation, require that the simulations should be carried out by changing (in a synchronous way) in equation 3 the distance, time, and depth at which the nail penetrates the foot, because such synchronisation is the closest to reality. This is because when you walk more, the distance is longer, time passes, the nail increasingly penetrates the foot, and it becomes more annoying. Hence, in this specific case of measuring happiness, the simultaneous change of variables seems to be the best solution. However, it should be noted that it is more a graphical representation of several specific walking situations made for various walkers than it is a simulation. The exemplary drawings show an exponentially increasing dependence of happiness on variables  $d$  and then  $r$ .

The simulations were carried out assuming the following constant values:

$$C = 5.6 \cdot 10^{-15} \text{ Hed}/(\text{cm} \cdot \text{g} \cdot \text{s}),$$

$$m = 60\,000 \text{ gram},$$

$$d = 0.5 \text{ cm the length of the nail in the foot},$$

$$h = 1 \text{ cm the total (maximum) depth at which the nail can penetrate a foot}.$$

Table 1 shows the values of model variables obtained during the simulation using equation 3.

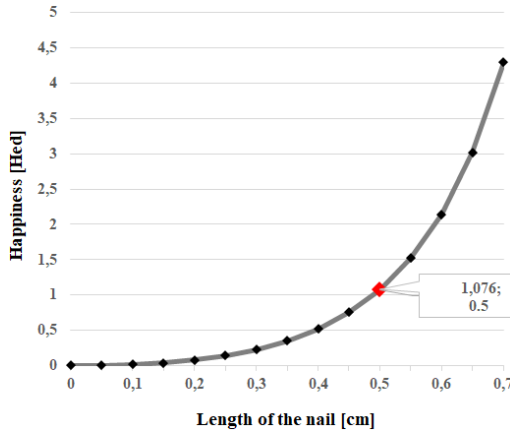
**Table 1.** Simulation results

Lp.	Distance $r$ [cm]	Time $t$ [s]	Nail in a foot $d$ [cm]	Sensitivity $s$	Happiness [Hed]
1	0	0	0	0.01	0.000
2	64 000	462	0.05	0.05	0.005
3	128 000	924	0.1	0.1	0.022
4	192 000	1386	0.15	0.15	0.053
5	256 000	1848	0.2	0.2	0.099
6	320 000	2310	0.25	0.25	0.166
7	384 000	2772	0.3	0.3	0.255
8	448 000	3234	0.35	0.35	0.374
9	512 000	3696	0.4	0.4	0.530
10	576 000	4158	0.45	0.45	0.732
11	640 000	4620	0.5	0.5	0.993
12	704 000	5082	0.55	0.55	1.336
13	768 000	5544	0.6	0.6	1.788
14	832 000	6006	0.65	0.65	2.399
15	896000	6468	0.7	0.7	3.245

Source: Own work using the MATLAB tool

The Line 11 (Table 1) shows the result that represents the definition of 1 Hed. The obtained results allowed drawing up the graphs of dependencies between variables.

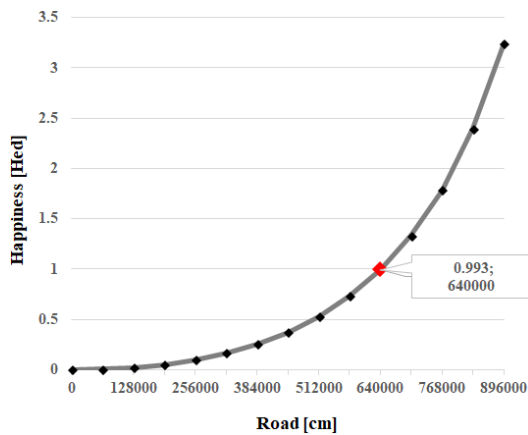
Figure 1 shows the exponential dependence of happiness on the length of the nail penetrating a heel. The level of happiness grows exponentially with the length of the nail penetrating a heel.



**Figure 1.** The dependence of happiness on the length of the nail penetrating a foot  $d$

Source: Own work based on performed simulation

As before, in this case (Figure 2), the level of happiness grows exponentially with the distance travelled by the walker.



**Figure 2.** The dependence of happiness on the distance  $r$  travelled by the walker

Source: Own work based on performed simulation

MATEMATYKA JAKO NARZĘDZIE ANALIZY LITERACKIEJ.

ZMIERZYĆ SZCZĘŚCIE –

PRZYCZYNEK DO DEFINICJI SZCZĘŚCIA W UJĘCIU STANISŁAWA LEMA

Szczęście i jego uwarunkowania są przedmiotem badań naukowych już od czasów Arystotelesa. Temat jest podejmowany z różnym powodzeniem w wielu dziedzinach nauki. Głównym problemem badawczym jest w niniejszym studium określenie definicji szczęścia, która dałaby możliwość sformułowania modelu matematycznego, umożliwiając w ten sposób zmierzenie poziomu szczęścia. W tym celu dokonano przeglądu literatury dotyczącej definicji szczęścia. Jednak w propozycji Stanisława Lema zidentyfikowano sformułowanie definicyjne pozwalające na osiągnięcie zamierzonego celu. Stanisław Lem w swoich futurystycznych pracach nie tylko podał precyzyjną definicję szczęścia, ale także zaproponował stosowną jednostkę jej pomiaru. Na tej podstawie został sformułowany model matematyczny, który opisuje poziomy szczęścia z ilościowego punktu widzenia, z zastosowaniem jednostki jego miary włącznie.

Słowa kluczowe: szczęście, filozofia i ekonomia, literatura i krytyka literacka, Stanisław Lem, modele matematyczne