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Quantification of Happiness using the Science of Metabolomic Profiling

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ABSTRACT

This article is a response to the United Nations Resolution 65/309, 2011, which calls for establishing a means to measure happiness. The social value of civilization must be directed towards true happiness rather than materialism and consumerism. Money (currency) is the only quantifiable measurement of possessions, which are perceived to make us happy. Happiness remains an abstract concept that is interpreted subjectively lacking scientific definition. When the distorted pursuit of happiness becomes the pursuit of fortune and fame, the ultimate result is global warming. A new science is needed to quantify happiness objectively. This would offer an alternative value system guiding individual/collective human behaviour as well as establishing new social values. Only then, social changes would occur to support sustainable developments. Up to now, Happiness Indexes are based on surveys and complicated measurements in the context of social science and economics. The concept of gross national happiness (GNH) was first proposed in 1972 by Bhutan's former King Jigme Singye Wangchuck as a supplement to the gross domestic product (GDP) concept. A 2nd-generation GNH concept, treating happiness as a socioeconomic development metric, was proposed in 2006 by the President of International Institute of Management. This metric measures wellness in seven areas including Economic, Environmental, Physical, Mental, Workplace, Social, and Political Wellness. Three major shortcomings of these approaches are: (1) The questionnaire surveys are qualitative, subjective, opinionated and culturally influenced; (2) Uncontrollable bias in sampling is highly probable; (3) The GNH result does not motivate or empower individual participants surveyed.

To alleviate these shortcomings, a "3rd-generation" breakthrough solution is hereby proposed to quantify happiness using reliable and reproducible laboratory analysis of human body metabolites. The scientific instrumentation, technology, feasibility and methodology are herein described. Proposed test subjects are categorized. The achievability of this new science is discussed in light of the state-of-the-art technology and proof-of-concept applications.
The proposed solution is unique in that it does not rely on behavioural change by education or persuasion. Instead, it provides an alternative to money for the fundamental decision-making process of the human mind. Working at the root of the human decision-making process is the key to bring about individual and social changes.

The implication of this new science extends beyond changing materialistic social values thereby fighting global warming and advancing medical sciences. Since the state of Nirvana in a human being must involve physiological and psychological components; Nirvana could perhaps be described by its metabolomic profile as an identifiable mental state(s). Similarly, steps along the

progression of spiritual development could possibly be supported by laboratory evidences. By bringing “faith” into an arena with scientific testable hypothesis, science and religion will become united rather than antagonistic.

Key Words: Happiness Index, metabolomic profile, UN Resolution 65/309, sustainable development, social change

INTRODUCTION

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is a landmark international treaty for a global action plan to mitigate "dangerous" anthropogenic interference of the climate system by setting binding obligations on industrialized countries to reduce emissions of greenhouse gases. The European Union and 191 states attended. The United States signed but did not ratify the Protocol and Canada withdrew from it in 2011. The Protocol was adopted on December 11, 1997 at the Kyoto International Convention Center, Japan, and enforced on February 16, 2005 (http://unfccc.int/kyoto_protocol/items/2830.php). To commemorate this landmark achievement, an “Earth Hall of Fame” was established to the right side of the lobby at the main entrance of the convention center.

Fig. 1. Photograph of Bhutan's former King Jigme Singye Wangchuck displayed at the “Earth Hall of Fame” at the Kyoto International Convention Center, Japan.

Amongst the many famous environmental leaders honored in this Hall of Fame, the first person in line is none other than the Bhutan's former King Jigme Singye Wangchuck who was inducted to the Hall in 2009. His Majesty's photograph (Fig. 1) is promptly displayed as the forerunner. His majesty's contribution was the proposition of Gross National Happiness (GNH) in 1972 as a supplement to the Gross Domestic Product (GDP) concept. His initiative may be regarded as the first-generation Happiness Index.

Evidently, irrespective of religious differences, the world communities which are environmentally conscious recognise the significance of the Happiness Index ideology in the fight against global warming and unsustainable development. Therefore, King Wangchuck represents an exemplary leadership in demonstrating a “Buddhist Response to Sustainable Development and Social Change”, which is one of the main themes of this 2014 conference “Buddhism and the UN Millennium Development Goals”.

Remarkable is the King's embodiment of leaderships in religion, political science, social science and economics.

Building on the shoulder of the giant King, several non-governmental organizations (NGO) have made significant progress in developing the second-generation of Gross National Happiness Indexes. Governments of the world have been slow to catch on. Almost 40 years since the King's proposal, the United Nations passed Resolution 65/309 Aug 25, 2011, which is a UN bill calling for the establishment of a means to measure happiness (http://uncsd.iisd.org/news/un-secretary-general-calls-for-gross-global-happiness-as-a-measure-of-sustainable-development). The UN

also declared March 20th the “International Day of Happiness”. This clearly demonstrates that Buddhist leaders have and should have the wisdom, foresight, and leadership to guide human civilization in the right direction.

This article is a response to the UN Resolution 65/309. The reality of global warming is undeniable and a root-cause analysis is hereby presented. The solution is to change society from a materialistic value system to a happiness value system; the latter needs a quantifiable measurement technique. This need can be addressed by a new science described in this presentation (Ching Lo, 2010a, b). This initiative can be regarded as the third-generation Happiness Index.

CRITICAL THINKING

The root causes of global warming can be elucidated by the following critical thinking steps:

1. Humans pursue happiness.
2. Happiness is an abstract quality.
3. Humans do not know how to make consistent decisions based on abstract quality.
4. Decisions are easy when based on quantity/number.
5. Money (currency) is the only number available and universally recognized.
6. Consequently, people pursue money in their attempt to pursue happiness.
7. Money translates into consuming power. Over-consumption demands over-production, creates wastes, depletes natural resources, pollutes the environment & causes global warming.

Therefore, the real solution to change the central value of the dominant civilization is to provide an alternative, quantifiable measurement of happiness.

FIRST-GENERATION HAPPINESS INDEX

The term "gross national happiness (GNH)" was invented in 1972 by Bhutan's fourth Dragon King, Jigme Singye Wangchuck. Although he opened Bhutan to modernization, he was adamant to build an economy based on Buddhist spiritual values. The four pillars of GNH were sustainable development, cultural integrity, ecosystem conservation, and good governance. The concept was implemented at the Centre for Bhutan Studies (President Dasho Karma Ura), which developed a sophisticated survey instrument to measure the population's general level of well-being. Two Canadians, Michael and Martha Pennock played a major role in developing the Bhutanese survey, which took a six to seven-hour interview to complete. The Pennocks also collaborated with Ura in the production of a policy lens which is used by the Bhutanese GNH Commission for anticipating the impact of policy initiatives upon the levels of GNH in Bhutan. (Source: http://en.wikipedia.org/wiki/Gross_national_happiness). Since then, the four pillars of GNH have been refined to nine domains — Psychological Well-being, Physical Health, Time Balance, Community Vitality, Education, Culture, Environment, Good Governance, and Standard of Living. Up-to-date status of the Bhutan initiative can be found at the following sites: http://www.grossnationalhappiness.com, http://www.gnhc.gov.bt and http://www.gnhbhutan.org. In 2008, a book on GNH was published http://www.amazon.com/Gross-National-Happiness-Matters-America/dp/0465002781.

In 2009, a small group of six USA citizens brought home the GNH concept from Bhutan and founded the non-profit branch GNHUSA http://www.gnhusa.org.

In 2013, with a new administration, the country shifted the focus from spreading GNH globally to the well-being of people within Bhutan. This shift has been interpreted by some as an abandonment of GNH in favour of more standard development initiatives.

SECOND-GENERATION HAPPINESS INDEX

In 2006 a second-generation GNH concept, treating happiness as a socioeconomic development metric, was proposed by Med Jones, President of the International Institute of Management. He identified 7 parameters contributing to happiness. For each parameter, metrics were categorized and measured by direct survey and statistics. The 7-parameters and their respective metrics are:

1. **Economic Wellness**: economic metrics such as consumer debt, average income to consumer price index ratio and income distribution.
2. **Environmental Wellness**: environmental metrics such as pollution, noise and traffic.
3. **Physical Wellness**: physical health metrics such as severe illnesses.
4. **Mental Wellness**: mental health metrics such as usage of antidepressants and rise or decline of psychotherapy patients.
5. **Workplace Wellness**: labor metrics such as jobless claims, job change, workplace complaints and lawsuits.
6. **Social Wellness**: social metrics such as discrimination, safety, divorce rates, complaints of domestic conflicts and family lawsuits, public lawsuits, crime rates.
7. **Political Wellness**: political metrics such as the quality of local democracy, individual freedom, and foreign conflicts.

Obviously, the cost to determine second-generation happiness indexes for countries worldwide is formidable. Today, there are three main camps that measure happiness index based on a blend of first- and second-generation methodologies.

Camp #1 Dr. Michael Pennock, epidemiologist, Vancouver Island Health Authority, British Columbia, Canada, was instrumental in designing the original Bhutanese survey. A shorter international version is available at http://gnh-movement.org/papers/pennock.pdf which has been used in their home region of Victoria B.C. as well as in Brazil. In 2009, 2400 random residents in Greater Victoria returned the survey, which was funded by the Victoria Foundation, B.C. The result showed a high level of well-being (7.6/10), similar to the Canadian average (7.7). In 2007-2009 Canada consistently ranked among the top five nations. According to this camp, the idea of "self reported happiness and life satisfaction" is becoming an accepted concept.

Camp #2 Jeffrey D. Sachs: director, the Earth Institute, Columbia University, New York (http://www.earth.columbia.edu/articles/view/2960) published the first World Happiness Report (download PDF) commissioned for the April 2nd 2012, United Nations Conference on Happiness (mandated by the UN General Assembly). The report reflects a new worldwide demand for more attention to happiness and absence of misery as criteria for government policy.

(Sources: http://www.earth.columbia.edu/articles/view/2960). The Earth Institute continue to publish the 2013 report. http://unsdsn.org/files/2013/09/WorldHappinessReport2013_online.pdf

Camp #3 Happy Planet Index (HPI) (http://www.happyplanetindex.org) is created at the New Economic Foundation (in UK) which is supported by the Friends of the Earth International (http://www.foei.org/en) and by Soil Association, UK (http://www.soilassociation.org). HPI measures how much resources a country consume to achieve the well-being of its citizens. HPI is an efficiency index which is the ratio of wellness to ecological foot print (http://www.happyplanetindex.org/about). HPI have been calculated for 151 countries. The overall index scores rank countries based on their efficiency, how many long and happy lives each country produces per unit of environmental output. The global results can be visualized by plotting Ecological foot print on the X-axis and happy life years on the Y-axis. Top 10 countries with highest HPI are listed in Table 1 (Source: http://www.happyplanetindex.org/data).

$$\text{Happy Planet Index} \approx \frac{\text{Experienced well-being} \times \text{Life expectancy}}{\text{Ecological footprint}}$$

Table 1. Top 10 HPI countries in 2012 survey

Rank	Countries	HPI	Well-being	Life expectancy	Ecological footprint
1	Costa Rica	64.0	7.3	79.3	2.5
2	Vietnam	60.4	5.8	75.2	1.4
3	Colombia	59.8	6.4	73.7	1.8
4	Belize	59.3	6.5	76.1	2.1
5	El Salvador	58.9	6.7	72.2	2.0
6	Jamaica	58.5	6.2	73.1	1.7
7	Panama	57.8	7.3	76.1	3.0
8	Nicaragua	57.1	5.7	74.0	1.6
9	Venezuela	56.9	7.5	74.4	3.0
10	Guatemala	56.9	6.3	71.2	1.8

Source: http://www.gfmag.com/tools/global-database/ne-data/11940-happiest-countries.html#axzz2M2bQvwBI

Nine out of 10 top countries are in the Caribbean Basin, despite high levels of poverty. Costa Rica is top, second time in a row, due to its very high life expectancy which is second highest in the Americas, and higher than the U.S. Among the top 40 countries by overall HPI score, only 4 countries have a GDP per capita of over US$15,000.

THIRD-GENERATION HAPPINESS INDEX

The need for third-generation happiness index

A major objection to the first- and second-generation happiness indexes is that the survey results merely reflect biased sampling inherent in its execution. Subjects who filled in and returned the voluntary surveys are usually those people who have the luxury, leisure and desire to do so. Therefore, uncontrollable sampling bias towards happier people is obvious. Another major shortcoming of the first- and second-generation happiness indexes derived by survey instruments are that the results are subjective, qualitative and culturally influenced at best. What is the difference between qualitative and quantitative? Quantity is measurable by number and unit. Let

us define the nature of the measurement for happiness. The scientific terminology is called “data quality objectives”; that is to say, what the measurement should look like, how accurate it needs to be and what unit the measurement should assume in order for the measurement to do its job satisfactorily. A measurement that does its job satisfactorily is called “fit for purpose”. A list of requirements for a happiness measurement is proposed below.

Data quality objectives for happiness index:

- Similar to the rise and fall of the stock market index, the happiness index only needs to be relative to itself. As such, it is a unit-less number, not an absolute unit.
- The number need not be perfect or accurate to the n^{th} degree.
- The calculation may be extremely complicated but the end number is easily understood.
- A majority should react to the number predictably, even if the numbering system is premature (e.g. first stock market in China a decade ago).

Given the above criteria, the derivation of a happiness index is doable and achievable within the scope of technologies available today.

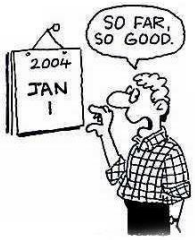
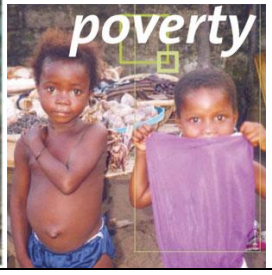
Materials and Methods

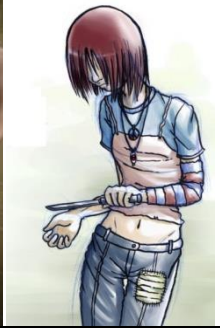
For our purpose of developing a happiness index, the materials are specimens from human test subjects. The methods are the instrumentation and schemes for measuring/testing the subjects.

Test Subjects
We wish to measure happiness in people, but happiness has not yet been defined! To circumvent this "chicken-or-egg first" irony, we could select categories of subjects based on their overall conditions. A list of fairly well defined human conditions is categorized in Table 2. Some of these categories are indisputable. For example, war veterans suffering from post-traumatic syndromes, patients diagnosed with defined psychiatric illnesses, refugees living under abhorrent conditions, etc. Each category could be subdivided, for example, the rich and famous with everything going their way or undergoing stressful periods. Thus, the category of test subjects could approximate some consensus scale of happiness from one to ten.

Table 2. Categories of Test Subjects

Category or Scale	**Description**	**Example**
10.	Spiritual	  

9.	Rich retired	 
8.	Optimists	 
7.	Celebrities, rich and famous	 
6.	Financier	 
5.	Average Joe	 
4.	Poor people	 

3.	Manic depression	 
2.	Suicidal/homicidal maniacs	 
1.	War veterans, post-traumatic experience	 

From the categorization of test subjects described above, it can be seen that stress reduction is one dimension of happiness. Numerous methodologies already exist for stress measurement in medicine and psychology. A good place to start would be to take advantage of these proven technologies and measurement techniques. Some of these techniques are summarized as follows:

Measurement Techniques for Happiness/Stressor:

1. Conventional techniques
    a. Subjective Evaluation
        i. Psychological self assessment
    b. Objective Evaluation
        i. Questionnaire assessments by social circle
        ii. Lie detector, heart beat rate, skin conductivity, perspiration, respiration.
        iii. Nuclear magnetic resonance imaging (MRI), CT scans
        iv. Infrared Spectrum
2. Proposed objective laboratory technique – Metabolomics

This list of stress measurements is self-explanatory except for the last technique, "metabolomics" which will be described in the next section. Today, an accurate DNA profile can be obtained from hair, skin, mouth swab, urine and menstrual blood. Hopefully, metabolomic profile can be obtained in similar specimens. The next question is how much weight should be assigned to each of the stressor indicators, in what combination and with what statistical correlations. This work will involve experts specializing in these measurement techniques to work together to develop a working statistical model.


Figure 2. A metabolomic laboratory.

Metabolomics

Metabolomics is an exciting new science which has emerged only within the past 10 years. This new science is born as a result of new generation of mass spectroscopy capable of generating enormous amount of data and the concomitant development of computer hard- and software powerful enough to handle such massive data. Figure 2 shows what a metabolomic laboratory looks like.

The excitement of this new science is that we now have the power to analyze or detect hundreds of physiological markers simultaneously. The physiological markers are called metabolites. Metabolites are small molecules that are associated with metabolism. For example, glucose (Figure 3) is a molecule that will be metabolized to produce energy; at the same time the amount of glucose is a marker for diabetes.

The general scheme of the living cell is illustrated in Figure 4. The blue print of life is coded in the DNA alphabet. The genetic information is transcribed by messengers called messenger RNA. The job of the messenger is to translate the genetic code into the manufacturing of proteins. Proteins are the building blocks of life. They make up enzymes, hormones, muscles, etc. The enzymes are responsible for metabolism. For example, a specific group of enzymes called glycosidase are responsible to break down glucose and produce energy.

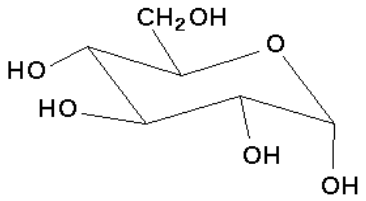


Figure 3. Chemical structure of a glucose molecule.

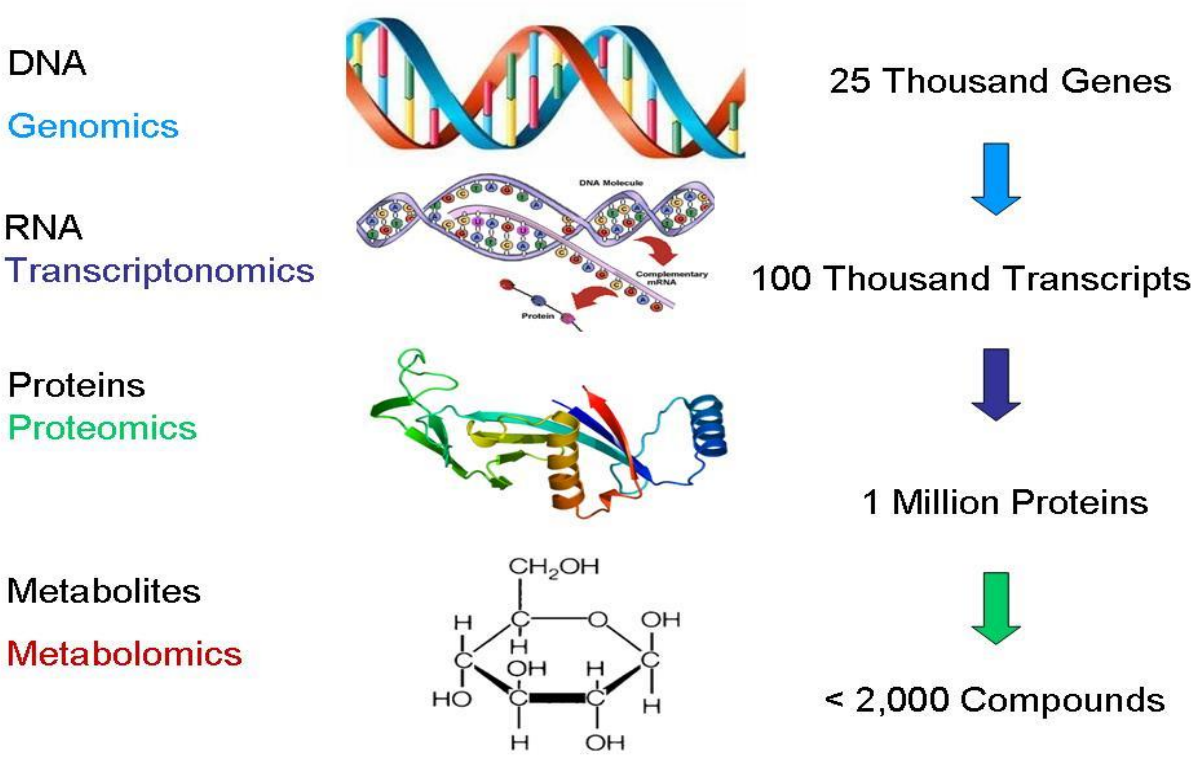


Figure 4. Genomics, Transcriptomics, Proteomics and Metabolomics.

We are all familiar with fingerprinting people using DNA profiling, for example, in criminal investigations or paternity determination. Can we fingerprint happiness? I think so. I think the power of metabolomics to analyze hundreds of compounds simultaneously will produce marker profiles sufficient to discriminate the categories of human test subjects as listed in Table 2. There are several good reasons in favor of analyzing metabolites rather than DNA or protein. Firstly, DNA profiles have poor discriminative power considering the similarity between human and ape is 98.4% at the DNA level. Secondly, there are too many genes to analyze as there are about 25 thousand genes in a human cell. This reason is worse for proteins because the 25 thousand genes translate into about a million proteins. In contrast, there are less than 2,000 metabolites in our body, a number that can be dealt with using metabolomic technology. The third reason is analytical reliability. Glucose is glucose either in the human body or in the yeast cell. Thus, the analysis of metabolites can be much more consistent compared to the analysis of DNA or protein. The final and most important reason is that our physiological and psychological states depend to a large extent on the metabolites. DNA is the potential. Protein is the mediator. Metabolites are the final products and markers.

The beauty of this approach is that we do not need to know the exact identity of the compound. For example, glucose can be compound No. 1 without having to find out No. 1 is glucose. This is because we are only interested in the presence and absence of each compound and their relative amount when compared across the categories of test subjects.

By testing all the subjects for the hundreds of metabolic compounds, we will have an average measurement for each compound. The average is placed at the zero line on the x-axis of the metabolomic profile chart (Figure 5). Then we analyze the quantity of each compound from a "happy" category. Those compounds which demonstrate a statistical deviation from the average norm are plotted in green. Similarly, we can obtain another profile representative of the "unhappy" category. We would now have the finger print for all the categories. Any individual can have their happiness tested over time by metabolomic analysis. The laboratory will report in which category the individual's profile most closely resembles.

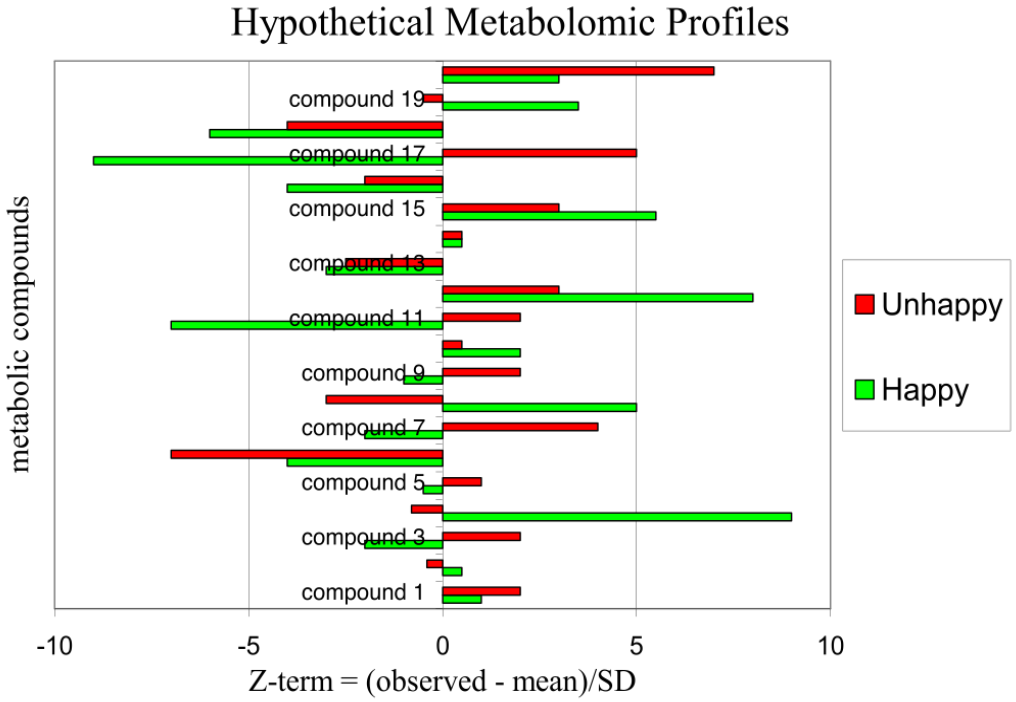


Figure 5. Metabolomic finger printing happiness or sadness.

Metabolomic studies today lack this vision; they are mainly concerned with identifying disease markers and drug discovery/monitoring. I see them as profitable and beneficial by-products of my mission. Although my concept has not yet been tested in humans, there are encouraging results from the study of bacteria. The following results were reported by researchers from the US Food and Drug Administration (FDA) in collaboration with Agilent Technologies. Cultured bacterial cells were lysed and subjected to liquid chromatography followed by Time-of-flight mass spectrometry, which used Matrix-assisted laser desorption/ionization (MALDI) technique. The first piece of instrument, liquid chromatography, marked each protein in the complex mixture by its unique retention time in the column run. Then, large molecule feature extraction software was used to detect and deconvolute the intact proteins followed by multivariate statistical analysis software to provide clustering and Principal Component Analysis. The term "Principal Component Analysis" means methods to sort out what are the major differences from the numerous similarities. The second piece of instrument, the mass spectrometry, provided results on the mass and the abundance of each protein. These three results (mass, abundance and retention time) are plotted in 3-dimensions on the X, Y and Z Axis (Figure 6) representing

deconvoluted protein masses, summed abundances of all the charge states reflecting those masses, and corresponding retention times, respectively.

Notice that the 3-dimensional plot is able to cluster members of a unique strain together. Hence, the four different strains were spatially located away from each other as four clearly identifiable clusters. Note that all four strains belong to the same species of bacteria, Salmonella, which cause food poisoning. This method can be used to track the source of a food poisoning outbreak. Possibly, human beings (same species) in different physiological/psychological states (metabolomic states) can be distinguishable by similar techniques as well.

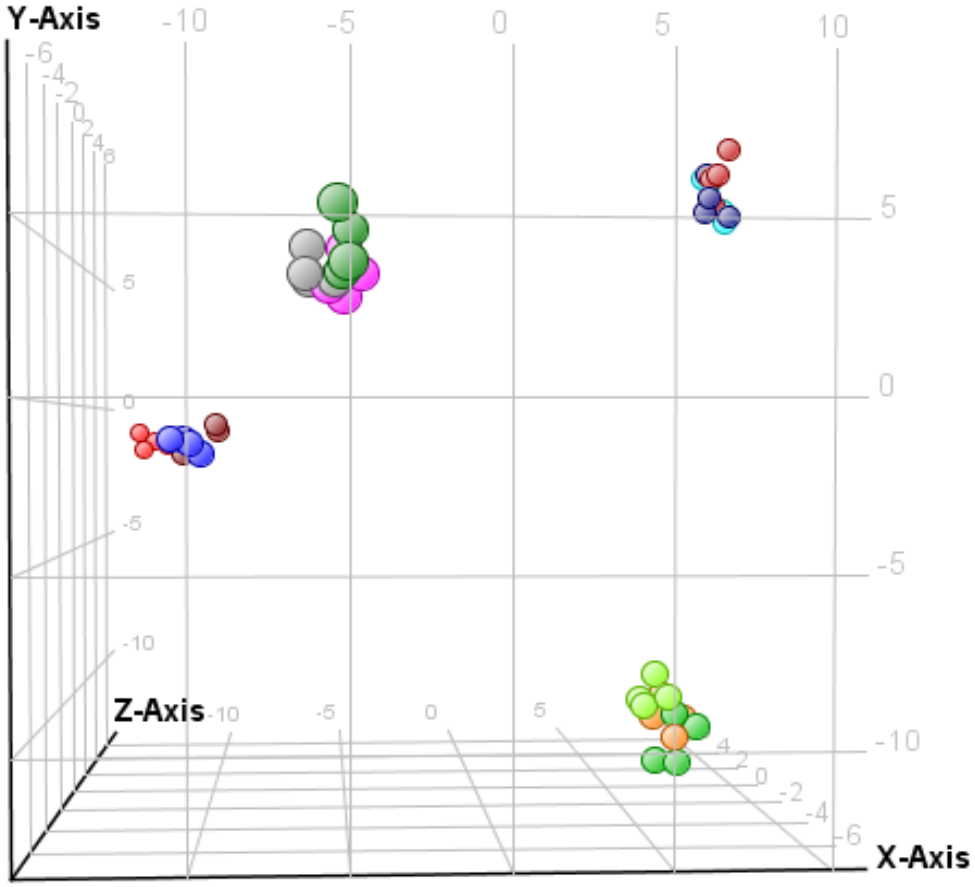


Figure 6. Four different strains of the same bacteria species distinguishable by proteomics/metabolomics. A1, A2 *Salmonella typhimurium*, A39, A40 *Salmonella Heidelberg*

DISCUSSION

To summarize on the technological status, current technology for measuring markers that will allow the creation of a happiness index already exists. These technologies are used mostly for medical and psychological purposes. These resources could be easily shared and redirected to create the third-generation “happiness index”, the advantages of which is spell out below.

Nature and functions of third-generation Happiness Index

This nature of the third-generation Happiness Index has the following characteristics. It is objective, neutral, informative and motivating. It is not confrontational and dogmatic.
The third-generation Happiness Index will function as follows. It will: measure the well being of society and individuals; entice and guide policy makers; redefine quality of life; empower individuals to make lifestyle choices in the short and long term; be a powerful alternative to the mighty dollar and other economic indexes. It will not be tradable (like carbon trading). Like any clinical laboratory measurements, the results are entirely objective and reliable.

Quantifying Nirvana

If we formulate a hypothesis that Nirvana is a state of mind reflecting a unique metabolism, then the profile of metabolites would be distinguishable from unhappy individuals. This hypothesis can now be tested using the same metabolomic technology. In fact, Category 10 in Table 2 of Happiness Scale 1 to 10 presumes that spiritual practitioners are probably the happiest of humans. As the test methodology is refined and data base accumulates, it is foreseeable that sub-categories patterns will emerge representing progressive levels within that category, such as different levels of enlightenment? Religions will no longer stand alone on faith. Science will become its backbone to validate the Nirvana claims. When science and religion unite, a new age of renewed spiritualism will dawn. This is an effective way to spread the dharma as each individual can objectively monitor his/her own claim of happiness and spiritual advancement.

CONCLUSION

The new science of metabolomics has the potential to dissect and fingerprint various states of metabolism reflective of one's physiological and psychological state. Happiness is the central value that all human pursue. The abstract quality of happiness could be quantified as happiness index by the scientific tools described. Scientific validation of spiritual attainment is possible. The root-cause of global warming is that the dominant civilization values a model of economic growth that the planet cannot sustain. In their pursuit of happiness, humans lack a quantitative definition of happiness. But humans have a quantitative value system called money. Human nature finds it easier to make decisions based on quantitative data rather than qualitative abstracts. Consequently, the pursuit of happiness is misguided to become the pursuit of fortune and fame.

We must avert decision-making solely based on money (bottom line) because the planet cannot sustain the consequences. An alternative, complementary value system must be made available for the human decision-making process. Therefore, the logistics of a new science to quantify happiness by the "Third-Generation Happiness Index" is presented. Using existing technology, quantifying happiness can be quickly accomplished within 5 years, just in time to avert our dooms day. In 2013, the Natural Sciences and Engineering Research Council of Canada considered the author's proposal "...very innovative...this could make an excellent pilot grant application to establish the feasibility of a larger study." This endorsement encourages the author to invite colleagues interested in international collaborations.

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