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10.1126/science.1184703

ECONOMICS

Measuring Subjective Well-Being

Richard Layard

How should human happiness and life-satisfaction be assessed?

What is progress, and how should we measure the well-being of a population? The Organization for Economic Cooperation and Development has held two major conferences on the subject, and last year, President Sarkozy of France established a distinguished commission to report on the same questions (*1*). This major debate reflects the fact that higher national income has not brought the better quality of life that many expected, and surveys in the United States show no increase in happiness over the past 60 years. These surveys rely on questions about subjective well-being, and it is reasonable to ask how reliable survey answers are as measures of the quality of life as people experience it. On page 576 of this issue (*2*), Oswald and Wu carry out an interesting test of this. First they measure subjective well-being in each U.S. state, and then compare it with the average objectively measured wage in the same U.S. state (both variables being controlled for personal factors). The negative correlation of the two variables is remarkably high—as it should be if higher wages are compensating for a lower experienced quality of life (and vice versa). The study will likely stimulate some lively debate across many disciplines, including scientists, economists, sociologists, psychologists, and policy-makers.

But should we really adopt subjective well-being as our measure of the quality of life? Philosophically, many would say "yes," as they have ever since the 18th-century Enlightenment. But, practically, can subjective well-being really be measured well enough to be used in policy analysis? Is what people say about their subjective state well enough correlated with the inner reality?

The science is, of course, very young, but it is well enough developed for us to say "yes." In the typical question, an individual is asked, "Taking all things together, how happy are you?" The possible answers range from 0 (extremely unhappy) to 10 (extremely happy). To evaluate the information content in the answers to such questions, we can examine whether these answers are well enough correlated with other relevant factors. They are in fact well-correlated with at least five relevant sets of variables: the reports of friends; the plausible causes of well-being; some plausible effects of well-being; physical functioning, such as levels of cortisol; and measures of brain activity.

When a subject's friends are asked about the subject's happiness, the answers correlate well with the subject's own report. (Were it not so, human society would find it hard to function.)

Moreover, questions on happiness and life satisfaction have now been asked in hundreds of routine population surveys, and in multiple regressions within countries, the following causal factors are always important: physical health, family status, employment, income, and age. This is true both in cross-section studies and in panel studies that include an individual fixed effect. Moreover, the sizes of the effects are remarkably similar in widely different studies done within different countries (*3*).

Similarly, responses on life satisfaction can be used to explain behavior such as quitting one's job and exiting from marriage. They can also, as Oswald and Wu show, be used to measure quality-of-life differences across the United States in a way that is consistent with the pattern of wage differences.

Answers about happiness are also well correlated with measurements of bodily function, such as amounts of salivary cortisol, fibrinogen stress responses, blood pressure, heart rate, and (in some cases) immune system responses to a flu vaccination. These correlations hold across individuals, as in the famous cross-sectional study of British Whitehall civil servants (*4*), and also in some cases within the same individual over time.

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Finally, there are reported correlations with brain activity across individuals, and within individuals over time. The best known of these is the correlation of positive affect with activity in the left dorsolateral prefrontal cortex (PFC) and negative affect with activity in the right dorsolateral PFC (*5*). This area of work is in its infancy but, if successful, it will reinforce the view that subjective experience is an objective reality. Because this is so often questioned, it is worth repeating the findings of Coghill (*6*), who applied the same very hot pad to

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the legs of many subjects; in that case, the reported pain varied widely and was well correlated with activity in the cortex.

There are, of course, many different ways to measure happiness and life satisfaction. Such measures can be based on a single question or (to reduce measurement error) on many questions, which can be combined into a single index using weights that reflect their average impact on answers to the single question. For most purposes, we would like the measurements to cover a substantial period of time, but this can also be achieved by repeated questioning. And as the Enlightenment tradition suggests, the questions should mainly aim at capturing pure affect (feeling), without too much involvement of judgment (*7*). Fifty years ago, there was considerable debate on how to measure depression, but by now this has become much less controversial. In all likelihood, the measurement of happiness will become similarly less controversial.

Now is the time for every government to collect data on a uniform basis on the happiness of its population. That was the most important of the recommendations of President Sarkozy's commission (although it also recommended better measurement of GDP). Once there is good information on levels of happiness, three things will be possible: the monitoring of trends, the identification of problem groups in the population, and the analysis of why some people are happy and others are not. To fully understand intercountry differences in happiness, we shall probably have to rely on biomarkers in addition to answers to verbal questions asked in different languages.

As for policy analysis, this has to be based on solid science, using either naturalistic data or controlled experiments. But the metric has to change. Today's cost-benefit analysis measures benefit in terms of the money that the beneficiary has shown he or she would be willing to pay for a change of state. But for many key areas of public policy, such measurements make no sense because little individual choice is involved—think, for example, of physical health, mental health, responsible parents, family stability, (un)employment, and community life. In these areas, we can get much better measures of the benefits of a policy change through direct measures of subjective well-being. It is therefore time to begin developing an alternative system of cost-benefit analysis in which the units are units of subjective well-being.

But sound measurement will only become possible if social science (including psychology) takes as a prime objective the quantitative study of the determinants of well-being. Every survey of individuals should automatically measure their well-being, so that in time we can really say what matters to people and by how much. When we do, it will produce very different priorities for our society.

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10.1126/science.1186315

MATERIALS SCIENCE

Turning Away from High Symmetry

John C. Crocker

Light microscopy studies of cluster formation by colloidal particles show that less-symmetrical structures are favored under equilibrium conditions.

A common sight in cold climates is the growth of crystalline ice "feathers" or "ferns" on a cold window pane. These structures are initiated by heterogeneous nucleation—the ice crystals form on the surface of a different substance, in this case, specks of dust. It is much harder to start crystal formation in pure fluids because the seed crystal must form spontaneously in solution (hence pure water can supercool and remain as a liquid for long times below its freezing point). Homogeneous nucleation is largely a mystery; observing small clusters of molecules directly is difficult, and their formation is a rare event. On page 560 of this issue, Meng *et al*. (*1*) report an exhaustive experimental study of the equilibrium cluster configurations in a model system consisting of microscopic plastic spheres that were designed to have a short-ranged, reversible attraction that drives them together (*2*). This work underscores the subtle geometrical difficulties associated with crystal nucleation, and helps us to understand the "rules" by which nature self-assembles small structures and ultimately crystals.

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In earlier work assembling clusters, Manoharan and co-workers (*3*) found that highly symmetric polyhedral clusters were the most stable in terms of bond energies. However, in their current work on clusters in thermodynamic equilibrium, the most common structures are typically the least symmetric. The essential difference lies in entropic effects—in thermal equilibrium, the most common clusters are not those with the lowest internal binding energy (*4*), but rather those with the lowest free energy, which is favored by higher entropy.

Entropy has been equated in popular culture with unavoidable disorder and decay, but its true nature can be appreciated in the context of self-assembly. In equilibrium, every possible way to build a cluster (having the same binding energy) will occur with the same probability—there are simply fewer ways of building symmetric clusters (see the figure, panel A). Specifically, Meng *et al.* hypothesized that the symmetric polyhedra would encounter two entropy penalties. Their rotational symmetry leads them to have very low rotational entropy, and their high degree of internal coordination makes them very rigid, which causes them to have very low vibrational entropy (see the figure, panel B).

To experimentally test their hypothesis, Meng *et al*. first prepared a suspension of microspheres that are large enough to image with a light microscope, but small enough to undergo random thermal fluctuations and obey equilibrium statistical mechanics. This sample was then loaded into an array of microfabricated chambers, each of which was small enough that it would contain only a small number of microspheres. An additional entropic effect—called a depletion attraction—was induced between the microspheres by the addition of much smaller, nanoscale particles (*2*). This force causes the microspheres to join up to form clusters, one per chamber. Each cluster was then scrutinized

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