Measure, Number and Weight

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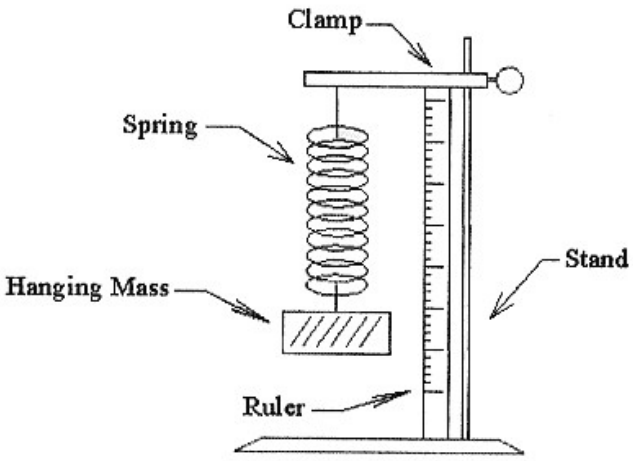
We cannot take great enough care when making inferences based on experiments. We should not try through experiments to directly prove something or to confirm a theory. For at this pass—the transition from experience to judgment, from knowledge to application—lie in wait all our inner enemies: imaginative powers that lift us on their wings into heights while letting us believe we have our feet firmly on the ground, impatience, haste, self-satisfaction, rigidity, thought forms, preconceived opinions, lassitude, frivolity, and fickleness. This horde and all its followers lie in ambush and suddenly attack both the active observer and the quiet one who seems so well secured against all passions.

- Johann Wolfgang von Goethe, *The Experiment as Mediator of Object and Subject*, 1792

Introduction

Developing the correct approach towards the methods of science is an essential aspect of scientific discovery. In order to do that, it is important to understand the current attitude, and then determine if that is sufficient or if changes are needed in the process.

To start examining this approach, let us take an example, such as determining the strength of a spring. In this case, it is possible to do it in two ways. In the first method, different weights can be hung from the spring, and its extension measured in each case. The ratio of weight to extension gives an estimate of its strength. This method is not always the best, because the spring can be stressed a lot by hanging heavier and heavier weights. So instead, the spring can be set into gentle oscillations with a known mass and its frequency of oscillation obtained from it. This frequency is then used to obtain the strength of the spring – greater the frequency, weaker the spring.



Vertical Spring-Mass Oscillator

SOURCE:
http://johnabbott.qc.ca/webpages/departments/physics/kerr/new/PhysicsKerr/FallWinter2001NYC/Experiments/ExpOne.pdf

It is seen that this simple setup has many operations that go into it. If the oscillation method is used, in the first place the mass of the object hung on the spring has to be determined. This is done by *comparing weights* on a scale, or by using *another* spring – the spring balance. The frequency is determined with the clock, or if one were to do it Galileo-style, by *counting* the pulse. Finally, the extensions are *measured* with a ruler, and the results combined.

This is what, at the first glance, appears to be the elementary operations: *to measure*, *to count (number)* and *to weigh*. It is now important to look into these aspects a little closer.

Measure

Digging a little bit more, the question can be asked: "How do I really know that the length of the spring is 5 inches?" This is mainly done by visually comparing a ruler and the spring. However, if this ruler was calibrated wrongly, there is no clear way for the eye to make out the difference, unless there is a long experience with measuring. In addition, the length of an inch, or a centimeter, is something that has been standardized across the world, by the institutes of Weights and Measures everywhere. This is as if one would pick an "average man", point at his foot, designate it as "one foot", and send out a decree across the world that all further measurements would be with respect to this "average man's" foot. It is only by fixing this as a "standard", that all measurement is possible.

But there are complications… what if, the standard ruler itself grows and shrinks? What if the "average man" shrinks with age or the standard ruler expands in the summer? Well, one can compare it with the surroundings to check if its size has varied. However, what if the surroundings also respond ever so slightly, to temperature for instance? When pursuing this theme, it is apparent that the standard unit must always be based on a comparison with something else that is *assumed* to stay fixed. Counting the units is hence an artifice, the reality lies in the *comparison*. And since these comparisons are primarily visual, one can say that human measurement is restricted to *comparison based on what the eye perceives*.

It may be argued that the other senses also compare, for instance whether one electric current is stronger than the other, one stove is hotter than the other, or one bag is heavier than the other. But as far as we can say that we are not "merely" comparing, but *measuring*, what do we usually do? We read the temperature on a thermometer, where the expansion of mercury (or any other regent) is along a line; therefore we read a length. We observe the weight of a scale, by either watching if the scale is horizontal, or by comparing the compression of the weight with a standard spring. This compression is again a length. Electric current is determined by obtaining the force of attraction of current carrying wires, and hence by measuring weight, which in turn is measured by length. By examining the way fundamental physical quantities are measured, one can trace all of it back to measuring a spatial length or angle, by visual comparison. It is instinctively felt that a *visual or spatial* comparison is the most definite in the sense of measurement.

Additionally, as an internal perception, this comparison is at the root of understanding *rationality* – through comparison or ratio, reason is applied. This is why the phrase "I did not know how to gauge that" is used. The visual dominance for understanding is also indicated by a phrase such as "Ah, I *see* now, that's how it works!"

In the *act* of measuring however, a certain amount of time is taken up. Even for the eye to sweep the length of a ruler, and fixate on the spot where it says "5 inches", and then read and comprehend the letters "5 inches", there is time involved. Although this time may just be a heartbeat, it nevertheless exists. Therefore every measurement involves time -- hovering in the background but still clearly present. In addition, the act of measuring also involves a comparison with the sense of touch. This depth perception that we all carry instinctively with us since childhood, is actually due to schooling the sense of sight with the help of the sense of touch. One would not, for instance, hold a ruler near the eye and measure a tree far away. Even if it does look like the tree is one inch high visually, it does not stay true to the sense of touch. This comparison, and the capacity of combining the senses, is therefore the faculty of *judgment*. It does not originate in the perception, but only in what the individuals introduce out of their own initiative.

These aspects – the presence of time, the comparison with touch, and the faculty of judgment – require elaboration. In order to look at these aspects in their distinctness, the spatial visual sense must be kept away from their definition as much as possible. Thus, when looking at the perception of time, without a visual aid such as a clock or an hourglass, one is led to the phenomenon of *counting via number*.

Number

The activity of attributing number begins primarily with a differentiation of experience. When there is either a variation or repetition of a particular experience, the *one* whole experience now becomes *two*. Variation and repetition are hence the two faces of number. When it is the counting of the sunrises, planetary movements, or the breaths and the heartbeat, it is number's *counting* aspect that gains predominance. When one looks at the *relation* between one sound and another, one size and another, or one planetary position and another, number shows up as an indicator of *harmony* which gains predominance.

Number is hence twofold itself: in counting and in proportion. One can take the example of the apple: there can be 5 apples on the one hand, and 5 apple-seeds on the other. It does not matter as such how many apples one picks, and hence it may be called simply a coincidence that there are 5 apples. However, 5 apple-seeds occurring together are not a coincidence, since every apple has 5 seeds. The 5 is now related to 1 apple, in other words, there is a proportion or a frequency to the number: 5 seeds *per* apple. Hence the number 5 potentially contains both the meanings: as a frequency and as a count. A similar meaning exists in with substances, where gases can be collected in 1 or 2 or 3 jars, but they react in specific whole number ratios, such as 1:2 or 2:3. Counting and proportion go together.

Number as counting, taken to an extreme, leads to chaos – such as the number of grains of sand, or the number of dust particles in a dust-storm. On the other hand, number as proportion reaches upward to a greater sense of harmony, such as music, higher mathematics, and the harmony of thought relationships as a whole. Hence, number has the capacity of emancipating itself from measure, since numbers such as -1 or i can exist, even though they are not measured.

However, in this emancipation from spatial measure, one enters the possibility of experiencing *time*. In the simple sense, time is recorded by periodic occurrences, visible, audible or otherwise, to obtain the frequency. The *experience* of time, however, does vary a lot, where a single moment can sometimes "feel like a million years", and vice versa. Emotion and feeling of well-being tune our perception of time, sometimes by literally speeding up the heartbeat and circulation. This "stretchability" of temporal experience is in sharp contrast to our visual experience which is more standardized and does not normally stretch and contract anywhere to the same degree.

The realm of number is hence very rich: countability on the one side, harmony on the other, but a stretchability that relates more to temporal experience than spatial. The sense organ most attuned to number is sound. As the philosopher Leibniz once said:

Music is the pleasure the human mind experiences from counting without being aware that it is counting.

Furthermore, one can ask the question: What provides this stretchability? The clue is obtained in observing the nature of the spring, where the frequency and the length of the spring are both dependent on the *force* or *weight* attached.

Weight

Externally, weight modifies space, and in turn modifies time. Hence, when a string on a violin is tightened, its pitch is altered. When a greater weight is hung on a spring, the frequency of oscillation reduces.

The *internal* experience of weight offers a far greater contrast than the internal experience of number. In number, there can be harmony or disharmony, a small count or large, but in terms of weight, the experience itself can disappear altogether when one is floating in dense sea water or even when deeply asleep! Similarly when one carries an extremely heavy weight, it tends to blot out consciousness when pressed to the limit i.e. one faints or "goes to sleep".

Another aspect of internal perception of weight during waking life is less transitory than that of feeling: the sensation of seriousness in terms of life goals as a whole. For instance, we speak of "weighty decisions," or people whose words "carry a lot of weight". When a great responsibility is taken up, it is said that one is "bearing a great burden" and when the responsibility ceases, it is a "great weight off the shoulders." When pursuing something with utmost seriousness, it is typical to "throw all of one's weight behind it". If being frivolous and arrogant, one "throws one's weight around." Hence, while emotions alter the internal perception of time, *morals* appear to be crucial in the internal perception of weight.

Hence, to state it succinctly: measure is most akin to the sense of sight, and is internally sensed as reason or understanding. Number is most akin to the sense of sound, and is internally sensed as the feeling of harmony or well-being. Weight is most akin to the sense of touch or pressure, and is internally sensed as the moral bearing of life. One normally leaves the internal sensations completely out of the picture, such as when measuring the strength of a spring. However, does that make the internal sensations irrelevant?

Faculty of Judgment: The Confusion

As outlined above, measure, number and weight are not neatly compartmentalized – each does carry over some of its nature into the other. Measuring has a relation to number, either through counting or through comparison with a standard unit number. Number and measure, in their capacity for "stretchability", have a relation to weight. Measure is corrected by weight, through the sense of touch as depth perception.

In combining the perceptions obtained from measure, number and weight, instead of observing the distinct qualities and understanding the mutual effect of one on the other, it is possible to confuse them. Here is where the "inner enemies" that Goethe mentions cause trouble by confusing our faculty of judgment. A confusion caused at this juncture can cause one to *directly* attribute properties of one aspect to the other. This can happen in several different ways.

When number is confused with weight, we have the rise of *material atomism*. In this case one assumes that matter is "made up" of numerous little chunks of matter. The important thing to realize is that *insofar as atomism bears a relation to number alone, the concept remains valid*. But if the number "spills over" into weight, then the world is assumed to be made of a *number of weights*, such as miniature billiard balls. This is the cause of the ubiquitous atomic picture of the world, with particles interacting with particles, or atoms being arranged in a lattice.

When number is confused with measure, we have the rise of *relativity*. Here, the reality of weight is completely set aside, and the stretchability of time perception "spills over" into space. One therefore has time dilation and length contraction as concepts that arise as a result of this confusion. It is worth obtaining a clear understanding of the phenomena that relativity is supposed to explain, without confusing the fundamental concepts of number with measure.

When measure gets confused with weight, we have the *particle picture of light*. As already pointed out above, measure is mainly visual. In this, even though light is supposed to be "massless" it is still treated as a "packet" of energy. A moving weight is energy, so the light gets burdened with a sort of "equivalent mass" with a corresponding "equivalent momentum".

When measure gets confused with number, one has the *wave picture of light*. The ideas about light, which radiates, are combined with the idea of a frequency, which is mainly a cyclical or circulatory measure. This leads to the view of light as a wave-form with a certain frequency. Once again, as far as there is reality to the fact that there is a "number" quality to light, we are on sure ground. But attributing a wave nature to light would mean ending up in conceptual knot: a wave form of light can only be recognized by the eye if there is a dark curve in a white background, but this image presupposes the existence of light and darkness which it is supposed to explain! So light behavior is caused by a wave-form which is caused by light behavior … a circular loop of logic is obtained.

When measure and number are clumped together, one has *quantum mechanics*. This is one of the main reasons why quantum mechanics is so confusing conceptually, since the offspring of the clumping together of measure and number (probability wave function) is used as a basis to explain behavior of matter. Weight as a function is left unexamined, resulting in a feeling of a Cheshire cat's smile without the cat. (Or was it Schrödinger's cat?)

When number and weight are clumped together, one has *string theory*. Here a taut string, with manifold vibrations, provides the basis for the entire world. This theory is removed almost entirely from the visual field of measure; hence there are a number of dimensions that can easily be added without major consequence, as they are all supposed to be "too small to see."

When measure and weight are clumped together, one has the *ether as a material medium*. This was the widely prevalent theory in a good part of the 19th century and the early part of the 20th. When this was abandoned at this time, the ether referred to was only a material medium. It is no wonder that it had contradictory properties, such as a very high density coupled with no response to touch.

Faculty of Judgment: The Clarification

Such confusions have occurred historically by the foremost of scientists who have had an extensive training of the intellect. So, in addition to rigorous schooling in logic, what other ways are there to school our faculty of judgment to prevent it from falling prey to the confusions created above? This is where the *internal senses* previously mentioned guide one towards the answers.

When we see something for the first time, the feeling of understanding that arises spontaneously is coupled with an important feeling: *wonder*. Hence, it is only when wonder is developed independently as an internal practice, that the necessary offset is created in the faculty of judging true measure. It is no wonder that the Fathers of Rational Thought, Socrates, Plato and Aristotle, had indicated that "All philosophy begins in wonder."

When we grasp the weight of a moral decision, it is the cultivation of *reverence* that provides a way to relate to the moral world. Without the attitude of reverence, it is very easy to treat the substances of the world with an attitude of pure utility. Yet this very ease ends up knotting up our theories in dead-ends of thought even if several practical results are forcefully obtained. Reverence serves as the corrective factor to perceiving the weight and substantiality of the physical world, and provides morality to technology as well.

When we hear the harmony of a calming note, our sense of music acknowledges the harmony in the world itself. Therefore, it is the feeling of the presence of a *wisdom-filled harmony in the world* that fine tunes our perception of time and rhythm in the world. This internal development prevents our perception of time from degenerating into a mechanical tick-tock, unconnected with anything else in the world. Number also regains its role as a guide to harmony, without which it degenerates into a worldview of ashes and dust.

It is also in this sense that one can understand parts of the lecture cycle by Rudolf Steiner: *World of the Senses and World of the Spirit* (GA134, Dec 27, 1911 – Jan 1, 1912). It opens the door to the right treatment of measure, number and weight on which all of physics and technology based.