Trial and Error

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Trial and error, or trial by error, is a general method of problem solving, fixing things, or for obtaining knowledge. "Learning doesn't happen from failure itself but rather from analyzing the failure, making a change, and then trying again." In the field of computer science, the method is called generate and test. In elementary algebra, when solving equations, it is "guess and check".

This approach can be seen as one of the two basic approaches to problem solving and is contrasted with an approach using insight and theory. However, there are intermediate methods which for example, use theory to guide the method, an approach known as guided empiricism.

Methodology

This approach is more successful with simple problems and in games, and is often resorted to when no apparent rule applies. This does not mean that the approach need be careless, for an individual can be methodical in manipulating the variables in an attempt to sort through possibilities that may result in success. Nevertheless, this method is often used by people who have little knowledge in the problem area.

Simplest applications

Ashby (1960, section 11/5) offers three simple strategies for dealing with the same basic exercise-problem; and they have very different efficiencies: Suppose there are 1000 on/off switches which have to be set to a particular combination by random-based testing, each test to take one second. . The strategies are:

the perfectionist all-or-nothing method, with no attempt at holding partial successes. This would be expected to take more than 10^301 seconds, ;
a serial-test of switches, holding on to the partial successes (assuming that these are manifest) would take 500 seconds; while
a parallel-but-individual testing of all switches simultaneously would take only one second.

Note the tacit assumption here that no intelligence or insight is brought to bear on the problem. However, the existence of different available strategies allows us to consider a separate ("superior") domain of processing -- a "meta-level" above the mechanics of switch handling -- where the various available strategies can be randomly chosen. Once again this is "trial and error", but of a different type. This leads us to:

Trial-and-error Hierarchies

Ashby's book develops this "meta-level" idea, and extends it into a whole recursive sequence of levels, successively above each other in a systematic hierarchy. On this basis he argues that human intelligence emerges from such organization: relying heavily on trial-and-error (at least

initially at each new stage), but emerging with what we would call "intelligence" at the end of it all. Thus presumably the topmost level of the hierarchy (at any stage) will still depend on simple trial-and-error.

Traill (1978/2006) suggests that this Ashby-hierarchy probably coincides with Piaget's well-known theory of developmental stages. . After all, it is part of Piagetian doctrine that children learn by first actively doing in a more-or-less random way, and then hopefully learn from the consequences -- which all has a certain to Ashby's random "trial-and-error".

The basic strategy in many fields?

Traill (2008, espec. Table "S" on p.31) follows Jerne and Popper in seeing this strategy as probably underlying all knowledge-gathering systems -- at least in their initial phase.

Four such systems are identified:

Darwinian evolution which "educates" the DNA of the species,
The brain of the individual (just discussed);
The "brain" of society-as-such (including the publicly-held body of science); and
The immune system.

An ambiguity: Can we have "intention" during a "trial"

In the Ashby-and-Cybernetics tradition, the word "trial" usually implies random-or-arbitrary, without any deliberate choice. However amongst non-cyberneticians, "trial" will often imply a deliberate subjective act by some adult human agent; (e.g. in a court-room, or laboratory). So that has sometimes led to confusion.

Of course the situation becomes even more confusing if one accepts Ashby's hierarchical explanation of intelligence, and its implied ability to be deliberate and to creatively design -- all based ultimately on non-deliberate actions. The lesson here seems to be that one must simply be careful to clarify the meaning of one's own words, and indeed the words of others. [Incidentally it seems that consciousness is not an essential ingredient for intelligence as discussed above.

Features

Trial and error has a number of features:

solution-oriented: trial and error makes no attempt to discover why a solution works, merely that it is a solution.
problem-specific: trial and error makes no attempt to generalise a solution to other problems.
non-optimal: trial and error is generally an attempt to find a solution, not all solutions, and not the

best solution.
needs little knowledge: trials and error can proceed where there is little or no knowledge of the subject.

It is possible to use trial and error to find all solutions or the best solution, when a testably finite number of possible solutions exist. To find all solutions, one simply makes a note and continues, rather than ending the process, when a solution is found, until all solutions have been tried. To find the best solution, one finds all solutions by the method just described and then comparatively evaluates them based upon some predefined set of criteria, the existence of which is a condition for the possibility of finding a best solution. (Also, when only one solution can exist, as in assembling a jigsaw puzzle, then any solution found is the only solution and so is necessarily the best.)

Examples

Trial and error has traditionally been the main method of finding new drugs, such as antibiotics. Chemists simply try chemicals at random until they find one with the desired effect. In a more sophisticated version, chemists select a narrow range of chemicals it is thought may have some effect using a technique called structure-activity relationship. (The latter case can be alternatively considered as a changing of the problem rather than of the solution strategy: instead of What chemical will work well as an antibiotic? the problem in the sophisticated approach is Which, if any, of the chemicals in this narrow range will work well as an antibiotic?) The method is used widely in many disciplines, such as polymer technology to find new polymer types or families.

The scientific method can be regarded as containing an element of trial and error in its formulation and testing of hypotheses. Also compare genetic algorithms, simulated annealing and reinforcement learning - all varieties for search which apply the basic idea of trial and error.

Biological evolution is also a form of trial and error. Random mutations and sexual genetic variations can be viewed as trials and poor reproductive fitness, or lack of improved fitness, as the error. Thus after a long time 'knowledge' of well-adapted genomes accumulates simply by virtue of them being able to reproduce.

Bogosort, a conceptual sorting algorithm (that is extremely inefficient and impractical), can be viewed as a trial and error approach to sorting a list. However, typical simple examples of bogosort do not track which orders of the list have been tried and may try the same order any number of times, which violates one of the basic principles of trial and error. Trial and error is actually more efficient and practical than bogosort; unlike bogosort, it is guaranteed to halt in finite time on a finite list, and might even be a reasonable way to sort extremely short lists under some conditions.

Jumping spiders of the genus Portia use trial and error to find new tactics against unfamiliar prey or

in unusual situations, and remember the new tactics. Tests show that Portia fimbriata and Portia labiata can use trial and error in an artificial environment, where the spider's objective is to cross a miniature lagoon that is too wide for a simple jump, and must either jump then swim or only swim.

Issues with trial and error

Trial and error is usually a last resort for a particular problem, as there are a number of problems with it. For one, trial and error is tedious and monotonous. Also, it is very time-consuming; chemical engineers must sift through millions of various potential chemicals before they find one that works. There is also an element of risk, in that if a certain attempt at a solution is extremely erroneous, it can produce disastrous results that may or may not be repairable. Fortunately, computers are best suited for trial and error; they do not succumb to the boredom that humans do, can test physical challenges in a virtual environment where they will not do harm, and can potentially do thousands of trial-and-error segments in the blink of an eye.