Morphological Analysis

Morphological analysis is the process of examining possible resolutions to unquantifiable, complex problems involving many factors. The root of the word morphology comes from the Greek word, morphe, for form.

Morphological analysis takes a problem with many known solutions and breaks them down into their most basic elements, or forms, in order to more completely understand them.

Morphological analysis is used in general problem solving, linguistics and biology. In many fields of study morphology facilitates clearer instruction for teachers to help students understand problems and their solutions.

For general problem solving, morphological analysis provides a formalized structure to help examine the problem and possible solutions. The elements of a problem and its solutions are arranged in a matrix to help eliminate illogical solutions.

In biology, the study of forms helps understand mutations, adaptation and evolution. The study of the features and structure of organisms helps us understand organisms and their place in the greater environment.

In linguistics, words are broken down into the smallest units of meaning: morphemes. Morphemes can sometimes be words themselves as in the case of free morphemes, which can stand on their own. Other morphemes can add meaning but not stand as words on their own; bound morphemes need to be used along with another morpheme to make a word. Cats, for example, is a two-morpheme word. Its base, cat, is a free morpheme and its suffix an s, to denote pluralization, a bound morpheme.

As a school of thought morphology is the creation of astrophysicist Fritz Zwicky. Zwicky contrived the methodology to address non quantified problems that have many apparent solutions. For problems to be suited to morphological analysis they are generally inexpressible in numbers. Other problems are better addressed with the more traditional decomposition method where complexity is broken down in parts and trivial elements are ignored to produce a simplified problem and solution.

Variations of his approach underlie many of the systems we use today to find the best new ideas, products, and solutions among a great variety of possibilities.

How to Use Morphological Analysis

Many problems challenge us with too many possible solutions, though yet uncovered, only some of which may be new and useful. This process, drains the swamp, so to speak, by systematically arranging appropriate and promising aspects of the situation and combining them just as systematically in order to identify new and suitable combinations.

The object is to break down the system, product, or process problem at hand into its essential parameters or dimensions and to place them in a multi-dimensional matrix. Then to find new ideas by searching the matrix for creative and useful combinations. Some combinations may already exist, others may not be possible or appropriate. The rest may represent prospective new ideas.

If you can describe a problem situation in terms of its aspects or dimentions, morphological analysis will uncover original and often innovative solutions.

Morphological Analysis Steps

1. Determine suitable problem characteristics. The individual problem solver or a facilitated group brainstorms to define problem characteristics, also refered to as parameters.

2. Make all the suggestions visible to everyone and group them in various ways until consensus is reached regarding the groupings.

3. Label the groups reduce them to manageable number. Rather than reaching for a recommended number, consider the capabilities of the group and the time available. Consider also that there are computer applications and other tools that can assist the process.

When working with the tangible aspects of something like a consumer product, for example, the labels gleaned from the groupings might include parameters such as product ingredients, color, textures, temperature, and flavor as well as package size, shape, function, and graphics. In the case of manufacturing issues, parameters might include material, function, process, construction, maintenance, and the like.

4. The next step is to fill a grid or grids with lists of parameters arranged along the axes. Now combinations can be identified within the grid. Depending on the number of items in play, great numbers of combinations may be available.

5. Eliminate those combinations that are impossible or undesirable to execute, put aside those that you do not want to eliminate but do not want to execute, and develop as many of the rest as possible.

The descriptions below offer a number of examples of parameter grids as examples.

Morphological Analysis was developed by Fritz Zwicky<ref>Zwicky, Fritz & Wilson A. (eds.) (1967), New Methods of Thought and Procedure: Contributions to the Symposium on Methodologies. Berlin: Springer. Reprint available at www.swemorph.com/ma.html</ref><ref>Zwicky, Fritz (1969), Discovery, Invention, Research - Through the Morphological Approach, Toronto: The Macmillian Company. </ref> (the Swiss astrophysicist and aerospace scientist based at the California Institute of Technology) in the 1940's and 50's as a method for systematically structuring and investigating the total set of relationships contained in multi-dimensional, usually non-quantifiable, problem complexes.

Morphological Analysis is an extension of Attribute Listing. Imagine you have a product that could be made of 3 types of material, in 6 possible shapes, and with 4 kinds of mechanism. Theoretically there are 72 (3x6x4) potential combinations of material, shape and mechanism. Some of these combinations may already exist; others may be impossible or impractical. Those left over may represent prospective new products. This method of can be extended to virtually any problem area that can be structured dimensionally.

Identifying Suitable Dimensions and Options

One possible approach is to use group techniques. Brainstorm issues, ideas, facts aspects, etc. associated with your problem, put each piece of information or suggestion on individual cards or Post-it, then group them and label the group (or arrange them using mind mapping). Iterate over and over again until you have condensed your information to a small quantity of labelled groups each of which constitutes an understandable element, and has only a small number of items inside it, each of which is a clear option, written on a card or Post-it.

Up to 7 dimensions of 7 values, gives up to nearly a million potential arrangements, making systematic examination out of the question without the use of computers to assist. However, devices are available to make it easier to study multiple re-combinations. An illustration of this taken from Allen’s Morphologiser a vertical strip is produced for each dimension, with the name of the dimension at the top, the options spaced one under the other below it (e.g. as Post-its stuck one under the other, edge to edge). Place the strips sis by side and slide them up and down to create different horizontal combinations.

Up to, say, 50-100 possible combinations, is a workable range with the aid of a computer to systematically go through every combination.

Upto, say, 3-400 combinations, various techniques/devices can narrow down this larger set of combinations. You could try eliminating less functional dimensions (or options) (e.g. a dimension such as ‘colour’ may well be of only minor significance). An alternative approach (see AIDA) is to recognize pairs of options that are clearly not of use, by eliminating a pair; exclusion is automatic for other combinations that involved that pair.

For still larger numbers, no systematic investigation is probable. Revert to Attribute Listing, using arbitrarily chosen permutations to stimulate ideas.

Computer Aided Morphological Analysis

Advanced Computer-Aided Morphological Analysis was developed in 1995-96 by Tom Ritchey, then at the Department of Technological Foresight and Assessment, at the Swedish National Defence Research Agency in Stockholm<ref>Ritchey, Tom (2002). General Morphological Analysis: A general method for non-quantified modelling. Available at http://www.swemorph.com/ma.html</ref>. MA/Casper is a dedicated software system which supports an extended form of Morphological Analysis. It serves as a development platform for creating scenario and strategy laboratories, and morphological inference models <ref>Ritchey, Tom (2003). MA/Casper: Advanced Computer Support for General Morphological Analysis. Available at http://www.swemorph.com/macasper.html</ref>. It is presently in its 4th programming version.

With dedicated computer support, far more than 7 variables, and many millions of configurations, can be treated quite rigorously. When a solution space is synthesized, the resultant morphological field becomes an inference model, in which any parameter (or multiple parameters) can be selected as "input", and any others as "output". Thus, with computer support, the morphological field can be turned into a laboratory with which one can designate initial conditions and examine alternative solutions.

Morphological Analysis (MA) can also be referred to as ‘problem solving’. It is visually recorded in a morphological overview, often called a ‘Morphological Chart’. The method was developed in the 1960s by Fritz Zwicky, an astronomer from Switzerland.

This analysis is about exploring all possible solutions to a complex problem. It is used when exploring new and different ideas. Morphological Analysis provides a structured inventory of possible solutions.

It is a question of splitting the problem into partial problems and looking at possible options for each part of the problem. In this way, all aspects of a problem are thoroughly investigated. This makes Morphological Analysis a relatively simple technique that produces good, useful results.

Characteristics of a Morphological Analysis

With Morphological Analysis, different solutions to a complex problem can already be found in the design phase. Fritz Zwicky applied Morphological Analysis to astronomical research and development of jet engines and missiles. A complex problem has the following characteristics:

1. Multidimensional

Each problem has multiple angles that need to be treated as a whole.

2. Quantifiable

The various aspects of a problem are quantifiable and expressed in numbers. They are also constantly changing, which must be included in the search for possible solutions.

3. Subjective

The right solution to the problem is a matter of opinion. The best solution does not exist, but there are better or worse solutions.

How to do a Morphological Analysis: the steps

When using Morphological Analysis, there is a Morphological Chart. The following process steps are necessary to get a useful model:

1. Problem Description

The problem is defined in a short and clear description; what it is, what it’s not and what it should be. A problem definition can now be formulated. Suppose a manufacturer of luxury wine glasses is looking for a beautiful gift box. Based on a number of conditions (safety, sturdiness etc.) the manufacturer indicates what the packaging should include.

2. Identify dimensions

This phase determines what is important for solving a problem. The problem is divided into different dimensions. These perspectives provide potential parameters that can solve the problem. The first dimension in the above example is the shape of the package, the second dimension is the colour of the package and the third dimension is the chosen materials. Multiple dimensions can also be chosen.

3. Properties

By looking for as many features as possible for the different dimensions, many options for solutions are created. Creativity is offered here. For example, the shape may be round, triangular, square or rectangular.

The colour may be black, green or red and the choice of materials may be wood, cardboard, glass or plastic. The more properties are included, the more options there are.

4. Combining

By making arbitrary combinations, there are many solutions that may be applied. From this, a Morphological Chart or Morphological Overview can be made, which is visualised as a matrix.

For each dimension, all possible conditions are summarised and it is possible to look at what new ideas this creates.

5. Evaluation

Finally, the possible solutions should be evaluated. Which solution is feasible and consistent and which will absolutely not be used? If a solution is not consistent or is unusable, then a cross will appear in the appropriate field of the matrix. That solution is excluded.

6. Implementation

The desired solution identified in the morphological overview can be chosen and implemented.

Morphological Analysis chart components

Morphological Analysis has several concepts that were discussed in the above steps. First, there is the Morphological Chart; this is the visual matrix containing so-called morphological cells.

In the columns (top to bottom), the dimensions are set and the rows (left to right) list the conditions that a dimension could meet. The combination of columns and rows creates the cells. In each cell, the value of the condition is mentioned.

The dimensions themselves indicate the viewpoints or characteristics that are related to the problem definition. The condition is the state of a dimension and the value is the relevance condition of a dimension.

In the Morphological Chart, you can see by looking at the crosses which solution is not possible. The list shows what the current choice and what the proposed choice is by connecting choices with lines.

Morphological Analysis: Input and output

The quality of the delivered solutions (input) is also a measure of the quality of the output (output). When the quality of the basic information is high, it is likely that the result will also be of high quality.

In the example given above, we are dealing with the following three dimensions: shape (round, triangular, square or rectangular), colour (black, green or red) and material (wood, cardboard, glass or plastic). With these data there are 4 x 3 x 4 = 48 possibilities shown in the morphological overview with a total of 48 cells.

The three dimensions will change the matrix into a three-dimensional cube. Each cell provides an option. If there are many variables included in the Morphological Chart, that results in a great deal of complexity. In order to overcome this, it is desirable to use computer support, which makes it easier to arrive at a good and useful result.

Morphological Analysis chart - toolshero

Figure 1 – The Morphological Analysis Zwicky Box

![](data:None;base64,iVBORw0KGgoAAAANSUhEUgAAAAEAAAABCAYAAAAfFcSJAAAABHNCSVQICAgIfAhkiAAAAAtJREFUCJljYAACAAAFAAFiVTKIAAAAAElFTkSuQmCC)

In addition, creativity is most welcome as application to Morphological Analysis. The more creative ideas, the more combinations of choices there are.

There are many creative thinking techniques that can be applied to Morphological Analysis, including Six Thinking Hats by Edward de Bono, mind mapping and Brainstorming.