# The Scientific Method and Language Semantics

by Sven Nilsen, 2019

*In this paper I argue for the position that the scientific method as a system might be viewed as a method of grounding language semantics. With other words, when the number of experiments goes to infinity, the language of hypotheses undergoing rational optimization converges toward an accurate model. In the limit, the observations can be reproduced by choosing a suitable hypothesis as a model.*

Assume that you design experiments to study the behavior of a particular animal, e.g. a dog.

For example, a simple experiment you can do is to count the legs.

Some valid hypotheses to make about this experiment:

- The dog has 3 legs
- The dog has 4 legs
- The dog has 5 legs

Usually, you observe that the dog has 4 legs. Sometimes, you observe that the dog has 3 legs. However, you will probably not observe a dog with 5 legs.

The language required to form hypotheses for a single experiment is not very complex. It suffices to be able to express what the observations will be. The hypothesis that reproduces observations accurately enough to fool someone for a single experiment, is the following:

- The dog has 4 legs

One can easily understand, using common sense, that this hypothesis is **not a dog**. It is just a sentence. A model is the subject which is studied, which can be arbitrary complex. Here, the model has been swapped by a hypothesis about a single experiment.

It might therefore seem strange, that the scientific method works, since any experiment can be faked. How can one consider a method to be reliable if it can be proven to be unreliable?
In science, this problem is worked around by carefully carrying out the experiments in reliable ways. Yet, I believe that it is precisely this ability, to fake any experiment, which grounds language semantics.

In a more accurate model, the same knowledge about the dog can be expressed as:

- The dog has 2 front legs and 2 back legs

From this knowledge, one can predict that the dog will have 4 legs, since `2 + 2 = 4`.
As the accuracy of the model increases for the dog, more work is required to derive the prediction.
The prediction of an experiment does not need to be trivially derived from the hypothesis.

However, one can also predict observations of more experiments than before. One can predict:

- The dog has 2 front legs
- The dog has 2 back legs

By increasing the accuracy of the model, more predictions can be made about more experiments.

For a single experiment, the language of hypotheses can be simple.
For making multiple predictions across multiple experiments, the language needs to be more complex.

Science is not just about conducting experiments and make observations.
It is also about developing better languages to form hypotheses.
A better language makes it possible to make better experiment designs.

Any person can become impressed by scientific experiments.
However, very few people are capable of judging quality of language semantics to form hypotheses.
Yet, developing better language semantics over time is often important for scientific progress.

The language of hypotheses can undergo a change through a rational optimization process.
When this happens, the language design is iterated upon to better make more and accurate predictions.
In this context, “rational optimization” means that decisions are made such that the end result is successful. Even if it is hard to analyze how this might be done.

To fake the dog convincingly, a lot of experiments must be designed and conducted.
In the limit, when the number of experiments goes to infinity, one can imagine a sophisticated language being developed that expresses how the dog looks, how it behaves etc.

Yet, a lot of predictions about the dog might be made by a **wrong language of hypotheses**.

For example, dogs and cats have a lot in common, e.g. they both have 1 head each and 4 legs each etc.

If one chooses experiments in a specific way, then it can take a lot of time to figure out that the hypotheses are predictions about cats and not dogs. In fact, it took at lot of work for scientists to figure out how to make an algorithm who could tell the difference between a picture of a cat and a picture of a dog. It turns out that when one tries to design a language to make predictions about complex models, the languages end up very complex.

Why?

Why is the complexity of hypotheses related to the complexity of models?

My suggestion is that this is because in the limit of number of experiments, the model can be swapped by some hypothesis and still produce the same observations as before.

Another way to express this using mathematical terminology is that, in the limit, the model and hypothesis are isomorphic up to the testing ability of the scientific method.

As a consequence, the scientific method viewed as a system can be viewed as a method of grounding language semantics.