# Inference

We are now entering the core of our course. Here, we apply probability techniques to make quantitative deductions from samples. To do this, we have to accept a *model* that is supposed to provide a mathematical description of our sampling procedure and that does so in a reasonably accurate way.

We cannot cover all possible models in an introductory course (and, in fact, creating models for new situations, and better ones for old ones, is much of what research in statistics is about). Thus, we will concentrate on the most common models used in practice. The philosophy behind these models, and how they translate into specific protocols should help you understand how statistics works, and provide a blueprint for further studies.

There are a few points you may want to notice when it comes to applying the techniques we will look at to any real situation:

* There are specific mathematical assumptions behind each technique, and it is necessary to verify whether these assumptions are a realistic model for the real life situation
* Formulas and techniques fall into two categories:
  + Rigorous tools, under the stated assumptions (most of the ones we will discuss)
  + Less, or even non rigorous tools, constructed as a more or less intuitive extension from the rigorous ones (a typical case is the estimate of the difference of two means, when variances are different, and unknown - see the relevant section)

The difference is that, always under the appropriate assumptions, the rigorous tools allow for a quantitative assessment of their validity, while the non rigorous ones have a fuzzier validity. While, in the end, the proof of the pudding should be in the eating, that's sometimes difficult to do for statistical statements that have no independent means of verification. To come up with a rigorous methodological evaluation, you would need to have access to the raw data, and the procedure used to come up with the statement - not a common situation. On the other hand, if the theoretical assumptions are not well satisfied, that does not, in itself, mean that the results are meaningless: there is plenty of research into the *robustness* of statistical procedures, that is, their ability to turn out useful results, even when the situation does not quite match the theory. In practice, though, it is not always easy to apply these results, and, in most cases, there is no independent way to verify the trustworthiness of a statistical statement (for example, if a study says that the economy is growing at a 2% rate, even if you have trouble matching this with your personal experience, it is extremely difficult to come up with a rigorous independent check of this statement. The only way to challenge it would be to challenge the method used, but it is unlikely that we could find an "experimental" proof or disproof of this statement that would not be open to the very same questions. Still, if it is not always possible to check the validity of somebody else's statement, you should at least be able to justify yours, and to be clear about its rigor.