1.2.1: A Classroom Story and an Inspiration

Several years ago, I was teaching an introductory Statistics course at De Anza College where I had several achieving students who were dedicated to learning the material and who frequently asked me questions during class and office hours. Like many students, they were able to understand the material on descriptive statistics and interpreting graphs. Unlike many introductory Statistics students, they had excellent math and computer skills and went on to master probability, random variables and the Central Limit Theorem.

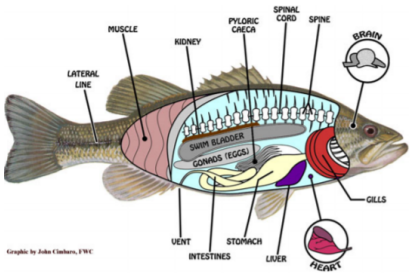
However, when the course turned to inference and hypothesis testing, I watched these students' performance deteriorate. One student asked me after class to again explain the difference between the Null and Alternative Hypotheses. I tried several methods, but it was clear these students never really understood the logic or the reasoning behind the procedure. These students could easily perform the calculations, but they had difficulty choosing the correct model, setting up the test, and stating the conclusion.

These students, (to their credit) continued to work hard; they wanted to understand the material, not simply pass the class. Since these students had excellent math skills, I went deeper into the explanation of Type II error and the statistical power function. Although they could compute power and sample size for different criteria, they still didn't conceptually understand hypothesis testing.

On my long drive home, I was listening to National Public Radio's Talk of the Nation[1] and heard discussion on the difference between the reductionist and holistic approaches to the sciences. The commentator described this as the Western tradition vs. the Eastern tradition. The reductionist or Western method of analyzing a problem, mechanism or phenomenon is to look at the component pieces of the system being studied. For example, a nutritionist breaks a potato down into vitamins, minerals, carbohydrates, fats, calories, fiber and proteins. Reductionist analysis is prevalent in all the sciences, including Inferential Statistics and Hypothesis Testing.

Holistic or Eastern tradition analysis is less concerned with the component parts of a problem, mechanism or phenomenon but rather with how this system operates as a whole, including its surrounding environment. For example, a holistic nutritionist would look at the potato in its environment: when it was eaten, with what other foods it was eaten, how it was grown, or how it was prepared. In holism, the potato is much more than the sum of its parts.

Consider these two renderings of fish:



The first image is a drawing of fish anatomy by John Cimbaro used by the La Crosse Fish Health Center.[2] This drawing tells us a lot about how a fish is constructed, and where its vital organs are located. There is much detail given to the scales, fins, mouth and eyes.

The second image is a watercolor by the Chinese artist Chen Zheng- Long[3] . In this artwork, we learn very little about fish anatomy since we can only see minimalistic eyes, scales and fins. However, the artist shows how fish are social creatures, how their fins

move to swim and the type of plants they like. Unlike the first drawing, the drawing teaches us much more about the interaction of the fish in its surrounding environment and much less about how a fish is built.

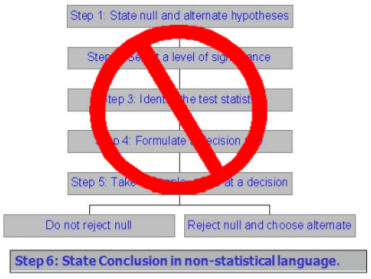
This illustrative example shows the difference between reductionist and holistic analyses. Each rendering teaches something important about the fish: the reductionist drawing of the fish anatomy helps explain how a fish is built and the holistic watercolor helps explain how a fish relates to its environment. Both the reductionist and holistic methods add to knowledge and understanding, and both philosophies are important. Unfortunately, much of Western science has been dominated by the reductionist philosophy, including the backbone of the scientific method, Inferential Statistics.

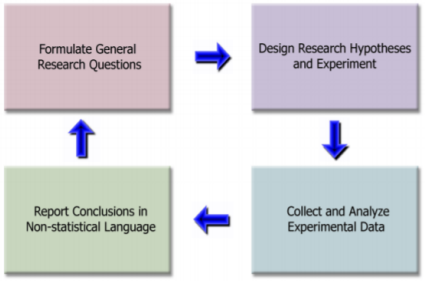
Although science has traditionally been reluctant, often hostile, to embrace or include holistic philosophy in the scientific method, there have been many who now support a multicultural or multi- philosophical approach. In his book Holism and Reductionism in Biology and Ecology[4], Looijen claims that "holism and reductionism should be seen as mutually dependent, and hence co-operating research programs than as conflicting views of nature or of relations between sciences." Holism develops the "macro-laws" that reductionism needs to "delve deeper" into understanding or explaining a concept or phenomena. I believe this claim applies to the study of Statistics as well.

I realize that the problem of my high-achieving students being unable to comprehend hypothesis testing could be cultural – these were international students who may have been schooled under a more holistic philosophy. The Introductory Statistics curriculum and most texts give an incomplete explanation of the logic of Hypothesis Testing, eliminating or barely explaining such topics as Power, the consequence of Type II error or Bayesian alternatives. The problem is how to supplement an Introductory Statistics course with a holistic philosophy without depriving the students of the required reductionist course curriculum – all in one quarter or semester!

I believe it is possible to teach the concept of Inferential Statistics holistically. This course material is a result of that inspiration, and it was designed to supplement, not replace, a traditional course textbook or workbook. This supplemental material includes:

- Examples of deriving research hypotheses from general questions and explanatory conclusions consistent with the general question and test results.
- An in-depth explanation of statistical power and type II error.
- Techniques for checking the validity of model assumptions and identifying potential outliers using graphs and summary statistics.
- Replacement of the traditional step-by-step "cookbook" for hypothesis testing with interrelated procedures.
- De-emphasis of algebraic calculations in favor of a conceptual understanding using computer software to perform tedious calculations.
- Interactive Flash animations to explain the Central Limit Theorem, inference, confidence intervals, and the general hypothesis testing model, which includes Type II error and power.
- PowerPoint Slides of the material for classroom demonstration.
- Excel Data sets for use with computer projects and labs.





This material is limited to one population hypothesis testing but could easily be extended to other models. My experience has been that once students understand the logic of hypothesis testing, the introduction of new models is a minor change in the procedure.

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