

MASTER'S NOTEBOOK

Type IV Errors: How Collaboration Can Lead to Simpler Analyses

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I started my graduate career in the department of statistics at Virginia Tech having had years of mathematical training and undergraduate research under my belt. Like many graduate students, I didn't like being wrong or uncertain about an answer. This attitude helped me succeed in the classroom, where questions have right and wrong answers, but I was inexperienced when it came to applying what I learned to real problems and felt very uncomfortable.

In my third year in the graduate program, I was asked to become a lead statistical collaborator at Virginia Tech's Laboratory for Interdisciplinary Statistical Analysis (LISA). I saw this as an opportunity to confront my insecurities and learn how statistics are used in practice. Naturally, I was apprehensive going into my first few meetings with clients I had never met before. I wasn't sure what they would expect from me or what I should expect from them, and I was terrified to be asked to do an analysis I didn't know how to do. Looking back, I now realize I was going into these meetings as if they were an exam I couldn't study for and had little chance of passing.

At LISA, we aim to answer a client's research question using statistics and refer to ourselves as collaborators, not consultants, to reflect our level of involvement in their project. LISA collaborators seek first to understand the client's overall goals outside a statistical framework and appreciate the effect of their research to their respective field. We then relate these goals to their collected data or advise them about how to design their data collection to best answer these goals. It is crucial for both the client and statistical collaborator to understand what the data will show if the client's hypotheses are correct. It is not until this stage is reached that we discuss potential statistical methodologies.

Focusing on the client's needs and wants outside of a statistical framework is the best way to prevent type III errors, which were introduced by A. W. Kimball's 1957 paper, "Errors of the Third Kind in Statistical Consulting." A type III error occurs when the statistician offers the correct statistical advice for the wrong research question. This was a difficult challenge for me; I had to get out of my comfort zone and fight the urge to talk about statistics. Once I became better at it, I realized that expressing interest in the client's research not only

fostered a more comfortable, collaborative relationship, but also gave me greater flexibility in choosing an appropriate statistical analysis.

What makes a statistical analysis "appropriate"? There are many criteria to compare methodologies such as type I errors, power, and validity of assumptions of the data like normality and constant variance. These criteria are meaningless to most clients, especially if they have limited statistical training. Clients I have interacted with are looking for techniques they can understand and give confident, accurate conclusions of the hypotheses. Maybe a latent growth curve model could be used to answer the research question, but if I could answer their research questions using a straightforward ANOVA, why wouldn't I just do that?

One of my first clients wanted to investigate the potential differences of tumor regression between immunocompetent (a functioning immune system) and immunodeficient (a poor immune system) mice after applying either a placebo or a technique known as irreversible electroporation. I made scatterplots for each group to see how the tumors grew across time and saw a clear trend that supported their hypotheses. Focusing on the data in front of me, I thought a repeated measures model that incorporated the presence of missing data was appropriate and spent a lot of time researching how those models worked. Eventually, I realized the client was not interested in modeling the growth curves; they just wanted to see whether differences existed. Ultimately, we chose to compare individual means at specific days using simple nonparametric tests and successfully answered their research question.

At this point, I would like to introduce what I call type IV errors: when a statistician performs the correct analysis that answers the right research questions when a simpler analysis would suffice. Why is a type IV error something to worry about? If the statistics are correct, isn't our job done? The issue is that when statisticians commit type IV errors, we are potentially alienating the client from the collaborative relationship and giving them results they cannot use. We also are giving ourselves too much work to do, spending days on something that could take hours or even minutes. At the end of the day, we have wasted everyone's time if the client doesn't understand what we did.