A Tutorial on Evaluating Hypotheses Using Bayesian Methods

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What do black bears have in common with Bayesian statistics? Both make an appearance in a 2013 paper written by Rens Van de Schoot, Marjolein Verhoeven, and Herbert Hoijtink in the European Journal of Developmental Psychology. In this paper, the authors use a hiking trip to illustrate Bayesian thinking and its advantages over traditional, sometimes called frequentist, statistics.

During a hiking trip in Alaska, one of the Dutch authors observed a bit of black fur behind some bushes. Was it a bear? Being a scientist, he applied a traditional significance testing approach to the problem, formulating a null hypothesis: “There is no bear.” The hiker then had to use the evidence available to decide whether to reject the null hypothesis, which he did, deciding, “It is not the case that there is not a bear.” Presumably, he turned around.

Of course, what the hiker was really interested in was whether there *was* a bear, which is not something that traditional hypothesis testing can determine: The best one can do, using traditional methods, is reject the null (see APS President C. Randy Gallistel’s upcoming September Observer column for more on this topic). But Bayesian statistics allow experimenters to formulate and directly test hypotheses of interest such as, “There *is* a bear.” The authors reason, “More can be learned from data by evaluating informative hypotheses than by testing the traditional null hypothesis” (p. 82).

Van de Schoot and colleagues define an “informative hypothesis” as an expectation that contains prior information. One important advantage of Bayesian statistics is that they allow the formulation of informative hypotheses, meaning that they enable the integration of pre-existing knowledge and evidence into hypotheses. The hiker might know, for example, that black bears are quite common in Alaska and that the cost of a false negative — assuming no bear but interrupting one that is in fact there — is greater than the cost of a false positive — assuming a bear even though none is there and needlessly rerouting the hike. With these details in mind, the hiker might not require much evidence to accept that a bear is hiding in the underbrush and to back away slowly. If the encounter were taking place in the Netherlands, where there are no native bears, a great deal of evidence would be required to support the hypothesis that “There is a bear.” (Of course, one could have escaped from the zoo.)

To translate this anecdote into a real research problem, the scientists describe a project studying

depression in adolescents. The project investigated whether adolescent girls show more symptoms of depression than do boys at a certain age and if this difference persists over time. To test the theory, the experimenters devised two hypotheses informed by prior literature. Next, they collected data using surveys and questionnaires, and then they used structural equation modeling and Bayesian methods to test these specific hypotheses rather than focusing on rejecting the null hypothesis. The analysis showed that differences in depression symptoms were related to coping styles common among both girls and boys — namely, negative coping styles were connected to depressive symptoms regardless of gender.

The authors used the statistical software Mplus (Muthén & Muthén, 1998–2012) to conduct the Bayesian analyses. They provide a step-by-step primer on how to do this in both Mplus and the R programming language.

“Many researchers want to evaluate their expectations directly, but have been unable to do so because the statistical tools were not yet available” say Van de Schoot and colleagues, “These tools are ready to be used for any researcher within the social sciences” (p. 94). According to these authors, Bayesian methods are tools researchers have been waiting for.

References

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