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THOUGHTS ON JUN OTSUKAS THINKING ABOUT STATISTICS THE PHILOSPHICAL FOUNDATIONS*

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Abstract. Jun Otsuka's excellent book, Thinking about Statistics - the Philosophical Foundations [11] is mostly organized around the idea that diferent statistical approaches can be illuminated by linking them to diferent ideas in general epistemology. Otsuka connects Bayesianism to internalism and foundationalism, frequentism to reliabilism, and the Akaike Information Criterion in model selection theory to instrumentalism. This useful mapping doesn't cover all the interesting ideas he presents. His discussions of causal inference and machine learning are philosophically insightful, as is his idea that statisticians embrace an assumption that is similar to Hume's Principle of the Uniformity of Nature. I discuss these topics in what follows, sometimes disagreeing with details while at other times adding ideas that complement those presented in the book.

1. Introduction: Bridging Epistemology and Statistical Practice

Jun Otsuka's book, "Thinking about Statistics - the Philosophical Foundations," represents a significant contribution to the field by explicitly connecting diverse statistical methodologies with fundamental concepts in epistemology. This ambitious project seeks to illuminate the underlying philosophical commitments inherent in different statistical approaches, moving beyond purely technical considerations to reveal their broader intellectual context. Otsuka posits that statistical frameworks are not

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simply neutral tools for data analysis but are, in fact, deeply intertwined with specific epistemological viewpoints. Specifically, the book argues for a connection between Bayesianism and internalism/foundationalism, frequentism and reliabilism, and the Akaike Information Criterion (AIC) with instrumentalism. This review paper undertakes a critical examination of these connections, evaluating their strengths, identifying potential limitations, and offering complementary perspectives. Furthermore, it considers Otsuka's discussions of causal inference, machine learning, and the often-implicit assumption of the Uniformity of Nature in statistical reasoning. By engaging with these topics, this paper aims to contribute to a deeper understanding of the philosophical underpinnings of statistical practice and to foster a more nuanced appreciation of the diverse approaches available to researchers. This paper, in essence, is a thought experiment, a reflection on the connections drawn by Otsuka, and an extension of the philosophical inquiries he initiates.

2. **Main Results: A Critical Examination of Otsuka's Framework**

The core of Otsuka's thesis lies in his association of specific statistical paradigms with particular epistemological stances. The present analysis focuses on three key areas: the Bayesian-internalist/foundationalist link, the frequentist-reliabilist link, and the AIC-instrumentalist connection. In each case, the analysis will elaborate on Otsuka's arguments and then present a critical consideration of them.

2.1. **Bayesianism, Internalism, and Foundationalism: A Nuanced Relationship.**

Otsuka argues that Bayesianism aligns with internalism, which he further characterizes as a form of foundationalism. Internalism, in this context, suggests that the justification of a belief depends on its relationship to other beliefs within an individual's cognitive system. Foundationalism, in turn, posits the existence of a privileged class of beliefs that are considered absolutely certain and serve as the bedrock for all other justified beliefs. While this characterization arguably holds true for radical subjective Bayesianism, where probabilistic coherence is the sole criterion for rationality and observations are treated as certainties, it overlooks the diversity within Bayesian thought. As Otsuka discusses, Neurath's boat analogy highlights the fact that Bayesianism does not require the system of beliefs to be on a perfectly certain foundation, rather, we start with the beliefs we currently have, and modify them in the light of new experiences.

Alternatives to foundationalist Bayesianism exist. Jeffrey's work challenges the notion of strict conditionalization, proposing that observations lead to probabilities rather than certainties, resulting in an infinite hierarchy of probability statements. Empirical Bayes methods, as illustrated by the insurance example, offer another departure. While Otsuka contends that empirical Bayes lacks justification within a strictly Bayesian framework due to its violation of the likelihood principle and "double-dipping," this paper argues that these features do not necessarily invalidate it. The practical utility of empirical Bayes in various contexts suggests that a more flexible interpretation of Bayesian principles may be warranted. Furthermore, the paper supplements Otsuka's analysis by addressing the

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challenge of assigning likelihoods to "catchall hypotheses." In many real-world scenarios, hypotheses are not mutually exclusive and exhaustive, leading to the need for a "catchall" category to account for all remaining possibilities. However, assigning probabilities to such broad and ill-defined hypotheses poses a significant challenge for Bayesian reasoning. The example of the allele fixation probability is a good example of how this is done: it is clear that the probability that an allele has of going to fixation is $1/(2N)$, if (1) the population is diploid, (2) the allele evolves by pure drift, and (3) the population has a fixed size in each generation of N individuals. But now consider what the probability of fixation is if this three-fold conjunction is false. This negation of the conjunction is a "catchall" in that it involves a vast disjunction of different possibilities (catching them all). It is puzzling, to say the least, what the probability of fixation is, given the negation (1)&(2)&(3). This issue highlights the limitations of Bayesianism in dealing with complex and uncertain situations and underscores the need for alternative or complementary approaches.

2.2. **Frequentism and Reliabilism: The Primacy of Procedure.** Otsuka connects classical frequentism, encompassing significance tests, Neyman-Pearson hypothesis tests, and confidence intervals, with reliabilism in epistemology. Reliabilism emphasizes the reliability of the methods or processes used to generate beliefs as the primary criterion for epistemic merit. While Otsuka also identifies the frequency interpretation of probability and the avoidance of assigning probabilities to hypotheses as key features of frequentism, this paper argues that the latter is the most central.

The core distinction between frequentism and Bayesianism lies in their treatment of hypotheses. Bayesianism assigns probabilities to hypotheses and updates them based on evidence using Bayes' theorem. Frequentism, on the other hand, evaluates hypotheses without directly computing their posterior probabilities. Instead, it focuses on the long-run performance of statistical procedures.

The paper critiques the asymptotic frequency interpretation of probability, arguing that it fails to provide a meaningful explication of the concept of probability. Rather, it simply restates the law of large numbers as the number of runs goes to infinity, providing no elucidation of probability itself.

Furthermore, the paper challenges the notion that reliabilism is exclusive to frequentism. Bayesianism, it argues, can also account for the reliability of observational processes. Eddington's example of estimating the size of the fish in a lake illustrates how Bayesian reasoning can incorporate information about the reliability of the sampling method. The Law of Likelihood, which states that evidence favors the hypothesis that renders the observation more probable, can be used to refine Bayesian inferences by considering potential biases or limitations in the data.

The evaluation of hypothesis testing procedures further highlights the differences between Bayesian and frequentist approaches. Bayesians prioritize the assessment of individual beliefs based on available evidence and prior probabilities, while frequentists focus on the operating characteristics of statistical rules. The paper draws an analogy to act and rule utilitarianism to illustrate this distinction. Bayesians, like act utilitarians, focus on the consequences of each individual action (belief), while

frequentists, like rule utilitarians, prioritize the adoption of general rules (statistical procedures) that maximize overall well-being (accuracy).

2.3. **The Akaike Information Criterion and Instrumentalism: Prediction over Truth.** Otsuka argues that the Akaike Information Criterion (AIC) aligns with the instrumentalist view of science. Instrumentalism posits that the primary goal of scientific inference is to make accurate predictions, rather than to uncover the true underlying mechanisms. The AIC, which balances model fit with model complexity, embodies this instrumentalist spirit.

The AIC provides a means of selecting the model that is expected to perform best in predicting new data. The surprising aspect of the AIC is that models with a higher number of adjustable parameters is not always better - rather, the best is to use a "false" model if it predicts more accurately. The paper agrees with Otsuka's assessment, reinforcing the connection between the AIC and instrumentalism.

3. Conclusions: Affirming Otsuka's Insights and Exploring Future Directions

In conclusion, Otsuka's work makes a valuable contribution by connecting statistical methodologies with philosophical concepts. While the paper offers critical perspectives and supplementary ideas, it affirms the book's insightful contributions to the philosophical foundations of statistics, particularly concerning Bayesianism, frequentism, and the instrumentalist perspective on model selection. Otsuka's exploration of causal inference, machine learning, and the assumption of the Uniformity of Nature further enriches the discussion.

Otsuka's work serves as a valuable starting point for further research. Future studies could explore the philosophical implications of other statistical methods or delve deeper into the relationship between statistical practice and specific scientific disciplines. By continuing to bridge the gap between statistics and philosophy, we can foster a more critical and informed approach to data analysis and scientific inference.

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