## **Contents**

1	Intro	duction		1		
	1.1					
	1.2	The Stranglehold of Significance Tests				
	1.3	Beyond the Significance Test Controversy				
	1.4	The Fe	asibility of Fiducial Bayesian Methods	5		
	1.5		the Book	5		
	Refe	rences		6		
2	Prea	mble—F	requentist and Bayesian Inference	9		
	2.1	Two D	different Approaches to Statistical Inference	9		
		2.1.1	A Simple Illustrative Example	10		
	2.2	The Fr	equentist Approach: From Unknown to Known	10		
		2.2.1	Sampling Probabilities	11		
		2.2.2	Null Hypothesis Significance Testing in Practice	11		
		2.2.3	Confidence Interval	12		
	2.3	The Ba	ayesian Approach: From Known to Unknown	13		
		2.3.1	The Likelihood Function and the Bayesian			
			Probabilities	13		
		2.3.2	An Opinion-Based Analysis	14		
		2.3.3	A "No Information Initially" Analysis	16		
	Refe	rences		19		
3	The	Fisher, I	Neyman–Pearson and Jeffreys Views			
		of Statistical Tests				
	3.1	The Fi	sher Test of Significance	21		
		3.1.1	An Objective Method for Reporting			
			Experimental Results	21		
		3.1.2	The Null Hypothesis	22		
		3.1.3	The Outcome of the Test of Significance	22		
		3.1.4	The Test Statistic and the Level of Significance $p$	22		
		3.1.5	How to Evaluate the Smallness of p?	22		

vi Contents

	3.2	THE IN	eyman—rearson rippoinesis test	23
		3.2.1	Rational Decision Rules	23
		3.2.2	The Hypothesis to be Tested and Alternative	
			Hypotheses	23
		3.2.3	The Outcome of the Hypothesis Test	24
		3.2.4	A Long-Run Control	24
		3.2.5	Two Types of Errors and Their Long-Run	
			Frequencies	24
		3.2.6	Power of the Test and Best Critical Region	25
	3.3	The Je	ffreys Bayesian Approach to Testing	25
		3.3.1	The Jeffreys Rule	26
		3.3.2	The Function of Significance Tests	26
		3.3.3	A Specific Prior for Testing Precise Hypothesis	27
		3.3.4	A Measure of Evidence Against the Null	
		5.5.1	Hypothesis	27
		3.3.5	An Averaged Risk of Error	28
	3.4		ent Views of Statistical Inference	29
	5.4	3.4.1	Different Scopes of Applications:	
		3.4.1	The Aim of Statistical Inference	29
		3.4.2	The Role of Bayesian Probabilities	31
		3.4.3	Statistical Tests: Judgment, Action or Decision?	33
	3.5		ossible to Unify the Fisher and Neyman-Pearson	55
	3.5		aches?	34
		3.5.1	Demonstrating Equivalence	34
		3.5.2	Neyman–Pearson's Criterion Leads to Incoherent	34
		3.3.2		35
		3.5.3	and Inadmissible Procedures	33
		3.3.3		26
	2.0	0 1	or Good Sense?	35
	3.6		uding Remarks	36
	Refe	rences	• • • • • • • • • • • • • • • • • • • •	36
	C116	NOTE 4	000111 70 1170 11	~
4			Officially Recommended Practice	39
	4.1		Iypothesis Significance Testing	39
		4.1.1	An Amalgam	39
	4.0	4.1.2	Misuses and Abuses	40
	4.2		About the Researcher's Point of View?	42
		4.2.1	A Cognitive Filing Cabinet	42
		4.2.2	It Is the Norm	42
	4.3		ficial Good Statistical Practice	43
		4.3.1	Guidelined Hypotheses Official	
			Significance Testing	43
		4.3.2	A Hybrid Practice	45
	Refe	rences		46

Contents	vii

5	The	Significa	nce Test Controversy Revisited	49		
	5.1	Signific	cance Tests Versus Pure Estimation	49		
		5.1.1	The Meehl Paradox	49		
	5.2		ull Hypothesis: A Straw Man	50		
	5.3	Usual '	Two-Sided Tests Do Not Tell the Direction	51		
		5.3.1	Two-Sided Verus One-Sided Tests			
			and Their Shortcomings	51		
		5.3.2	Jones and Tukey's Three-Alternative			
			Conclusion Procedure	51		
	5.4	Determ	nining Sample Size	52		
	5.5	Critiqu	e of P-values: A Need to Rethink	53		
		5.5.1	Jeffreys' Answer to the Problem			
			of Pure Estimation	53		
		5.5.2	The Bayesian Interpretation of the P-value	54		
		5.5.3	Student's Conception	54		
		5.5.4	Jaynes' Bayesian Test	54		
		5.5.5	The Methodological Shortcomings of NHST			
			Clearly Pointed Out	55		
		5.5.6	The Bayesian Interpretation			
			of the Two-Sided P-value	55		
		5.5.7	Killeen's $P_{\text{rep}}$	56		
	5.6	Decisio	on and Estimation	57		
		5.6.1	The Decision-Making Viewpoint:			
			A Very Controversial Issue	57		
		5.6.2	Jeffreys' Bayesian Methodology	58		
	5.7	The Re	ole of Previous Information and the Sample Size	58		
	5.8	The Limited Role of Significance Problems				
	5.9	Other 1	Issues	59		
		5.9.1	Noninferiority and Equivalence Questions	59		
		5.9.2	Stopping Rules and the Likelihood Principle	60		
	Refe	rences		61		
6	Repo	orting E	ffect Sizes: The New Star System	63		
	6.1					
		6.1.1	A Definition Restricted to Standardized Measures	64		
	6.2	Abuse	s and Misuses Continue	64		
		6.2.1	A Psychological Example	64		
		6.2.2	An ES Indicator that Does Not Tell the Direction	65		
		6.2.3	Disregarding the Robust Beauty			
			of Simple Effect Sizes	65		
		6.2.4	Heuristic Benchmarks: A New Star System	66		
		6.2.5	Observed ES Indicators Can Be Misleading	66		
		6.2.6	A Good Adaptive Practice Is Not a Good			
			Statistical Practice	67		

viii Contents

		6.2.7	The Need for a More Appropriate Sample Size	67
		6.2.8	The Shortcomings of the Phi Coefficient	68
	6.3		Things Get Worse	69
		6.3.1	A Lot of Choices for a Standardized Difference	69
		6.3.2	A Plethora of ES Indicators	70
		6.3.3	Don't Confuse a Statistic with a Parameter	71
	6.4		essons	73
		6.4.1	The New Star System	73
		6.4.2	Should Standardized Effect Sizes Ever be Used?	74
	Refe	rences	•••••	74
7	Repo	orting C	onfidence Intervals: A Paradoxical Situation	77
	7.1	Three	Views of Interval Estimates	77
		7.1.1	The Bayesian Approach (Laplace, Jeffreys)	77
		7.1.2	Fisher' Fiducial Inference	79
		7.1.3	Neyman's Frequentist Confidence Interval	80
	7.2	What I	Is a Good Interval Estimate?	82
		7.2.1	Conventional Frequentist Properties	82
		7.2.2	The Fatal Disadvantage of "Shortest Intervals"	82
		7.2.3	One-Sided Probabilities Are Needed	83
		7.2.4	The Jeffreys Credible Interval is a Great	
			Frequentist Procedure	83
	7.3	Neyma	an-Pearson's Criterion Questioned	83
		7.3.1	The Inconsistencies of Noncentral F Based	
			Confidence Intervals for ANOVA Effect Sizes	84
		7.3.2	The Official Procedure for Demonstrating	
			Equivalence	86
	7.4	Isn't E	Everyone a Bayesian?	87
		7.4.1	The Ambivalence of Statistical Instructors	87
	Refe			89
8	Basi	c Fiduci:	al Bayesian Procedures for Inference	
•			8	91
	8.1		al Bayesian Methods for an Unstandardized Contrast	92
	0.1	8.1.1	The Student Pharmaceutical Example	92
		8.1.2	Specific Inference	92
	8.2		al Bayesian Methods for a Standardized Contrast	94
	0.2	8.2.1	A Conceptually Straightforward Generalization	94
		8.2.2	Inference About the Proportion	7-
		0.2.2	of Population Differences	97
	8.3	Inforce		97
	ō. <i>3</i>	merer	nce About Pearson's Correlation Coefficient	9/

Contents ix

	8.4	A Coherent Bayesian Alternative to GHOST			
		8.4.1	NHST: The Fiducial Bayesian Interpretation		
			of the p-Value	98	
		8.4.2	Interval Estimates: The Fiducial Bayesian		
			Interpretation of the Usual CI	99	
		8.4.3	Effect Sizes: Straight Bayesian Answers	99	
		8.4.4	Making Predictions	100	
		8.4.5	Power and Sample Size: Bayesian Data		
			Planning and Monitoring	102	
	8.5	Our G	uidelines	102	
	Refe	rences		102	
	•		136 4 11 1 10 13 4		
9			ons and Methodological Considerations	105	
			r Waste to Fiderical December Matheds	105	
	9.1		F Tests to Fiducial Bayesian Methods	106	
			NOVA Effect Sizes	106	
		9.1.1	The Traditional Approach		
		9.1.2	Fiducial Bayesian Procedures	108	
		9.1.3	Some Conceptual and Methodological	110	
		4.1.	Considerations	112	
	9.2		atives to the Inference About ANOVA ES	114	
		9.2.1	The Scheffé Simultaneous Interval Estimate	114	
			and Its Bayesian Justification	114	
		9.2.2	Contrast Analysis	117	
	9.3		ustrative Example: Evaluation of the "0.05	110	
			Effect"	118	
		9.3.1	Numerical Results	118	
		9.3.2	A Cliff Effect Indicator	119	
		9.3.3	An Overall Analysis Is Not Sufficient	122 123	
		9.3.4	A Simultaneous Inference About All Contrasts		
		9.3.5	An Adequate Analysis	124 124	
	0.4	9.3.6	What About Standardized Effects?	124	
	9.4		uidelines for ANOVA	125	
	Reie	rences		125	
10	Con	clusion .		127	
	Refe	rences		129	
Ind	ex			131	