

Group Work 09

```
library(bayesrules) # R package for our textbook
library(tidyverse) # Collection of packages for tidying and plotting data
library(janitor) # Helper functions like tabyl
library(rstan) # for fitting models
library(rstanarm) # for fitting standard regression models
library(broom.mixed) # for tidy() function
library(bayesplot) # helpful plotting functions
library(tidybayes) # helpful for wrangling Bayesian model output
library(patchwork)
```

1 Exercise 15.3 (Hierarchical data)

Interested in the impact of sleep deprivation on reaction time, Belenky et al. (2003) enlisted 18 subjects in a study. The subjects got a regular night's sleep on "day 0" of the study, and were then restricted to 3 hours of sleep per night for the next 9 days. Each day, researchers recorded the subjects' reaction times (in ms) on a series of tests. The results are provided in the `sleepstudy` dataset in the `{lme4}` package.

This data is hierarchical. Draw a diagram in the spirit of Figure 15.8 that captures the hierarchical framework. Think: What are the "groups?"

```
lme4::sleepstudy
```

	Reaction	Days	Subject
1	249.5600	0	308
2	258.7047	1	308
3	250.8006	2	308
4	321.4398	3	308
5	356.8519	4	308
6	414.6901	5	308
7	382.2038	6	308

8	290.1486	7	308
9	430.5853	8	308
10	466.3535	9	308
11	222.7339	0	309
12	205.2658	1	309
13	202.9778	2	309
14	204.7070	3	309
15	207.7161	4	309
16	215.9618	5	309
17	213.6303	6	309
18	217.7272	7	309
19	224.2957	8	309
20	237.3142	9	309
21	199.0539	0	310
22	194.3322	1	310
23	234.3200	2	310
24	232.8416	3	310
25	229.3074	4	310
26	220.4579	5	310
27	235.4208	6	310
28	255.7511	7	310
29	261.0125	8	310
30	247.5153	9	310
31	321.5426	0	330
32	300.4002	1	330
33	283.8565	2	330
34	285.1330	3	330
35	285.7973	4	330
36	297.5855	5	330
37	280.2396	6	330
38	318.2613	7	330
39	305.3495	8	330
40	354.0487	9	330
41	287.6079	0	331
42	285.0000	1	331
43	301.8206	2	331
44	320.1153	3	331
45	316.2773	4	331
46	293.3187	5	331
47	290.0750	6	331
48	334.8177	7	331
49	293.7469	8	331
50	371.5811	9	331
51	234.8606	0	332
52	242.8118	1	332

53	272.9613	2	332
54	309.7688	3	332
55	317.4629	4	332
56	309.9976	5	332
57	454.1619	6	332
58	346.8311	7	332
59	330.3003	8	332
60	253.8644	9	332
61	283.8424	0	333
62	289.5550	1	333
63	276.7693	2	333
64	299.8097	3	333
65	297.1710	4	333
66	338.1665	5	333
67	332.0265	6	333
68	348.8399	7	333
69	333.3600	8	333
70	362.0428	9	333
71	265.4731	0	334
72	276.2012	1	334
73	243.3647	2	334
74	254.6723	3	334
75	279.0244	4	334
76	284.1912	5	334
77	305.5248	6	334
78	331.5229	7	334
79	335.7469	8	334
80	377.2990	9	334
81	241.6083	0	335
82	273.9472	1	335
83	254.4907	2	335
84	270.8021	3	335
85	251.4519	4	335
86	254.6362	5	335
87	245.4523	6	335
88	235.3110	7	335
89	235.7541	8	335
90	237.2466	9	335
91	312.3666	0	337
92	313.8058	1	337
93	291.6112	2	337
94	346.1222	3	337
95	365.7324	4	337
96	391.8385	5	337
97	404.2601	6	337

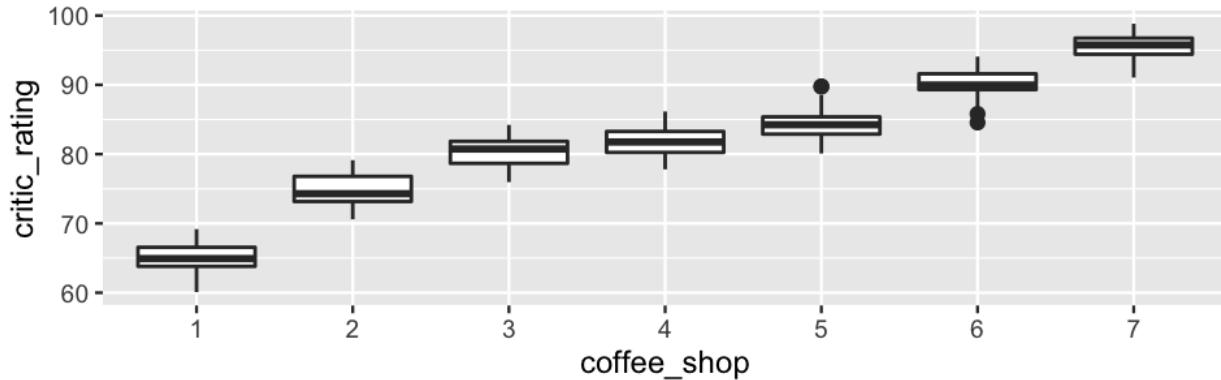
98	416.6923	7	337
99	455.8643	8	337
100	458.9167	9	337
101	236.1032	0	349
102	230.3167	1	349
103	238.9256	2	349
104	254.9220	3	349
105	250.7103	4	349
106	269.7744	5	349
107	281.5648	6	349
108	308.1020	7	349
109	336.2806	8	349
110	351.6451	9	349
111	256.2968	0	350
112	243.4543	1	350
113	256.2046	2	350
114	255.5271	3	350
115	268.9165	4	350
116	329.7247	5	350
117	379.4445	6	350
118	362.9184	7	350
119	394.4872	8	350
120	389.0527	9	350
121	250.5265	0	351
122	300.0576	1	351
123	269.8939	2	351
124	280.5891	3	351
125	271.8274	4	351
126	304.6336	5	351
127	287.7466	6	351
128	266.5955	7	351
129	321.5418	8	351
130	347.5655	9	351
131	221.6771	0	352
132	298.1939	1	352
133	326.8785	2	352
134	346.8555	3	352
135	348.7402	4	352
136	352.8287	5	352
137	354.4266	6	352
138	360.4326	7	352
139	375.6406	8	352
140	388.5417	9	352
141	271.9235	0	369
142	268.4369	1	369

143	257.2424	2	369
144	277.6566	3	369
145	314.8222	4	369
146	317.2135	5	369
147	298.1353	6	369
148	348.1229	7	369
149	340.2800	8	369
150	366.5131	9	369
151	225.2640	0	370
152	234.5235	1	370
153	238.9008	2	370
154	240.4730	3	370
155	267.5373	4	370
156	344.1937	5	370
157	281.1481	6	370
158	347.5855	7	370
159	365.1630	8	370
160	372.2288	9	370
161	269.8804	0	371
162	272.4428	1	371
163	277.8989	2	371
164	281.7895	3	371
165	279.1705	4	371
166	284.5120	5	371
167	259.2658	6	371
168	304.6306	7	371
169	350.7807	8	371
170	369.4692	9	371
171	269.4117	0	372
172	273.4740	1	372
173	297.5968	2	372
174	310.6316	3	372
175	287.1726	4	372
176	329.6076	5	372
177	334.4818	6	372
178	343.2199	7	372
179	369.1417	8	372
180	364.1236	9	372

2 Exercise 16.1 (Shrinkage)

The plot below illustrates the distribution of critic ratings for 7 coffee shops. Suppose we were to model coffee shop ratings using three different approaches: complete pooled, no pooled,

and hierarchical. For each model, sketch what the posterior mean ratings for the 7 coffee shops might look like on the plot below.



3 Exercise 16.2 (Grouping variable or predictor?)

- The `climbers_sub` data in the `{bayesrules}` package contains outcomes for 2076 climbers that have sought to summit a Himalayan mountain peak. In a model of climber `success`, is `expedition_id` a potential predictor or a grouping variable? Explain.
- In a model of climber `success`, is `season` a potential predictor or a grouping variable? Explain.
- The `coffee_ratings` data in the `{bayesrules}` package contains ratings for 1339 different coffee batches. In a model of coffee ratings (`total_cup_points`), is `processing_method` a potential predictor or a grouping variable? Explain.
- In a model of coffee ratings (`total_cup_points`), is `farm_name` a potential predictor or a grouping variable? Explain.

Exercise 16.3 (Speed typing: interpret the coefficients)

Alicia loves typing. To share the appreciation, she invites four friends to each take 20 speed-typing tests. Let Y_{ij} be the time it takes friend j to complete test i .

- In modeling Y_{ij} , explain why it's important to account for the grouping structure introduced by observing each friend multiple times.
- Suppose we were to model the outcomes Y_{ij} by (16.5). Interpret the meaning of all model coefficients in terms of what they might illuminate about typing speeds:

- μ_j :
- μ :
- σ_y :
- σ_μ :