<u>Suggested Exercises from M&M Chapter 6</u> *Homegrown exercises begin on page 2*

These pages were updated on September 30

To start with, do some of the odd-numbered exercises. answers to all odd-numbered exercises are given on textbook pages S-1 onwards.

Do some or all of the following even-numbered exercises. You are asked to hand in answers to designated ones.. see the list, and the deadline, on the main course page. Some of these will be discussed in tutorials or answers to them posted on the course web page

§ 6.1	§ 6.2	§ 6.3
6.4	6.26	6.53
6.6	6.28	6.54
6.12	6.30	6.55
6.17	6.32	6.58
6.18	6.34	6.59
6.20	6.38	6.62
6.22	6.40	
6.24	6.48	
6.76	6.50	
6.82a	6.52	
	6.84	
	6.85	

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"Homegrown" Exercises around M&M Chapter 6

-1- Help a journalist to be "statistically correct"

See -- under resources for Chapter 6 -- the excerpt from the article <<Controverse autour des pesticides comme agents du cancer du sein>> by M Perreault, La Presse, Montreal, Jeudi 29 Juillet 1999.

After reporting that a finding was 'not statistically significant', the journalist goes on to explain what 'statistically significant' means. For those who need it, here is my translation [with approximately 85% confidence!] of what was stated

> *"In general, an average increase in risk is valid if 95% of the data show a higher risk than in the control group; in other words, the results can be reproduced 19 times out of 20"*

Rewrite this to explain

a a reported relative risk which has an associated "P-value of 0.03"

b a "95% Confidence Interval" accompanying the reported relative risk.

-2- Handedness and Mortality: A Follow-Up Study of Danish Twins Born between 1900 and 1910

Olga Basso, Jørn Olsen, Niels V. Holm, Axel Skytthe, James W. Vaupel, and Kaare Christensen

Epidemiology vol 11 no 5 sept 2000

The declining prevalence of left-handed individuals with increasing age has led to two main avenues of hypotheses; the association is due either (1) to a birth cohort effect and/or an age effect caused by a switch to right-handedness with advancing age or (2) to mortality selection that reduces survival in left-handed individuals, or both. It is uncertain whether a cohort or age effect can explain the decline in age-related prevalence, and conflicting evidence exists in favor of the mortality hypothesis. We compared mortality in a subgroup of 118 opposite-handed twin pairs by counting in how many instances the right-handed twin died first. There was no evidence of differential survival between right-handed and non-right-handed individuals in the entire 1900-1910 cohort. With respect to the number of right-handed twins who died first, there was no material disadvantage among those who were not right-handed. <u>In 60% (95% confidence interval = 49.0-71.5%) of dizygotic pairs, the right-handed twins died first</u>[a] In 50% of <u>monozygotic</u> pairs[b], right-handed twins died first. The prevalence of not being right-handed was higher among males (9.2%) than females (6.5%); there was a similar frequency of non-right-handedness in monozygotic (8.0%) and dizygotic (7.8%) twins. We did not find evidence of excess mortality among non-right-handed adult twins in this follow-up study.

Key words: mortality, survival, handedness, twin studies.

a (Approximately) how many <u>dizygotic</u> twin pairs must there have been?

b (Approximately) what is the corresponding CI to accompany the estimate of 50% calculated from <u>monozygotic</u> pairs?

c Is the 60% significantly different from the 50% at the "conventional" significance level ($P < 0.05$)?

d Calculate the percentage -- of the overall 118 twins pairs -- where the right-handed twin died first, along with an accompanying 95% CI.

DISTINGUISHING POPULATIONS WITH DIFFERENT MEAN *BIRTHWEIGHTS*

The entries in the 4 panels below represent birthweights, recorded to the nearest 10 grams, but with the ending 0 removed to save space. Thus the very first entry of 336 in Panel A represents a birthweight of 3360 grams or 3.36 Kg. The birthweights in a panel are all from infants of the same sex, but different panels may be from different sexes. The standard deviation of the entries in each panel is approximately SD = 43 (430 grams).

By eye, by comparing all the entries in a panel with all of those in another, you may be able to discern if two panels have different means. But what can you conclude if you take just a sample from each of 2 panels and perform a formal test of significance on the difference in the sample means? **Details for exercise are explained on p 5.**

PANEL A

336	357	338	379	386	362	277	340	404	300
295	340	264	317	303	342	340	400	348	327
294	390	347	346	294	407	408	380	343	413
346	360	321	379	338	345	377	362	318	341
428	346	354	358	353	401	338	283	356	275
366	303	351	378	413	381	319	312	298	281
372	380	282	303	345	282	445	304	339	357
314	264	380	389	264	325	327	298	334	347
299	428	338	277	268	310	345	316	396	381
400	318	341	321	328	370	336	371	371	449

PANEL B

397	399	306	371	356	368	362	396	338	326
331	411	422	413	381	399	385	333	293	311
319	349	268	383	398	328	385	373	274	467
328	377	300	341	386	387	265	411	378	358
373	336	366	325	322	283	329	323	327	401
292	313	340	424	311	363	335	350	343	364
348	298	314	401	384	362	370	375	373	312
399	355	435	437	362	316	371	340	315	359
414	302	317	407	432	334	428	386	406	388
325	334	448	344	373	296	301	347	361	294

PANEL C

344	382	358	429	398	336	406	366	385	357
258	346	401	315	430	373	377	346	378	357
346	406	425	346	367	347	388	348	300	326
333	397	355	282	360	421	416	346	370	329
366	360	282	393	329	352	450	371	379	323
430	397	349	321	334	369	367	274	427	355
349	393	295	372	283	313	316	268	334	413
322	397	309	348	376	345	497	343	361	391
327	374	344	354	322	277	287	396	323	389
391	303	319	314	368	389	343	342	330	369

PANEL D

262	328	363	399	328	375	310	417	278	346
340	350	364	299	318	339	307	381	314	388
355	290	331	304	351	333	382	310	331	287
370	356	394	265	368	288	448	416	350	333
306	360	236	273	381	435	332	323	349	354
294	337	390	408	299	345	375	428	273	353
407	419	333	331	330	387	303	275	334	335
391	348	348	302	356	370	374	353	352	432
353	346	356	342	382	293	348	332	375	350
346	407	339	364	288	389	282	434	380	378

Key
Cailíní[céad/deireadh -- trí céad, daiched is a trí/seacht]
Buachaillí [-- trí céad, deich is daichead, is a sé]

DISTINGUISHING POPULATIONS WITH DIFFERENT MEAN *ADULT HEIGHTS*

The entries in the 4 panels below represent adult heights, recorded to the nearest centimetre. Thus the 1st entry (188) in Panel A represents a height of 188 cm or 1.68m. The birthweights in a panel are all from adults of the same sex, but different panels may be from different sexes. The standard deviation of the entries in each panel is approximately SD = 6cm.

By eye, by comparing all the entries in a panel with all of those in another, you may be able to discern if two panels have different means. But what can you conclude if you take just a sample from each of 2 panels and perform a formal test of significance on the difference in the sample means? **Details for exercise are explained on p 5.**

PANEL A

188	178	175	168	169	171	170	166	161	171
180	178	184	174	168	176	175	167	182	177
181	183	185	178	165	172	178	176	164	186
176	179	169	169	184	169	173	173	173	177
177	170	179	183	183	172	189	181	174	171
170	182	163	171	176	176	183	181	174	175
171	167	175	175	174	168	170	175	185	181
183	180	178	170	174	173	176	173	175	173
165	172	175	183	167	171	176	182	174	170
187	185	167	169	168	178	182	178	171	175

PANEL B

156	159	169	161	157	158	171	166	169	170
168	170	175	171	167	168	160	170	173	165
160	162	156	150	168	157	168	167	159	168
159	165	165	165	164	163	159	169	176	176
166	155	164	162	172	172	156	166	166	161
165	162	177	162	160	171	164	174	164	173
174	160	164	163	171	172	159	157	159	168
161	166	160	167	168	162	158	154	159	167
166	163	166	177	168	172	177	169	175	166
158	156	165	161	162	157	168	163	167	166

PANEL C

171	175	178	168	181	177	185	174	177	177
169	174	184	173	182	179	178	167	186	175
176	172	176	174	174	170	184	173	174	174
179	177	177	176	171	161	172	168	177	176
186	172	173	184	167	161	166	171	180	163
181	176	179	176	170	172	165	178	174	182
169	179	176	183	172	172	170	178	179	178
179	166	174	184	169	164	177	180	183	172
183	164	178	166	177	186	174	179	175	179
183	165	174	173	172	171	176	188	181	169

PANEL D

165	161	168	155	172	160	176	170	162	161
167	158	155	163	158	159	174	179	161	157
176	171	160	164	167	173	174	163	162	157
155	167	161	163	169	168	158	166	160	167
163	162	165	167	169	161	174	164	154	174
171	168	162	173	164	172	170	166	165	163
166	168	158	161	175	164	164	164	167	173
162	164	161	169	170	157	164	169	161	166
174	168	174	168	156	160	153	167	167	156
176	165	161	164	161	163	168	161	173	166

Key
Fir [ar clé -- céad, deich is trí fichid, cúig]
Mná [-- céad, trí fichid, cúig]

-3- Exercise to Illustrate Type I Errors and Statistical Power

• **Birthweight**:
Perform a test of each of the following 4 (obviously competing, so not independent) contrasts; use **new** samples of size n=4 and n=4 for each of the 4 tests; use a z-test (σ is given) with alpha = **0.10** (two-sided, so z_{alpha}=1.645) for each. []

1. μ_A vs. μ_B 2. μ_C vs. μ_D 3. μ_A vs. μ_D 4. μ_B vs. μ_C

• **Adult heights**:
test the following 4 contrasts*, again using n = 4 vs n = 4.

1. μ_A vs. μ_C 2. μ_B vs. μ_D 3. μ_A vs. μ_D 4. μ_B vs. μ_C

* NB: 1 and 2 are not the same as 1 and 2 for birthweight above.

To save you time, the structure of the tests is laid out below.

To help with rapid compilation of results in class, circle below which contrasts yielded "statistically significant" differences and <u>BRING YOUR 8 DECISIONS TO CLASS.</u>

Birthweights	A vs. B	C vs. D	A vs. D	B vs. C
Adult Heights	A vs. C	B vs. D	A vs. D	B vs. C

<u>"Arithmetic" of Testing if 2 panels have same mean</u>

H_0: $\mu_1 = \mu_2$ [same sex] α = **0.10** (2-sided) H_{alt}: $\mu_1 \neq \mu_2$ [different sexes]

Reject H_0 (i.e. infer that $\mu_1 \neq \mu_2$) if

$$\frac{\bar{x}_1 - \bar{x}_2}{\sigma\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}} > 1.645 \quad \text{or} \quad \frac{\bar{x}_1 - \bar{x}_2}{\sigma\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}} < -1.645$$

(use z-test since σ is given)

i.e. conclude "different sexes" if

$$|\bar{x}_1 - \bar{x}_2| > 1.645\,\sigma\sqrt{\frac{1}{n_1}+\frac{1}{n_2}} \qquad ***$$

σ is given, so we can work out ahead of time (from ***) what difference between $\bar{x}$)$_1$ and $\bar{x}_2$ would lead us to conclude "different sexes"... the average birthweights need to be > 50 (ie 500g) apart, and average heights > 7 cm apart.

[with t-tests, we don't have σ, and in fact have to calculate s from sample)

Value of $1.645\,\sigma\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$

	BIRTHWEIGHTS σ = 43 g x 10	ADULT HEIGHTS σ = 6 cm
$n_1 = n_2 =$ 4	**50** g x 10	**7.0** cm

Just for interest, here is what is is for other sample sizes...

$n_1 = n_2 =$ 8	35.4 g x 10	4.9 cm
$n_1 = n_2 =$ 16	25.0 g x 10	3.5 cm

On class, I will 'play god' and tell you which contrasts belong in which rows. In practice, you may not be able to unequivocally determine the truth -- or it may take a lot more work. And determining <u>how big</u> a difference is takes even more work.

<u>Results of statistical tests [columns] performed by students in relation to real situations[rows]</u>

BIRTHWEIGHT	"Can't say" p > 0.10 ("negative") ("N.S")	"different" p < 0.10 ("positive") ("Stat. sig.")	No. of Tests
same sex			
different sexes			

ADULT HEIGHT	"Can't say" p > 0.10 ("negative") ("N.S")	"different" p < 0.10 ("positive") ("Stat. sig.")	No. of Tests
same sex			
different sexes			

Results of statistical tests [columns] performed by students in relation to real situations [rows]

BIRTHWEIGHT

	"Can't say" p > 0.10 ("negative") ("N.S")	"different" p < 0.10 ("positive") ("Stat. sig.")	No. of Tests
3. A vs. D (=) same sex 4. B vs. C (=)	KD KD AB AB AC AC AS AS BF TE TE NW NW NW NW NW NW NW NW PW PW RB RB AS AS BM AS SP SP MPS MPS VC VC SR SR RP RP AE JB JB MS MS KO KO CF CF US1 US1 LR LR BM MA MA BMcG BMcG USZ USZ VS VS KR JS JS JMcK JMcK TdiP TdiP AM AR AR SF SF GF GF 73	AS MPS MS MM MM KR AM BF 8	81
1. A vs. B (≠) different sexes 2. C vs. D (≠)	BM AS AS SP SP MPS MPS MS VC VC SR SR RP RP AE JB JB MS MS KO KO CF CF USI US1 LR LR MA MA BMcG BMcG US2 US2 MM MM VS VS KR JS JS JMcK JMcK SF SF AM AM AR AR TdiP TdiP PW PW RB RB AS AS NW NW NW NW NW NW NW BF BF TE TE AC AC AS AB AB KD KD GF GF 76	BM MS AS KR NW AS 6	82

Results of statistical tests [columns] performed by students in relation to real situations [rows]

ADULT HEIGHT

	"Can't say" p > 0.10 ("negative") ("N.S")	"different" p < 0.10 ("positive") ("Stat. sig.")	No. of Tests
3. A vs. C (=) same sex 4. B vs. D (=)	BM BM SP AS AE AE RP SR SR MS MS USI CF CF KO KO JB JB KD KD AS AS AC AC TE TE BF BF NW NW NW NW NW NW NW NW AS RB PW PW PW SF SF AR AM AM TdiP TdiP JMcK JMcK JS JS KR KR VS MM MM US2 USZ BMcG BMcG MA MA LR LR GF GF 67	AS RB AR VS VC VC SP AS 8	75
1. A vs. D (≠) different sexes 2. B vs. C (≠)	EB NW NW NW JMcK MA MA US1 KO JB MS SP GF 13	KD KD EB AS AS AC AC TE TE BF BF NW NW NW BMcG AS BMcG AS RB RB PW PW SF SF AR AR AM AM TdiP JS TdiP JS KR KR VS VS MM MM JMcK CF CF KO JB AE RP SR US2 US2 NW NW LR LR USI SR VC VC MS SP AS AS BM BM GF 63	76