Nov. 14 Statistic for the day:
Number of deaths from 1978-1995 due to consumers rocking or tilting vending machines in an attempt to obtain free soda or money: at least 37

Assignment: Read Chapter 22

Three types of confidence intervals:

1. CI for population proportion
2. CI for population mean
3. CI for difference of two population means

Each follows the same basic recipe: A ± (B × C)

A = sample estimate of population quantity
B = multiplier depending on confidence level
C = estimated standard deviation of A

95% confidence intervals for weight change (bottom row)

Birth weights (in grams)					
2510-3000		3010-3500		3500-	
Heartbeat	Control	HB	C	HB	C
mean = 65	mean = −20	40	−10	10	−45
SD = 50	SD=60	50	50	35	75
n=35	n=28	n=45	n=45	n=20	n=36
SEM = 8.45	11.33	7.45	7.45	7.83	12.50
CI: 48.1 to 81.9	CI: −42.7 to 2.7	25.1 54.9	−24.9 4.9	−5.7 25.7	−70 −20

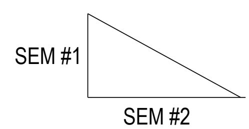
Difference between the two sample means = 85. SD of difference = ?

SD for difference between means

The standard deviation of the difference between two sample means is estimated by

$$\sqrt{(\text{SEM } \#1)^2 + (\text{SEM } \#2)^2}$$

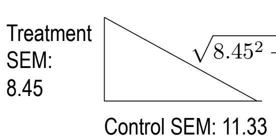
(To remember this, think of the Pythagorean theorem.)



Question: How can we get the standard deviation of the difference from information on the two samples?

Answer: Start with the SEMs for the two sample means:

- Treatment (heartbeat) SEM = 8.45 g
- Control (no heartbeat) SEM = 11.33 g



$$\sqrt{8.45^2 + 11.33^2} = 14.13$$

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perfect pitch (*Science*, Feb. 3, 1995)

In Vivo Evidence of Structural Brain Asymmetry in Musicians

Gottfried Schlaug,*† Lutz Jäncke, Yanxiong Huang, Helmuth Steinmetz*

Certain human talents, such as musical ability, have been associated with left-right differences in brain structure and function. In vivo magnetic resonance morphometry of the brain in musicians was used to measure the anatomical asymmetry of the planum temporale, a brain area containing auditory association cortex and previously shown to be a marker of structural and functional asymmetry. Musicians with perfect pitch revealed stronger leftward planum temporale asymmetry than nonmusicians or musicians without perfect pitch. The results indicate that outstanding musical ability is associated with increased leftward asymmetry of cortex subserving music-related functions.

A number of studies have demonstrated that the left hemisphere of the brain is dominant in the production and comprehension of language in the vast majority of persons (*1*). Similar attempts to localize musical functions have yielded conflicting data, mainly because studies of amusia—that is, impairment of musical skills as a result of cerebral lesions—have failed to reveal structural-functional maps similar to those of language organization (*2*). This situation has now changed with the introduction of positron emission tomography (PET) to measure regional cerebral blood flow and metabolism during the processing of verbal and nonverbal stimuli. Whereas left hemispheric activation sites are seen during phonological, lexical, or semantic language task performance (*3*), right hemispheric preponderances are found for melodic and pitch perception, at least in musically naïve subjects (*4*). However, process-

higher primates, suggesting a relation with the evolution of language (*10*); (ii) the left PT coincides with the center of Wernicke's speech area as identified by lesion studies (*11*); (iii) macroscopic asymmetry of the PT correlates with cytoarchitectonic asymmetry of association cortices thought to play a role in higher order auditory processing (*12*); and (iv) asymmetry of the PT is correlated with handedness, with left-handers being anatomically more symmetrical (*13*).

Rightward deviation from the usual pattern of cerebral asymmetry may be associated with increased giftedness for talents for which the right hemisphere is assumed to be important (*14*). This proposed relation has been partially substantiated by connections between nonrighthandedness, atypical visuospatial lateralization, spatial giftedness, and musical talent (*15*). We have used high-resolution in vivo magnetic resonance morphometry of the PT as an index of laterality in 30 healthy, right-handed professional musicians and compared the results with those from nonmusicians matched for age, sex, and handedness (*16–18*).

Table 1. Means (±SD) for age, degree of anatomical planum temporale asymmetry (δPT), and size of left and right PT determined with in vivo magnetic resonance morphometry in healthy, right-handed musicians and nonmusicians.

Subjects	Age	δPT†	PT size (mm^2) Left	Right
Musicians (n = 30)	26 (4)	−0.36 (0.25)*	1063 (189)	750 (187)
Perfect pitch (n = 11)	27 (5)	−0.57 (0.21)**	1097 (202)	611 (105)
No perfect pitch (n = 19)	26 (4)	−0.23 (0.17)	1043 (183)	830 (178)
Nonmusicians (n = 30)	26 (3)	−0.23 (0.24)	896 (236)	736 (263)

†Negative values indicate leftward asymmetry of the PT (*15*). *P = 0.028 compared to nonmusicians. **P < 0.001 compared to musicians without perfect pitch (*21*).

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perfect pitch (closeup)

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A study to see if perfect pitch (the ability to reproduce music notes without reference to a standard) is related to a physical structure in the brain.

Structure is called the planum temporale (PT)

Using brain scans the PT surface area in mm^2 was measured for three groups:
- musicians with perfect pitch
- musicians without perfect pitch
- non-musicians without perfect pitch

A measure of asymmetry in the PT was computed for each subject:

$$dPT = \frac{L - R}{(L + R)/2}$$

The researchers found:
- musicians with perfect pitch: mean dPT = −.57
- musicians without perfect pitch: mean dPT = −.23

Question: Are the dPT means close or not? Is there a difference between musicians with and without perfect pitch?

Equivalently we ask:
Is the difference in means

Randomly derived quantity ↓ Fixed constant ↓

−.57 − (−.23) = −.34 close to 0?

We need some additional information to answer the question: the StDev of the random quantity.

To find standard deviation of difference

Sample Mean 1	Sample Mean 2
sample size 1	sample size 2
sample standard deviation 1: SD 1	sample standard deviation 2: SD 2
SEM 1: (SD 1)/sqrt(sample size 1)	SEM 2 (SD 2)/sqrt(sample size 2)
Standard deviation of the difference of sample mean 1and sample mean 2: sqrt [(SEM 1)^2 + (SEM 2)^2]	

	musicians perf pitch	musicians no perf pitch
means	−.57	−.23
sample size	11	19
SD	.21	.17
SEM	.019	.039
Pythagoras	SD of difference sqrt(.019^2 + .039^2) = .043	

Diff in means = −.57 − (−.23) = −.34
So: −.34 ± 2×(.043) or −.34 ± .086 or −.43 to −.26
Conclusion: They are not close. There is a difference.

	musicians perf pitch	non-musicians
means	−.57	−.23
sample size	11	30
SD	.21	.24
SEM	.019	.044
Pythagoras	SD of difference sqrt(.019^2 + .044^2) = .048	

Diff in means = −.57 − (−.23) = −.34
So: −.34 ± 2×(.048) or −.34 ± .096 or −.44 to −.24
Conclusion: They are not close. There is a difference.

	musicians no perf pitch	non-musicians
means	−.23	−.23
sample size	19	30
SD	.17	.24
SEM	.039	.044
Pythagoras	SD of difference	

Difference in sample means = −.23 − (−.23) = 0
Conclusion: They are close. There is no evidence of a difference.

General conclusions:

There is a significant difference between the asymmetry of the PT for musicians with perfect pitch and both musicians without perfect pitch and non-musicians.

This strongly suggests that there is a relationship between the physical structure of the PT in the brain and perfect pitch ability.

Confidence intervals: Main exam topic

- Difference between population values and sample estimates
- Rules of sample proportions and sample means
- The logic of confidence intervals (what does a confidence coefficient like 95% mean?)
- SD for proportions, SE for means, and SD for differences between means
- How to create CI's for (a) one proportion; (b) one mean; (c) the difference of two means.
- Different levels of confidence (other than 95%)

Difference between population values and sample estimates

A population value is some number (usually unknowable) associated with a population. *Technical term: parameter*

A sample estimate is the corresponding number computed for a sample from that population. *Technical term: statistic*

Examples include:

population proportion vs. sample proportion

population mean vs. sample mean

population SD vs. sample SD

Rule of sample proportions (p. 359)

IF:
1. There is a population proportion of interest
2. We have a random sample from the population
3. The sample is large enough so that we will see at least five of both possible outcomes

THEN: If numerous samples of the same size are taken and the sample proportion is computed every time, the resulting histogram will:
1. be roughly bell-shaped
2. have mean equal to the true population proportion
3. have standard deviation estimated by

$$\sqrt{\frac{\text{sample proportion} \times (1 - \text{sample proportion})}{\text{sample size}}}$$

Rule of sample means (p. 363)

IF:
1. The population of measurements of interest is bell-shaped, OR
2. A large sample (at least 30) is taken.

THEN: If numerous samples of the same size are taken and the sample mean is computed every time, the resulting histogram will:
1. be roughly bell-shaped
2. have mean equal to the true population mean
3. have standard deviation estimated by

$$\frac{\text{sample standard deviation}}{\sqrt{\text{sample size}}}$$

The logic of confidence intervals

What does a 95% confidence interval tell us? (What's the correct way to interpret it?)

IF (hypothetically) we were to repeat the experiment many times, generating many 95% CI's in the same way, then 95% of these intervals would contain the true population value.

Note: The population value does not move; the hypothetical repeated confidence intervals do.

Confidence intervals

All confidence intervals in this class look like this:

Estimate of population value ± (**multiplier**)(SD of estimate)

1. Know how to match up estimate with SD (three possibilities)
2. Know how to find the **multiplier** on p. 157 if I give you a confidence coefficient other than 95% (for 95%, the multiplier is **2**).

How to create 95% CI's for:

a) A population proportion

   Sample proportion ± **2**(SE of sample proportion)

b) A population mean

   Sample mean ± **2**(SE mean)

c) The difference between two population means

   Diff of sample means ± **2**(SE of diff of sample means)

Different levels of confidence

a) A population proportion

   Sample proportion ± **2**(SE of sample proportion)

b) A population mean

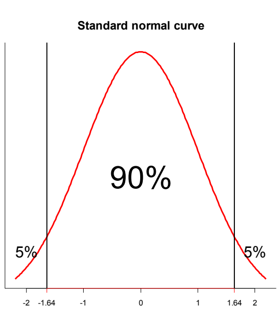
   Sample mean ± **2**(SE mean)

c) The difference between two population means

   Diff of sample means ± **2**(SE of diff of sample means)

Replace the **2**'s with another number from p. 157!

Example: 90% confidence interval



Since 90% is in the middle, there is 5% in either end.

So find z for .05 and z for .95.

We get z = ±**1.64**

90% confidence interval: sample estimate ± **1.64**(Std Dev)