

DSC 152: Applied Statistical Data Analysis and Inference

Lecture #5 Statistical Significance vs. Effect Size

Tuesday, April 14
Spring Quarter 2026
Peter Chi

Today's Question

The overall question for today is: What is the relationship between statistical significance and effect size?

Examples

- From last time: what if the true amount of sleep that UCSD students get is different from 6 hours, but by a very small amount?
- Is this poker player a theoretically winning player?

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These two examples investigate the following concepts:

- Is there a sample size at which we would reject H_0 for even a miniscule difference from H_0 ?
- What should we do if we estimate a large effect size but do not reject H_0 ?

Example: Sleep of UCSD students

Recall from last time that, as sample size increases, statistical power increases.

This is true for ANY effect size!

For example, what if the true average amount of sleep that UCSD students get is 5 hours and 45 minutes per night?

- Would we really care that this is different from our H_0 of 6 hours?
- What would happen if we had an extremely large sample size?

Example: Sleep of UCSD students

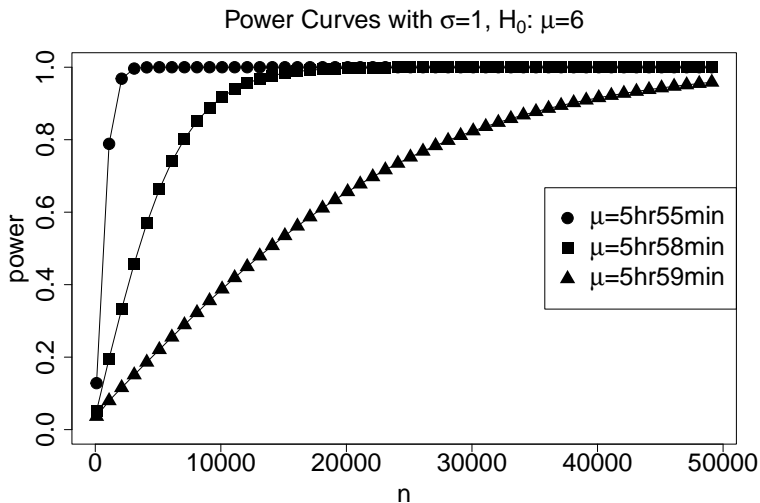
5 hours and 45 minutes of sleep corresponds to an effect size of $\frac{1}{4}$ of an hour. And suppose, for example, we were able to obtain a sample size of 500 students...

```
power.t.test(n=500, delta=0.25, type="one.sample")
```

```
##  
##      One-sample t test power calculation  
##  
##              n = 500  
##            delta = 0.25  
##              sd = 1  
##      sig.level = 0.05  
##            power = 0.9998524  
## alternative = two.sided
```

Example: Sleep of UCSD students

And now we can follow this logic to even more extremes...



Example: Sleep of UCSD students

Key takeaways:

- At the very small effect size of 5 minutes, we attain nearly 100% statistical power with sample sizes of less than $n=5000$ or so
- With the miniscule effect size of 2 minutes, we attain nearly 100% statistical power by $n=20,000$
- With the even smaller effect size of 1 minute, we get quite close to 100% statistical power by $n=50,000$

And in our era of Big Data, sample sizes on this order are not uncommon!

Example: Sleep of UCSD students

Your Turn

Daily Check Question #1

Open up an RStudio session (no need to start an R Markdown file), and then:

- Simulate a sample of size 50,000, with values of sleep that come from a $N\left(\mu = 5\frac{59}{60}, \sigma^2 = 1\right)$ distribution.
- Run a t-Test (you may use the `t.test` function) with our $H_0: \mu = 6$.
- Put your responses in Question #1 of the Daily Check #5 assignment in Gradescope when you are ready to.

Example: Sleep of UCSD students

The point is:

- The p-value should not be the sole determining metric for whether we care about a result or not.
- Particularly if our sample size is very large, we need to also look at the estimated effect size and ask whether that is big enough to care.

To this end, confidence intervals are often much more useful and less misleading than p-values. For my specific simulation, the 95% confidence interval is:

```
t.test(sleep50k, mu=6)$conf.int
```

```
## [1] 5.972078 5.989708  
## attr(,"conf.level")  
## [1] 0.95
```

Quote of the Day

Daily Check Question #2



X · Ted_Underwood

910+ likes · 9 years ago

A stubborn love of bacon just taught more Americans the difference between p values and effect size than 100 stats courses could.




Cancer

 This article is more than 10 years old

Processed meats rank alongside smoking as cancer causes - WHO

UN health body says bacon, sausages and ham among most carcinogenic substances along with cigarettes, alcohol, asbestos and arsenic

 Sarah Boseley Health editor

Mon 26 Oct 2015 08:30 EDT

 Share 4,455

 Prefer the Guardian on Google



Bacon and Cancer

What was found in the actual research study?

Carcinogenicity of consumption of red and processed meat

In October, 2015, 22 scientists from ten countries met at the International Agency for Research on Cancer (IARC) in Lyon, France, to evaluate the carcinogenicity of the consumption of red meat and processed meat. These assessments will be published in

more than 200 g per person per day.⁴ Less information is available on the consumption of processed meat.

The Working Group assessed more than 800 epidemiological studies that investigated the association of cancer with consumption of red meat

day of red meat and an 18% increase (95% CI 1.10–1.28) per 50 g per day of processed meat.¹²

Data were also available for more than 15 other types of cancer. Positive associations were seen in cohort studies and population-based case-

What does an 18% increase in risk of colon cancer actually mean?

- It's an 18% increase above your starting risk of colon cancer
- For example: from a baseline risk of 5%, an 18% increase would be $0.05 \times 1.18 \approx 0.06$

Bacon and Cancer

So recall that the headline said...

Processed meats rank alongside smoking as cancer causes - WHO

UN health body says bacon, sausages and ham among most carcinogenic substances along with cigarettes, alcohol, asbestos and arsenic

Why is this headline misleading?

- For a typical person, it is estimated that the effect size of 18% corresponds to an overall increase in the lifetime risk of colon cancer from 5% to 6%.
- This result had a highly statistically significant p-value (much less than 0.05), because the sample size of their study was huge!
- But compare this to the risk of lung cancer from smoking cigarettes, which is estimated to have an effect size of between 1500% and 3000%...

And so again...

Daily Check Question #2



X · Ted_Underwood

910+ likes · 9 years ago

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- **Is this poker player a theoretically winning player?**

Example: Poker

Background: In November 2019, the state of Pennsylvania (where I lived at the time) introduced fully legalized and regulated online gambling, including poker.



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PokerStars Reportedly Launching Nov. 4 in Pennsylvania



Mo Nuwwarah
Live Reporter

Oct 30, 2019 • 3 min read • Last updated Oct 31, 2019

Example: Poker

In my younger days, I played a lot of online poker (often on shady offshore sites), but even with the promise of a safe regulated environment, I did not initially feel inclined to start playing again.

Then, the pandemic hit in 2020...

Example: Poker

The image displays six screenshots of online poker hands, arranged in a 2x3 grid. Each screenshot shows a virtual poker table with various player avatars, their current bets, and the community cards on the table. The dealer's position is indicated by a white box at the bottom of each hand.

- Top Left:** Session 01-21 - Etamin - \$0.25/\$0.50 USD - No Limit Hold'em. Pot: \$43.14. Dealer: Hand #233393746251: Philly4fo4 wins pot (\$1.66).
- Top Middle:** Session 01-21 - Aegle - \$0.50/\$1 USD - No Limit Hold'em. Pot: \$3. Dealer: Chip3ter, it's your turn. You have 8 seconds to act.
- Top Right:** Session 01-21 - Indus - \$0.25/\$0.50 USD - No Limit Hold'em. Pot: \$0.75. Dealer: Hand #233393747521: cqcq07 wins pot (\$0.50).
- Bottom Left:** Session 01-21 - Kurydite - \$0.30/\$1 USD - No Limit Hold'em. Pot: \$1.50. Dealer: Hand #233393747232: Chip3ter wins pot (\$2).
- Bottom Middle:** Session 01-21 - Heze - \$0.25/\$0.50 USD - No Limit Hold'em. Pot: \$3.40. Dealer: Hand #233393747389: Chip3ter wins pot (\$3.60) with two pair, Tens and Eights.
- Bottom Right:** Session 01-21 - Kassandra - \$0.25/\$0.50 USD - No Limit Hold'em. Pot: \$0.75. Dealer: Hand #233393747389: Chip3ter wins pot (\$0.50).

Example: Poker

If you have never played poker before (or otherwise do not have much knowledge of it), here is what you need to know for the purpose of this example.

What you need to know:

- Poker is a card game (played with an ordinary 52-card deck of cards)
- Money is potentially won or lost on each round of play
- Each round of play is referred to as a “hand.”

Example: Poker

I have a history of being an overall winning player, but:

- it had been a long time since I had played regularly (since about 2014)
- the population of players has changed over time (overall, players have gotten better over the years due to the ever increasing availability of information)

So the question I had was, am I now (in 2020) a theoretically winning player?

Ideally, I would like to know this as quickly as possible...

<https://pollev.com/chi>

Example: Poker

Some data

Hand #	Marked	Site	Date	Stake	My C Won	Final Hand	Hole Cards	PF Act	Flop	F Act	Turn	
5979	2.13287e+11	NA	PokerStars	5/7/2020 21:30	\$1 NL (6 max)	(\$0.50)	(folded preflop)	9d6h	F	0	NA	0
5980	2.13287e+11	NA	PokerStars	5/7/2020 21:30	\$1 NL (6 max)	(\$10.00)	(folded river)	AsTc	R	2s7h5c	B	Qd
5981	2.13287e+11	NA	PokerStars	5/7/2020 21:30	\$1 NL (6 max)	(\$0.50)	(folded preflop)	Kd8h	F	0	NA	0
5982	2.13287e+11	NA	PokerStars	5/7/2020 21:31	\$1 NL (6 max)	\$0.00	(folded preflop)	9h5d	F	8d2s7d	NA	0
5983	2.13287e+11	NA	PokerStars	5/7/2020 21:31	\$1 NL (6 max)	\$0.00	(folded preflop)	6h3s	F	AhKc9c	NA	9h
5984	2.13287e+11	NA	PokerStars	5/7/2020 21:32	\$1 NL (6 max)	\$0.00	(folded preflop)	Ks4s	F	9c3s6s	NA	6d
5985	2.13287e+11	NA	PokerStars	5/7/2020 21:32	\$1 NL (6 max)	\$6.78	(did not show hand)	AsKh	RC	4s4hKc	B	0
5986	2.13287e+11	NA	PokerStars	5/7/2020 21:32	\$1 NL (6 max)	\$99.50	Flush, Ace High	Ts9s	R	5s8c7s	BC	As
5987	2.13287e+11	NA	PokerStars	5/7/2020 21:32	\$1 NL (6 max)	\$0.00	(folded preflop)	Ad9h	F	3dAcTh	NA	Qs
5991	2.13287e+11	NA	PokerStars	5/7/2020 21:33	\$1 NL (6 max)	\$0.00	(folded preflop)	As4d	F	0	NA	0
5992	2.13287e+11	NA	PokerStars	5/7/2020 21:33	\$1 NL (6 max)	(\$0.50)	(folded preflop)	9d2c	F	Kh5d4c	NA	Ac
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5994	2.13288e+11	NA	PokerStars	5/7/2020 21:34	\$1 NL (6 max)	\$1.85	High Card, King	Qs8s	C	Th2s4h	X	5h

Showing 5,978 to 5,994 of 10,000 entries, 19 total columns

The “Stake” of “\$1 NL (6 max)” refers to the following:

- “\$1 NL” indicates a standard buy-in of \$100
- “6 max” has higher variance than “9 max” or “10 max”...

Example: Poker

Some data

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Showing 5,978 to 5,994 of 10,000 entries, 19 total columns

Sidenote: how were we all doing on May 7, 2020?

- We were about 1 month into stay-at-home orders
- I was under 2 months from becoming a dad

Example: Poker

Recall: the question (from a few slides ago) was, “Am I a theoretically winning player in 2020?”

How exactly would we formulate this as a statistical test?

<https://pollev.com/chi>

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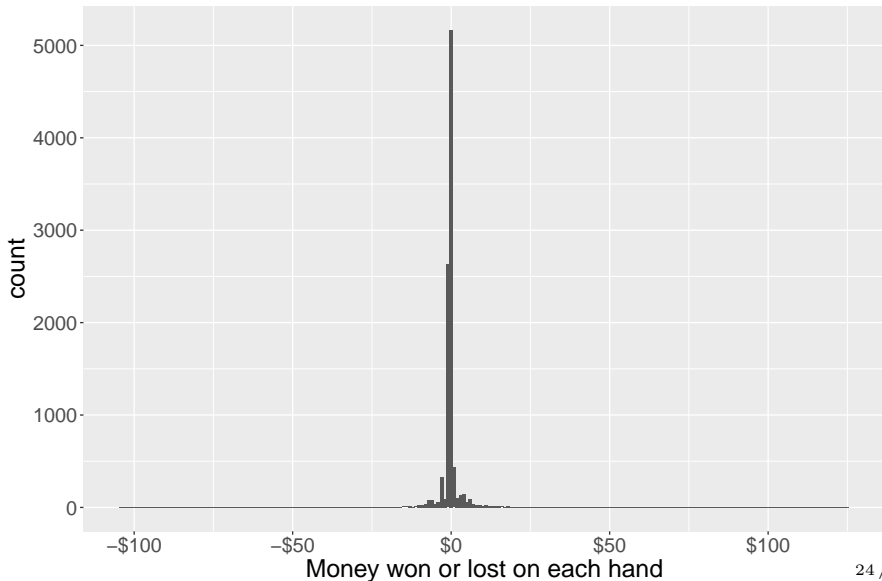
The data

I have pulled the results from my first 10,000 hands at the stake of “\$1 NL (6 max)” (corresponding to approximately five weeks of data). Let's see what this sample tells us.

Example: Poker

The data

Distribution of money won/lost, n=10000



Example: Poker

What does the evidence suggest? (<https://pollev.com/chi>)

Some summary statistics:

```
summary(won)
```

##	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
##	-103.7100	-0.5000	0.0000	0.1023	0.0000	125.2200

Example: Poker

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Here is the total amount of dollars I won over five weeks:

```
sum(won)
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```
## [1] 1022.95
```

Example: Poker

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##	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
##	-103.7100	-0.5000	0.0000	0.1023	0.0000	125.2200

Here is the total amount of dollars I won over five weeks:

```
sum(won)
```

```
## [1] 1022.95
```

Here is the standard deviation (per hand):

```
sd(won)
```

```
## [1] 7.181245
```

Example: Poker

The analysis

```
t.test(won, alternative="greater")
```

```
##  
## One Sample t-test  
##  
## data: won  
## t = 1.4245, df = 9999, p-value = 0.07717  
## alternative hypothesis: true mean is greater than 0  
## 95 percent confidence interval:  
## -0.01583691 Inf  
## sample estimates:  
## mean of x  
## 0.102295
```

Example: Poker

But wait, isn't it just because the effect size is really small?

What's the effect size?

```
mean(won)
```

```
## [1] 0.102295
```

- So on average, I win about 10 cents per hand. That seems pretty small...
- But recall, I play 6 tables at a time and get approximately 300 hands per hour, meaning that this translates to an hourly rate of about \$30/hour...

Example: Poker

<https://www.thepokerbank.com/strategy/other/winrate/>

What is a good winrate?

This is easily the most frequently asked question when it comes to win rates, and the answer is always the same...

| Any winrate above 0 is good.

A winrate above 0 means that you are a winning player and you should be happy about that. Something crazy like 95% of all online poker players lose money, so be thankful that you're good enough to be in this elite group. However, I know that you're not going to be satisfied with a very general answer like that. You want some figures don't you?

Rough ballpark figures for good and great winrates.

- 1 – 4 bb/100 = Great. A solid winrate if you can sustain it.
 - 5 – 9 bb/100 = Amazing. This is a very high winrate at any level. Consider moving up.
 - 10+ bb/100 = Immense. Very, very few have a winrate like this. You probably have a small sample size though.
-

Notes:

- $\text{bb}/100 = \text{“big blinds per 100 hands”}$
- In my case, ≈ 0.10 per hand corresponds to 10 bb/100, which is on the very high end of what is attainable in the long run.

Example: Poker

Daily Check Question #3

So, we failed to reject H_0 . What does that mean here?

<https://pollev.com/chi>

Example: Poker

So how big of a sample do we need?

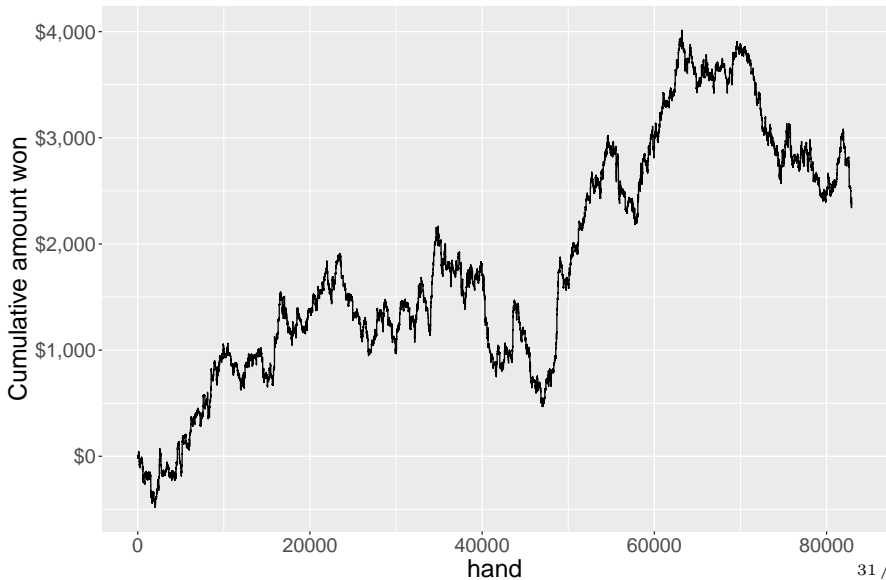
We can do a power calculation! (Daily Check Question #4)

How might we do that here?

Example: Poker

Now, the full data

Running total of money won starting from May 7, 2020



Example: Poker

```
t.test(won_all, alternative="greater")

##
## One Sample t-test
##
## data: won_all
## t = 1.0759, df = 82913, p-value = 0.141
## alternative hypothesis: true mean is greater than 0
## 95 percent confidence interval:
## -0.0155553      Inf
## sample estimates:
## mean of x
## 0.02941675
```

Welp.

I mean, losing more than \$1500 in the last 20k hands didn't help.

Parting thoughts

- Recall that a t-Test requires that the observations are independent in order to be valid. Do we think that condition is met here?
 - We'll revisit this as time-series data in Week 9.
- Situations with high variance can require a shockingly high sample size in order to attain traditional “statistical significance” at any reasonable α level. This includes:
 - most gambling games
 - financial market data
 - social media engagement and impact
 - insurance claim amounts
 - etc.

The primary point of both examples from today was: the p-value is not everything!

Summary of today's Daily Check

- Overall conclusions from the t-Test on Slide 7
- Explanation of Quote of the Day in your own words
- What we should or should not conclude from the result of failing to reject H_0 on Slide 29
- Explanation of power calculation and results on Slide 30

Next time

- A/B testing
 - Also known as experimental studies (as opposed to observational)
 - This is a very rich topic that we do not have time to treat fully; we will focus on the statistical inference aspects therein.