META ANALYSIS: USEFUL TOOL OR TORTURING DATA UNTIL THEY CONFESS?

Chris Dubelaar

June 2015

AGENDA FOR THE DAY

- Basics of Meta Analysis
  - Nuts and Bolts
  - One example in Marketing
- More examples from other areas
  - How it works
  - What it shows
- Where Meta can go wrong
  - Why it drifts
- What about Qual Data?
  - Meta Synthesis to the rescue!
- Wrap

AGENDA FOR FIRST PART

- Meta-Analysis
  - What it is
  - Why do it?
  - How it works
  - Data requirements
  - Types of Analysis
  - How to interpret results
  - Limitations

META-ANALYSIS

- Meta Analysis is where you collect a body of research to draw more general conclusions
- Specifically, you are looking to find out what the whole literature says about a specific issue
- E.G., Effects of portion size on consumption
  - Zlatevska, N, C. Dubelaar, S. Holden (2014) "Sizing Up the Effect of Portion Size on Consumption: A Meta-Analytic Review" *Journal of Marketing*, Vol 78(3)

WHAT IS A META ANALYSIS?

- Takes properties of individual studies and creates standardized parameters
- These can be compared, and traded off
- Also creates a weighted average to give a better insight
- Weights are proportional to the standard error of the estimates in each paper (most of the time)

WHY DO IT?

- Provides a more general (Meta) conclusion about the state of the art in a fractured field
- For example, in portion size literature much confusion!
  - Some found changes in portion size had no effect.
  - Sound found it had a negative effect
  - Some found very large positive effects
  - Others smaller effects
- What is going on?

WHY DO IT (CONT'D)?

- Allows a researcher to (scientifically) bring together ALL the research in an area
- Provides direction for future research
- Answers questions about contradictions in existing research
- Addresses confusion and scepticism in literature

HOW IT WORKS

- Back to basic statistics…
- A "test" is a way of determining whether something is the same or different from something else, whether it be:
  - A set value
  - Another estimator
- To create a test you need to have
  - A distribution
  - Knowledge about the values being compared
  - Information on the distribution

META ANALYSIS NUTS AND BOLTS

- The same thing exists in Meta Analysis
- We assume a normal distribution
- We have the values published in other people’s works
- We have information on sample sizes and standard errors from other people’s works

FACE VALIDITY CHECK

- Which would you trust more?
  - A study of 25 people showing that increasing portion size has a strong positive effect on your consumption
  - A study of 2500 people showing that increasing portion size has only a slight positive effect on your consumption
- What is your rationale?
- Are they actually saying different things, or the same thing?
- Why might results be different?

THIS IS WHAT META ANALYSIS DOES

- It takes into account the estimate, the sample, and the error to come up with a standardised effect size.
- These effect sizes can then be combined in a simple linear fashion to arrive at a final estimate of the overall effect.
- A brief history lesson is in order

META ANALYSIS THROUGH TIME

- The Cochrane group have looked at meta analyses on a lot of things
  - http://www.cochrane.org/
- Most meta analyses deal with direct replications
  - I try medication X on disease Y on 20 mice and find 8 survive while none survive in control group
  - You try medication X on disease Y on 250 mice and find 90 survive while 20 survive in control group
- Note that treatments and contexts are identical
- But what if context varies?

VARYING CONTEXTS

- In portion size studies you see a large number of variations
  - Adults vs children
  - Males vs females
  - Obese vs normal weight people
  - Snack vs non-snack foods
  - Food vs other focus
  - Within vs between subjects

OTHER ISSUES TO CONSIDER

- Amount of portion size change
- Package size
- Granularity of food
- Partitioning
- Actual vs perceived consumption
- Lab vs field experiments
- Utensil size
- Vessel size/shape
- Vessel colour/contrast
- Presence of others
- Palatability of food
- Package windows
- Status of person eating
- Authors (!)

HOW TO RESOLVE?

- Difficult question!
  - Editor wanted paper to be simpler, so left out a lot of potential influences on consumption
    - Some of these are quite important
- This means that even a Meta Analysis can get the answer wrong!
  - There is no truth!
    - Only clues along the way.

IMPLICATIONS?

- Even with Meta Analysis you can get egregious outcomes
- The choice of
  - What data to exclude
  - How to split the data
  - Including unpublished papers (or not)
- Can have massive effects on the outcome
- This has resulted in the PRISMA approach to data collection
  - (Beller et al. 2013)

PRISMA

- **P**referred **R**eporting **I**tems for **S**ystematic Reviews and **M**eta-**A**nalyses
  - **Interventions**
  - Outcomes
  - Participants and Study Design
  - Search Strategy
  - Data Extraction
- Point is to make everyone do it the one way so results are consistent

SIDE NOTE ON UNPUBLISHED PAPERS

- This is known as the “file drawer effect”
  - Researcher runs a study, gets no result
    - All work is dropped, results are stuck in her desk
- When results are not interesting
  - Or in the case of the tobacco or food industries, not wanted
- Then studies are hidden
- When enough studies are hidden, meta analytic results are bogus
  - But how many need to be hidden to cause problems?
    - Depends on distribution of results

DEAKIN UNIVERSITY AUSTRALIA Worldly

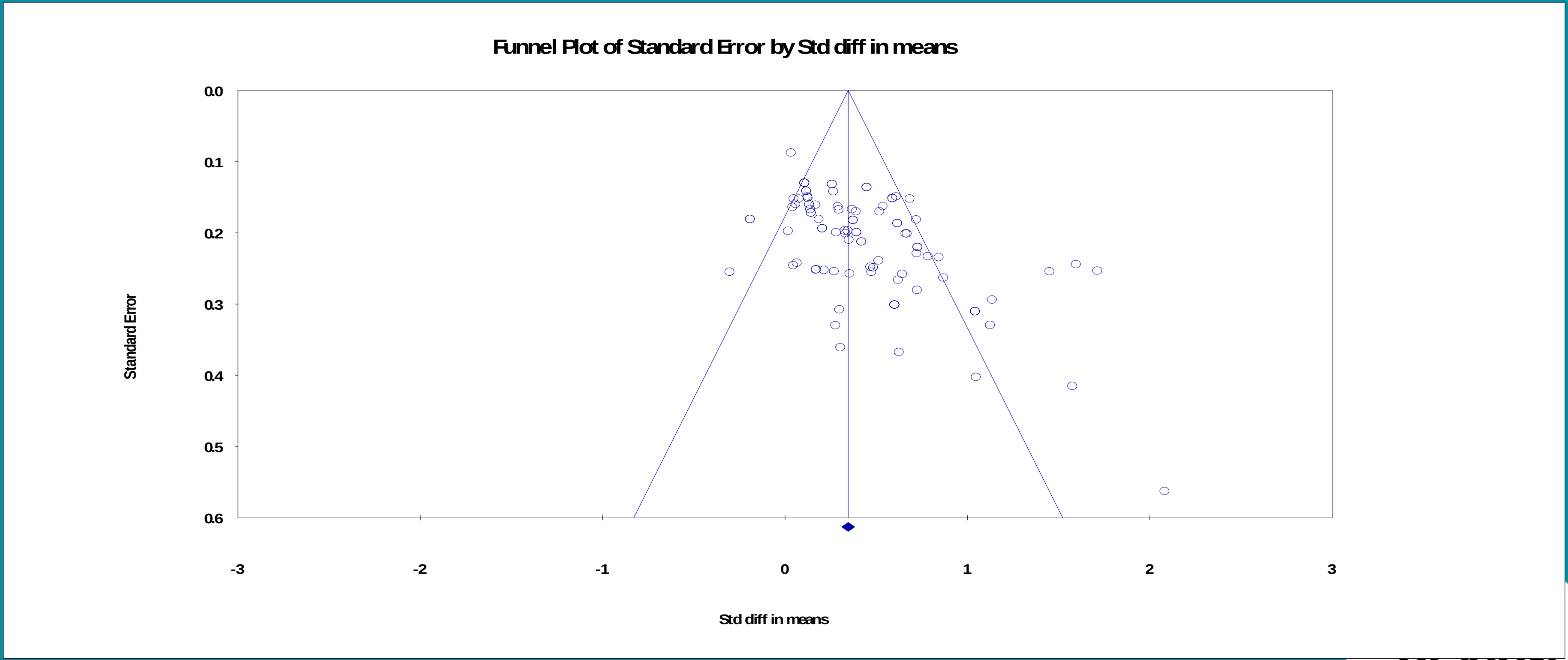
FILE DRAWER EFFECT

- Most calculations consider it likely that results hidden only if result is “null”
  - Do not count papers that give opposite result as likely to be hidden
    - Consider the dangers of this assumption!
- Can calculate number of papers required to be hidden to make your meta analysis “wrong.”
  - That is, number required to change a significant result to a non-significant result.

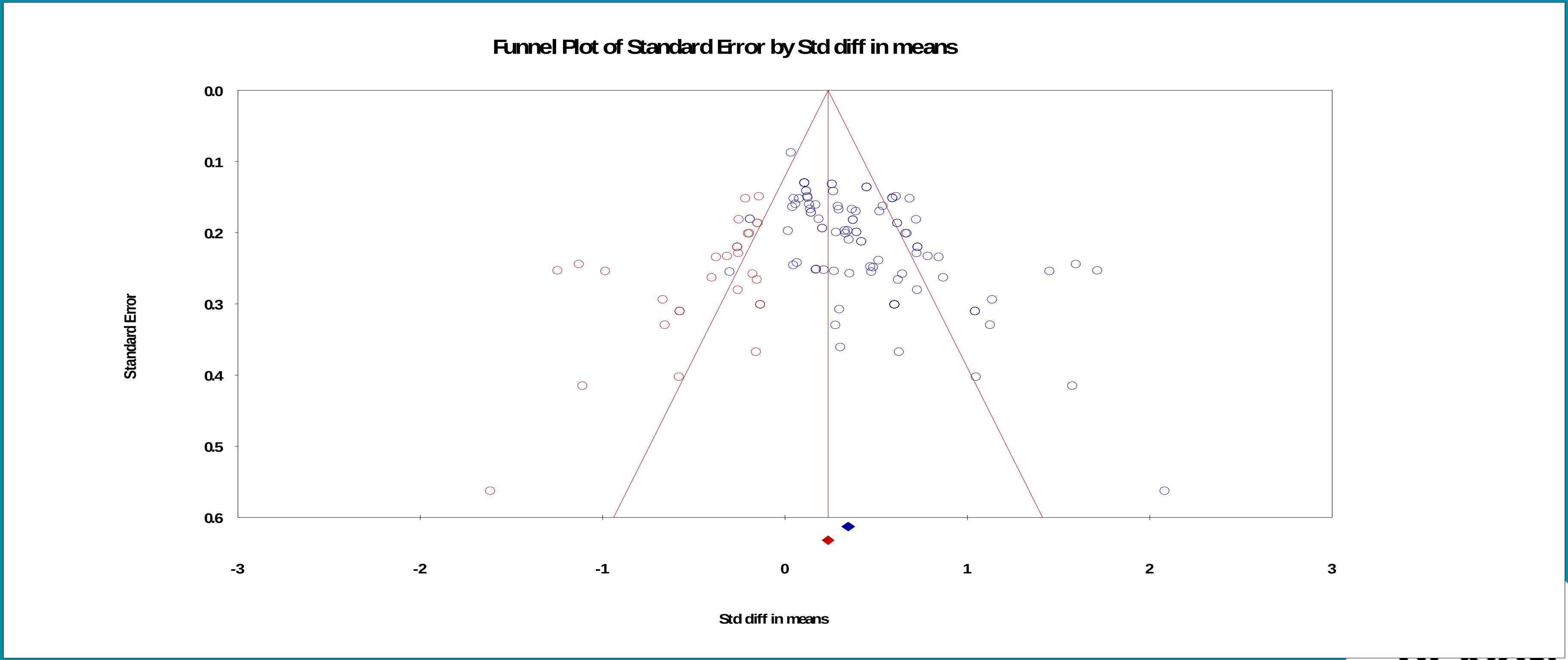
FUNNEL PLOTS

- These are another way of detecting file drawer effects
  - If the “science” is correct
    - Then results should follow a normal distribution
- Specifically, plot standard errors against effect sizes and you see a funnel shape
  - Most packages take the inverse of the standard error to give something that looks like this…

SAMPLE FUNNEL PLOT



LOPSIDED!



Funnel Plot of Standard Error by Std diff in means
Standard Error
0.0
0.1
0.2
0.3
0.4
0.5
0.6
-3
-2
-1
0
1
2
3
Std diff in means

WHAT JUST HAPPENED?

- There are two possibilities here
  - Either, there is a HUGE publication bias
    - But it’s still not enough to negate the results
  - Or, there is a lot of variance across the studies
    - And we know this to be the case
- So, the apparently lopsided funnel plot is due to combining quite different studies
  - Across all those treatments mentioned earlier

DEAKIN UNIVERSITY AUSTRALIA Worldly

WHAT TO DO?

- Be cautious!
  - Assume the worst (publication bias)
  - But hope for the best (variance in treatments)
    - Use tests to determine if this is the case

WHAT ABOUT THOSE VARYING TREATMENTS?

- In medicine (for example) often a treatment will be standardised
  - X μg of Y drug per kg of bodyweight
- But what if treatments change?
  - Increasing or decreasing dosages
- Then direct comparisons are difficult
  - But not impossible

META REGRESSION

- Here we need to use Meta Regression
  - Where varying treatments compared to varying responses
- Allows a means of comparison of efficacy
  - Is more of the drug a good thing?
- For example, can look at dosage levels and survival rates
  - Check to see if survival rates are related to dosage

CAVEATS

- All these analyses are hindered when there are moderators
  - That is, conditions under which the response is expected to be different
- In that case, moderation analysis is necessary
  - Most Meta Analysis programs allow direct comparisons across moderators
    - But only one or two at a time
- What if there are many moderators?
  - Then you need a different approach

BACK TO BASIC META ANALYSIS

- Assuming away all the problems of various treatments, contexts, moderators, and so on…
- Then we have a fairly simple process to follow
- We can use one of two approaches
  – Fixed effects model, or
  – Random effects model

FIXED EFFECTS MODEL

- This is used where the treatments are consistent and the associated effects should also be consistent
  - Survival rates in the case of a fatal disease when a consistent new drug treatment regime is used
- This is the classic case of replications
  - You are comparing exact, or nearly exact, replications of the same experiment
    - With only very minor modifications

FIXED EFFECTS MODEL (CONT'D)

- Here you are finding the weighted average of the outcome variable
- Ideally you will have the raw data from every study
  - In this case, no fancy stats are required
    - Each observation is just an observation and the estimate is formed directly
      - Almost never happens!
- Instead, you use estimates from published papers and their standard errors
- These are weighted to provide the new estimate
  - ✖ Weights are the inverse of the standard errors of the estimates being combined
  - Thus, large studies with low standard errors provide a lot of weight, while small studies provide almost none.

RANDOM EFFECTS MODEL

- Here you know that the studies are taken from a distribution of possible treatments
  - In portion size, they can vary portions by any amount, across different eating occasions, using different foods, in different contexts, etc…
- We know that the studies are different, but expect this
  - Trick is to know how to combine them to not lose the important differences while ditching the design based differences

RANDOM EFFECTS MODEL (CONT'D)

- Here the weighting process looks a bit like sleight of hand
  - You weight, then unweight, then reweight
    - And hope for the best!
- Not quite that bad…
- Assume that the distribution of effects is normal
  - Then create a point estimate and a variance estimate
    - To describe the expected distribution of effects
    - Then use this to create your estimate of the meta result

WHAT KINDS OF DATA CAN YOU USE?

- Pretty much anything quantitative
  - Interval and Ratio scaled (Continuous) measures
  - Ordinal (Rankings) scaled measures
  - Nominal (Multichotomous) scaled measures
- Each scale type requires a different approach
  - Won’t go into the maths
    - Although they’re not that bad
- Modern software (such as CMA) handles pretty much anything you can throw at it.
  - Doing it manually is now just pointless

DATA REQUIREMENTS

- First, define unit of analysis
  - A study
    - A single paper may have multiple studies
- Some sources in our paper had up to six studies
  - So, different portion sizes across different genders
    - Each result constitutes a study
- Note that this can increase the influence of specific papers
  - And thus authors

DATA REQUIREMENTS (CONT'D)

- For each study you need:
  - A point estimate
  - A standard error
- Sometimes the point estimates are not quite what you want
  - Maybe the differences between two points that you DO want
- Then you have to try to convert the information
  - This can, hopefully, allow extraction of info necessary

DATA REQUIREMENTS (CONT'D)

- Sometimes information only presented graphically
- Then have to make a call:
  - Try to get original data from authors?
  - Leave it out?
  - Measure the graph and guess?
- Ideally you will get original data from authors
  - But don't hold your breath!

DEAKIN UNIVERSITY AUSTRALIA Worldly

SO YOU'VE DONE A META ANALYIS!

- How do you interpret it?
  - Need to look at the point estimate and its confidence interval
- But what is this "effect size" thing anyway?
- The effect size (Cohen's d in this case) is:
  - A report of how much variance in the dependent can be explained by variance in the independent
  - It is used when comparing two means
    - In the example here, the mean of consumption from the small portion against the mean of consumption from the large porti
      - Or any other treatment effect

CONVERTING EFFECT SIZES INTO REAL NUMBERS

- Not possible directly
- Have to take a different approach
- Back to basics!
  - Use a completely different approach
    - See our paper in Journal of Marketing for an example of this in action
    - Note! Does NOT take into account any weights

GETTING THOSE REAL NUMBERS…

- Cohen's d is not much use to a practitioner
- After all, does not say how much to reduce portion size to eliminate obesity
  – Or cure cancer
- In our case, created new data base
  – All results for all levels of consumption
    - Both large and small portions separately

THEN ANALYSE THEM USING THIS…

- (1) Δ_S / S_S
- (2) Δ_C / C_S
- Δ_S = change in portion size (larger portion size – smaller portion size)
- S_s = smaller portion size
- Δ_C = change in consumption (amount eaten from larger portion – amount eaten from smaller portion)
- C_s = consumption from smaller portion size

DEAKIN UNIVERSITY AUSTRALIA Worldly

IN A MULTILEVEL MODEL LIKE THIS…

- Δ_C / C_{Sij} = B_{0j} + B_{1j}* Δ_S / S_{Sij} + r_{ij}
- B_{0j} = γ_{00} + γ_{01} * $Design_j$ + γ_{02} * $Paper(Design)_j$ + u_{0j}
- B_{1j} = γ_{10} + γ_{11} * $Design_j$ + γ_{12} * $Paper(Design)_j$ + u_{1j}

DEAKIN UNIVERSITY AUSTRALIA Worldly

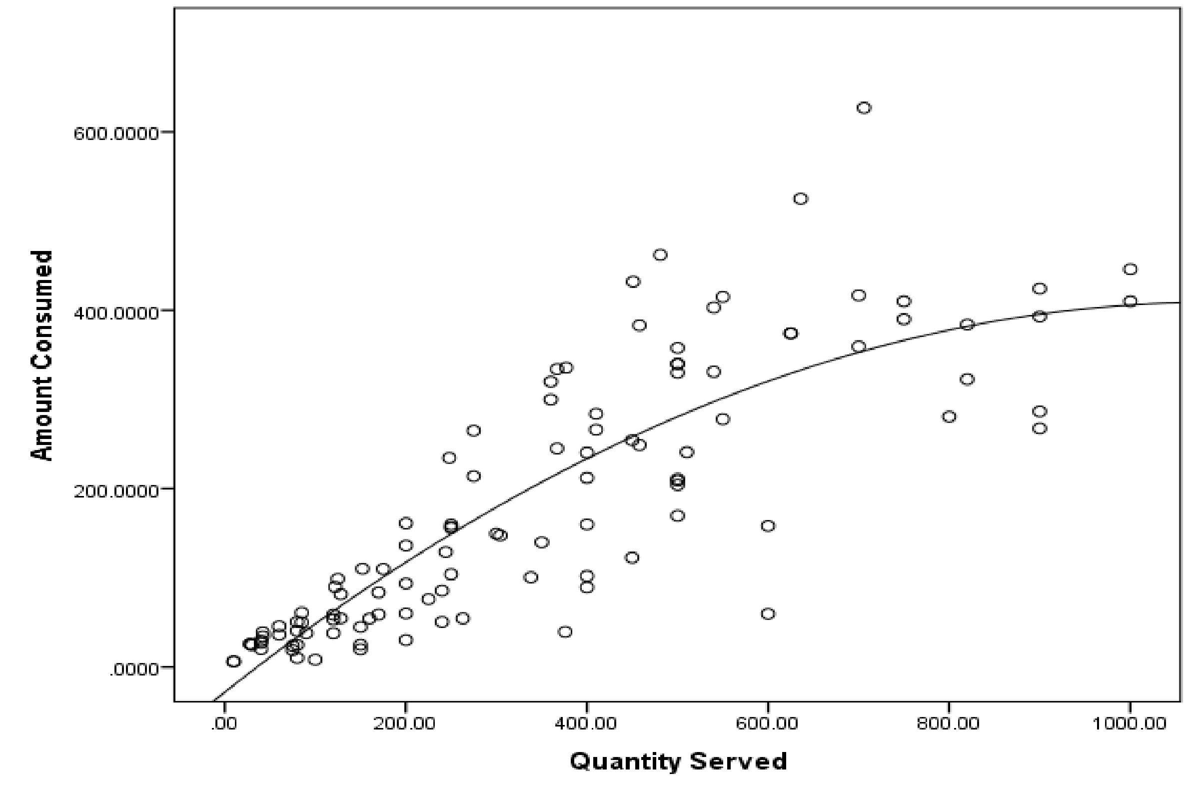
TO GET THIS…

- When $\Delta_S / S_{sij} = 1$
  - That is, when you double portion size
- Then, $B_{1j} = 0.35$
- So, when you double portion size
  - The average person eats 35% more of the average thing being served
- But this number (.35) varies wildly from 1 down to nearly 0
  - Depending on the context

SO, NEXT STEP?

- Check for face validity
- Create a data base using only those studies either in grams, or convertible to grams
- This creates the following graph

THE GRAPH



DEAKIN UNIVERSITY AUSTRALIA Worldly

SAY WHAT?

- Shows that as portion size increases
  - Proportion eaten decreases
- That is, change has biggest effect at small portion sizes
  - But we KNEW that!
    - If I give you a tiny drink and then double it, you'll drink ALL of both for a 100% increase
- But the data show how it tapers off
  - Except for four outliers top right
    - From a study by Brian Wansink using uni students in a dark restaurant in Berlin

LOOK AT ANOTHER PAPER

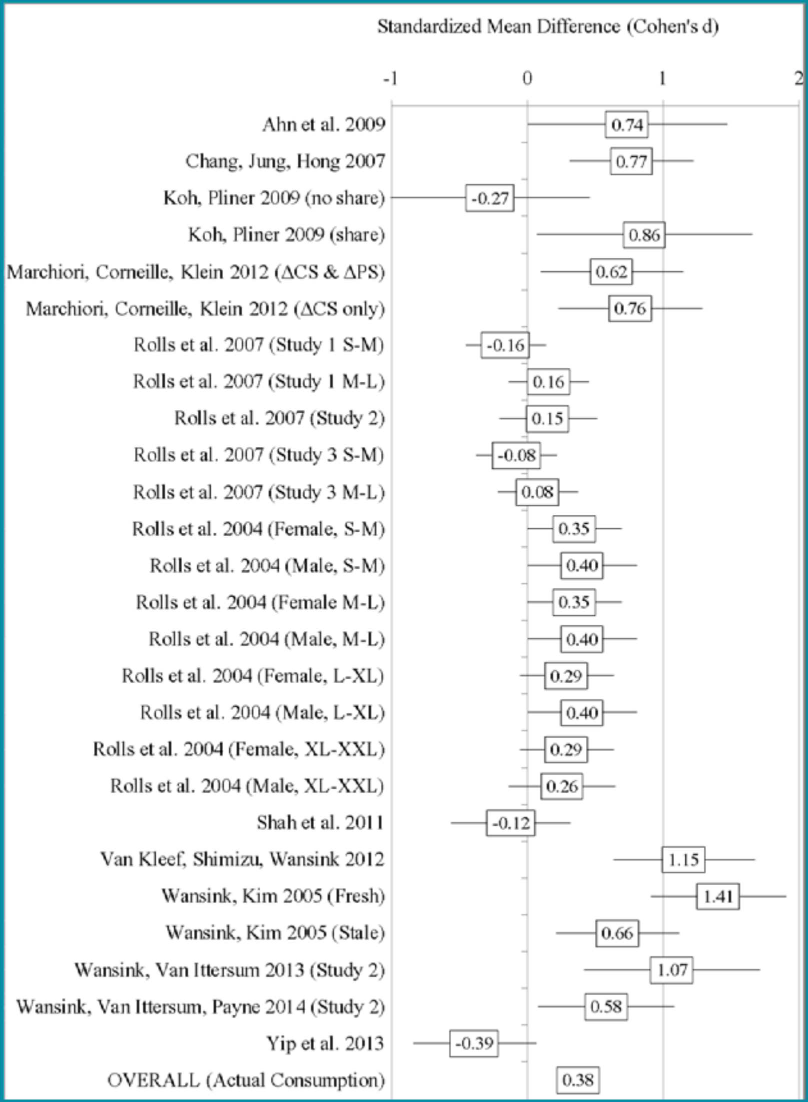
- Does container (plate, bowl, box, etc) influence the amount you eat?
- Results vary wildly from massively (in marketing) to not at all (in nutrition).
- So who is right?

JACR PAPER

- Meta Analysis of Bowl and Plate sizes
- Very interesting findings
  - Some studies (mainly by nutritionists) show zero effects
  - Other studies (mainly by marketers) show HUGE effects
- Aside from the discipline, only other difference is awareness of who is watching
  - Marketing studies all between subjects and disguised or surreptitious
  - Nutrition studies all within subjects and fully aware of st

DISAMBIGUATION OF THE DATA

- Like the portion size literature, this literature is also a mess
- Manipulations can be:
  - Container volume
  - Container diameter
  - Container height
  - Plate diameter
  - Plate area
    - Effective surface area (excluding outer ring)
    - Total area (including outer ring)
  - Worse still, sometimes include changes in portion size confounded with these manipulations
  - And the list goes on



AFTER SIFTING THROUGH ALL THAT

YES, VIRGINIA, THERE IS A PLATE EFFECT!

- But it sure is messy!

		Actual Consumption	Intended Consumption
Consumption Container	Area	13% R^2 = .22, p = .22 (k = 10)	41% R^2 = .36, p = .08 (k = 7)
	Volume	51% R^2 = .94, p <.001 (k = 15)	56% R^2 = .65, p =.007 (k = 10)
Serving Container	Area	(k=0)	(k=0)
	Volume	(k=1)	27% R^2 = .62, p =.001 (k = 12)
OVERALL		48% R^2 = .83, p <.001 (k = 26)	38% R^2 = .49, p <.001 (k = 26)

DEAKIN UNIVERSITY AUSTRALIA Worldly

WHY IS IT SO MESSY?

- Because people are lousy at estimating area and worse at estimating volume!
- Many papers have shown this
  - Chandon and Ordabayeva (2009); Ordabayeva and Chandon (2013)
- Our paper supports these observations
  - But also suggests also that once we know someone is watching we change our habits completely!

DEAKIN UNIVERSITY AUSTRALIA Worldly

SUMMARY

- Meta analysis is a good tool to extract meaning from multiple sources of data
- There is a lot of subjectivity in the process
- Choices along the way can greatly influence the final result
- Worse still, final result may be mathematically questionable due to reasons to be discussed later today
- Still, if you can do one, it’s a fabulous way to pull together results
- In marketing alone, there have been 22 meta analyses just in the Journal of Marketing (or top A**) in the past 5 years.

DEAKIN
UNIVERSITY AUSTRALIA
Worldly

QUESTIONS?

DEAKIN
UNIVERSITY AUSTRALIA
Worldly