Meta-Analytic Visualizations

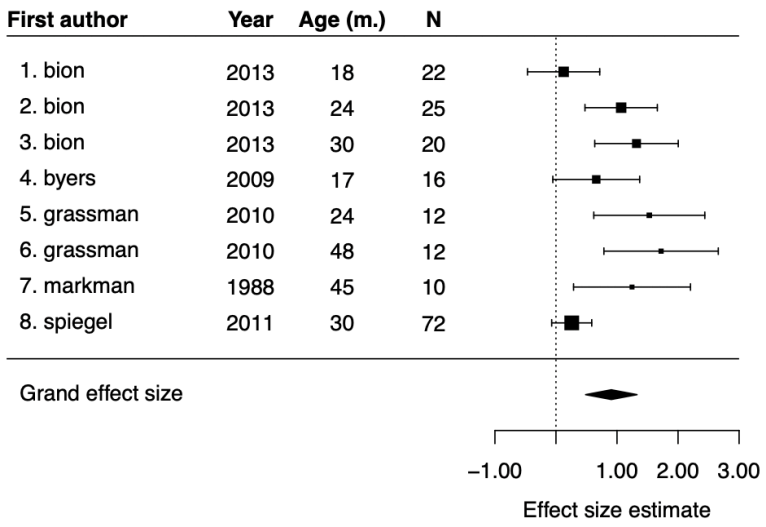
8 November 2021

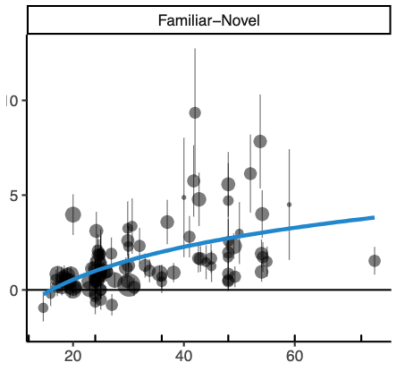
Modern Research Methods

Logistics

- Group meetings today and tomorrow
- A7 due Friday (11/12) - literature search
- A8 due the following Thursday (11/18) - coding data from papers you found)
- Draft of poster due Tuesday before Thanksgiving (11/23)
- Will be in-person poster session with other research methods classes (12/2; still working out details)
- Poster awards will be given

Conducting a Meta-analysis

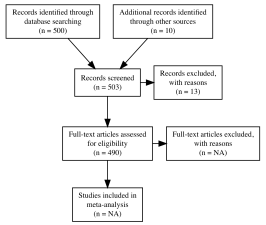


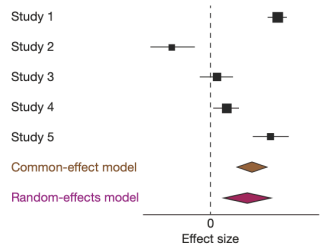


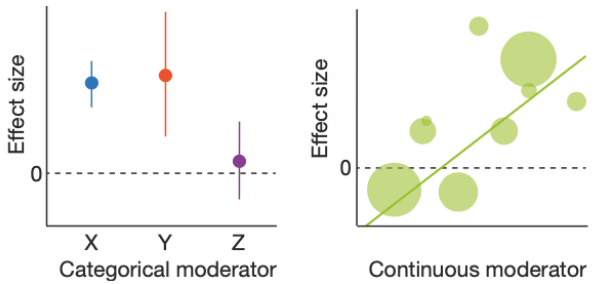
1. Identify topic
2. Conduct literature search
3. Code studies and calculate ES
4. Plot and analyze data
5. Report and discuss results

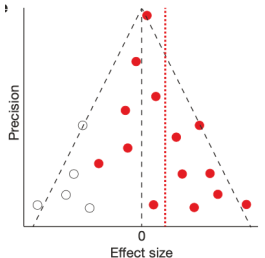
Four meta-analytic visualizations

1. PRISMA flow diagram
2. Forest plot
3. Moderator plots
4. Funnel plot

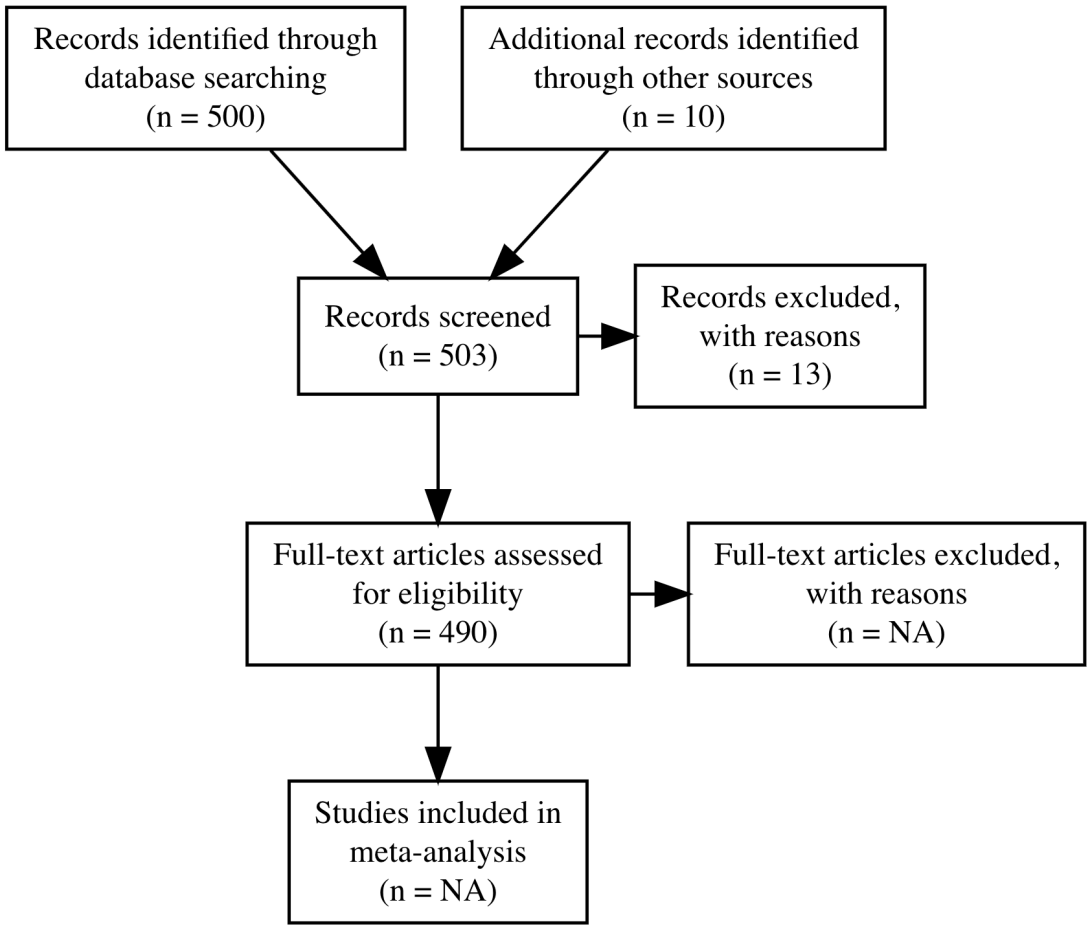








PRISMA flow diagram

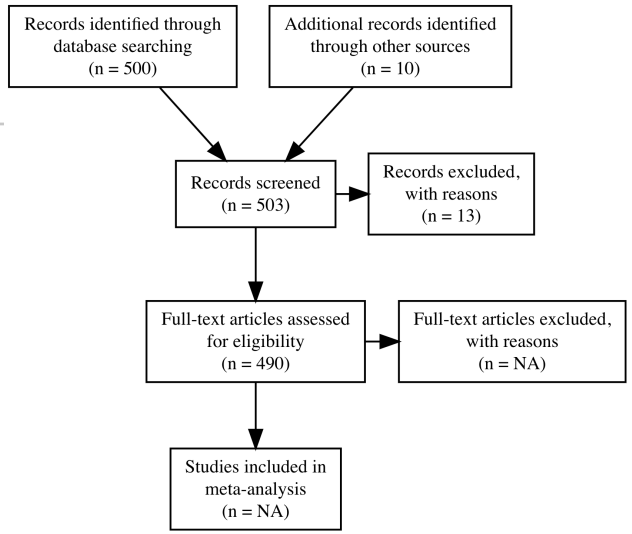


- Questions addressed:
  - What is the scope of the literature on topic X?
  - What was your method for identifying papers for a meta-analysis on topic X?
- Standardized diagram for reporting paper selection process for meta-analytic review
- Describes 4 stages: Identification, Screening, Eligibility, Excluded

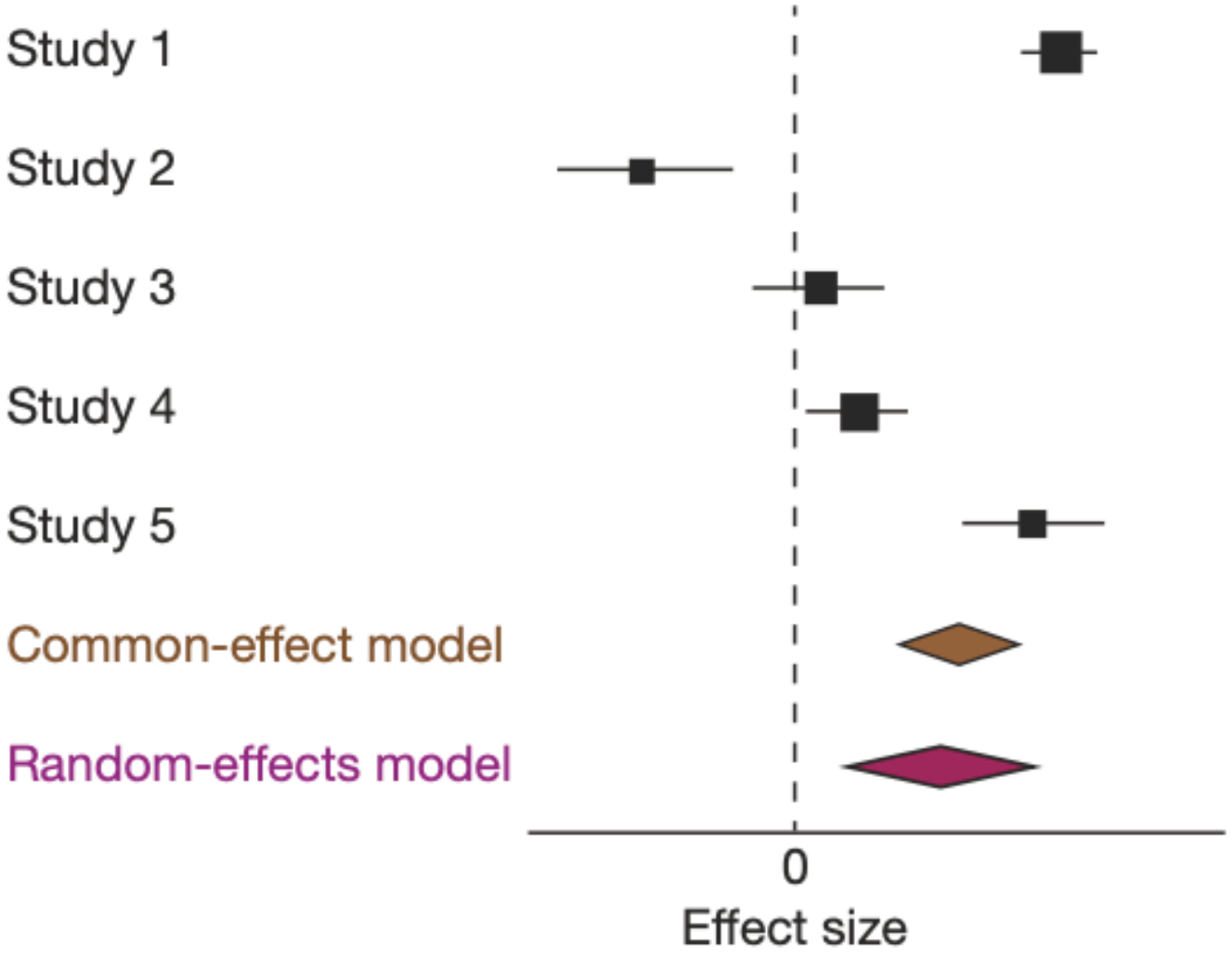
Making your own PRISMA diagram

```
my_prisma_plot <- prisma2(found = 500, # how many unique papers did you find through database searches (goo
        found_other = 10,  # how many papers did you find through other sources?
        screened = 503, # how many of those papers did you screen by looking at the title/abstract?
        screen_exclusions = 400, # how many of those papers that you screened did you exclude?
        full_text = 103, # how many papers did you look at the full text for?
        full_text_exclusions = NA, # how many papers did you exclude after looking at the ful text?
        quantitative = NA, # how many papers went in your final meta-analysis
        width = 800, height = 800)

my_prisma_plot
```



Forest Plots



- Point = study
- Size of square = weight
- Length ‘arms’ = individual confidence intervals (uncertainty)
- Diamond = weighted mean
- Dashed line = ES of 0
- If diamond overlap with dashed line the overall effect sizes does not differ from zero

(Text adapted from slide from A. Cristia; Fig. from Gurevitch et al, 2018)

Forest Plots: Questions addressed

1. What is the overall effect size for phenomenon X?
   - Because this estimate reflects data from many more participants than a single study, it should be more accurate than the effect size from a single study.
   - How big is this effect relative to other effects in psychology?

2. Does the effect significantly differ from zero?
   - If it does not, this suggests there may be no effect (even though individual studies may show an effect).

3. How much variability is there?
   - Are the effects of individual studies roughly the same, or is there a lot of variability?
   - If there's a lot of variability, this suggests there might be an important moderator

ma_data for mutual exclusivity MA

We'll calculate these two columns once you have all the raw data entered for your MA

Effect size

Variance of effect size

study_ID	short_cite	expt_num	n	d_calc	d_var_calc	mean_age	response_mode
bedford2013	Beford et al (2013)	1	31	4.0000000	0.2903226	748.7471	behavior
bedford2013	Beford et al (2013)	1	31	3.0000000	0.1774194	739.6161	behavior
beverly2003	Beverly & Estis (2003)	1	5	2.5862069	0.8688466	1765.3390	behavior
beverly2003	Beverly & Estis (2003)	1	5	4.5000000	2.2250000	1795.7760	behavior
beverly2003	Beverly & Estis (2003)	1	5	4.8780488	2.5795360	1217.4750	behavior
bion2013	Bion, Borovsky, & Fernald (2013)	2	22	0.1428571	0.0459184	547.5600	eye-tracking
bion2013	Bion, Borovsky, & Fernald (2013)	2	25	1.1538462	0.0666272	730.0800	eye-tracking
bion2013	Bion, Borovsky, & Fernald (2013)	2	20	1.2857143	0.0913265	912.6000	eye-tracking
byers2009	Byers-Heinlein & Werker (2009)	1	16	0.4210526	0.0680402	517.4270	eye-tracking
byers2009	Byers-Heinlein & Werker (2009)	1	16	-0.1250000	0.0629883	547.8638	eye-tracking

N = 50 effect sizes

Making your own forest plot

- To make a forest plot, we need to calculate the grand mean (pooled effect size estimate)
- To do that, we use a package called *metafor* in R
- The rma() function fits a model that estimates the grand mean effect size taking into account study size
- It's actually a random effect model – happy to talk more about the details offline
- The syntax:

```
model <- rma(effect_size, effect_size_variances)
```

Fitting the meta-analytic model

study_ID	short_cite	expt_num	n	d_calc	d_var_calc	mean_age	response_mode
bedford2013	Beford et al (2013)	1	31	4.0000000	0.2903226	748.7471	behavior
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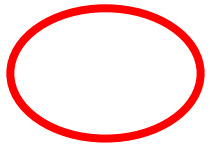
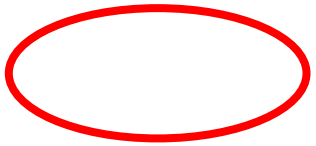
```
ma_model <- rma(ma_data$d_calc, ma_data$d_var_calc)

ma_model
```

Is the grand effect size significantly different from zero?

Grand meta-analytic effect size



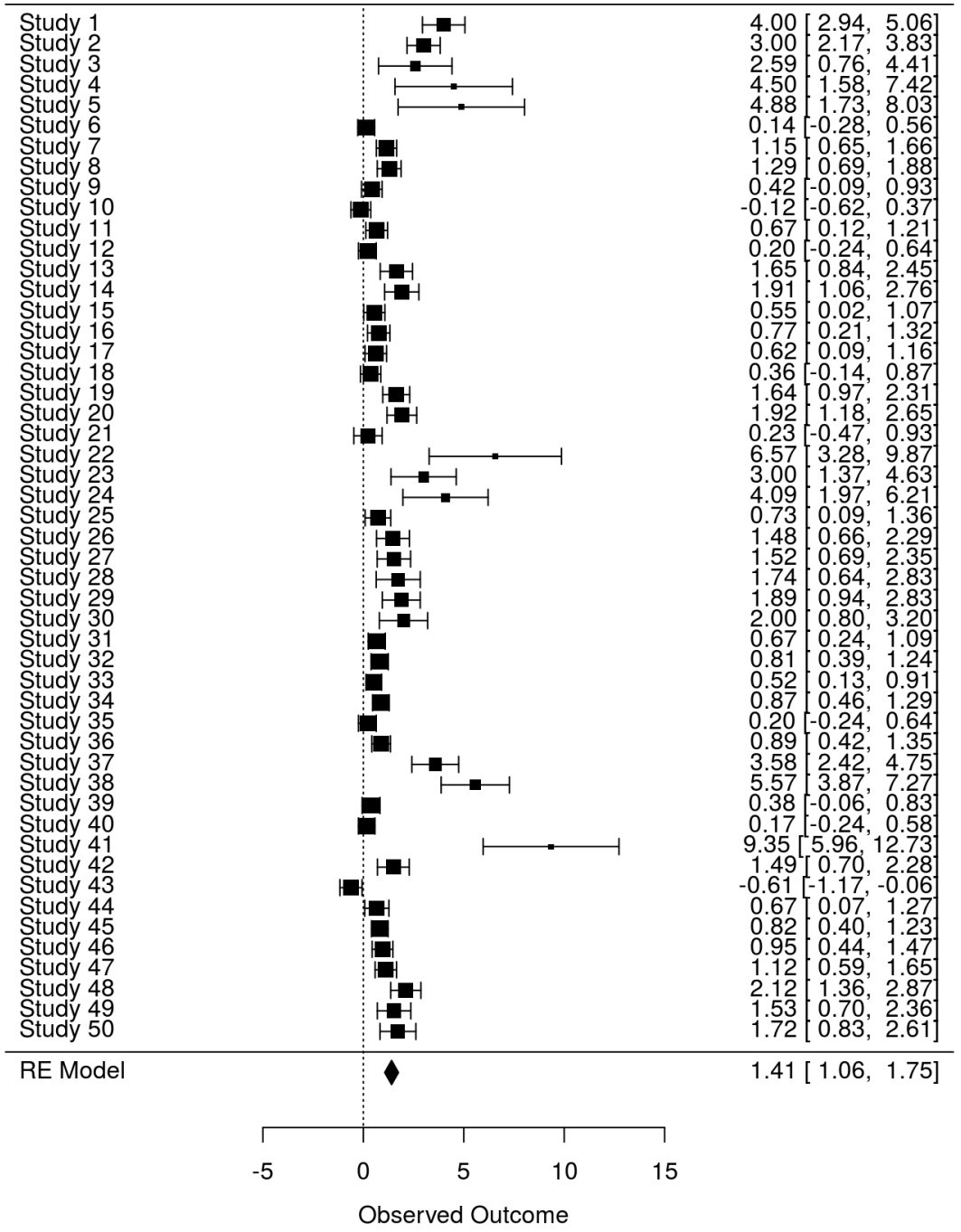


Grand meta-analytic effect size confidence interval

Making the forest plot

Use a function in metafor to make forest plot (unfortunately there doesn't exist a good forest plot ggplot function (yet!))

```
forest(ma_model)
```

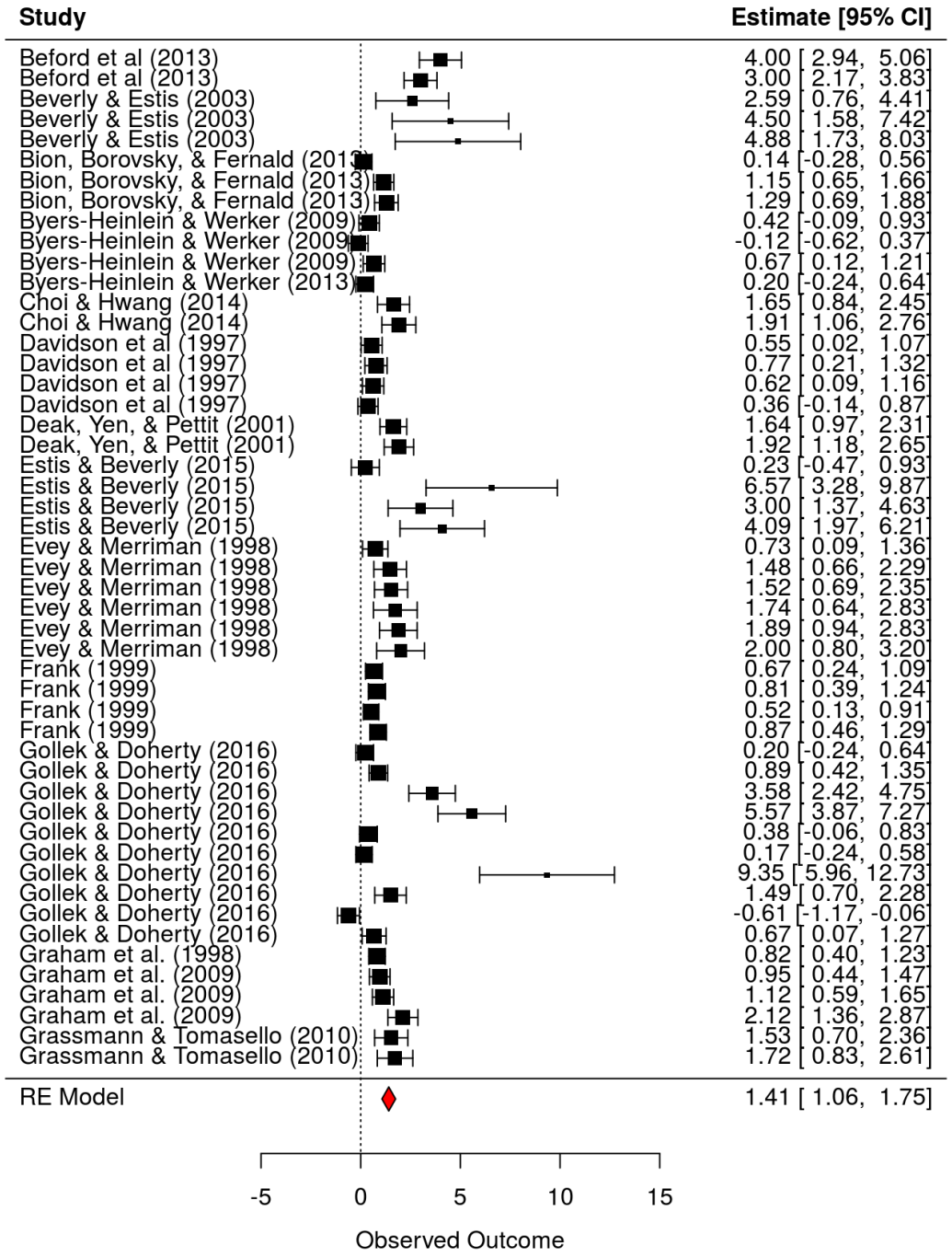


Making a better forest plot

```
forest(ma_model,
       header = T,
       slab = ma_data$short_cite,
       col = "red")
```

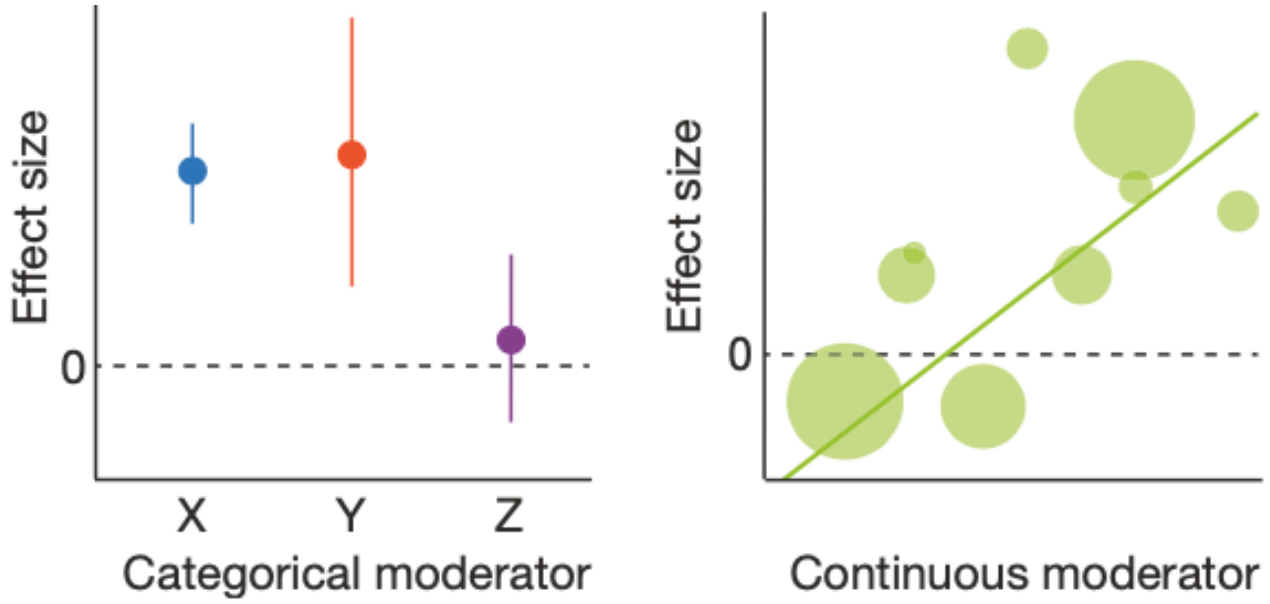
There are lots of modifications you can make to this plot to make it more informative.

You can see all the options here: https://www.rdocumentation.org/packages/metafor/versions/2.4-0/topics/forest.rma.



Moderator plots

- Question addressed: Does the effect size vary by different features of the experiment?
- Two kinds of moderators: Categorical and Continuous



(Fig. from Gurevitch et al, 2018)

ma_data for mutual exclusivity MA

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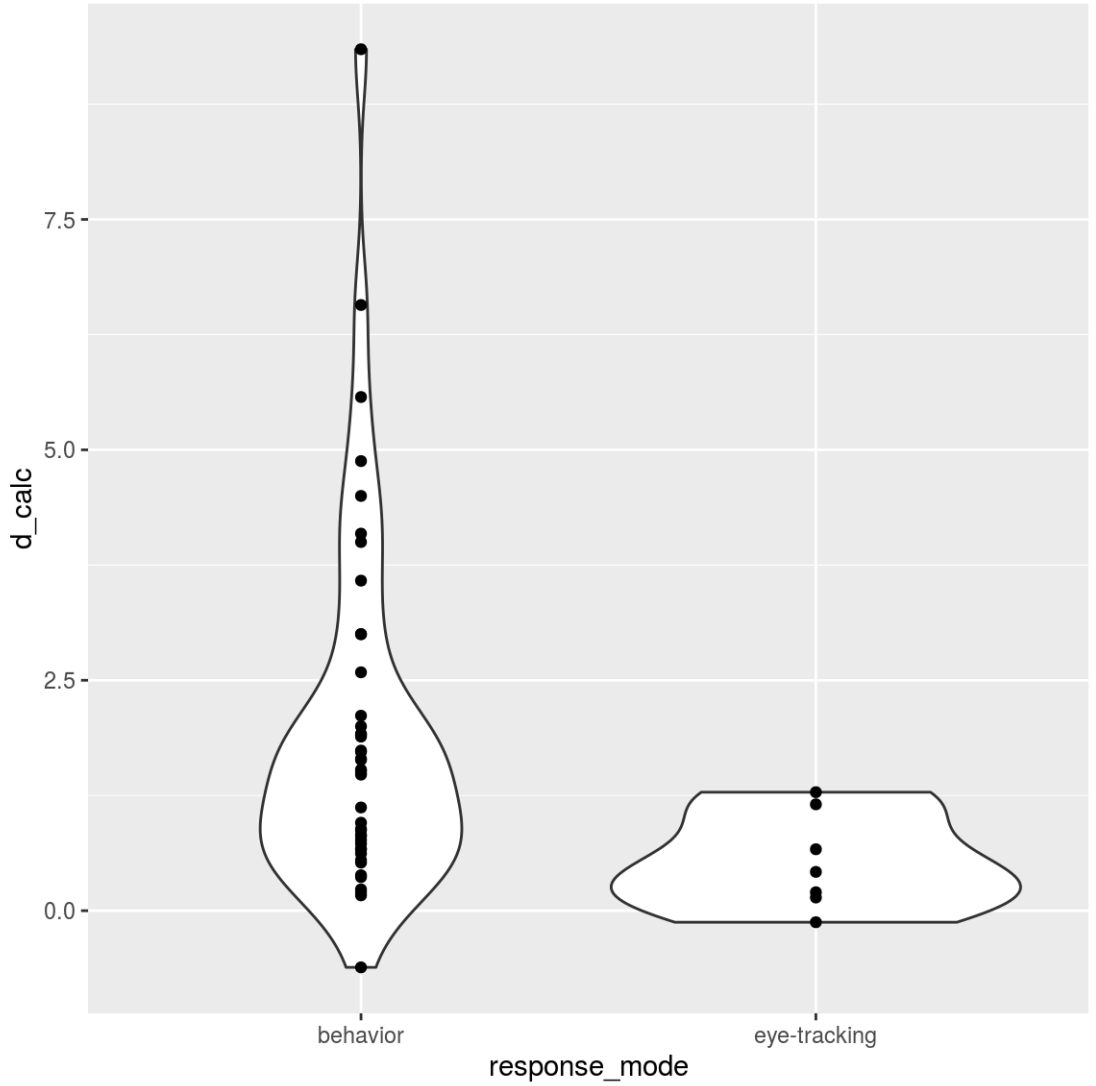
N = 50 effect sizes

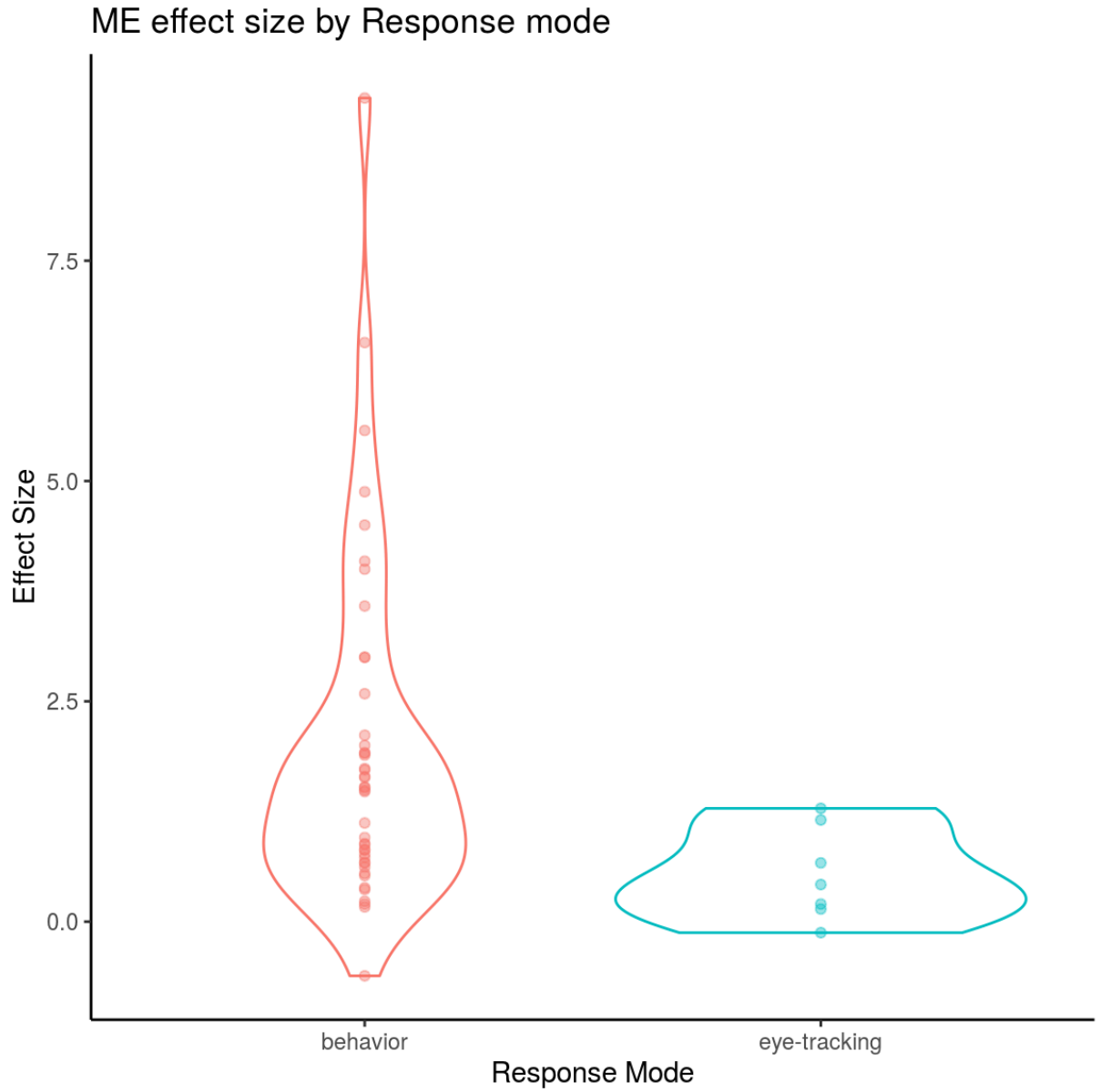
Making a categorical moderator plot

```
ggplot(ma_data, aes(x = response_mode, y = d_calc)) +
  geom_violin() +
  geom_point()
```



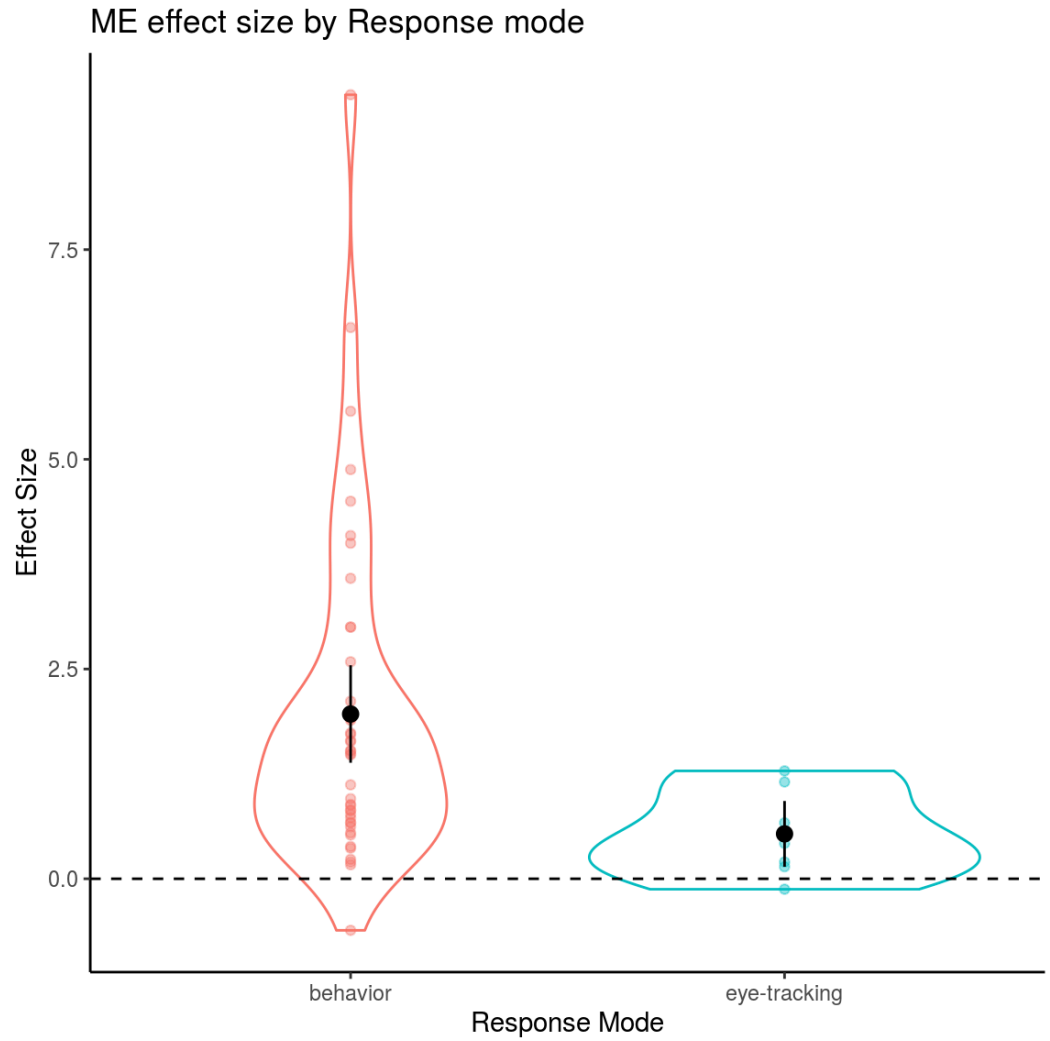
Making a better categorical moderator plot

```
ggplot(ma_data, aes(x = response_mode,
                    y = d_calc,
                    color = response_mode)) +
  geom_violin() +
  geom_point(alpha = .4)  +
  ylab("Effect Size") +
  xlab("Response Mode") +
  ggtitle("ME effect size by Response mode") +
  theme_classic() +
  theme(legend.position = "none")
```



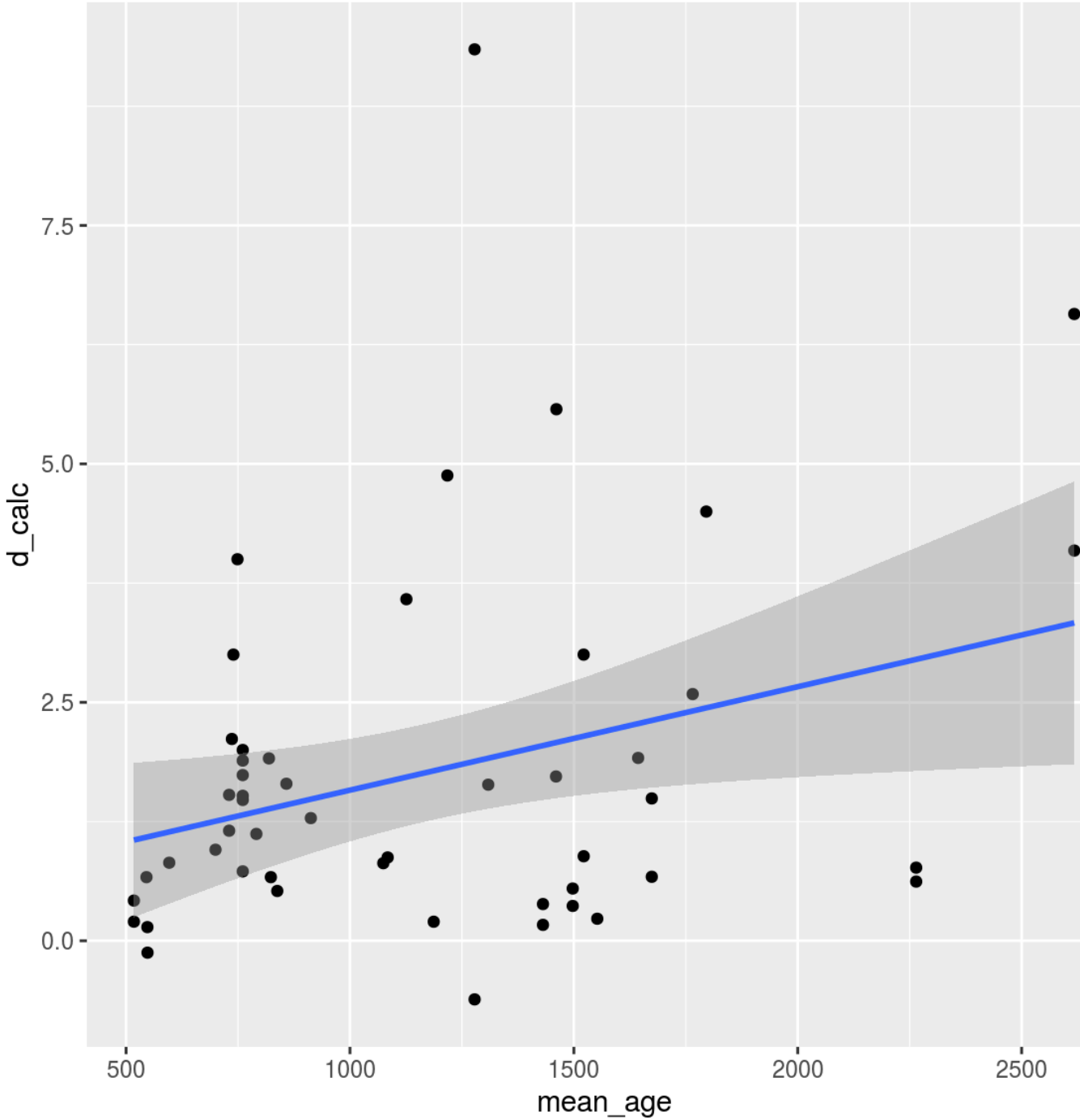
```r
cis_by_response_mode <- ma_data %>%
    group_by(response_mode) %>%
    summarize(mean = mean(d_calc),
              sd = sd(d_calc),
              n = n()) %>%
    mutate(ci_range_95 =  1.96 * (sd/sqrt(n)),
           ci_lower = mean - ci_range_95,
           ci_upper = mean + ci_range_95)
```

```r
ggplot(ma_data, aes(x = response_mode,
                    y = d_calc,
                    color = response_mode)) +
  geom_violin() +
  geom_point(alpha = .4)  +
  ylab("Effect Size") +
  xlab("Response Mode") +
  ggtitle("ME effect size by Response mode") +
  geom_pointrange(data = cis_by_response_mode,
                  aes(x = response_mode,
                      y = mean, ymin = ci_lower,
                      ymax = ci_upper),
                  color = "black") +
  geom_hline(aes(yintercept = 0), linetype = 2) +
  theme_classic() +
  theme(legend.position = "none")
```



Making a continuous moderator plot

```
ggplot(ma_data, aes(x = mean_age, y = d_calc)) +
  geom_point() +
  geom_smooth(method = "lm")
```



Making a better continuous moderator plot

```
ma_data_for_age_plot <- ma_data %>%
  mutate(age_months = mean_age/30.4)
```

```
ggplot(ma_data_for_age_plot, aes(x = age_months,
                                 y = d_calc,
                                 size = n)) +
  geom_point() +
  geom_smooth(method = "lm") +
  ylab("Effect Size") +
  xlab("Age (months)") +
  ggtitle("ME effect size vs. Age") +
  theme_classic() +
  theme(legend.position = "none")
```