Assignment 5

- Code and data can be found at: JanCoUnchained
- Branch: Master

Task 1

Preprocessing

We started out with a data frame containing the metadata for 55 experiments studying pitch in schizophrenics. After excluding the purely qualitative studies, as well as the quantitative studies that lacked any observations, we were left with 18 studies to conduct our meta-analysis.

Because most of the studies only contained quantitative data on either pitch mean or pitch sd (standard deviation), this meant 5 studies for pitch mean and 14 for pitch sd. We used the escalc function (metafor package) to compute effect size measured by cohen's d (yi) and standard error (vi) for both pitch mean & pitch standard deviation. These were appended to the original data frame. We called this data frame 'meta'.

We need these values in the analysis since our models will be using studies to predict effect size and the studies will be weighted according to their standard error. Next we split meta up into two data frames: one of which contained the studies which had data on effect of mean pitch, and one of which contained studies which had data on effect of standard deviation of pitch.

We de-selected some variables while creating these new data frames. The two data frames will be used to conduct two parallel analyses of the two different predictors.

Meta-Analysis

Analysis pipeline

We started by creating a mixed effects model in which the studies predict effect size of mean:

```
lmer(yi ~ 1 + (1|StudyID), weights = 1/vi, data..)
```

From now we will not comment upon lmer() models as we will be sticking with rma(). This function from metafor allows us to easily make forest plots as well as using the confint() function:

```
rma(yi, vi, data, slab = StudyID)
```

The rma()-function will take this form throughout the different analyses, and thus we will not be highlighting it again. The 'slab' argument is where the random effects are put in.

We previously specified slab = Article because this made the plot more interpretable. However, the issue with this approach was that Article doesn't actually correspond to StudyID (as we had erroneously thought).

StudyID is a better random effect because it gives same studies the same intercept. The random intercept takes into account the fact that different studies might be examining heterogeneous populations (whereas the same study shouldn't).

StudyID is the same as ArticleID in that it is always the case that when StudyID's are the same ArticleID's are also the same. ArticleID would thus have been an equally good random effect.

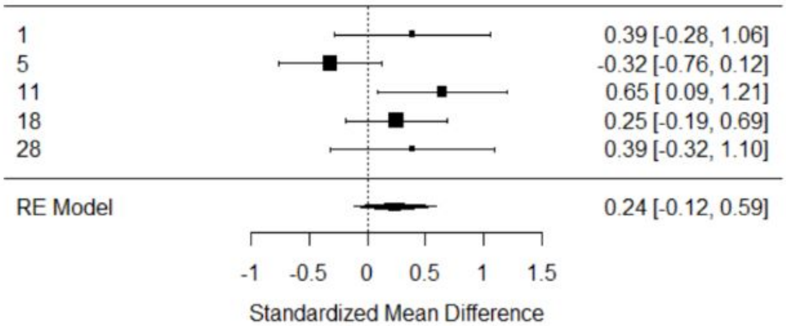
We tested the statistical significance of our values for Cochran's Q to access heterogeneity in the studies. However, as our sample of studies is small *(n<20)*, the p-values should be considered with caution as Q values can be quite underpowered for small sample sizes.

Results for mean of pitch

The overall estimate (Cohen's d) of pitch mean between the schizophrenics and the healthy controls across the studies was 0.235, SE = 0.181, p > .05, rendering the difference between groups non-significant.

The studies did not show significant heterogeneity, Q(df = 4) = 8.3757, p > .05.

Figure 25: Forest Plot for mean of pitch

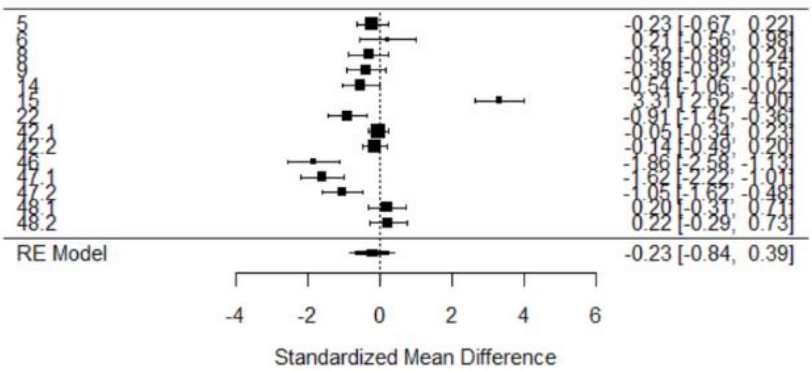


Results for mean of standard deviation

The overall estimate (Cohen's d) of mean pitch variability between the schizophrenics and the healthy controls across the studies was -0.229, SE = 0.314, p > .05, rendering the difference between groups non-significant.

The studies showed significant heterogeneity Q(df = 13) = 164.2886, p < .0001. It is slightly suspicious that the new random effect (slab) 'StudyID' does not change the estimates here (even to the last decimal point).

Figure 26: Forest Plot for standard deviation of pitch



Assessing Quality

The forest plot for mean pitch variability showed one big outlier. We decided to check whether this study and/or any of the other studies had a big influence on the estimates of the meta-analysis.

For this we used influence() from the metafor package.

This showed that the study by Cohen et al. (2014) had a Cook's D = 0.6224; the study disproportionately influenced our estimates of heterogeneity in the effect sizes, and we decided to investigate this study further.

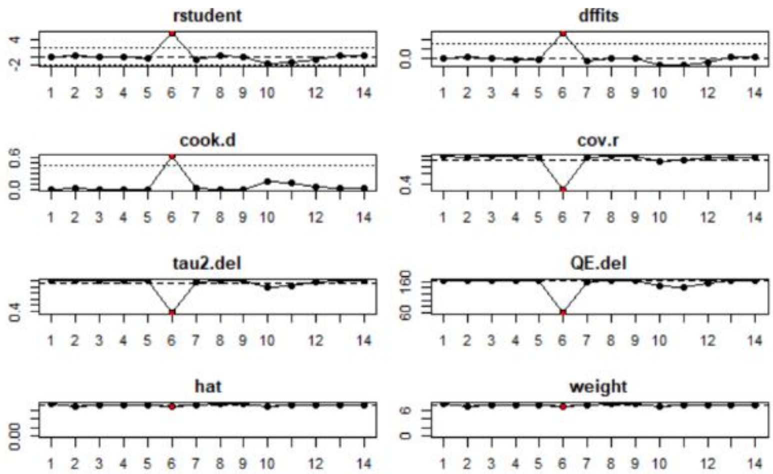
After reading Cohen et al. (2014), we concluded the following: What the rest of the studies refer to as the standard deviation of f0, Cohen et al. refers to as “global intonation”, the standard deviation of local intonation, which is the standard deviation of each utterance.

Based on their description:

local intonation – average standard deviation of fundamental frequency values computed separately for each utterance, global intonation – standard deviation of local intonation values across the speech sample”.

The underlying effect measured in the study differed substantially from the rest of our studies, and on those grounds we decided to exclude it from our analysis. Below you can see Cohen’s influence (Cohen = study 6).

Figure 27: Forest Plot for standard deviation of pitch

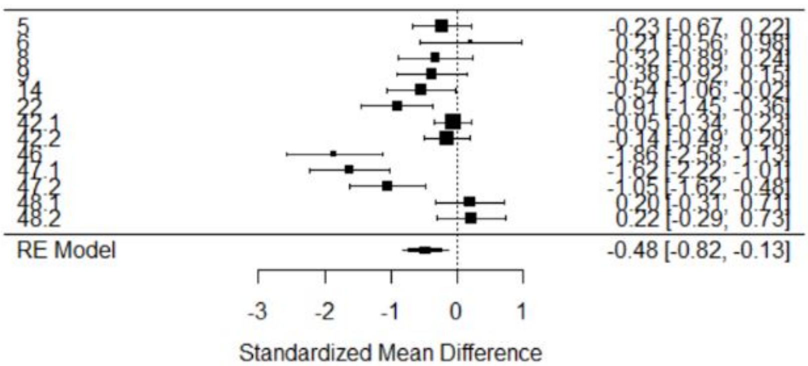


Results for mean of SD excluding Cohen et al. (2014)

After excluding Cohen, the overall estimate (Cohen’s d) of mean pitch variability (sd) between the schizophrenics and the healthy controls across the studies was -0.476, SE = 0.177, p < .01, rendering the difference between groups significant.

The studies still showed significant heterogeneity Q(df = 12) = 60.983 , p < .0001. Notice however that the Q estimate has dropped by over 100 (164.2886 to 60.983).

Figure 28: Forest plot for mean of SD, excluding Cohen et al. (2014)



Current evidence for distinctive patterns in mean pitch & SD

Before excluding Cohen et al. (2014) from the used studies, there were no significant results of either pitch mean or pitch sd. After excluding Cohen et al. (2014) pitch SD became significant with a Cohen's D = -0.48, a medium effect size. The conclusion here is that schizophrenics on average have significantly less pitch variability than healthy controls.

Task 2

Adding our own study

The data from assignment 3 (pt. 1) was loaded into the environment as 'schizo_data'.

Mean effect of pitch & sd

We previously created a mixed effect model to predict data. However, this approach had a conceptual issue.

The issue being that the mixed effect model pooled the estimates from the three different studies (or runs of the study). The meta-analysis (using a mixed effects model) pools the estimates of all the studies, and it is conceptually wrong to pool our studies towards their mean before they enter the meta-analysis.

In essence we pooled twice in our previous analysis.

Now we simply group the data by study and diagnosis and summarise the values that we need (mean of mean, mean of standard deviation, standard deviation of mean, standard deviation of standard deviation and n of participants). The same estimates (or summarised values) would be produced had we used six fixed effects models (one for each study and predictor) with only one predictor:

```
lm(sd ~ diagnosis, data = study_n) lm(mean ~ diagnosis, data = study_n)
```

The `escalc()` function needs both the estimates of mean and standard deviation, as well as their respective standard deviations to compute effect size (yi) and standard error (vi).Having obtained these values we computed these values and combined the data with the studies from the previous meta-analysis (including Cohen).

We created a column called StudyID where we (crucially) gave these three the same value. This means that they will receive the same random intercept being from the same study (or at least author, Riccardo).

Analysis with our data

Results for mean of pitch

The overall estimate (Cohen's d) of mean of pitch between the schizophrenics and the healthy controls across the studies was 0.183, SE = 0.127, $p > .05$, rendering the difference between groups non-significant.

The studies did not show significant heterogeneity Q(df = 7) = 11.2139, $p > .05$.

Results for mean of SD

The overall estimate (Cohen's d) of mean pitch variability between the schizophrenics and the healthy controls across the studies was -0.222, SE = 0.256, $p > .05$, rendering the difference non-significant. The studies showed significant heterogeneity Q(df = 16) = 165.667, $p < .0001$.

Figure 29: Forest Plot for mean of pitch

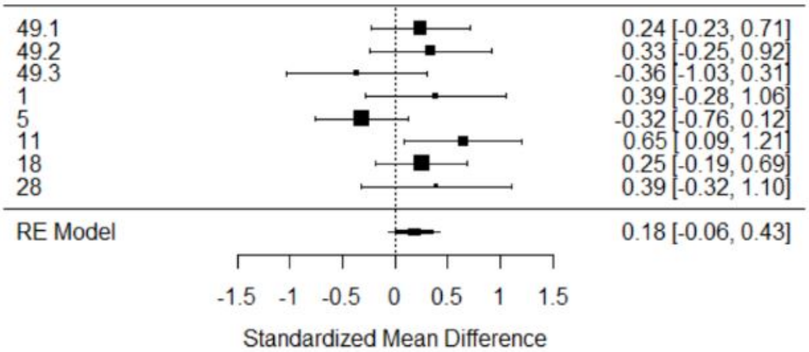
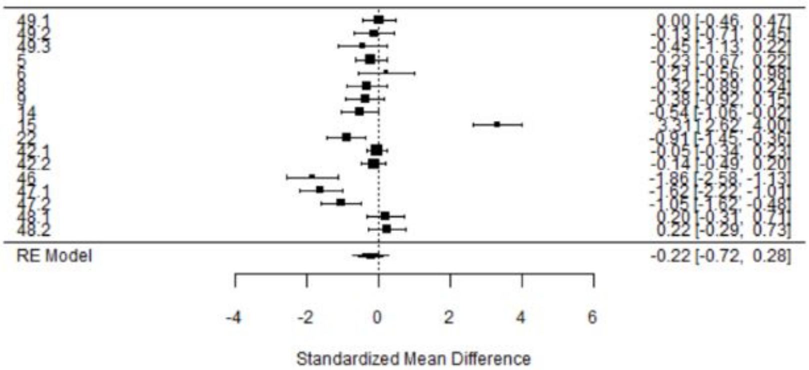


Figure 30: Forest Plot for standard deviation of pitch



Results for mean of SD excluding Cohen et al. (2014)

The overall estimate (Cohen's d) of mean pitch variability between the schizophrenics and the healthy controls across the studies was -0.419, SE = 0.146, $p < .01$, rendering the difference significant.

The studies showed significant heterogeneity Q(df = 15) = 67.796, $p < .0001$.

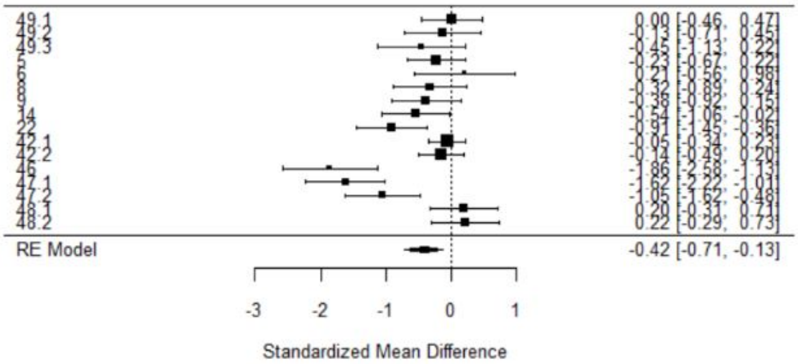
The estimate is slightly more conservative than the one obtained without the inclusion of JanCo et al. (3000) studies (which was -0.476). However, the estimate has a smaller SE than the 0.177 obtained without JanCo et al. (3000) studies. Thus, this more conservative estimate of the true effect is probably more accurate.

Task 3

The state of the literature depends greatly upon which studies are included as being part of it. We don't believe that there is any good reason to exclude our own studies. In this section we will be considering the literature with and without the inclusion of Cohen et al. (2014).

First, let's consider the full literature (with our study & Cohen). As we saw earlier there was significant heterogeneity in the literature on standard deviation of pitch, but not concerning mean of pitch.

Figure 31: Forest Plot for mean of standard deviation, excluding Cohen et al. (2014)

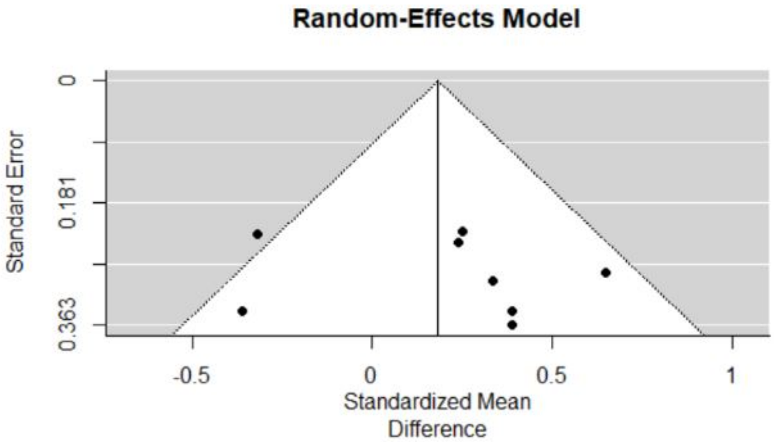


Heterogeneity of means

Overall variance (t2) of 0.049 (95% CIs: 0.00 0.43). Some of the variance (I2: 38.36%, 95% CIs: 0.00–84.86) could be reduced to random sample variability between studies (Q = 11.2139, p-val = 0.1296).

In order to access publication bias, we plotted the data on funnel plots (figure X).

Figure 32: Funnel plot for means



Overall the plot does not look too bad. It does appear like there might be some missing studies with a standardized mean difference around (and slightly below) 0.

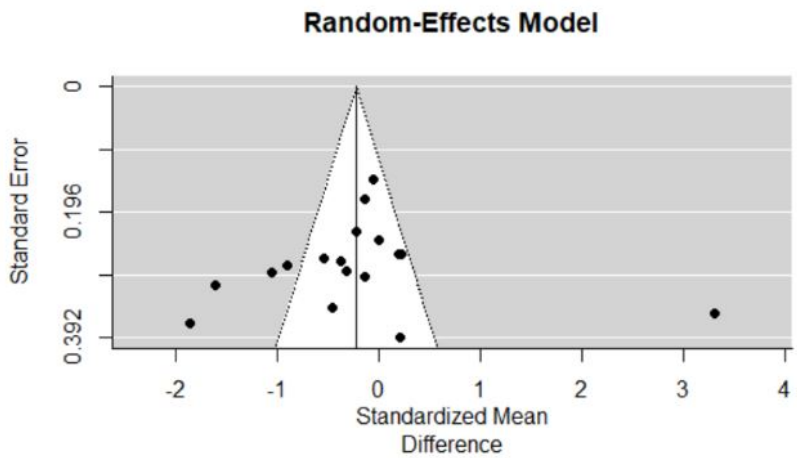
Heterogeneity of standard deviations

Overall variance (t2) of 1.035 (95% CIs: 0.54 2.64). Almost none of the variance (I2: 94%, 95% CIs: 89.15–97.56) could be reduced to random sample variability between studies and should thus be attributed to actual heterogeneity (Q = 165.67, p < 0.0001).

The funnel plot of sd looks like this:

This funnel plot is difficult to interpret because so many studies fall outside of the “funnel”. The positive outlier is Cohen et al. (2014), but there are also some negative outliers. Overall, it does not look balanced which is reflected in the fact that the literature of sd of pitch is significantly heterogeneous.

Figure 33: Funnel plot for standard deviation

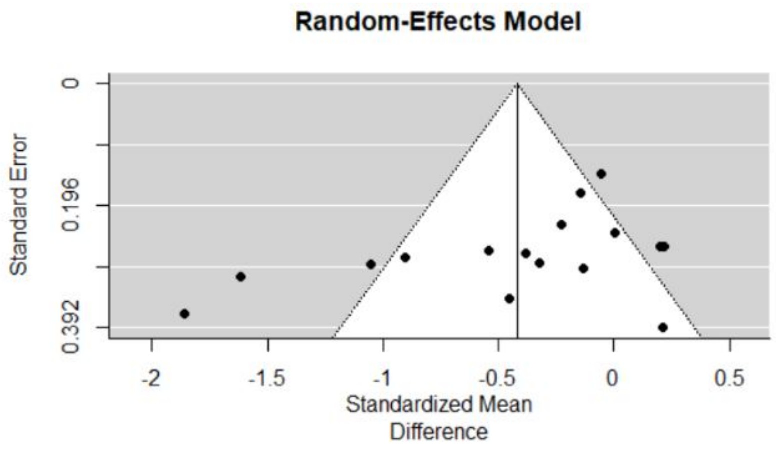


Heterogeneity of standard deviations excluding Cohen et al. (2014)

Overall variance (t2) of 0.27 (95% CIs: 0.11 - 0.83). Almost none of the variance (I2: 80.57%, 95% CIs: 63.95 92.83) could be reduced to random sample variability between studies and should thus be attributed to actual heterogeneity (Q = 63.5225, p-val < 0.0001).

The funnel plot looks like this:

Figure 34: Funnel plot for standard deviation, excluding Cohen et al. (2014)



The funnel plot is still (without Cohen) difficult to interpret as many values fall outside of the "funnel".

It does look like there are a couple of studies finding very significant negative scores which are outside of what the literature should contain (based on the other studies). These might be surveying another effect or another population than the rest of the studies.

Discussion

Excluding Cohen et al. (2014) does not change the assessment of the literature on mean of pitch as Cohen et al. (2014) only surveys standard deviation of pitch. However, even with the exclusion of Cohen et al. (2014) the heterogeneity in the literature concerning SD is still significant as shown earlier.

However, the funnel plot indicates that there is publication bias in the literature. There are low-powered studies (high SE) lacking which find a positive effect as well as high-powered studies (low SE) lacking which find an effect stronger than the mean of the funnel plot.

Conclusion

In conclusion, the literature on mean pitch as a predictor of schizophrenia seems more homogeneous and less biased than the literature on standard deviation. The main conclusions from this meta-analysis were:

- Pitch mean is not a significant predictor of schizophrenia. This fact does not change whether or not JanCo studies are included. The number of studies on pitch mean is way smaller than on pitch sd (n = 8 vs. n = 17), and more studies might help us better understand whether pitch mean actually contains different patterns between schizophrenics and healthy controls.
- The second emerging pattern is that whenever Cohen et al. (2014) is included in the literature pitch sd seizes to be significant. As we have surveyed Cohen (2014) differs enormously from the rest of the literature. We do find that it is justified to exclude Cohen, however - the literature on pitch sd is still very heterogeneous.
- The meta analysis without Cohen (and with JanCo studies, or Riccardo studies…) supports the claim that SD is a significant predictor of schizophrenia, and that schizophrenics on average have a lower mean pitch (effect size -0.419) compared to healthy controls. There is still the caveat that the studies showed significant heterogeneity.

Assessment	Pitch mean effect size & p-value	Pitch Sd effect size & p-value
Literature without JanCo	Cohen's D = 0.235, p>.05	Cohen's D = -0.229, p>.05
Without Cohen	-//-	Cohen's D = -0.476, p<.01
With JanCo & Cohen	Cohen's D = 0.183, p > .05	Cohen's D = -0.22, p > .05
with JanCo & without Cohen	-//-	Cohen's D = -0.419, p < .01

List of Figures

References

Coco, Moreno I., and Rick with contribution Dale. 2018. https://CRAN.R-project.rg/package=crqa.

Wallentin, Mikkel. 2018. Personal Correspondence.

Figure 35: The truth of JanCoUnchained