

## Outputs inspection half CIFAR100

```
library(ggplot2)

## Warning: package 'ggplot2' was built under R version 4.0.5

library(dplyr)

## Warning: package 'dplyr' was built under R version 4.0.5

## 
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
## 
##     filter, lag

## The following objects are masked from 'package:base':
## 
##     intersect, setdiff, setequal, union

library(tidyr)

## Warning: package 'tidyr' was built under R version 4.0.5

library("ggpubr")

## Warning: package 'ggpubr' was built under R version 4.0.5

library(LDATS)

## Warning: package 'LDATS' was built under R version 4.0.5

library(stringr)

source("utils.R")

## Warning: package 'hash' was built under R version 4.0.5

## hash-2.2.6.1 provided by Decision Patterns

## Warning: package 'reticulate' was built under R version 4.0.5
```

```

## Warning: package 'berryFunctions' was built under R version 4.0.5

##
## Attaching package: 'berryFunctions'

## The following object is masked from 'package:dplyr':
##   between

## Warning: package 'purrr' was built under R version 4.0.3

## Warning: package 'reshape2' was built under R version 4.0.3

##
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyverse':
##   smiths

```

Visualization on CIFAR100. We are using data of three neural networks trained on reduced CIFAR100 training set. Half of the CIFAR100 training set was extracted as a validation set. We then divided both the reduced training set and validation set into 5 disjoint subsets and trained an ensemble on each of them. This was done in 10 replications, each time with random split of the training set into validation and new training set. In this visualization, we are trying to inspect the outputs deeper, mainly to make sense of strange behavior of nll metric for ensemble outputs.

```

base_dir <- ".../data/data_train_val_half_c100"
repls <- 0:9
folds <- 0:4
classes <- 100

nets_outputs <- load_network_outputs(base_dir, repls)
ens_outputs <- load_ensemble_outputs(base_dir, repls, folds)
net_results <- read.csv(file.path(base_dir, "net_accuracies.csv"))
ens_results <- read.csv(file.path(base_dir, "ensemble_accuracies.csv"))

preds <- nets_outputs$test_outputs
for (ri in repls + 1)
{
  for (net_i in seq_along(nets_outputs[["networks"]]))
  {
    preds[ri, net_i, ,] <- softmax(preds[ri, net_i, , ])
  }
}
nets_test_cor_probs <- gather(preds, 1 + nets_outputs$test_labels[1, ], 3, 4)
nets_test_cor_probs <- melt(nets_test_cor_probs)
nets_test_cor_probs <- nets_test_cor_probs[, c(-3, -4)]
names(nets_test_cor_probs) <- c("replication", "network", "prediction")
nets_test_cor_probs$network <- as.factor(nets_test_cor_probs$network)
levels(nets_test_cor_probs$network) <- nets_outputs$networks

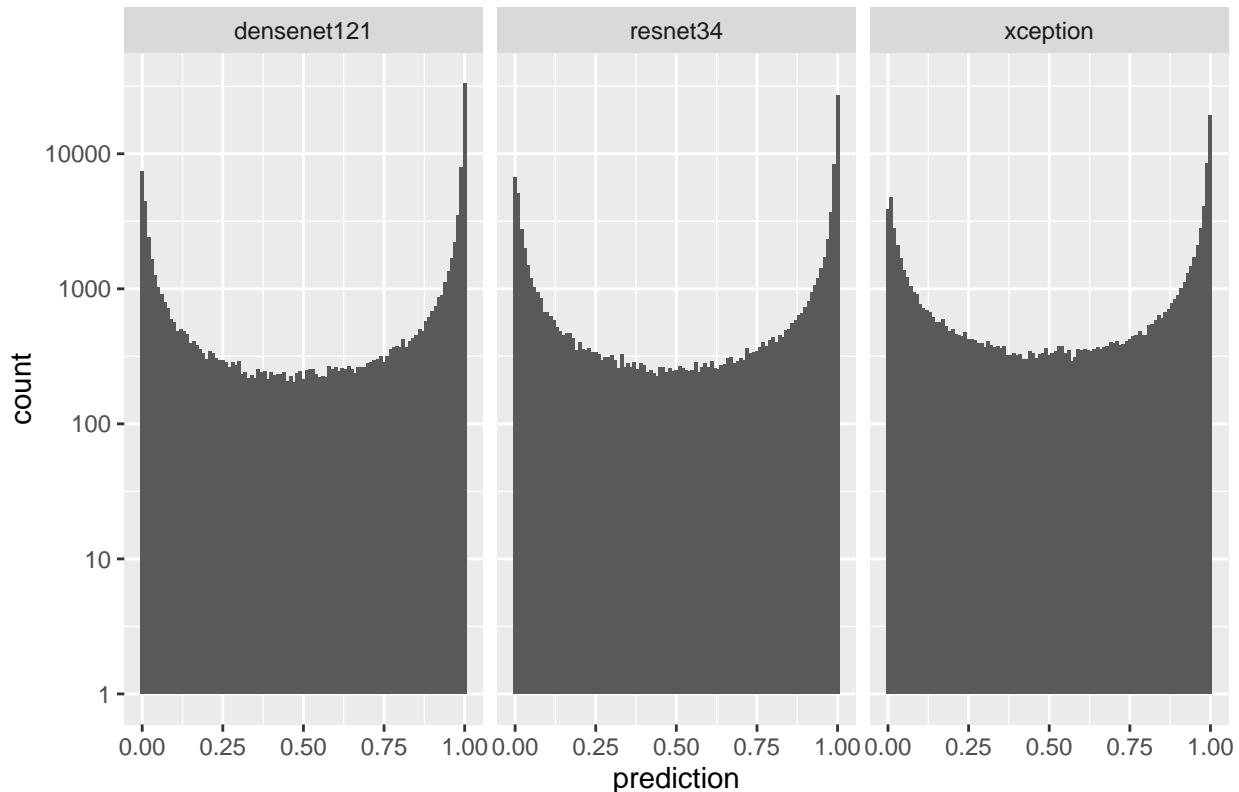
```

```

nets_cor_preds_histo <- ggplot(data=nets_test_cor_probs) + geom_histogram(mapping=aes(x=prediction), bins=100)
  ggttitle("Histograms of predicted probability for the correct class") + facet_wrap(~network) + scale_y_log()
nets_cor_preds_histo

```

Histograms of predicted probability for the correct class



```

val_ens_cor_probs <- gather(ens_outputs$val_training, 1 + nets_outputs$test_labels[1, ], 4, 5)
val_ens_cor_probs <- melt(val_ens_cor_probs)
val_ens_cor_probs <- val_ens_cor_probs[, c(-4, -5)]
names(val_ens_cor_probs) <- c("replication", "method", "fold", "prediction")
val_ens_cor_probs$method <- as.factor(val_ens_cor_probs$method)
levels(val_ens_cor_probs$method) <- ens_outputs$methods

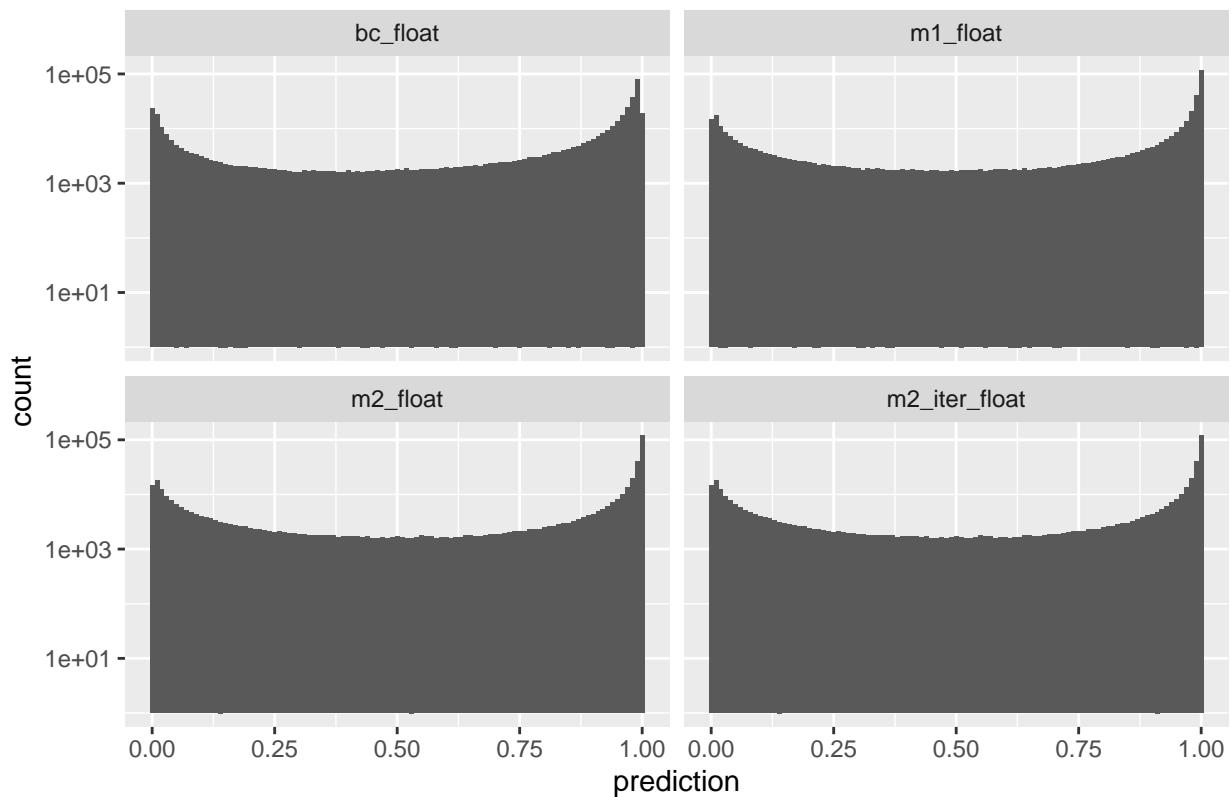
```

```

val_ens_cor_preds_histo <- ggplot(data=val_ens_cor_probs) + geom_histogram(mapping=aes(x=prediction), bins=100)
  ggttitle("Histograms of predicted probability for the correct class") + facet_wrap(~method) + scale_y_log()
val_ens_cor_preds_histo

```

## Probabilities predicted for the correct class – ens trained on val



```
val_ens_zero_counts <- ggplot(data=val_ens_cor_probs[val_ens_cor_probs$prediction <= 0, ]) + geom_hist()
```

```
## Warning: Ignoring unknown parameters: binwidth, bins, pad
```

```
val_ens_zero_counts
```

Counts of subzero probabilities predicted for the correct class by coup method  
Validation training

count

method

No method produced probabilities zero or lesser for the correct class.

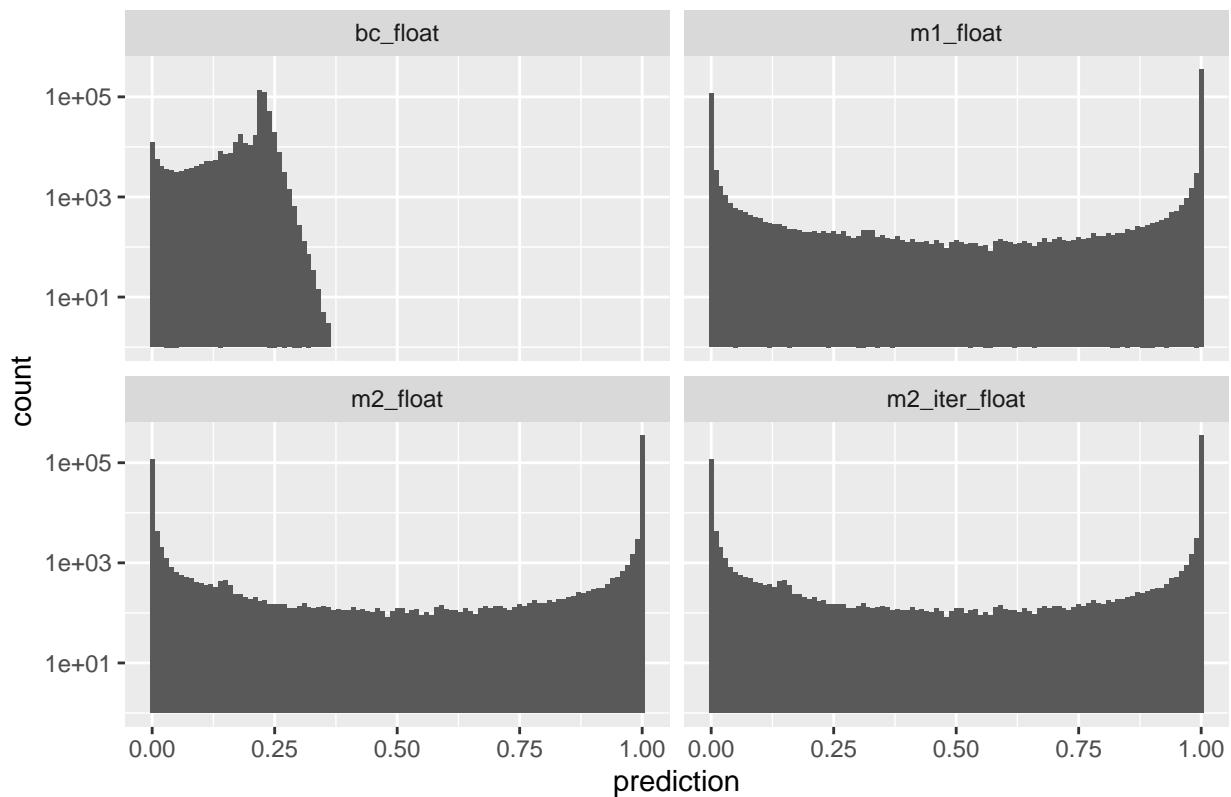
```
train_ens_cor_probs <- gather(ens_outputs$train_training, 1 + nets_outputs$test_labels[1, ], 4, 5)
train_ens_cor_probs <- melt(train_ens_cor_probs)
train_ens_cor_probs <- train_ens_cor_probs[, c(-4, -5)]
names(train_ens_cor_probs) <- c("replication", "method", "fold", "prediction")
train_ens_cor_probs$method <- as.factor(train_ens_cor_probs$method)
levels(train_ens_cor_probs$method) <- ens_outputs$methods

train_ens_cor_preds_hist <- ggplot(data=train_ens_cor_probs) + geom_histogram(mapping=aes(x=prediction,
train_ens_cor_preds_hist

## Warning: Transformation introduced infinite values in continuous y-axis

## Warning: Removed 64 rows containing missing values (geom_bar).
```

## Probabilities predicted for the correct class – ens trained on train

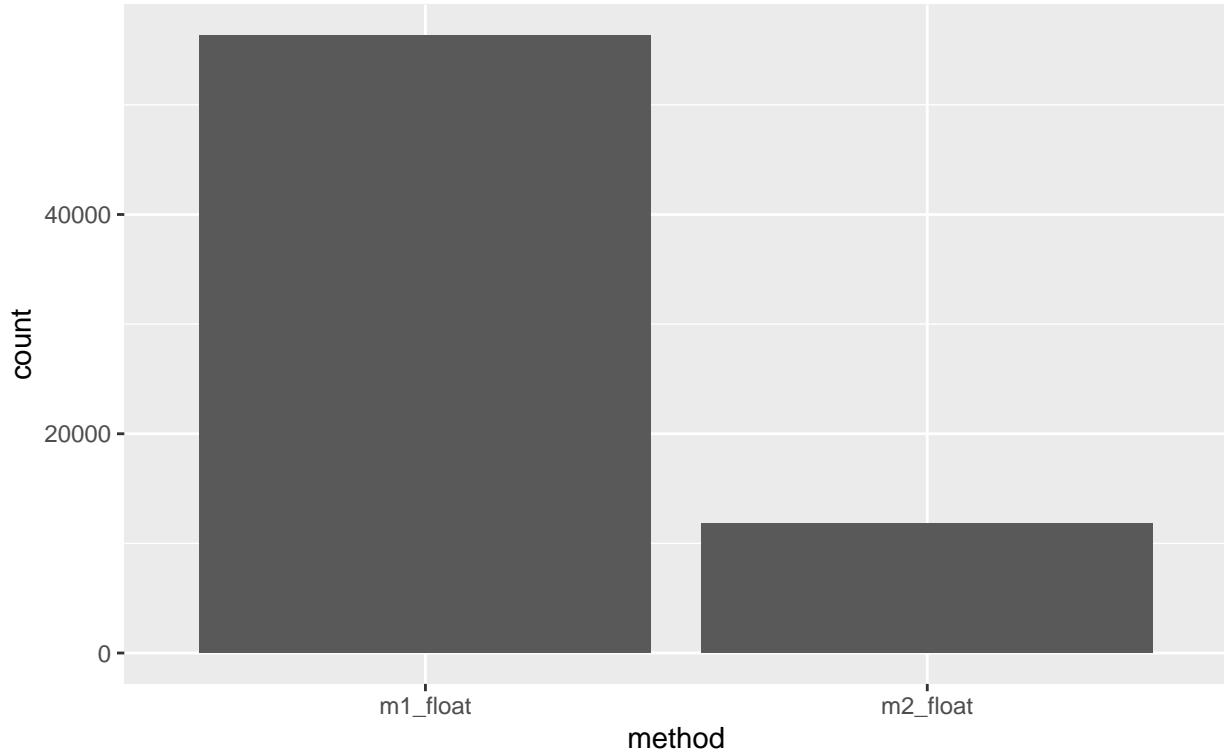


```
train_ens_zero_counts <- ggplot(data=train_ens_cor_probs[train_ens_cor_probs$prediction <= 0, ]) + geom_bar(binwidth = 0.01)
```

```
## Warning: Ignoring unknown parameters: binwidth, bins, pad
```

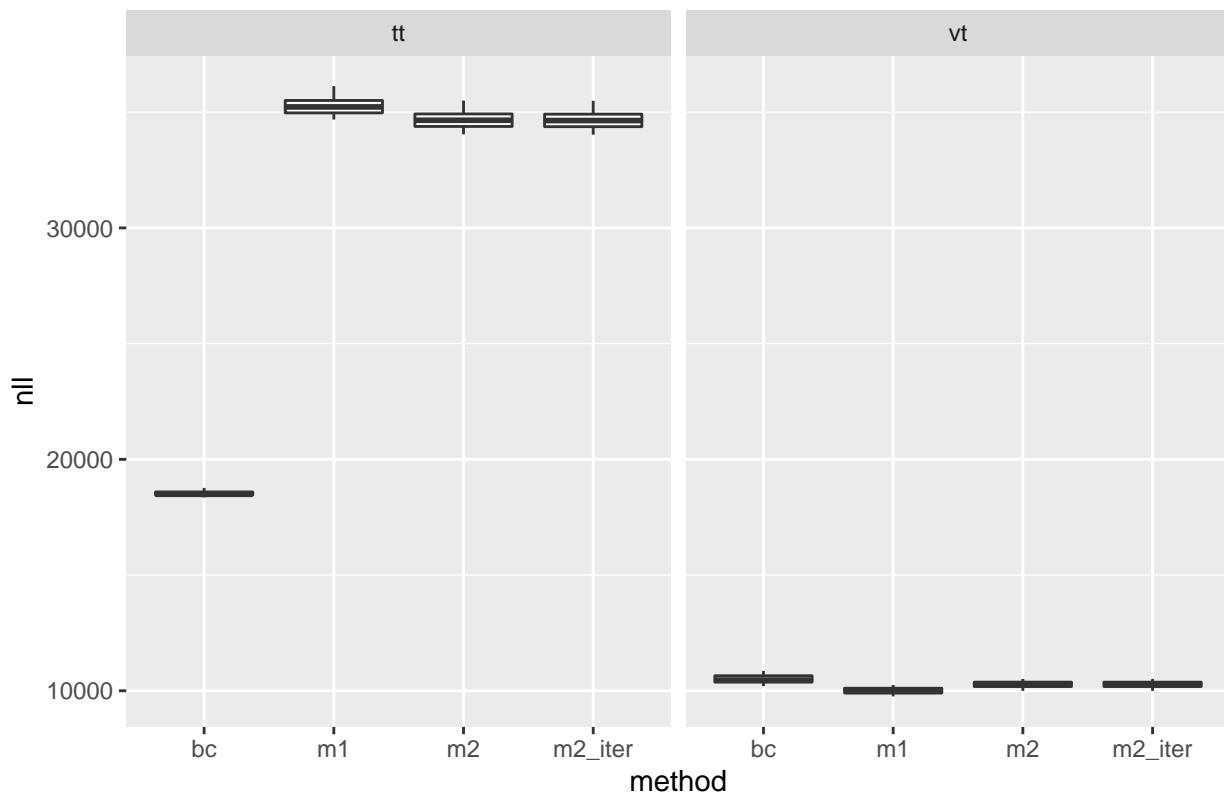
```
train_ens_zero_counts
```

Counts of subzero probabilities predicted for the correct class by coup m  
Train training



```
val_ens_nll <- ggplot(data=ens_results) + geom_boxplot(mapping=aes(x=method, y=nll)) + facet_wrap(~train)  
  ggtitle("Comparison of nll for coupling methods for different LDA train methodologies")  
val_ens_nll
```

## Comparison of nll for coupling methods for different LDA train methodologies



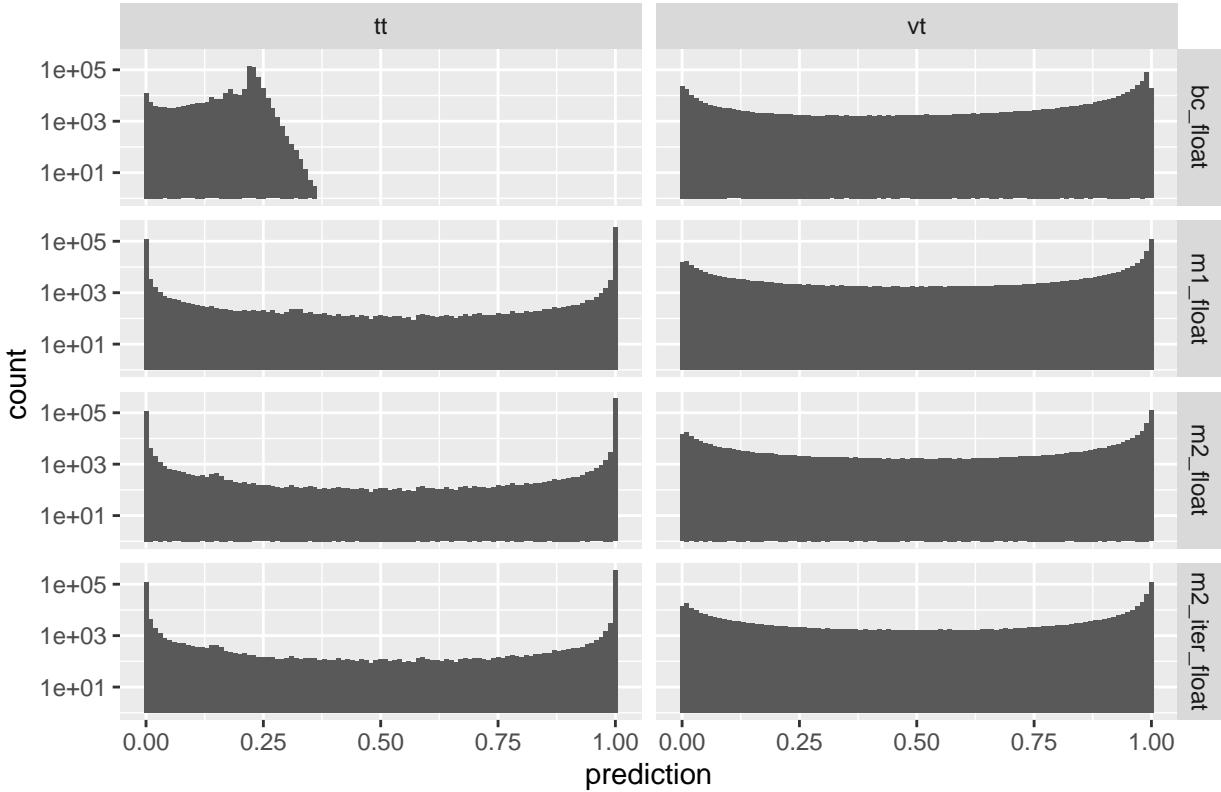
```
val_ens_cor_probs$train_type <- "vt"
train_ens_cor_probs$train_type <- "tt"
ens_cor_probs <- rbind(val_ens_cor_probs, train_ens_cor_probs)
```

```
ens_cor_preds_histo <- ggplot(data=ens_cor_probs) + geom_histogram(mapping=aes(x=prediction), binwidth=
```

```
## Warning: Transformation introduced infinite values in continuous y-axis
```

```
## Warning: Removed 64 rows containing missing values (geom_bar).
```

## Probabilities predicted for the correct class



Very strange behavior for the bc method trained on training set. Needs further attention. Otherwise similar results to those for CIFAR 10. Ensembles trained on validation set have smoother histograms of correct class probability.

```

val_aggr_Rs <- np$load(file.path(base_dir, "val_training_class_aggr_R.npy"))
train_aggr_Rs <- np$load(file.path(base_dir, "train_training_class_aggr_R.npy"))
df_val_aggr_Rs <- melt(val_aggr_Rs)
names(df_val_aggr_Rs) <- c("precision", "class", "class1", "class2", "prob")
df_train_aggr_Rs <- melt(train_aggr_Rs)
names(df_train_aggr_Rs) <- c("precision", "class", "class1", "class2", "prob")
df_val_aggr_Rs$train_type <- "val_training"
df_train_aggr_Rs$train_type <- "train_training"
df_aggr_Rs <- rbind(df_val_aggr_Rs, df_train_aggr_Rs)
df_aggr_Rs[, c("class", "class1", "class2")] <- lapply(df_aggr_Rs[, c("class", "class1", "class2")], as

df_aggr_Rs_diff <- df_aggr_Rs %>% pivot_wider(names_from = train_type, values_from = prob) %>% mutate(v

```

```

for (cls in 1:classes)
{
  cur_class_Rs <- df_aggr_Rs %>% filter(class == cls)
  plot_cls <- ggplot(cur_class_Rs, aes(x = class2, y = class1)) +
    geom_raster(aes(fill=prob)) +
    facet_wrap(~train_type) +
    scale_fill_gradient(low="grey90", high="red") +
    scale_y_discrete(limits=rev, breaks=seq(0, classes, 10)) +
    scale_x_discrete(breaks=seq(0, classes, 10)) +

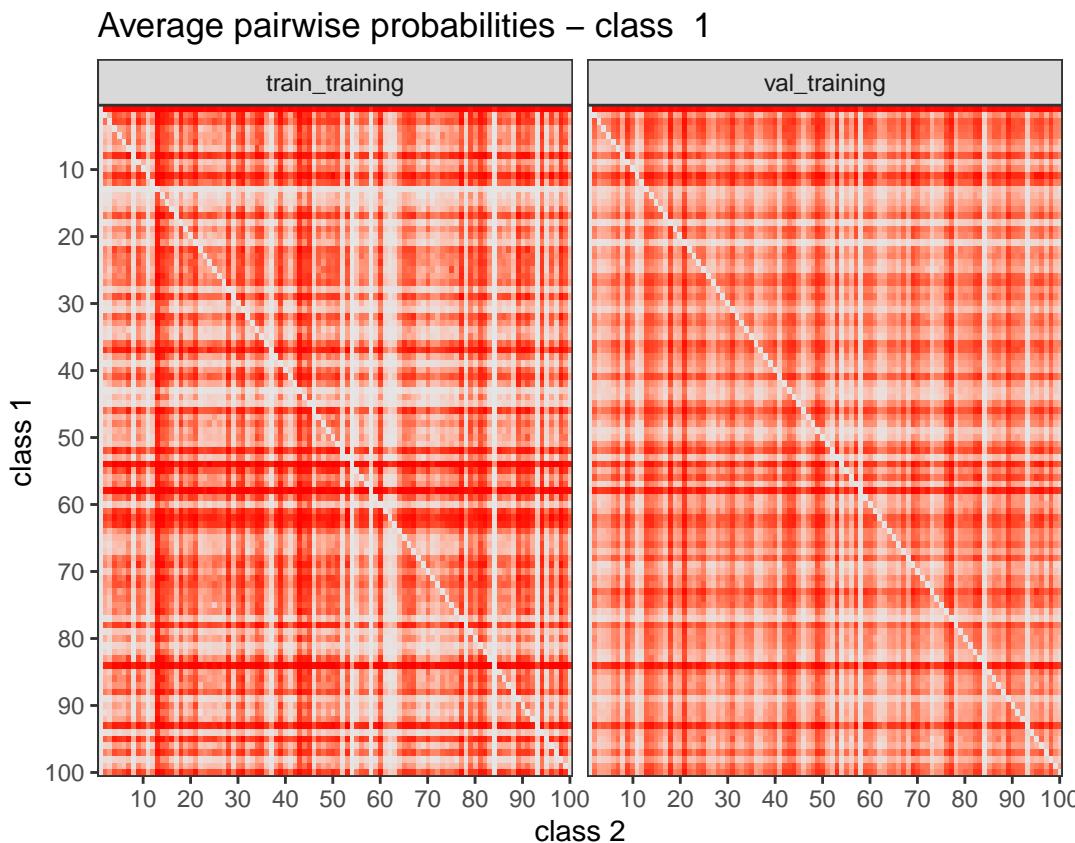
```

```

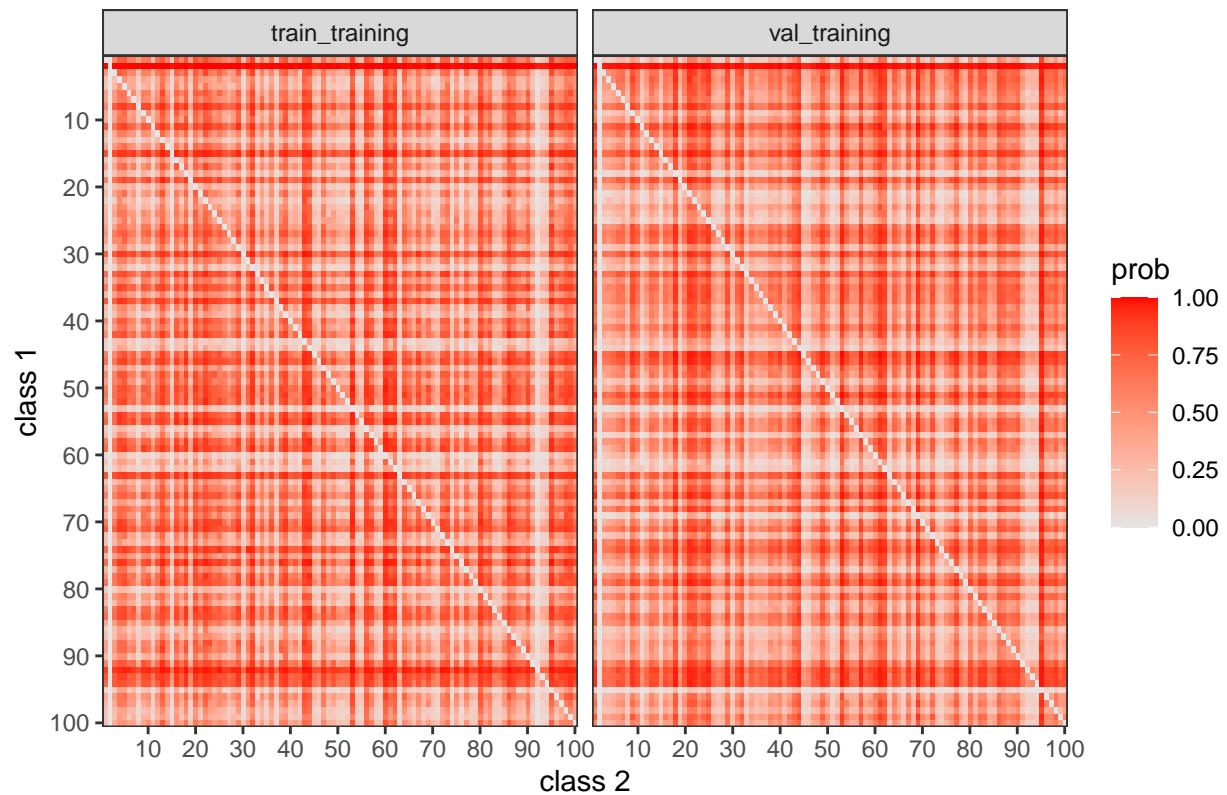
    labs(x="class 2", y="class 1", title=paste("Average pairwise probabilities - class ", cls)) +
    theme_bw()

print(plot_cls)
}

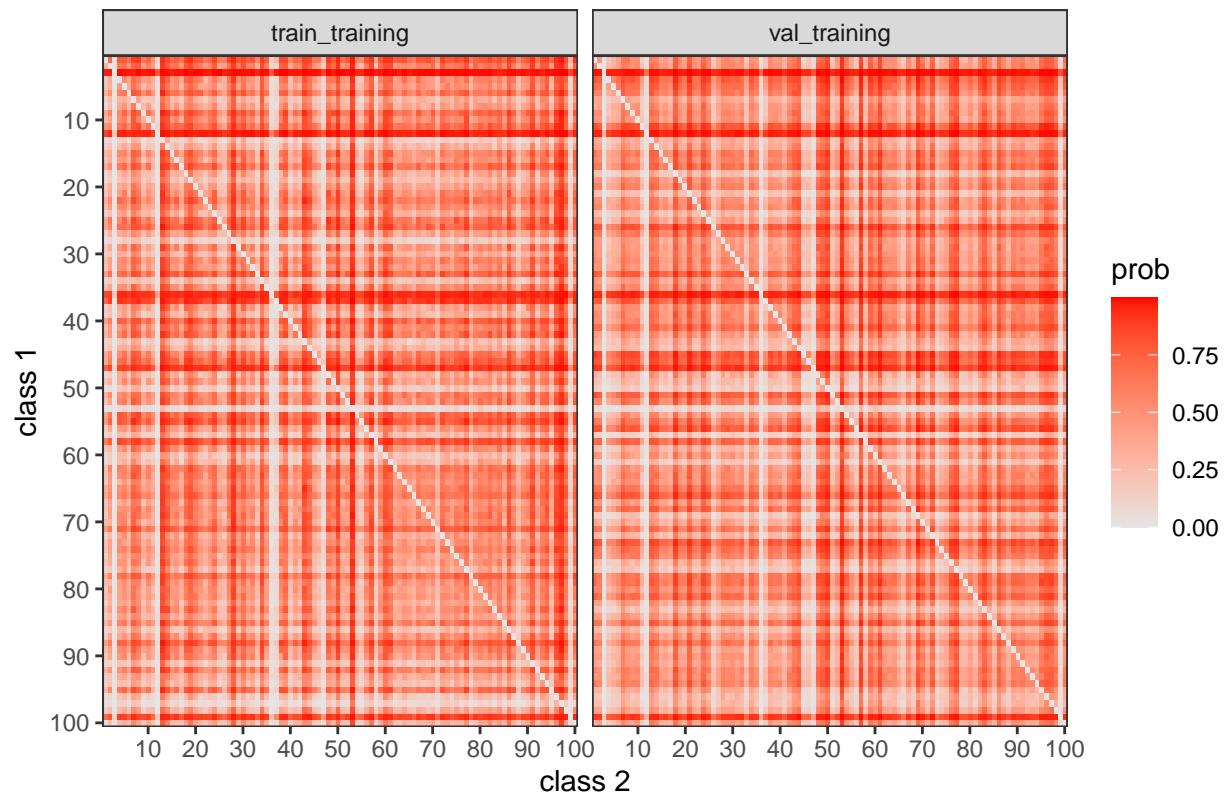
```



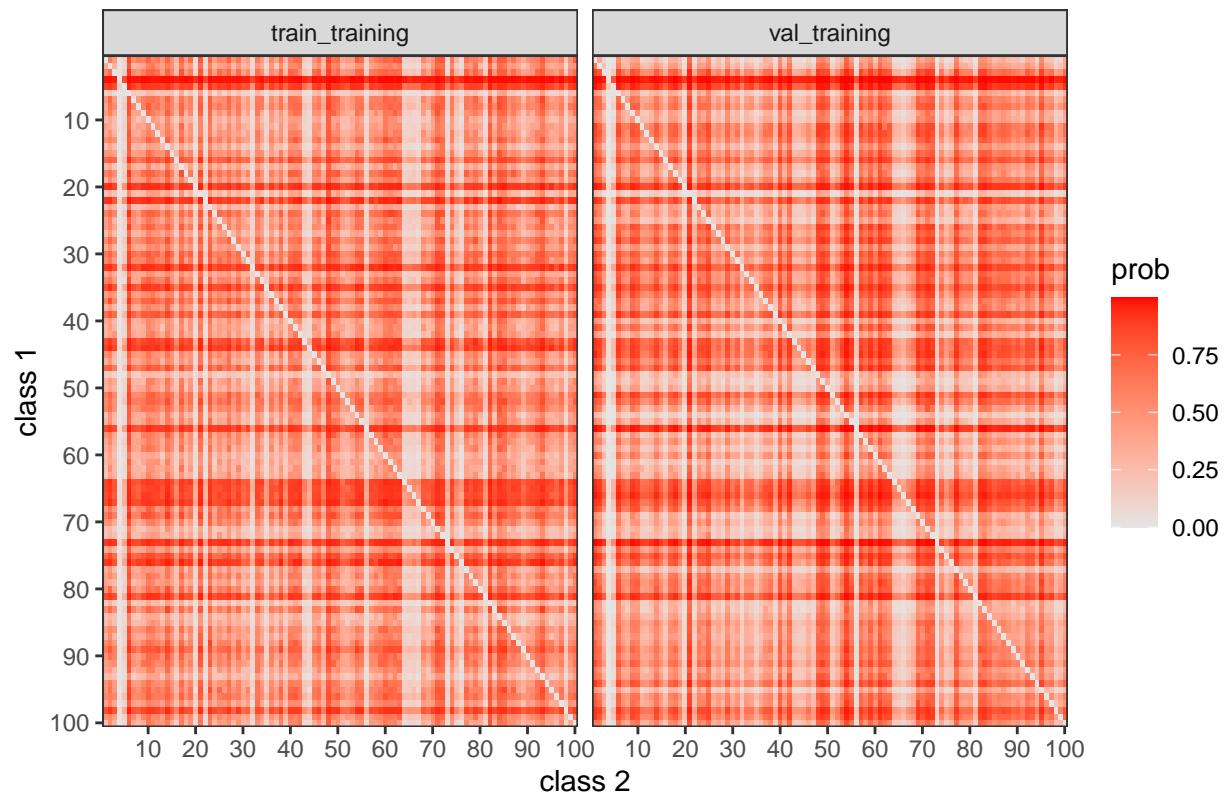
Average pairwise probabilities – class 2



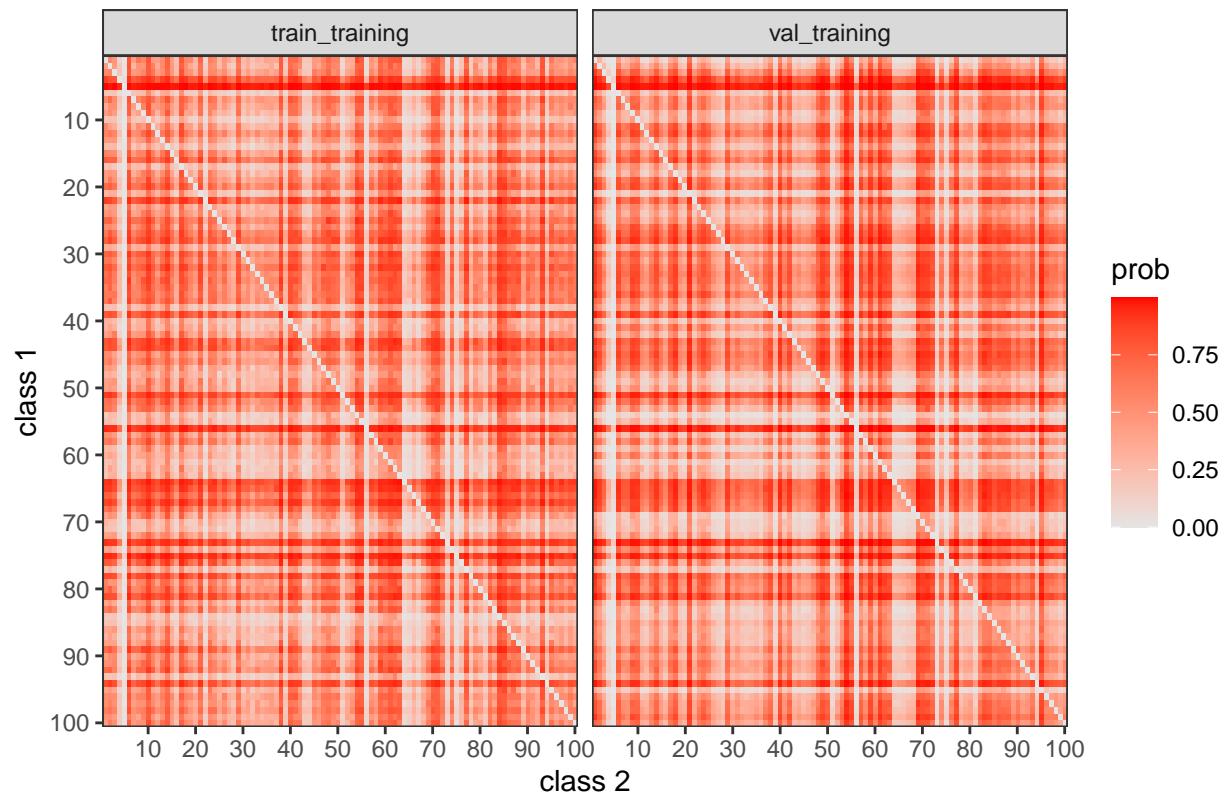
Average pairwise probabilities – class 3



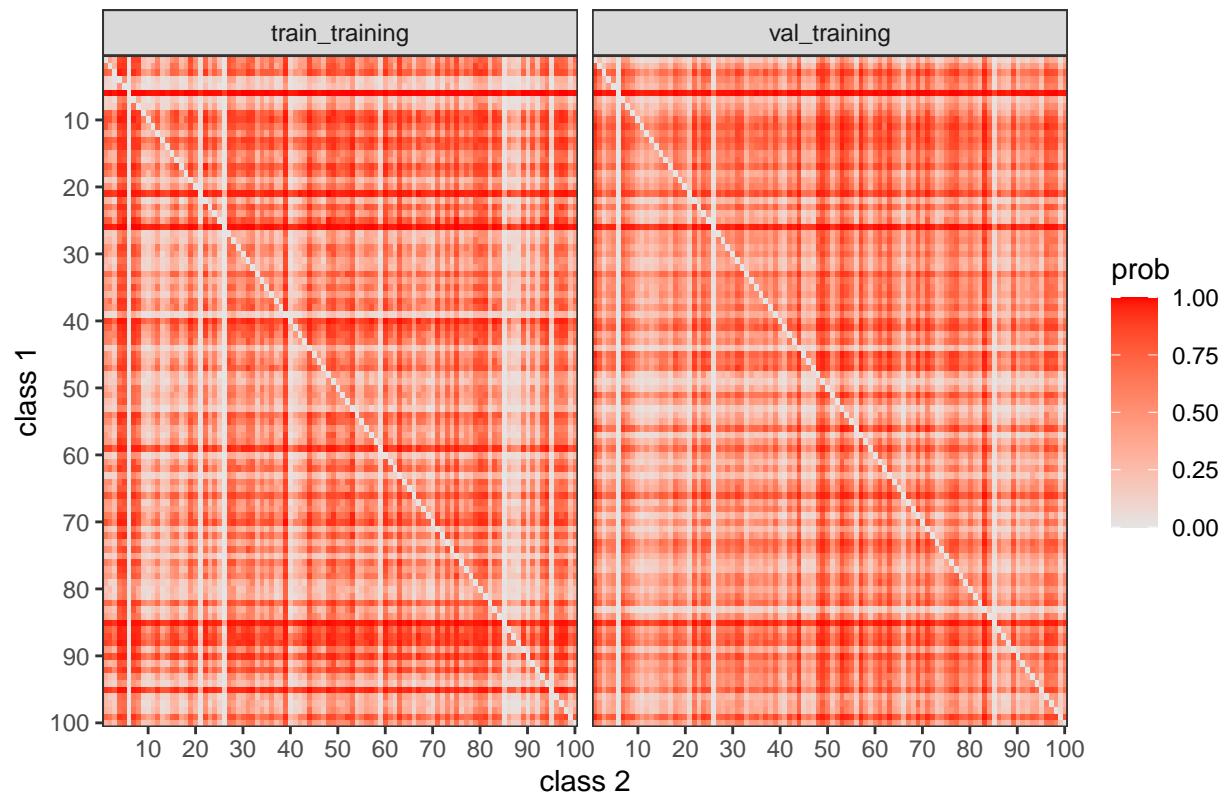
Average pairwise probabilities – class 4



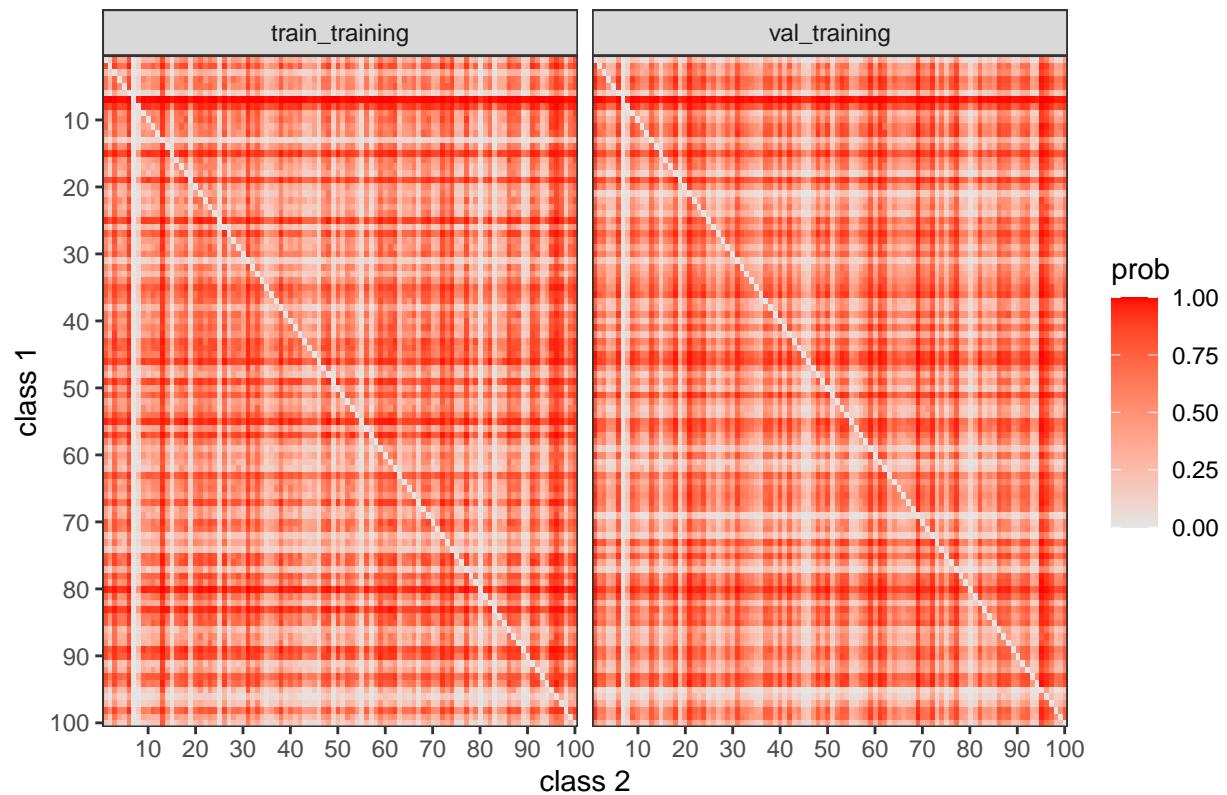
Average pairwise probabilities – class 5



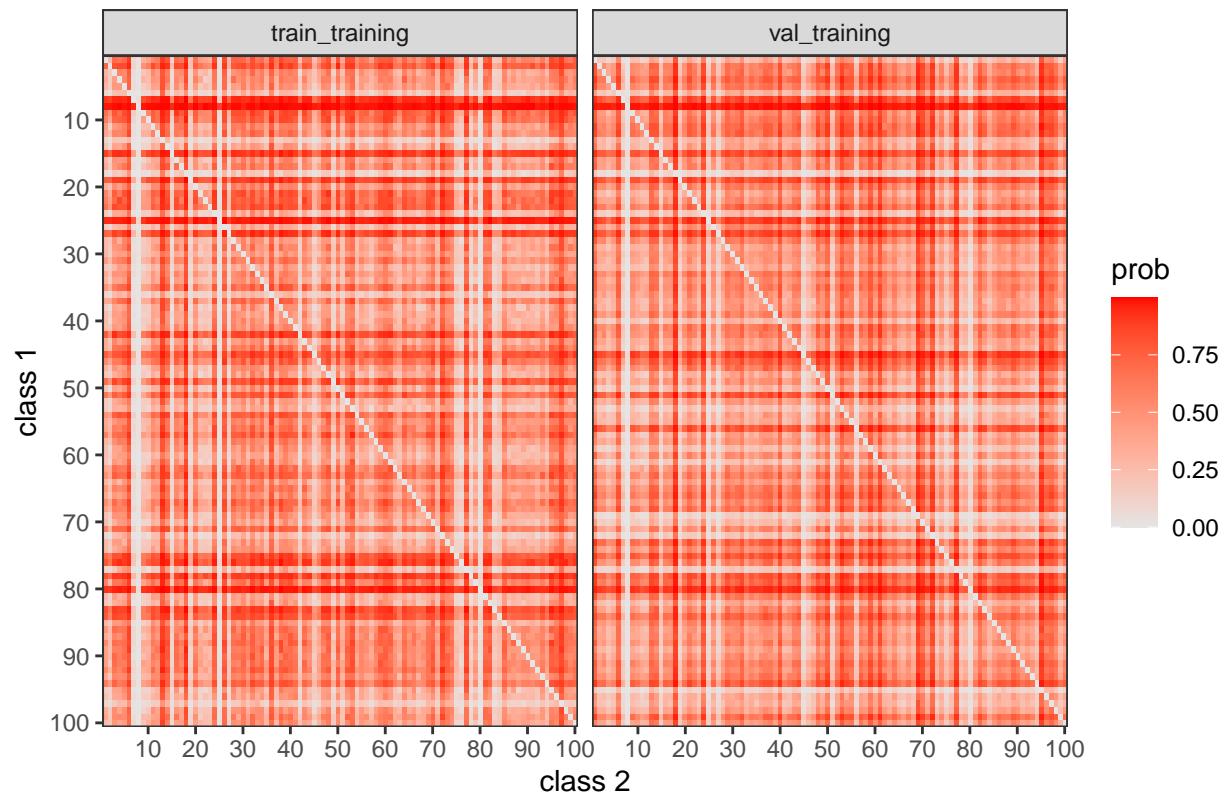
Average pairwise probabilities – class 6



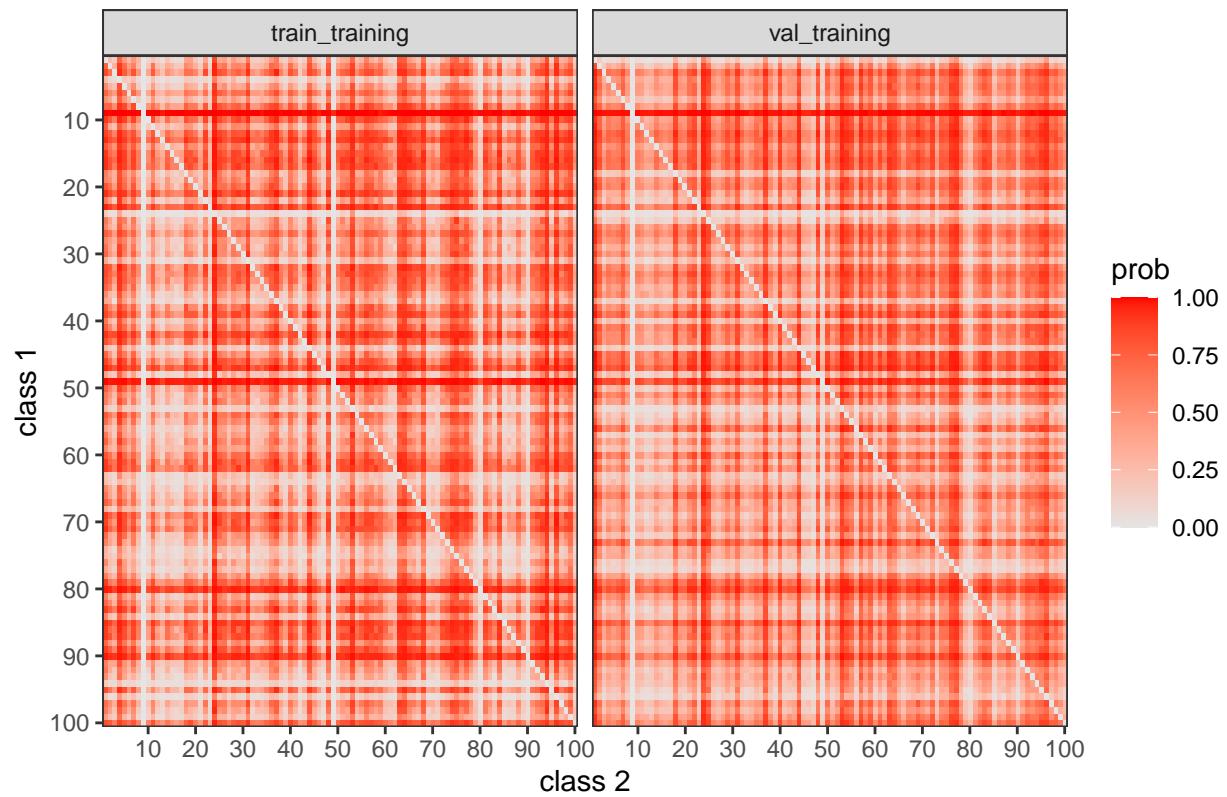
Average pairwise probabilities – class 7



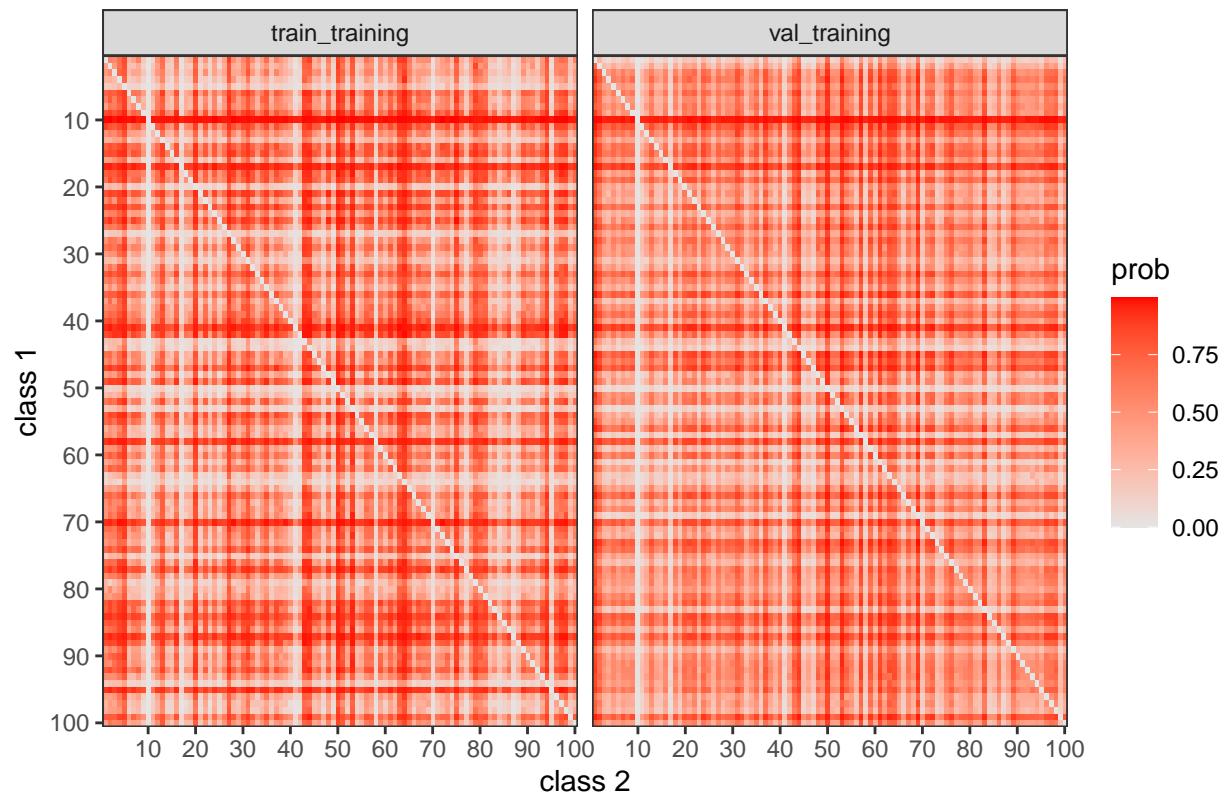
Average pairwise probabilities – class 8



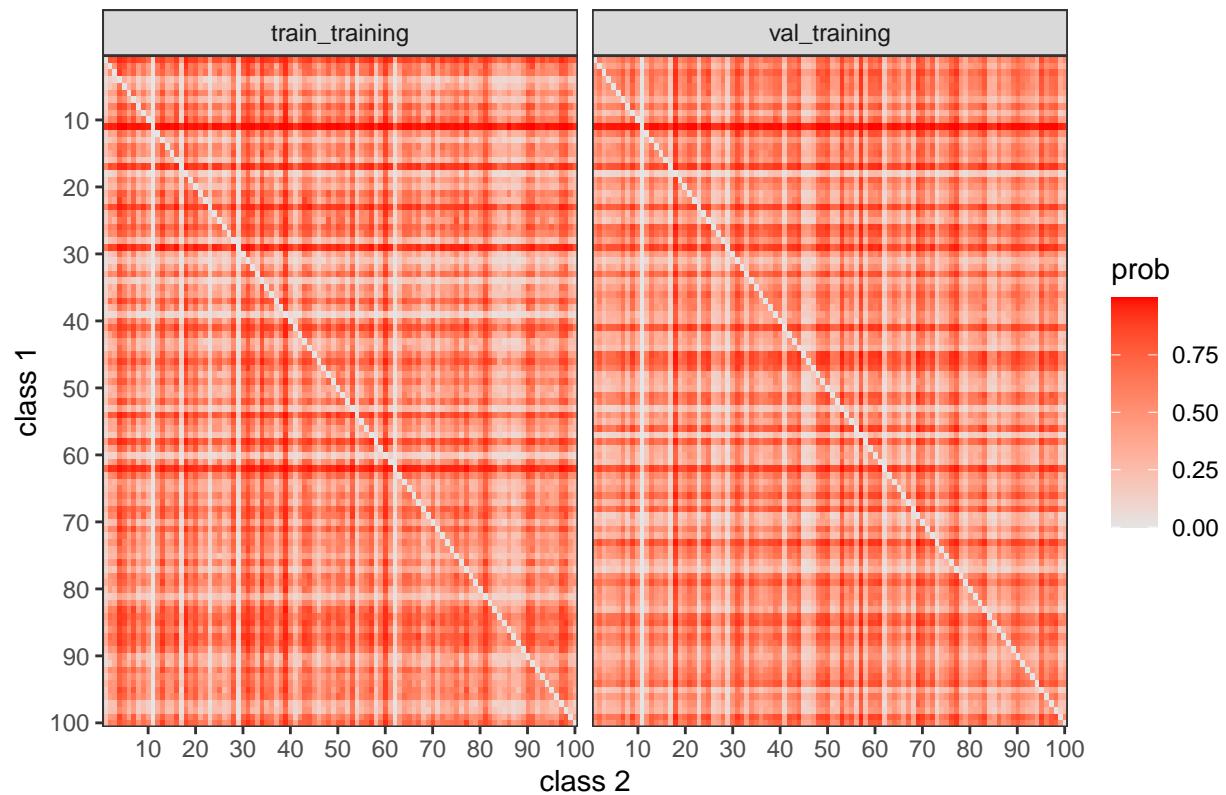
Average pairwise probabilities – class 9



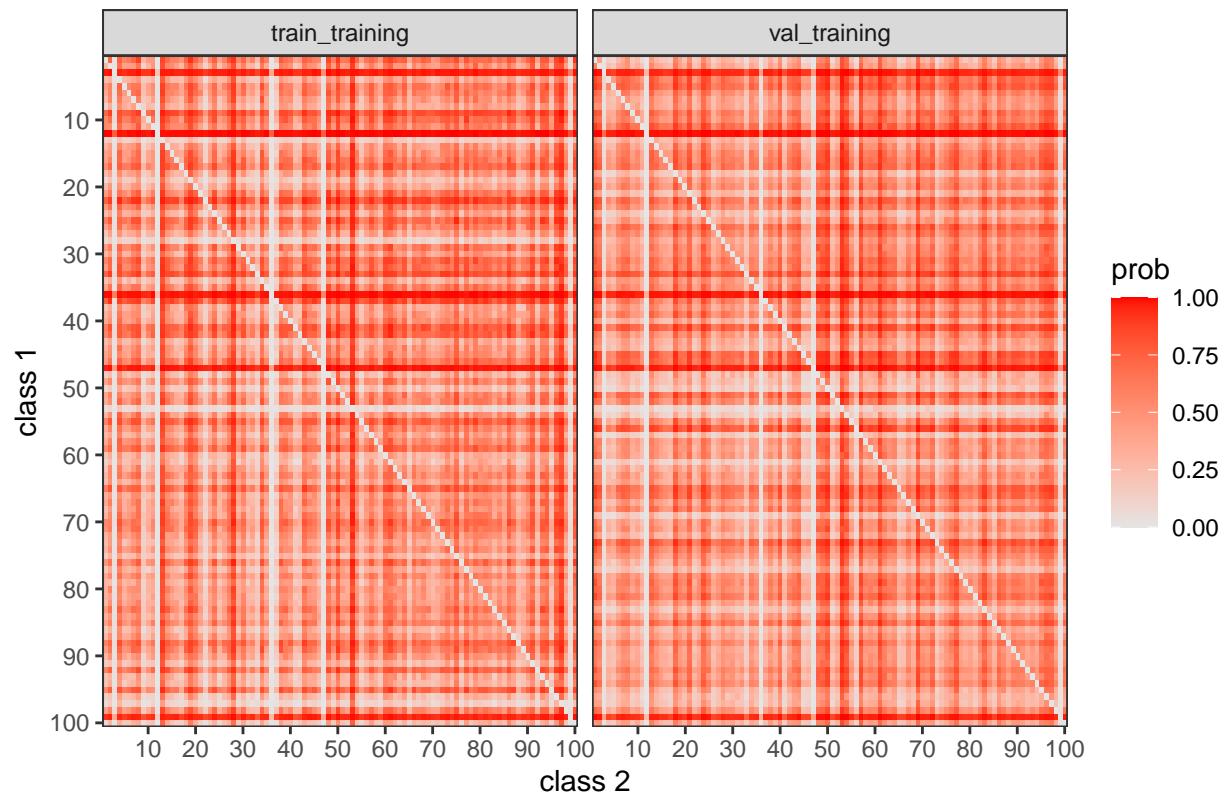
Average pairwise probabilities – class 10



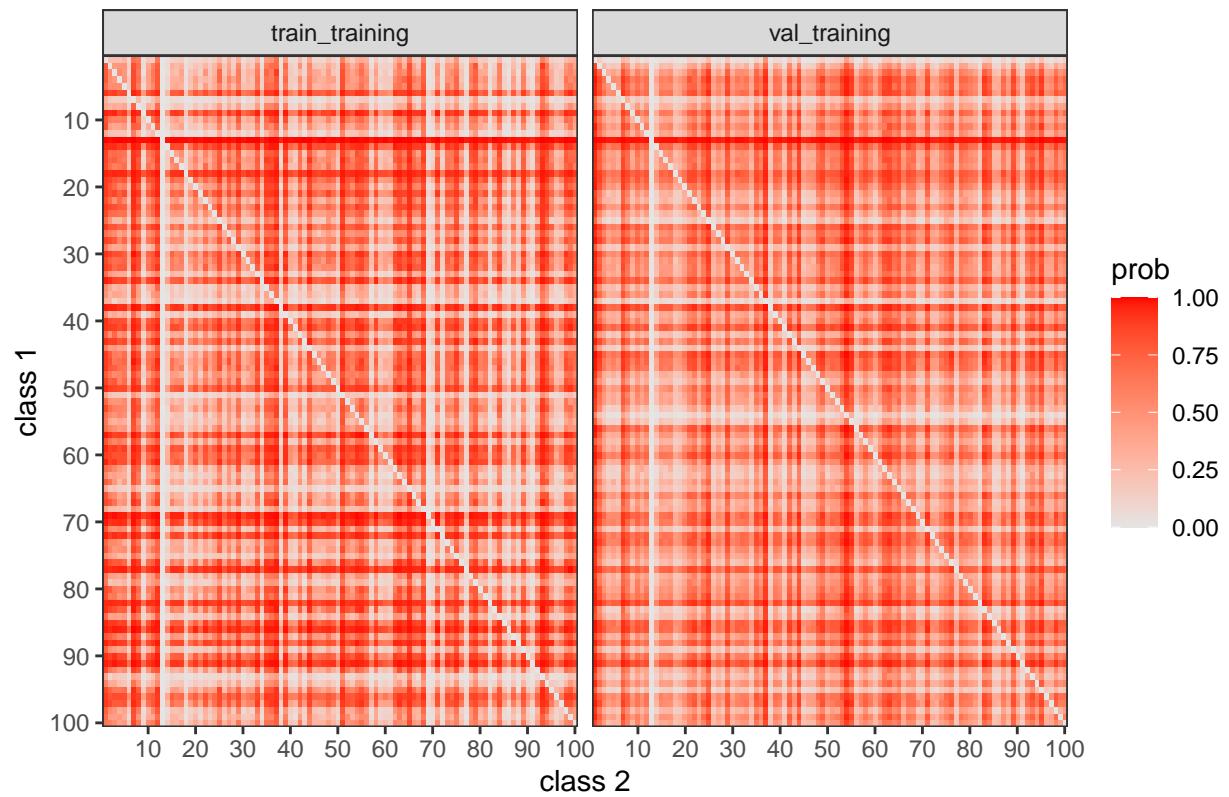
Average pairwise probabilities – class 11



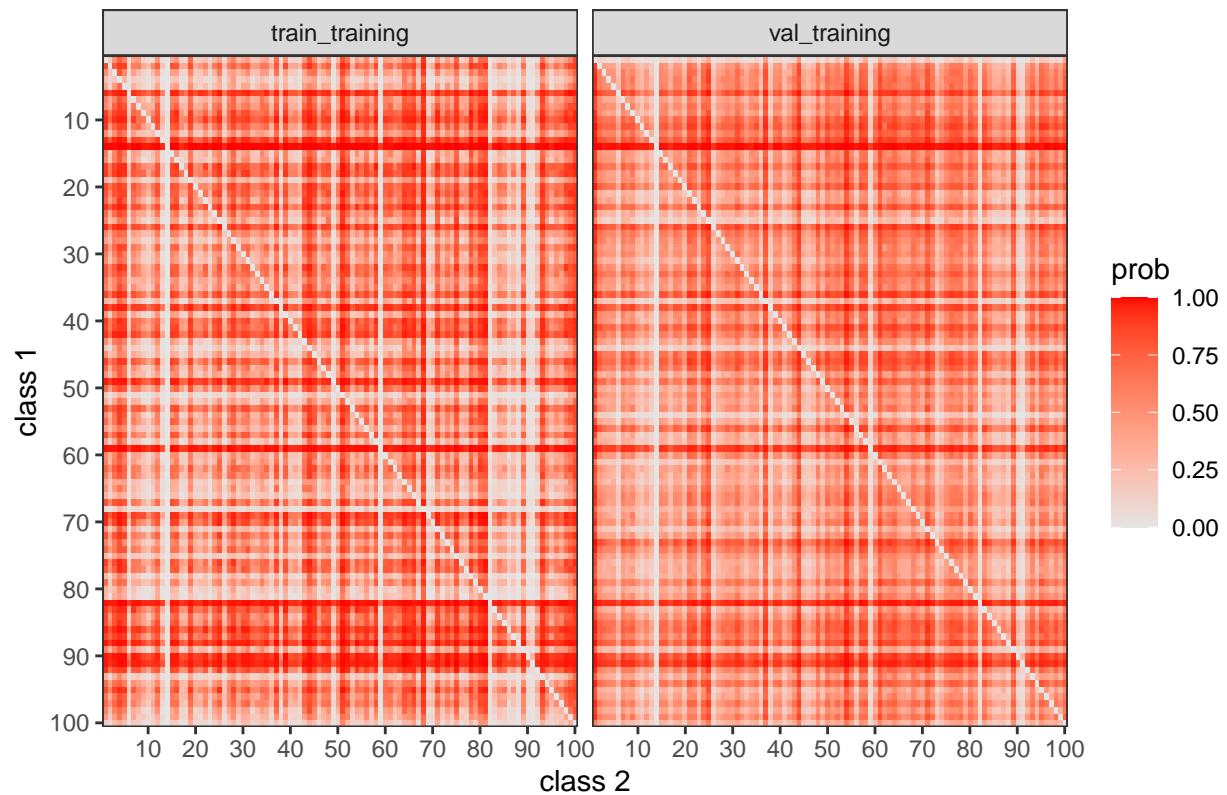
Average pairwise probabilities – class 12



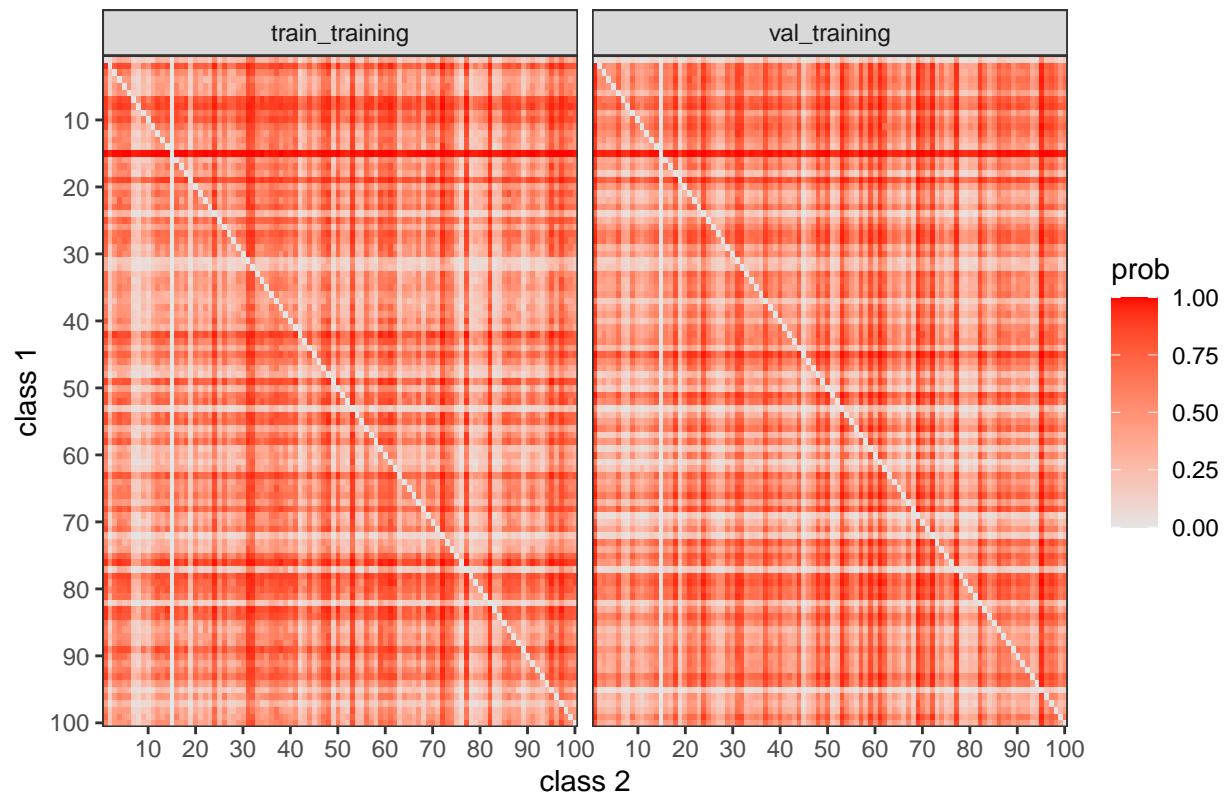
Average pairwise probabilities – class 13



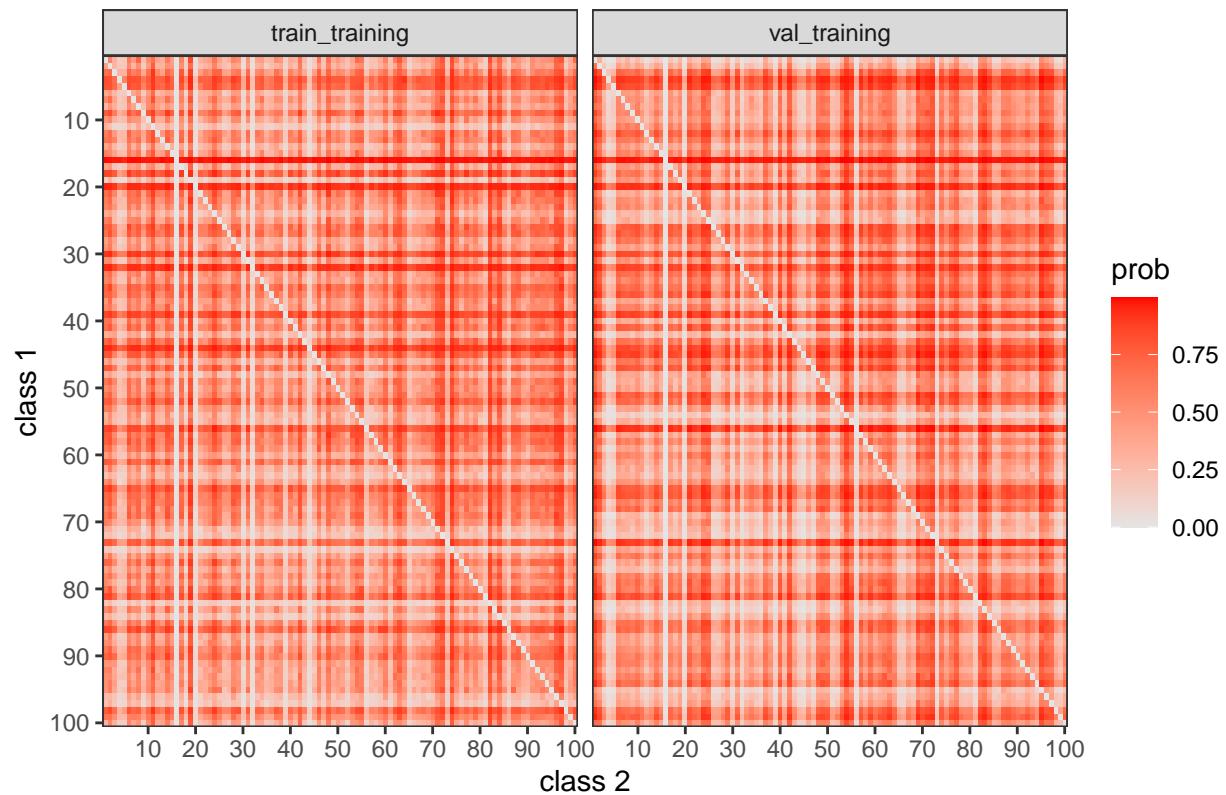
Average pairwise probabilities – class 14



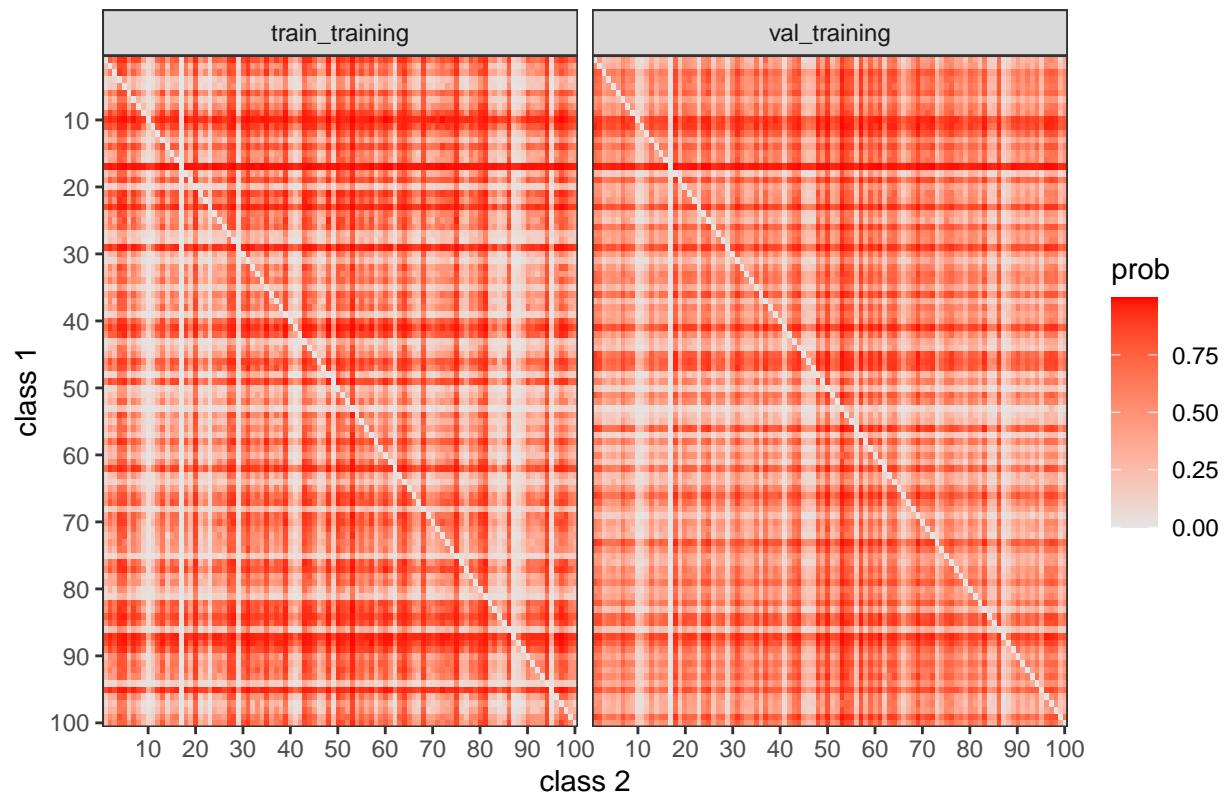
Average pairwise probabilities – class 15



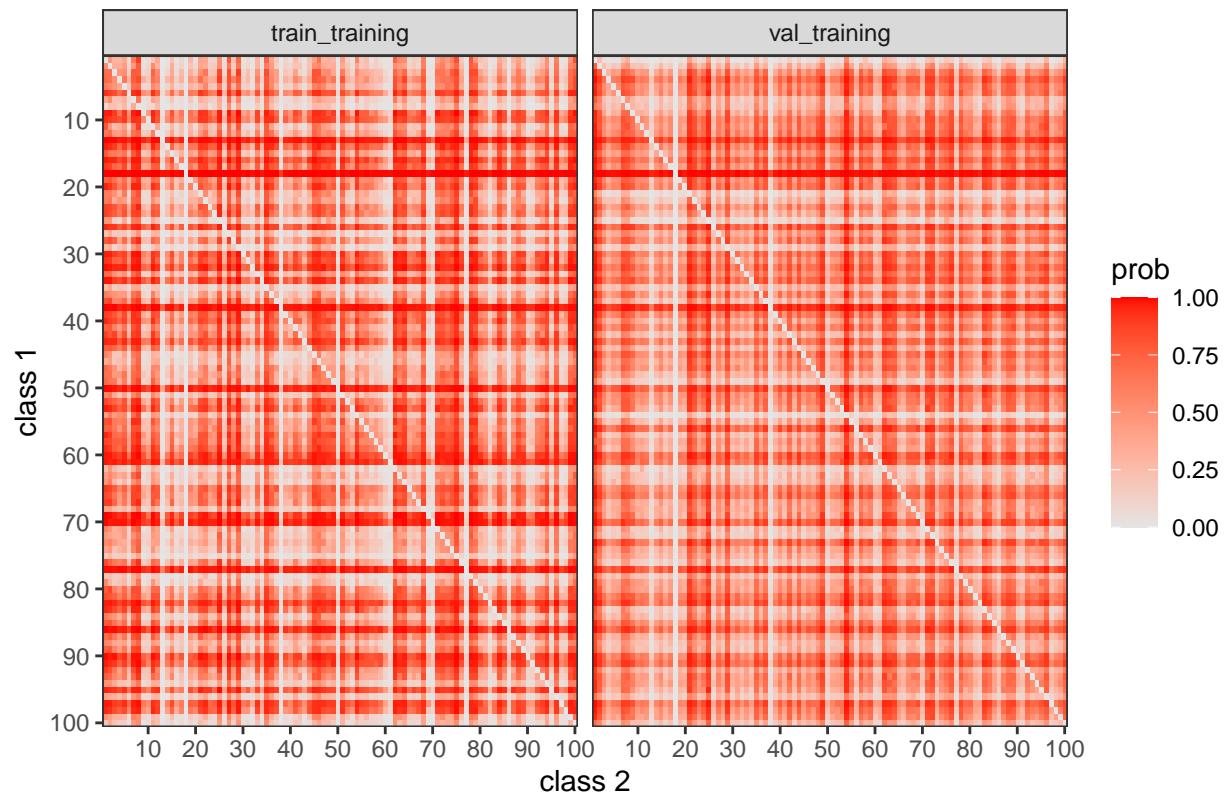
Average pairwise probabilities – class 16



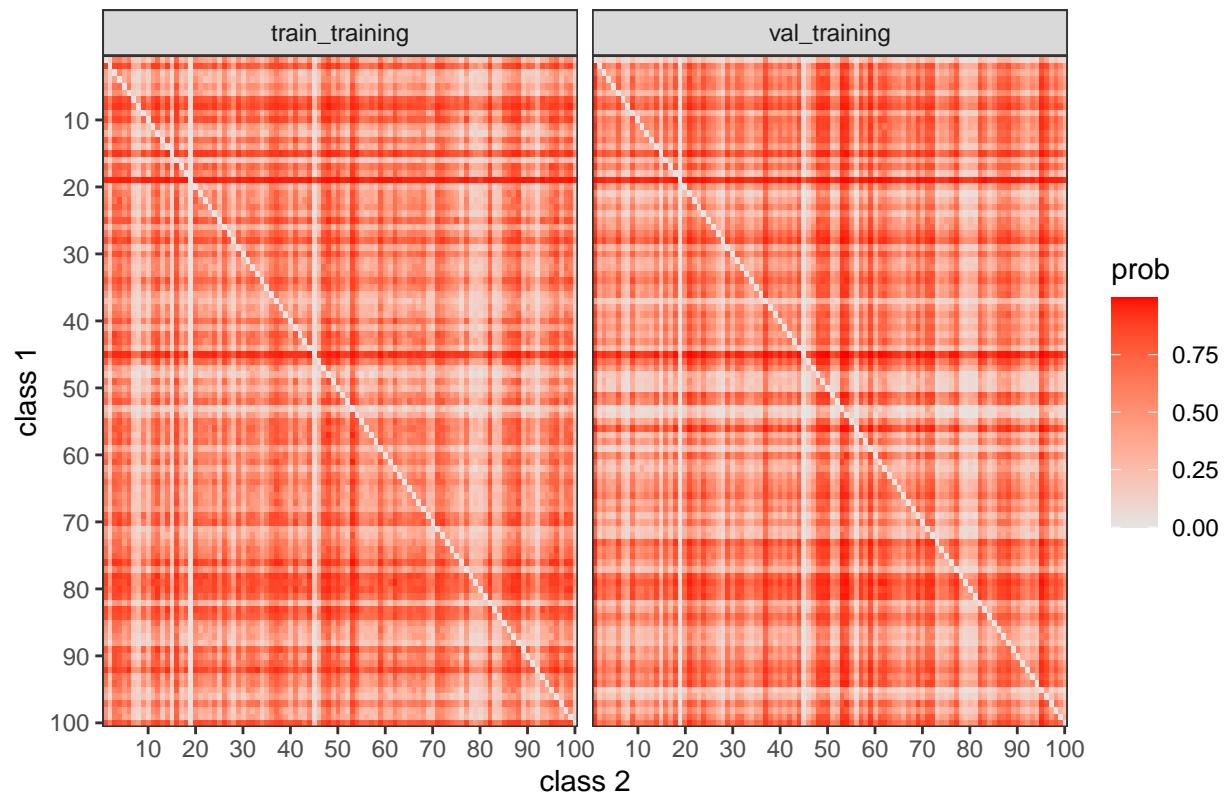
Average pairwise probabilities – class 17



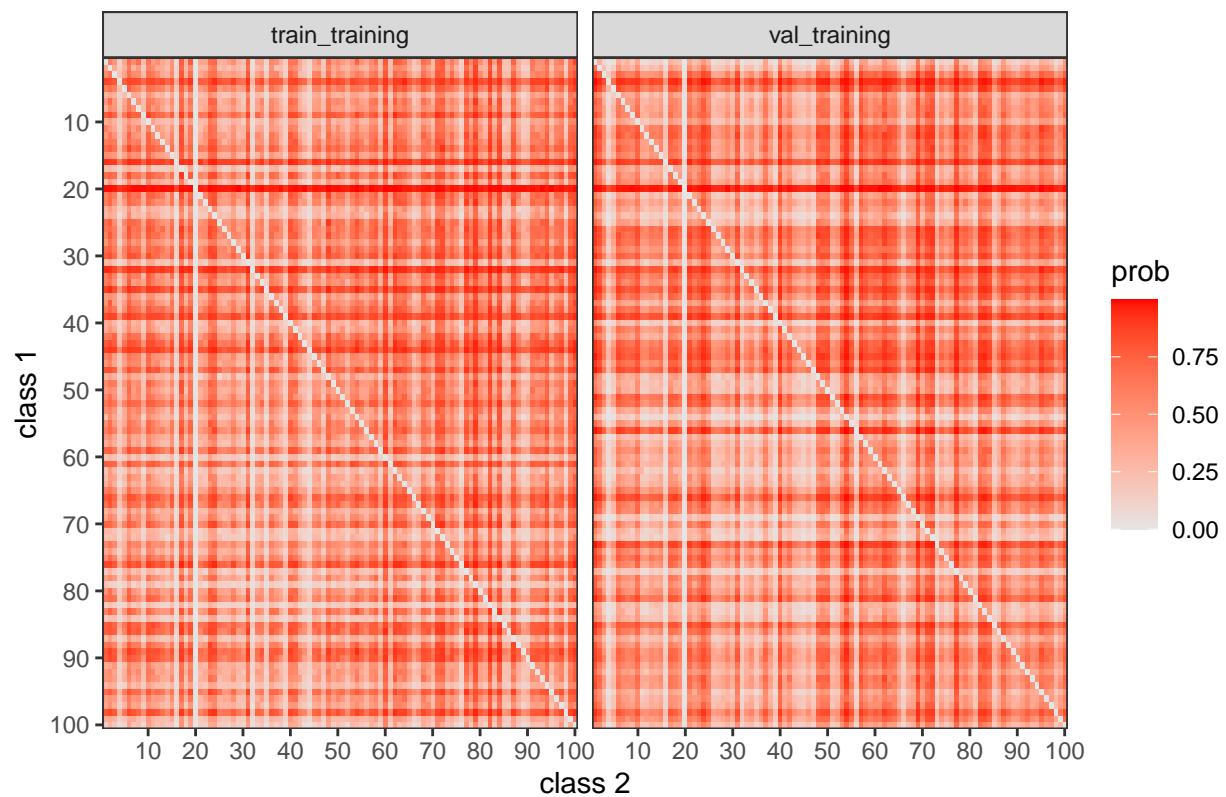
Average pairwise probabilities – class 18



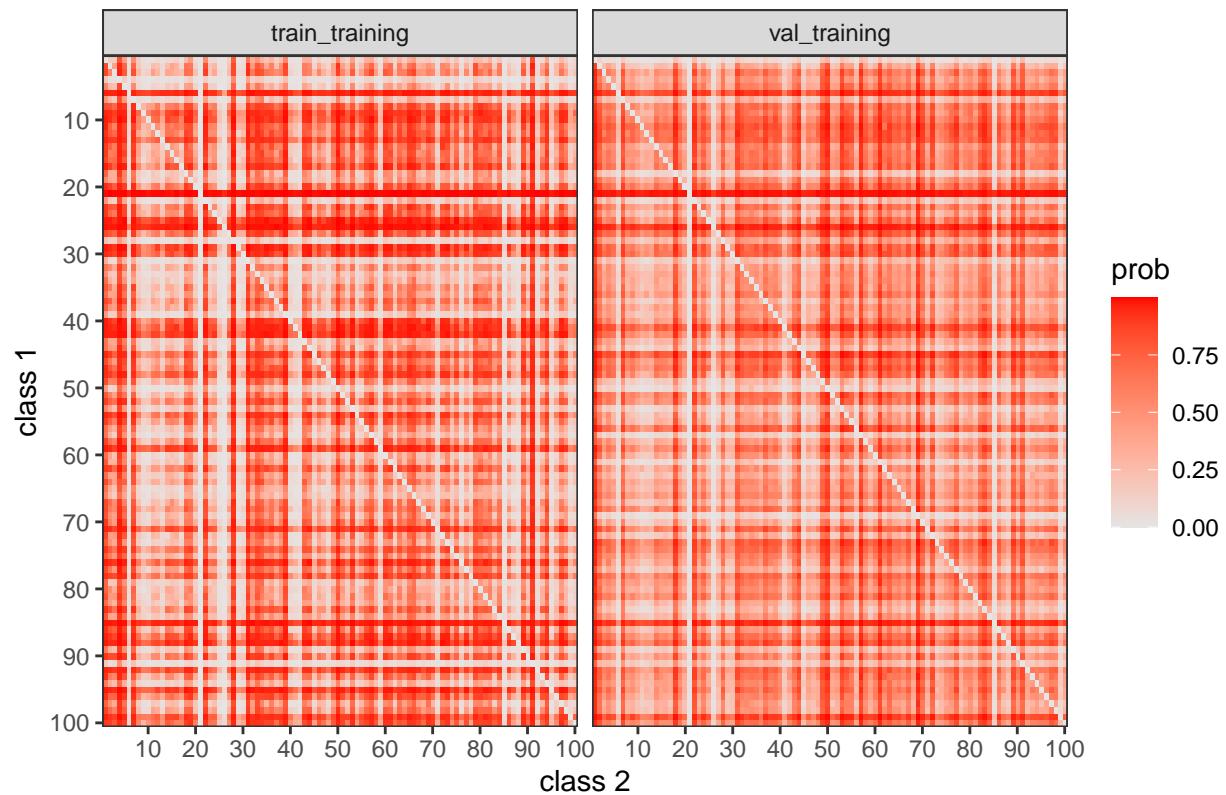
Average pairwise probabilities – class 19



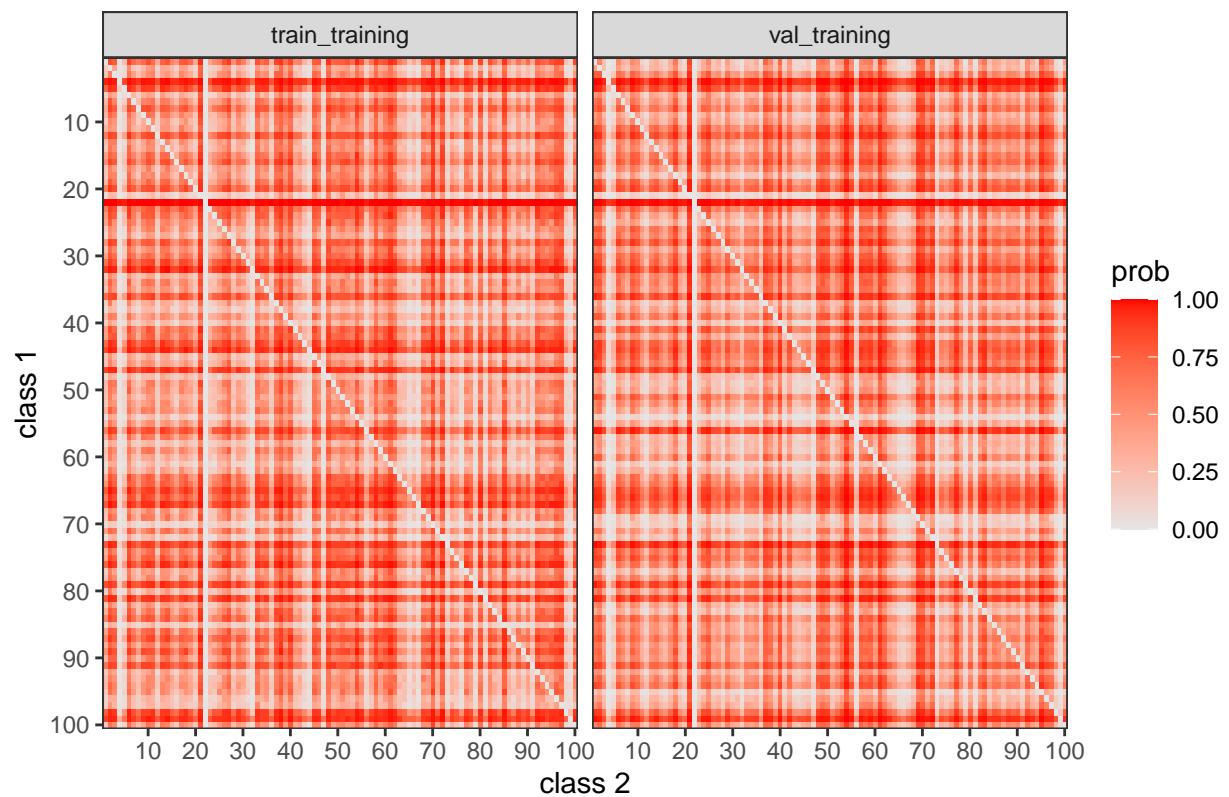
Average pairwise probabilities – class 20



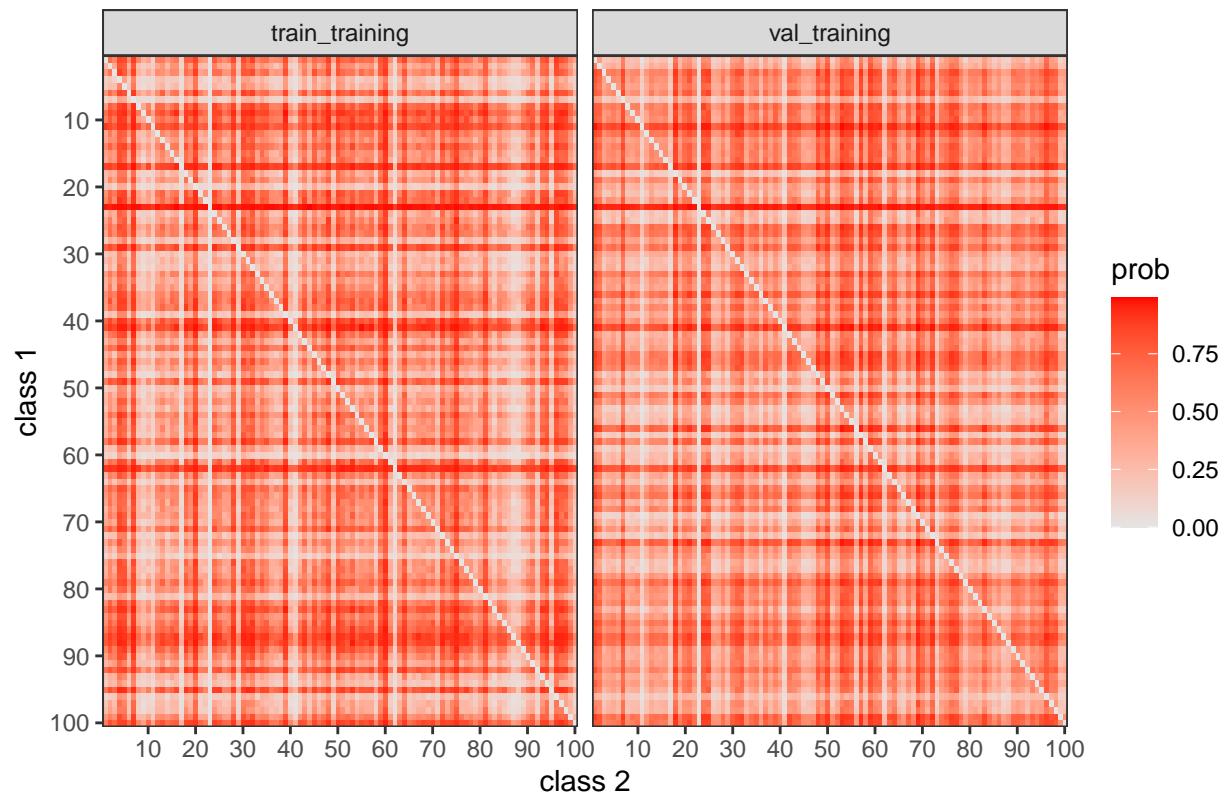
Average pairwise probabilities – class 21



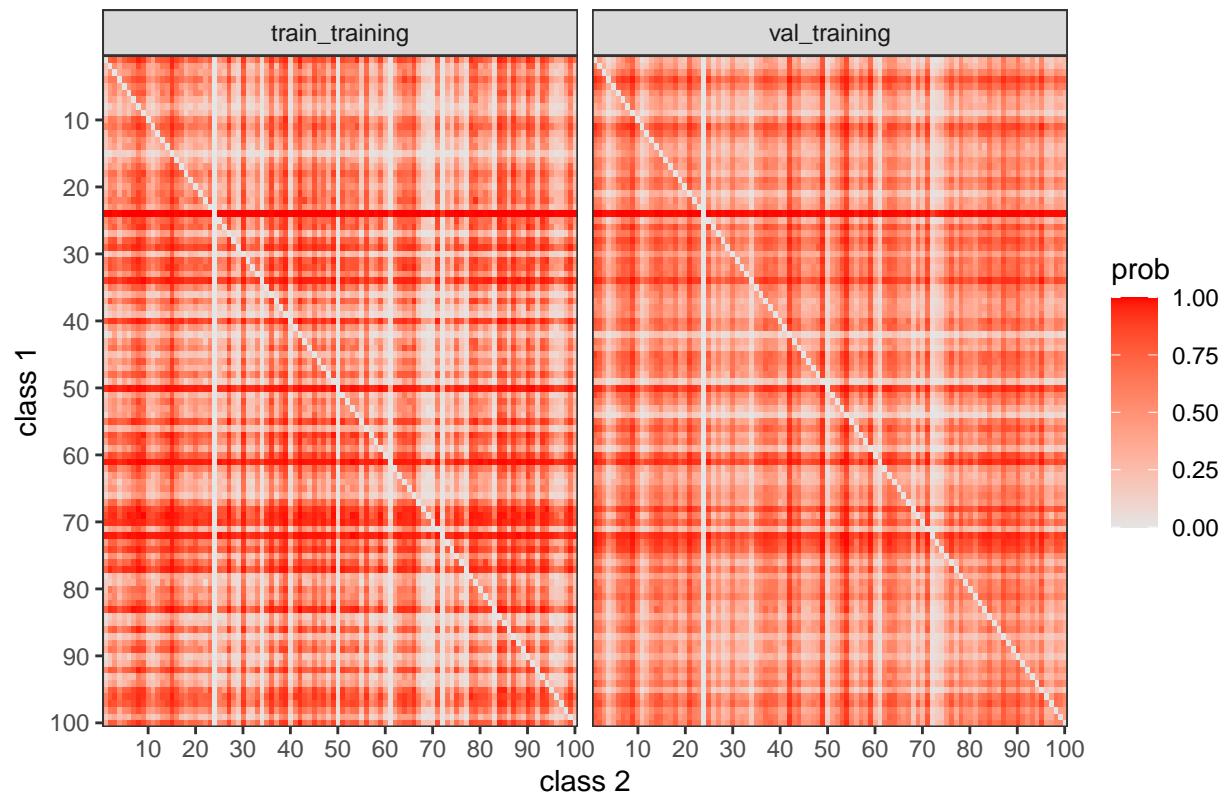
Average pairwise probabilities – class 22



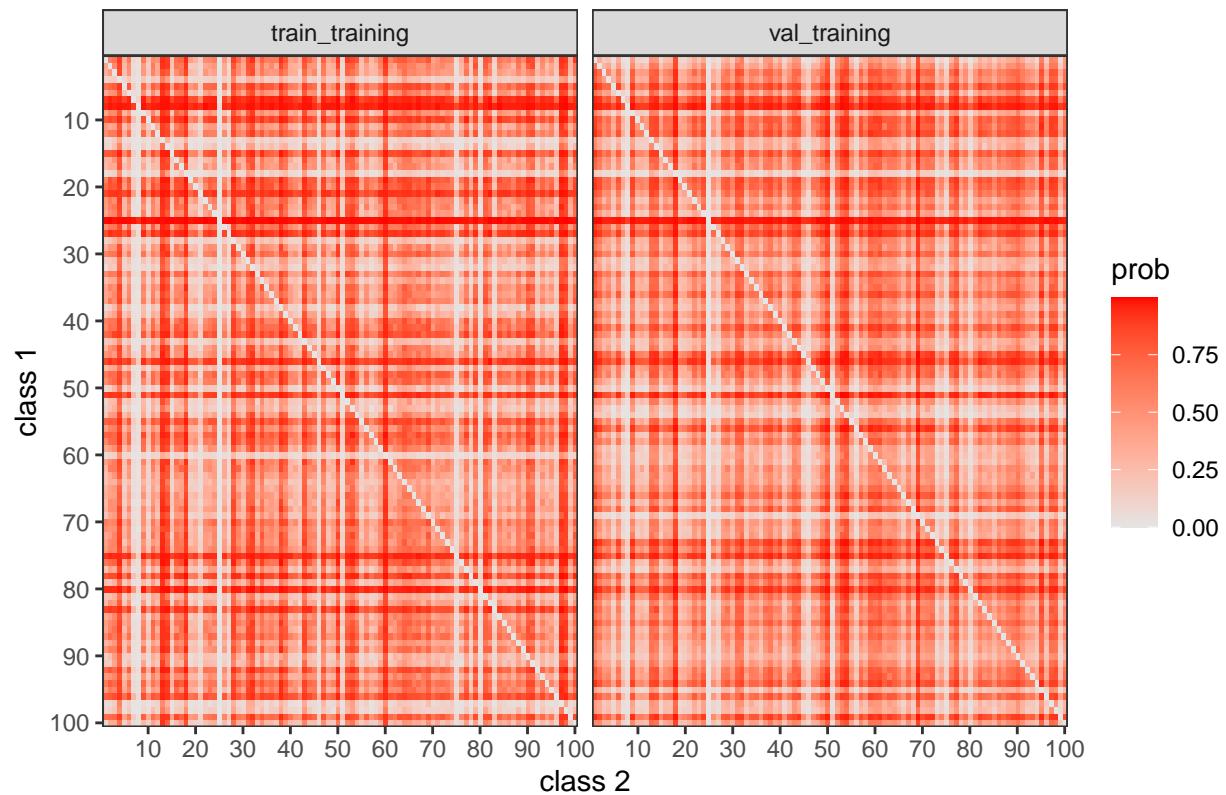
Average pairwise probabilities – class 23



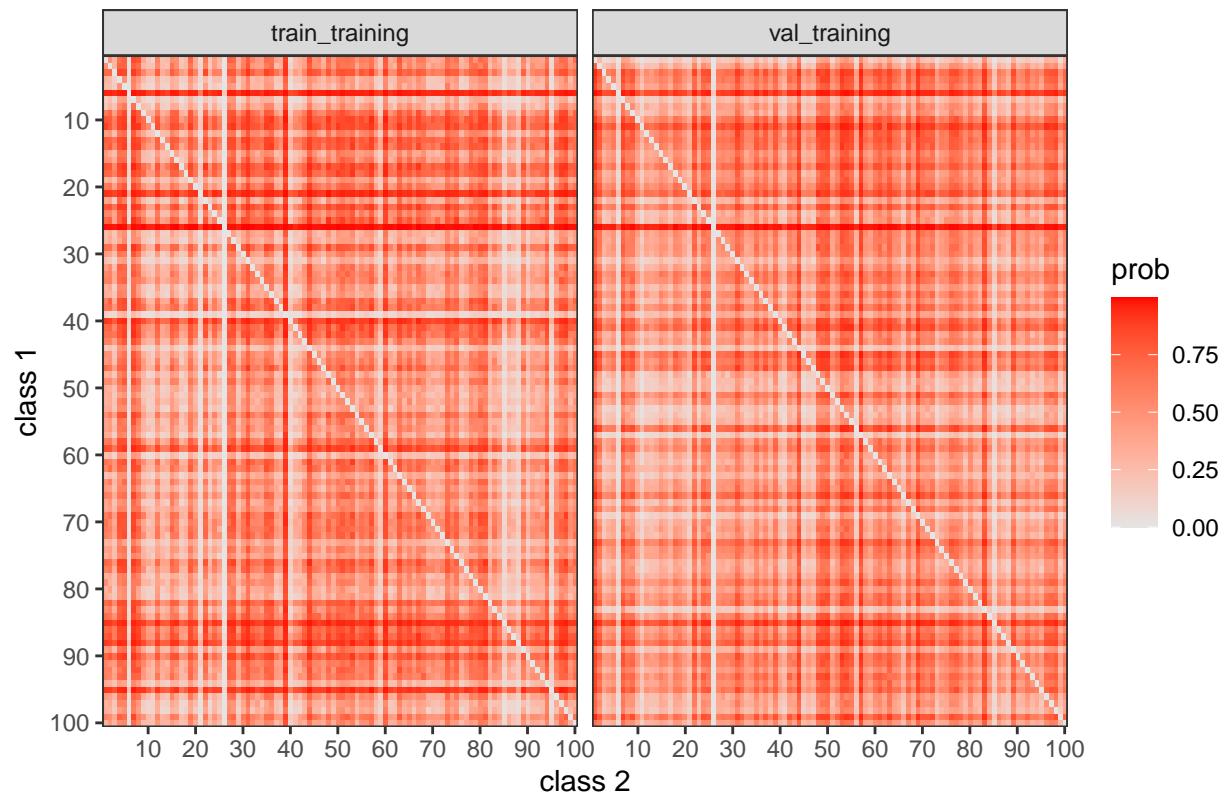
Average pairwise probabilities – class 24



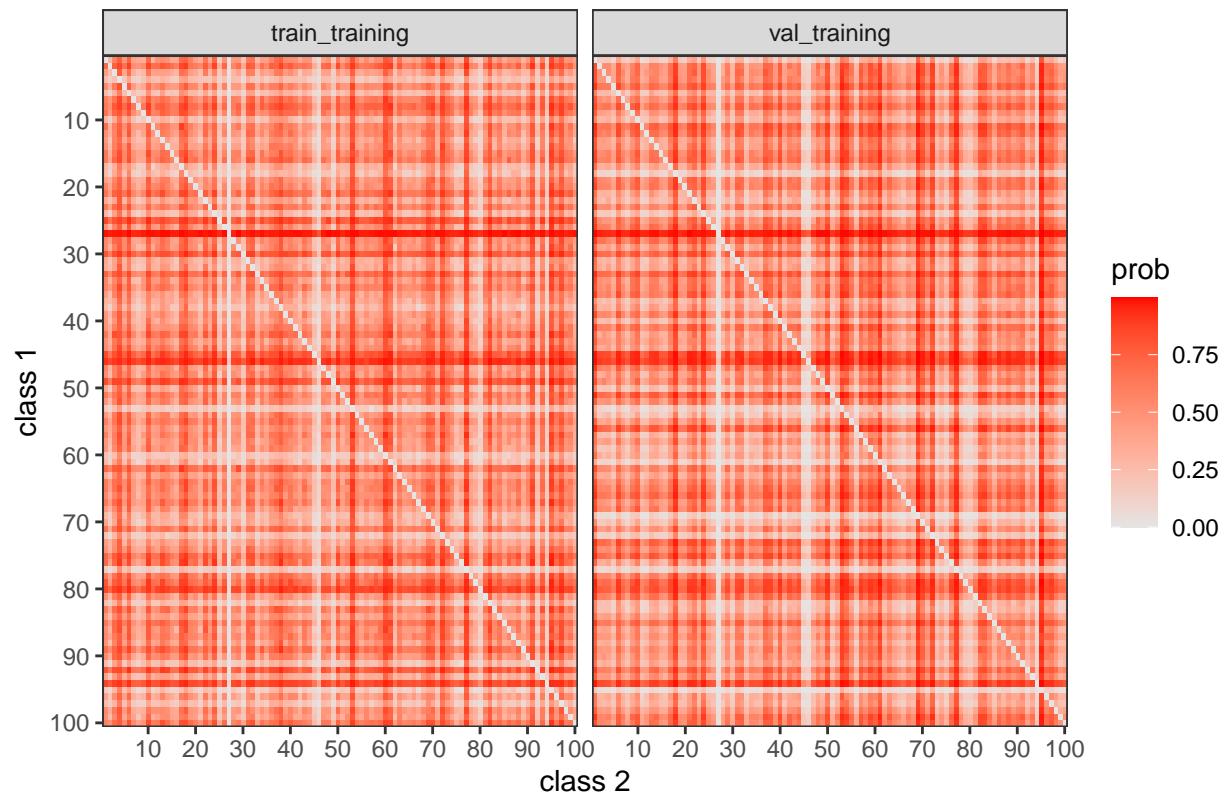
Average pairwise probabilities – class 25



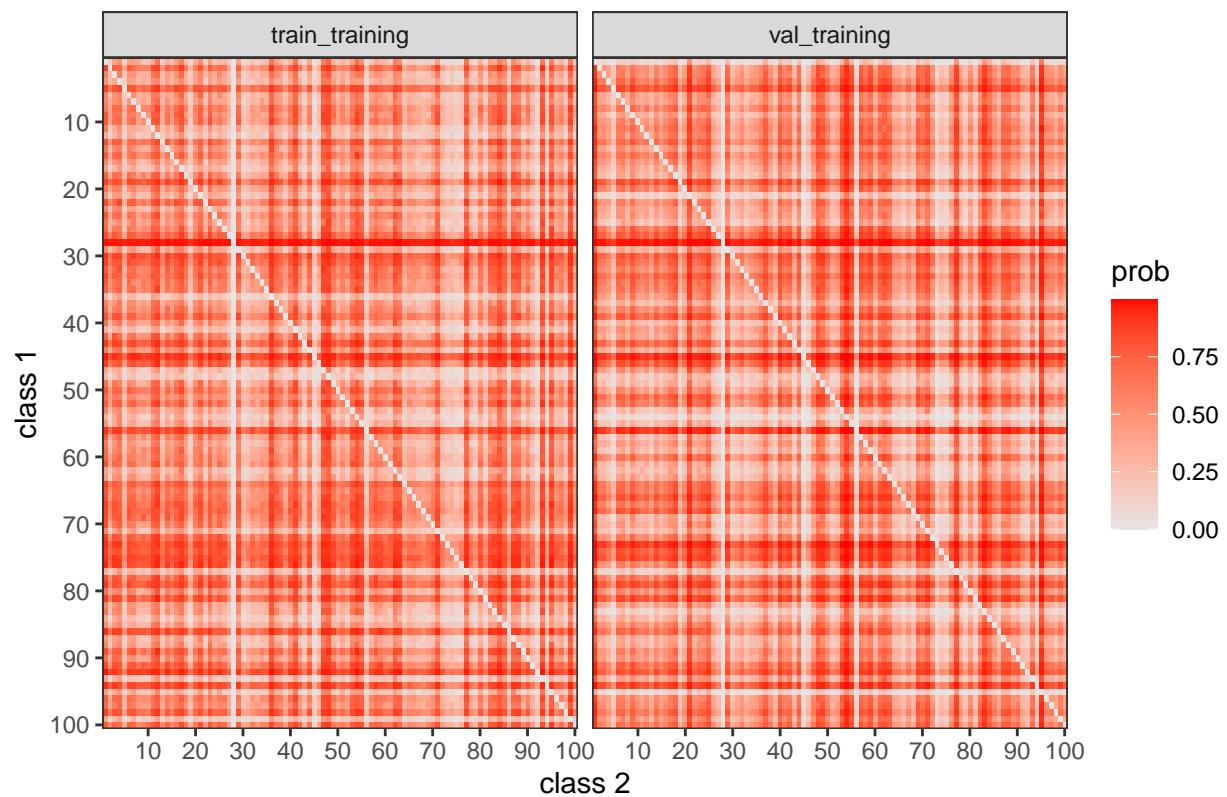
Average pairwise probabilities – class 26



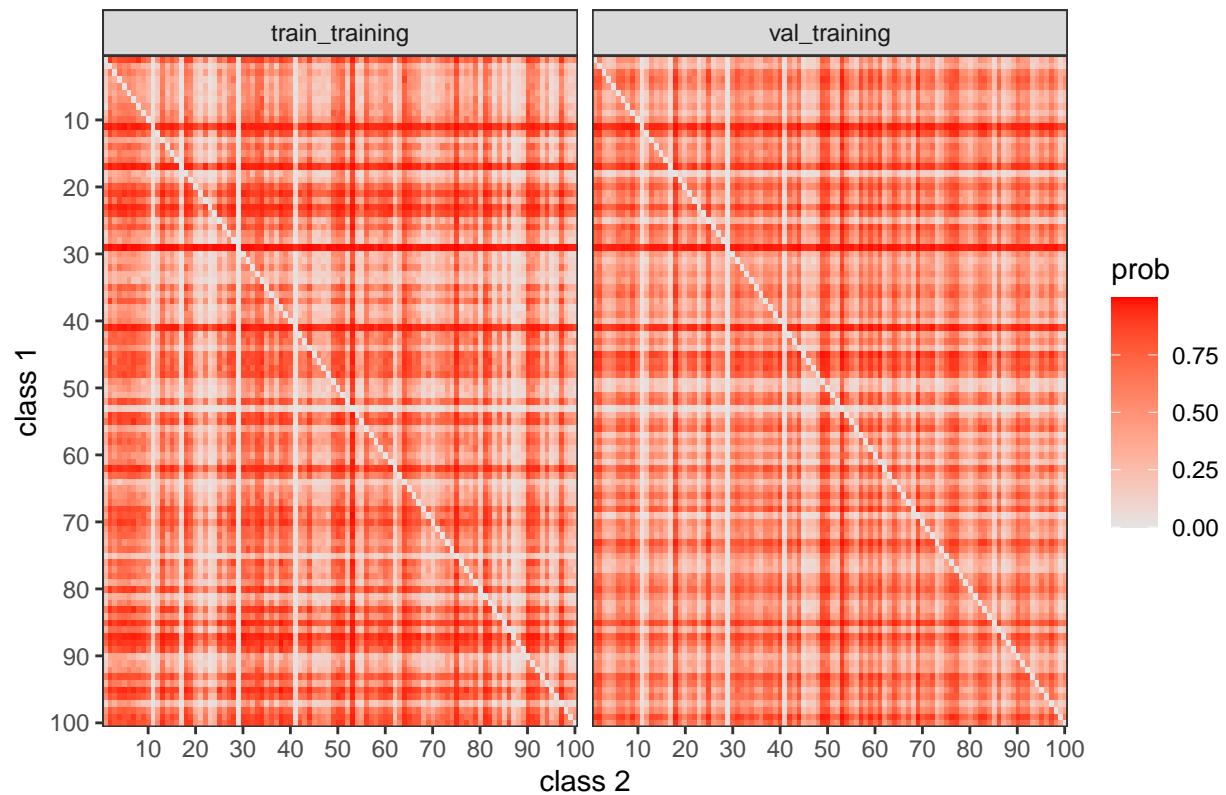
Average pairwise probabilities – class 27



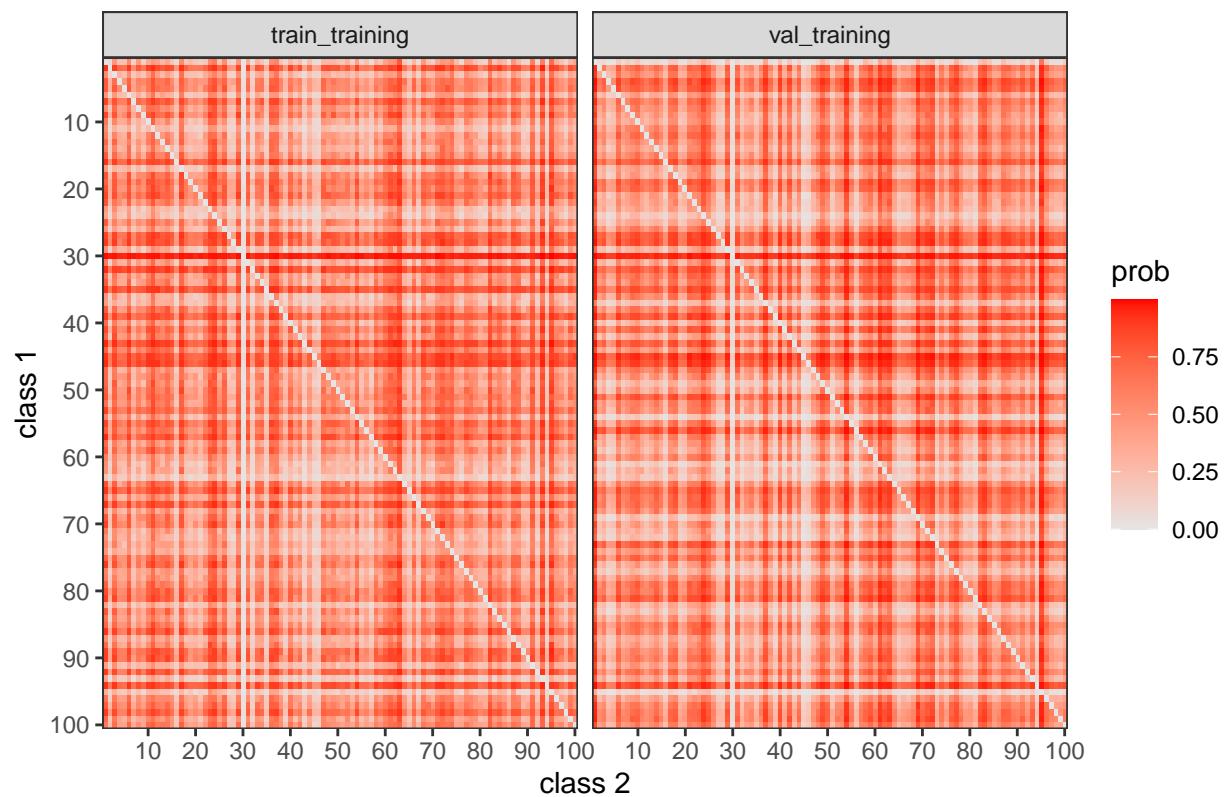
Average pairwise probabilities – class 28



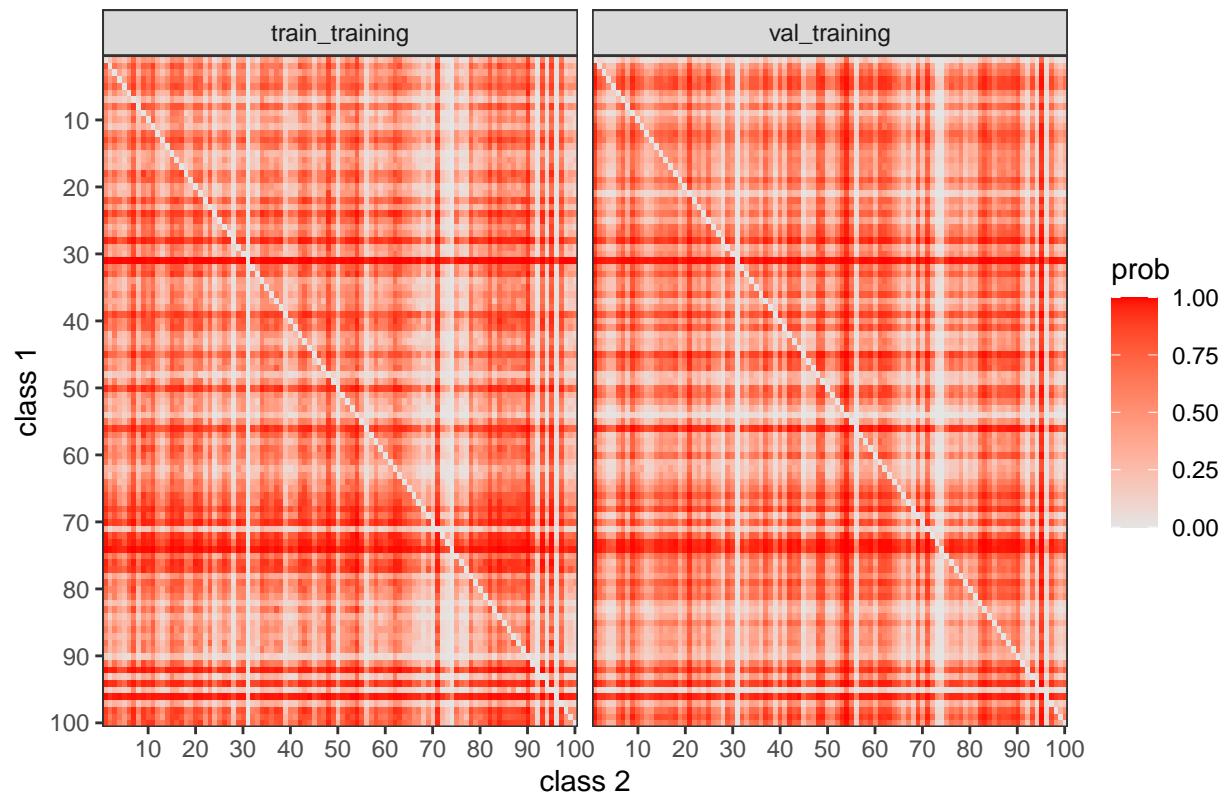
Average pairwise probabilities – class 29



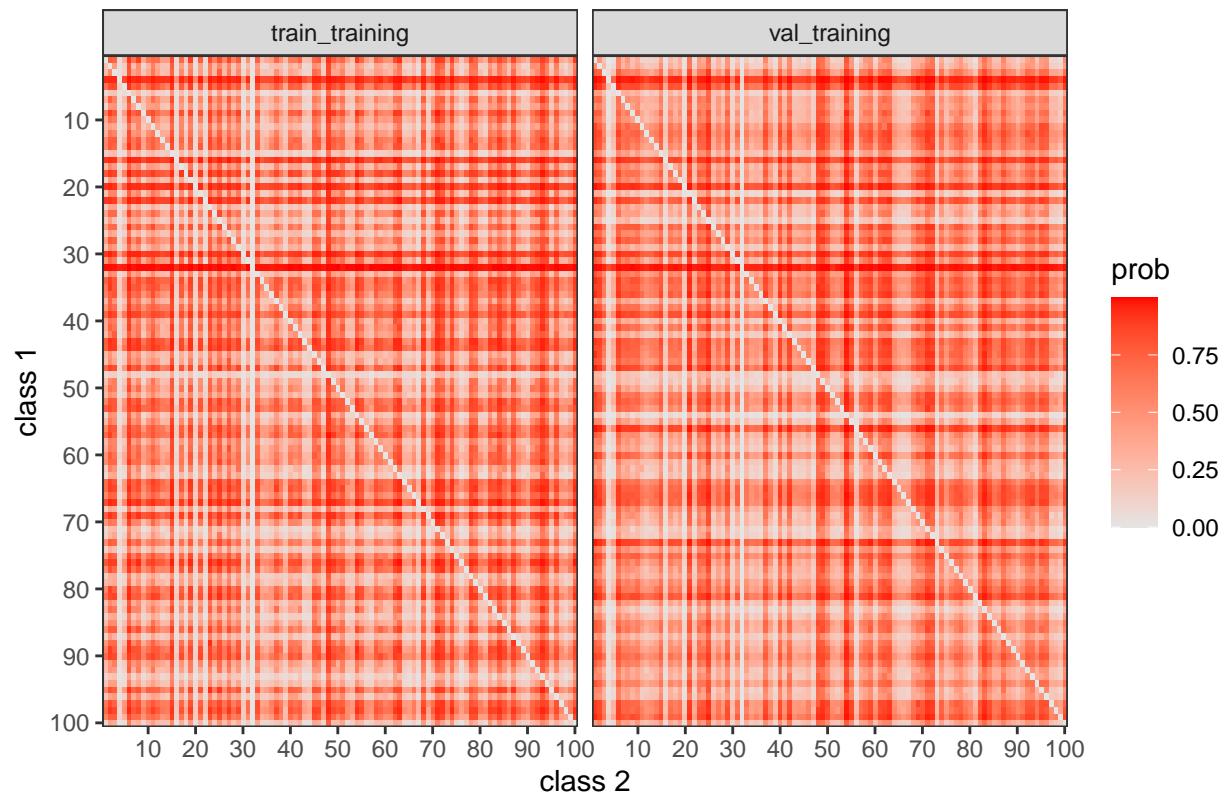
Average pairwise probabilities – class 30



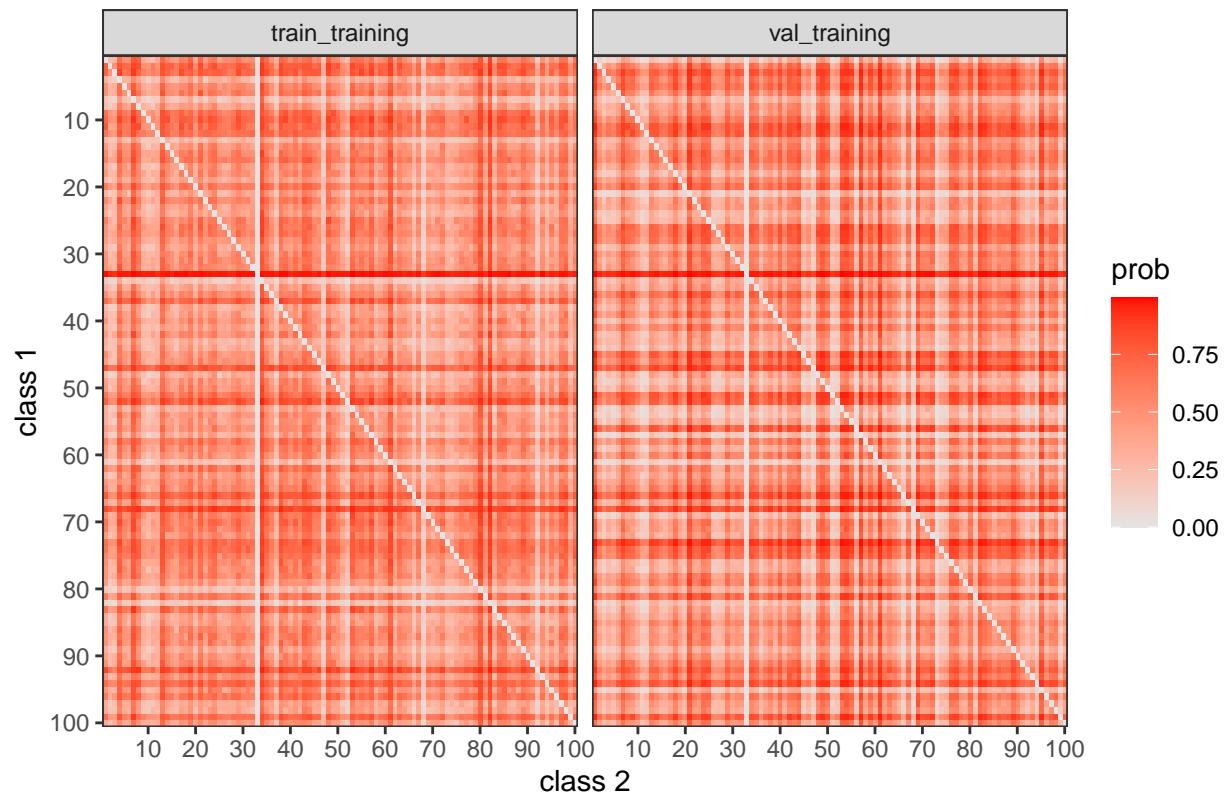
Average pairwise probabilities – class 31



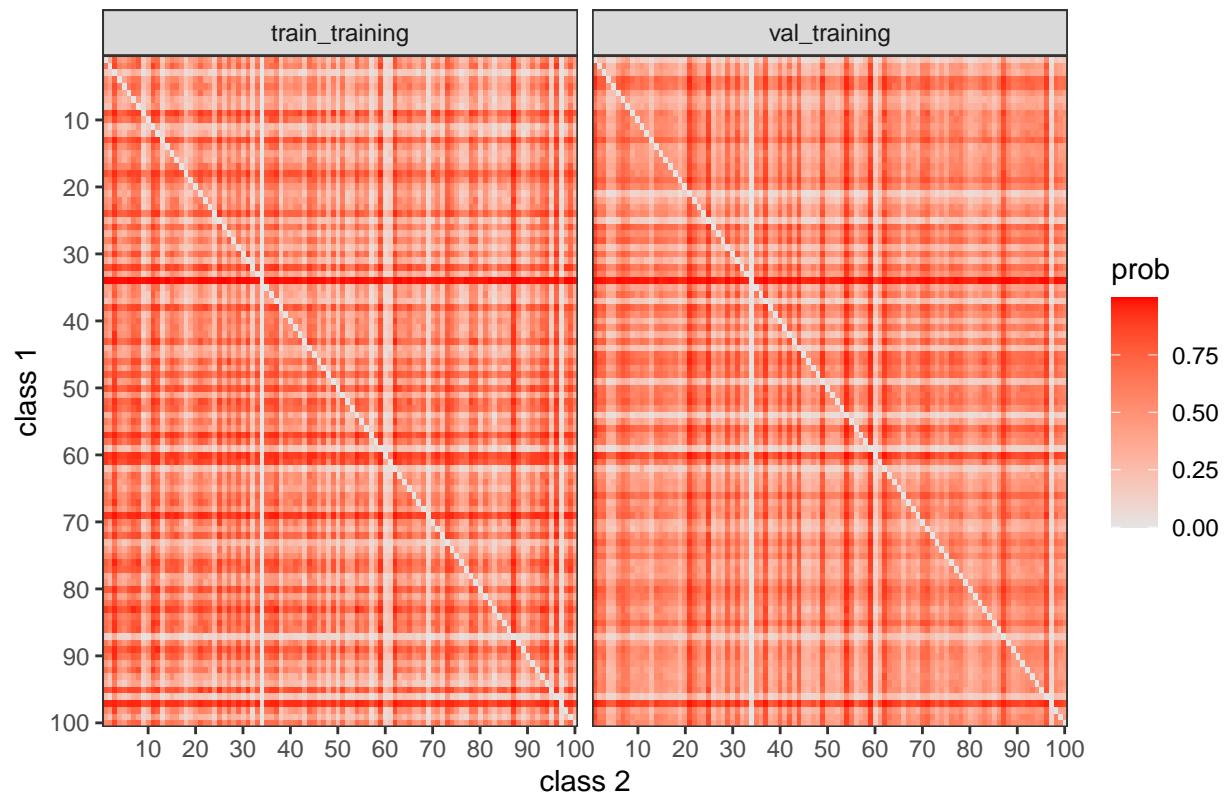
Average pairwise probabilities – class 32



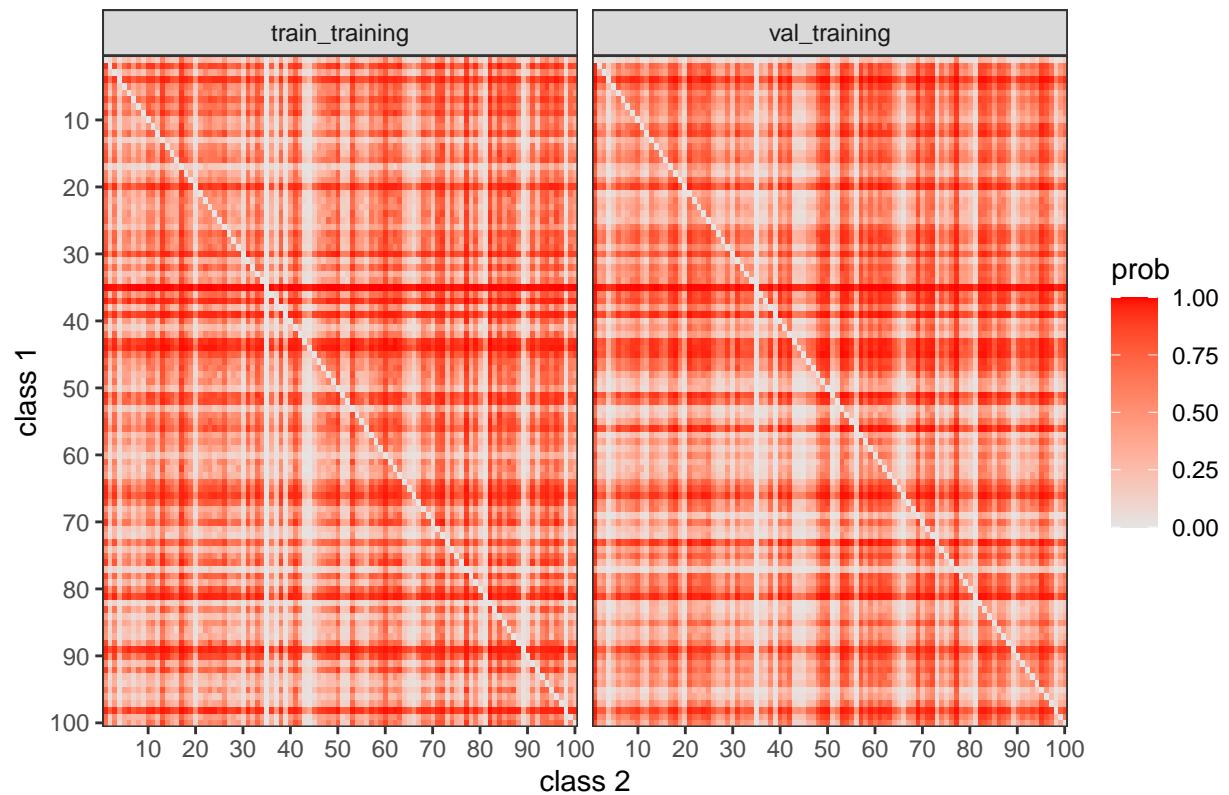
Average pairwise probabilities – class 33



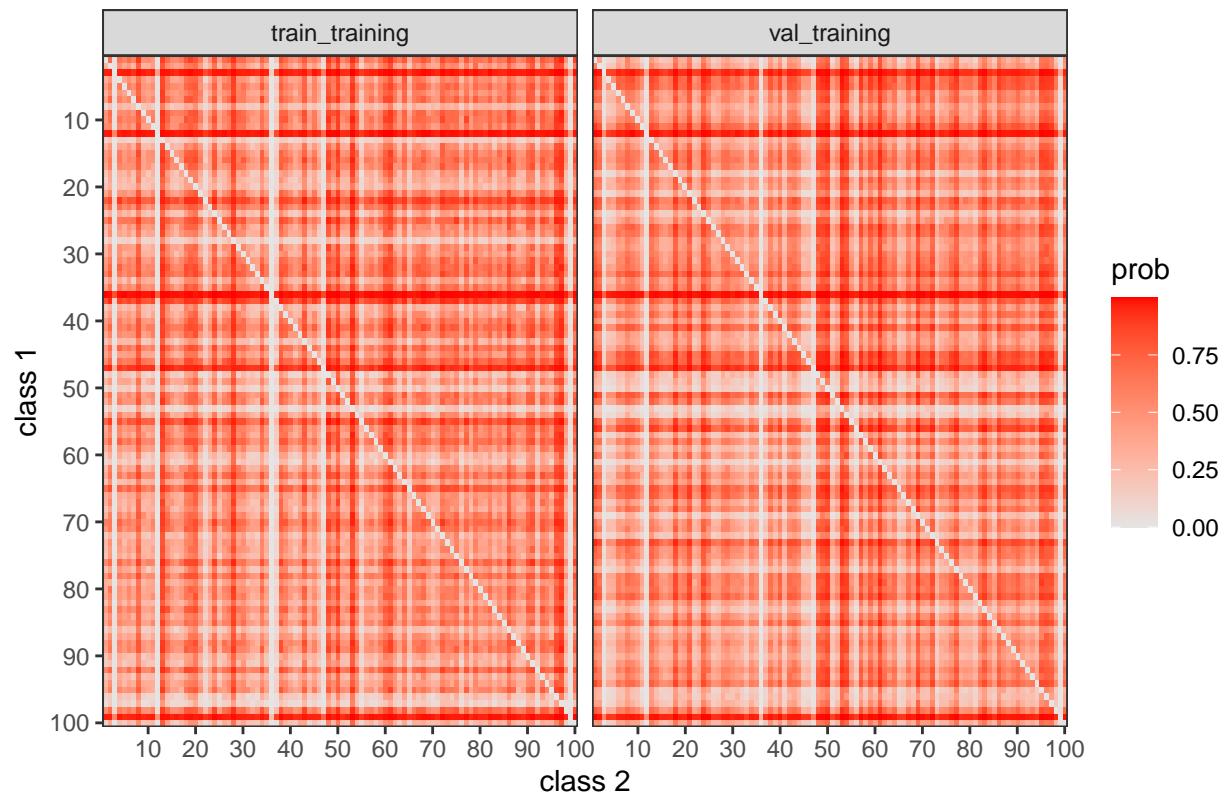
Average pairwise probabilities – class 34



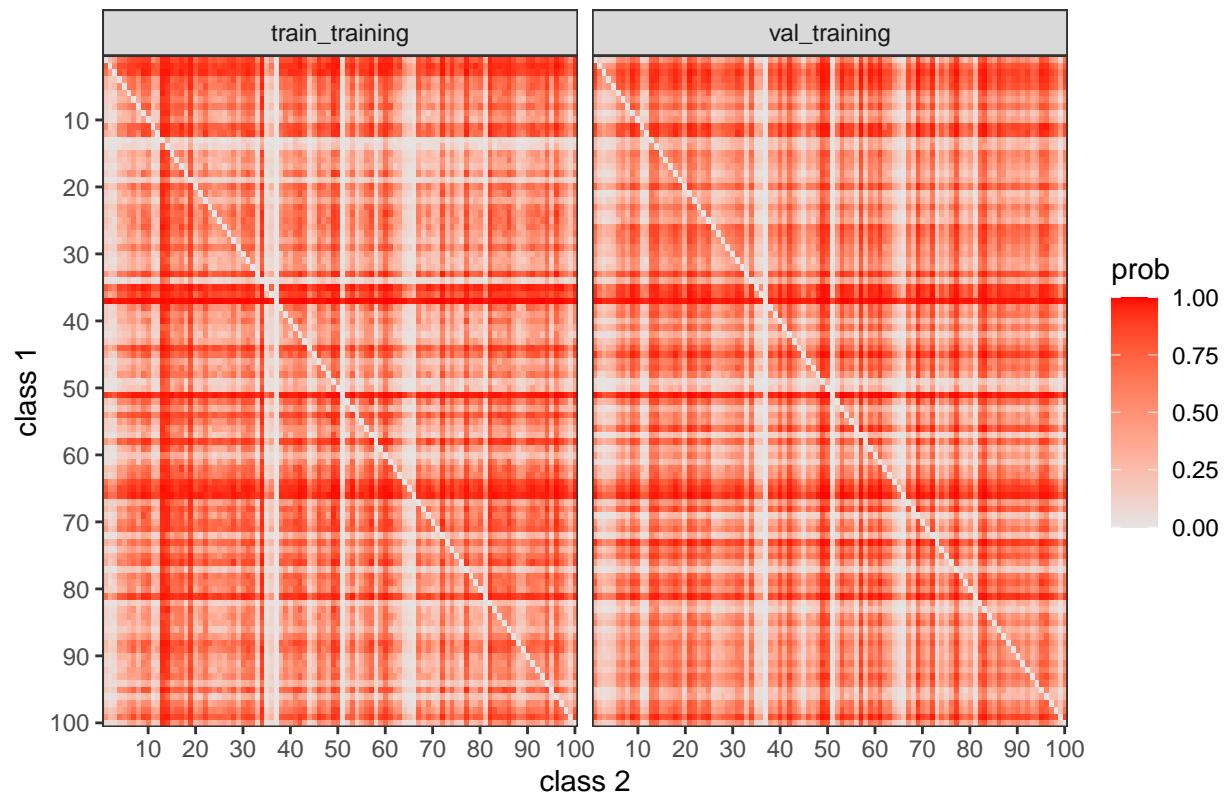
Average pairwise probabilities – class 35



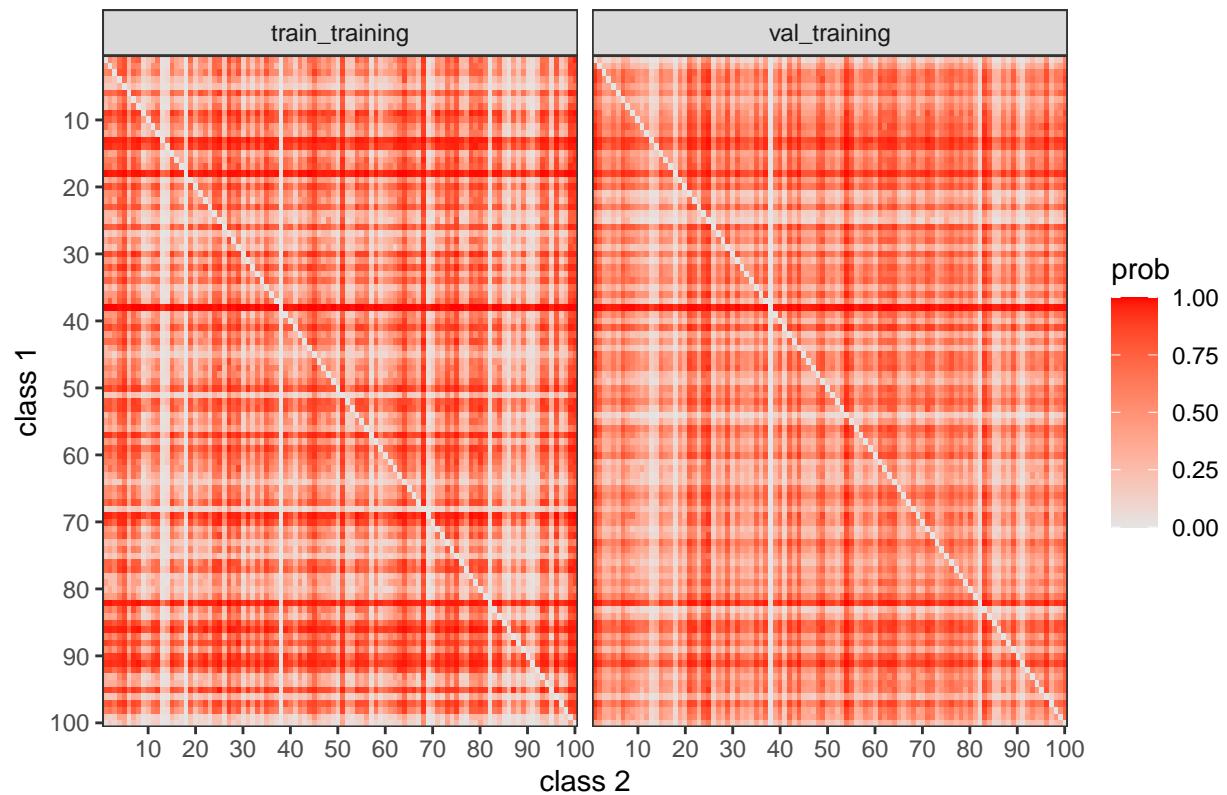
Average pairwise probabilities – class 36



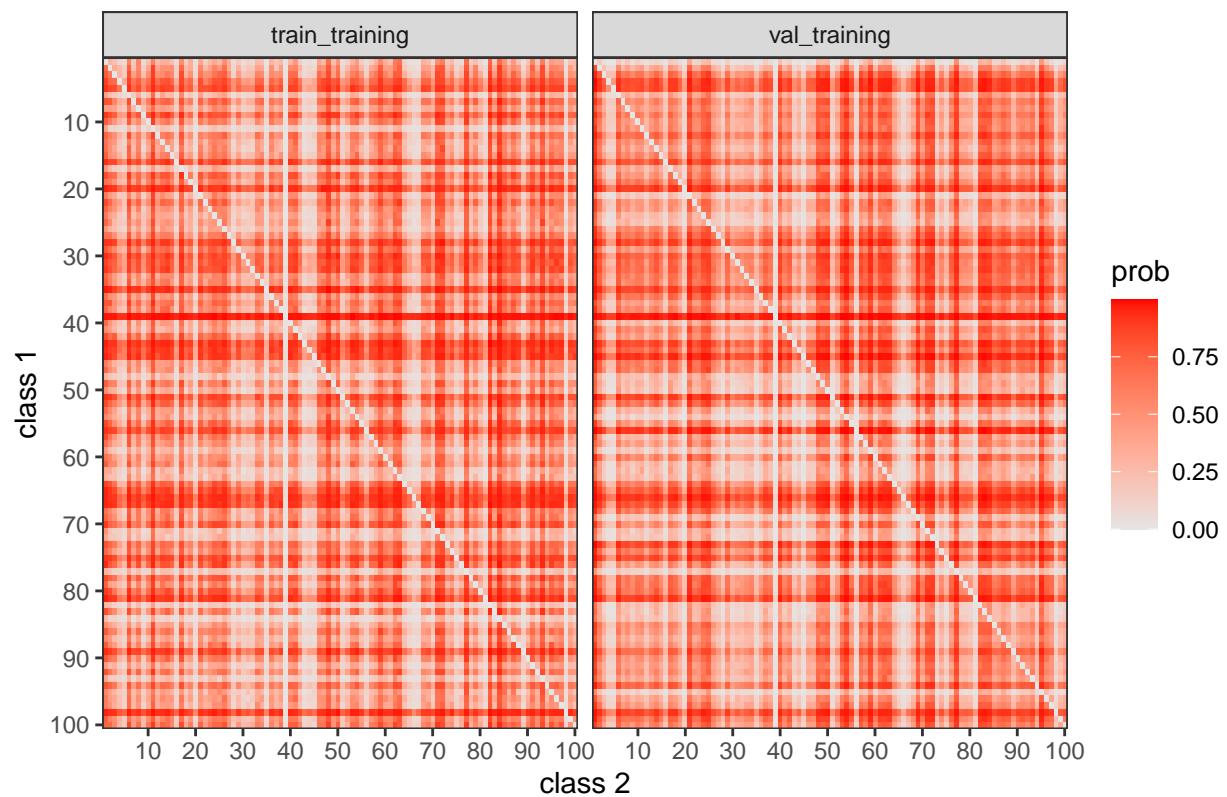
Average pairwise probabilities – class 37



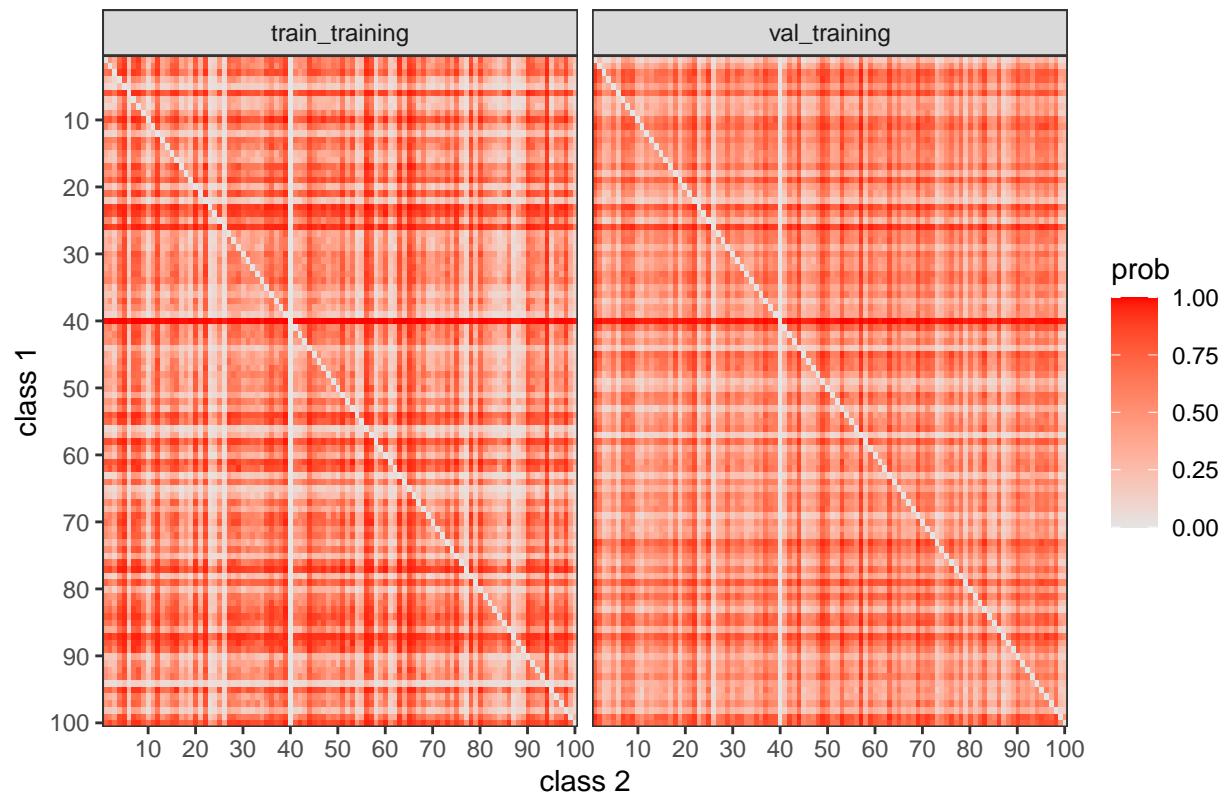
Average pairwise probabilities – class 38



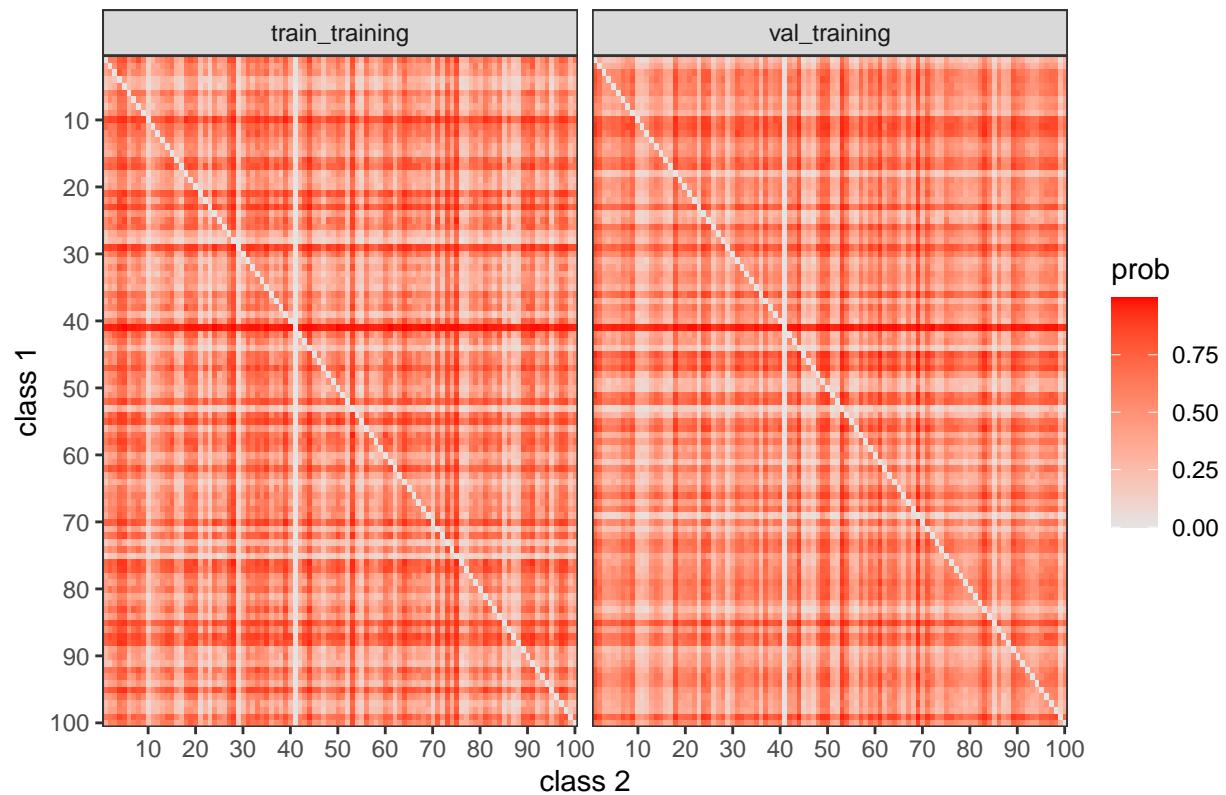
Average pairwise probabilities – class 39



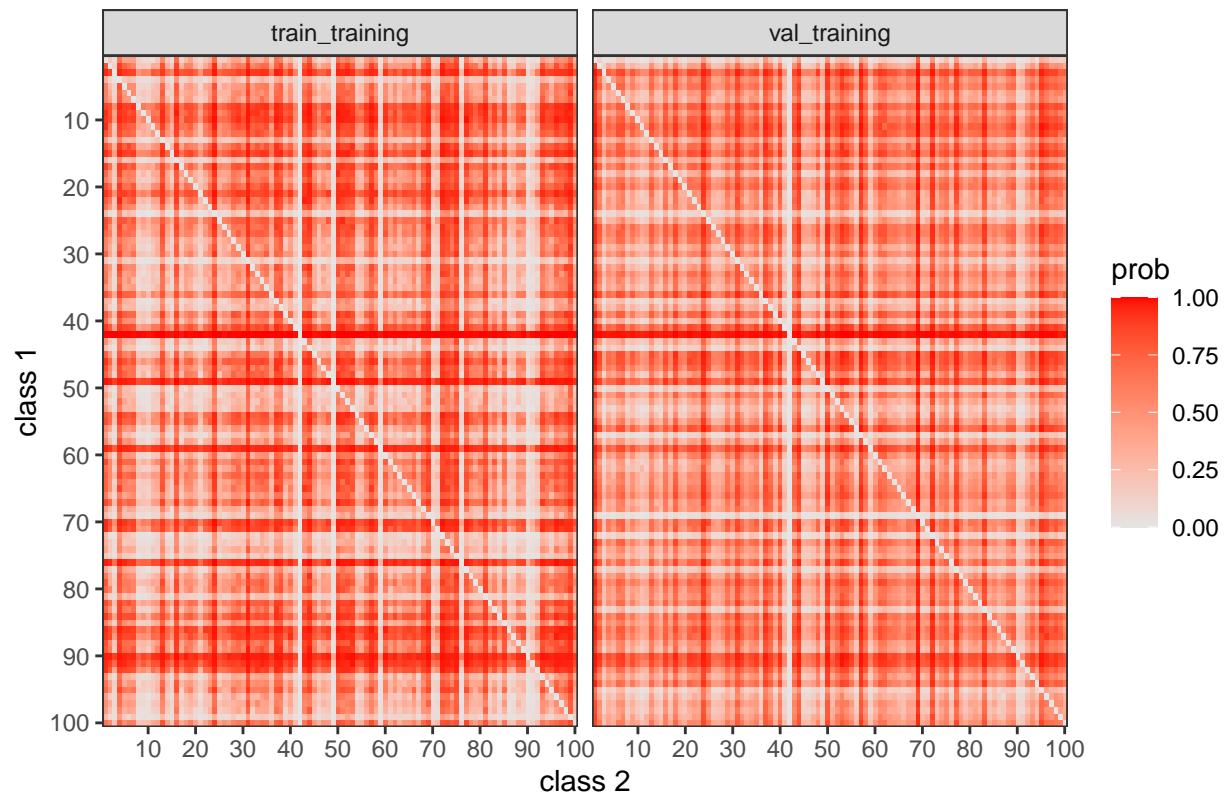
Average pairwise probabilities – class 40



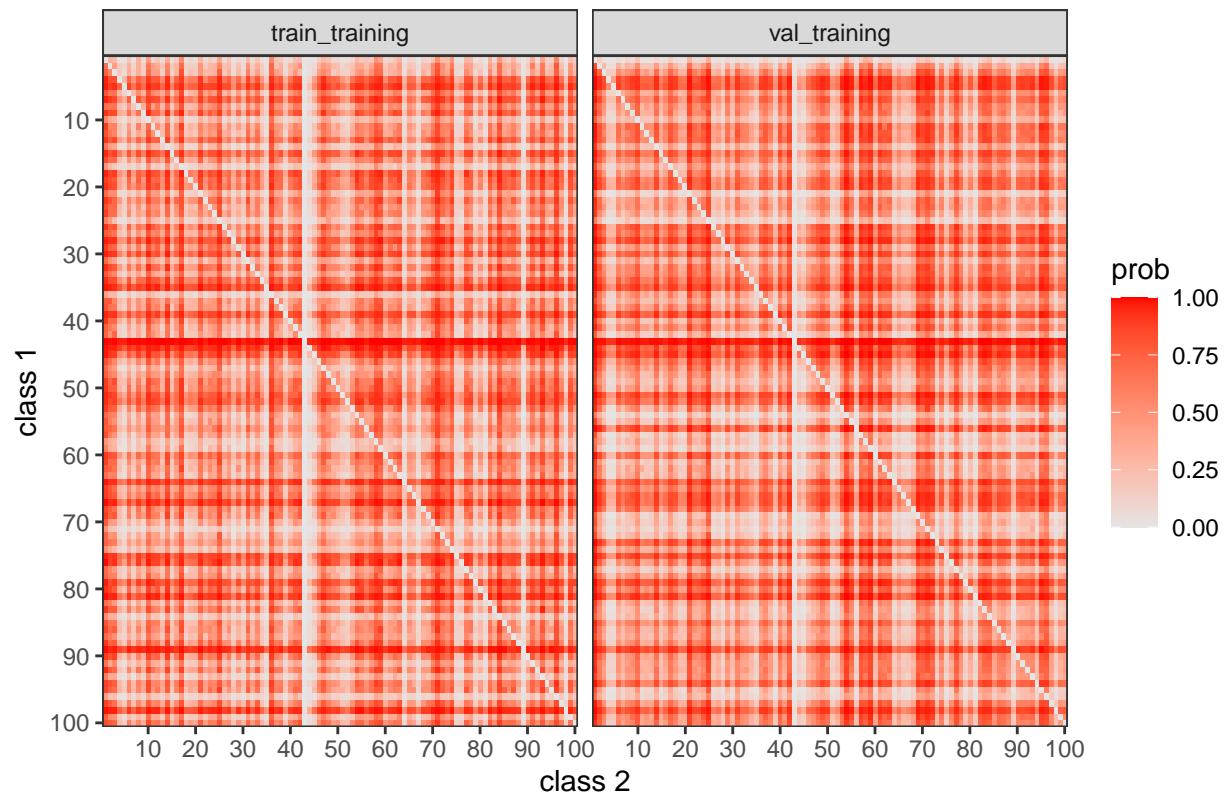
Average pairwise probabilities – class 41



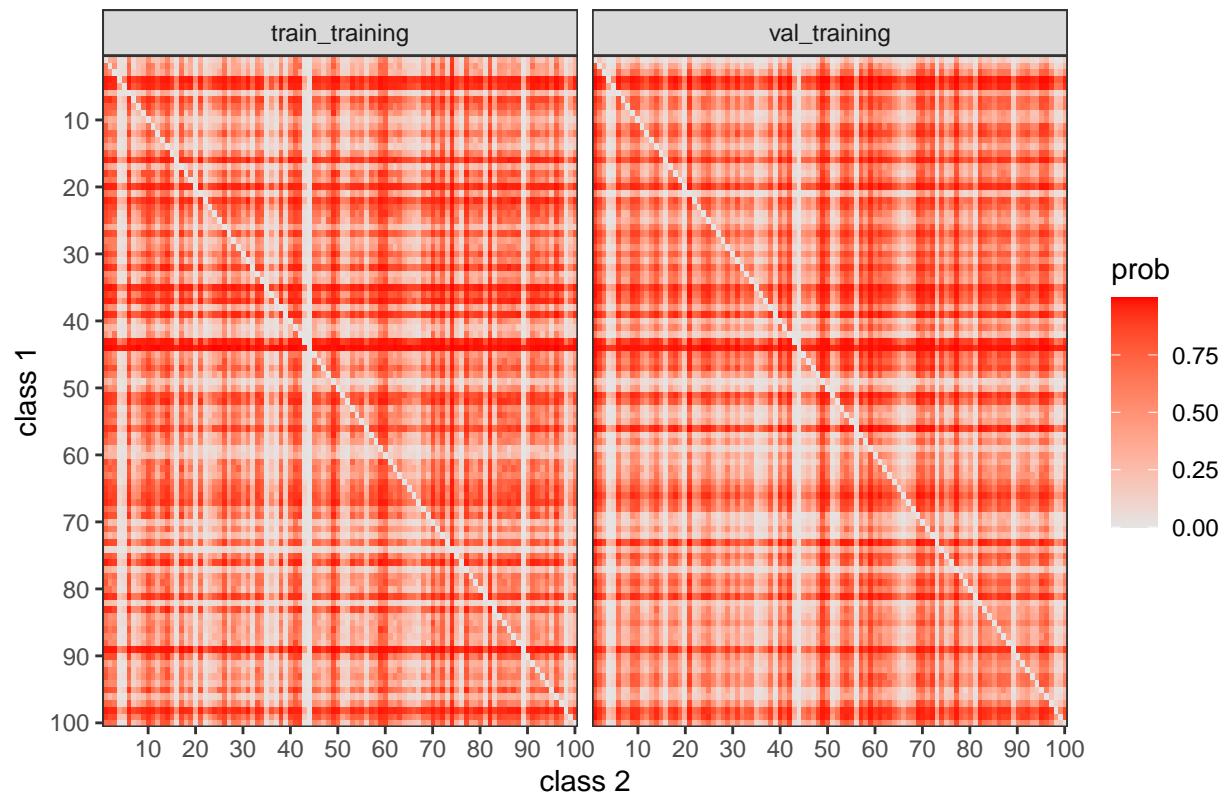
Average pairwise probabilities – class 42



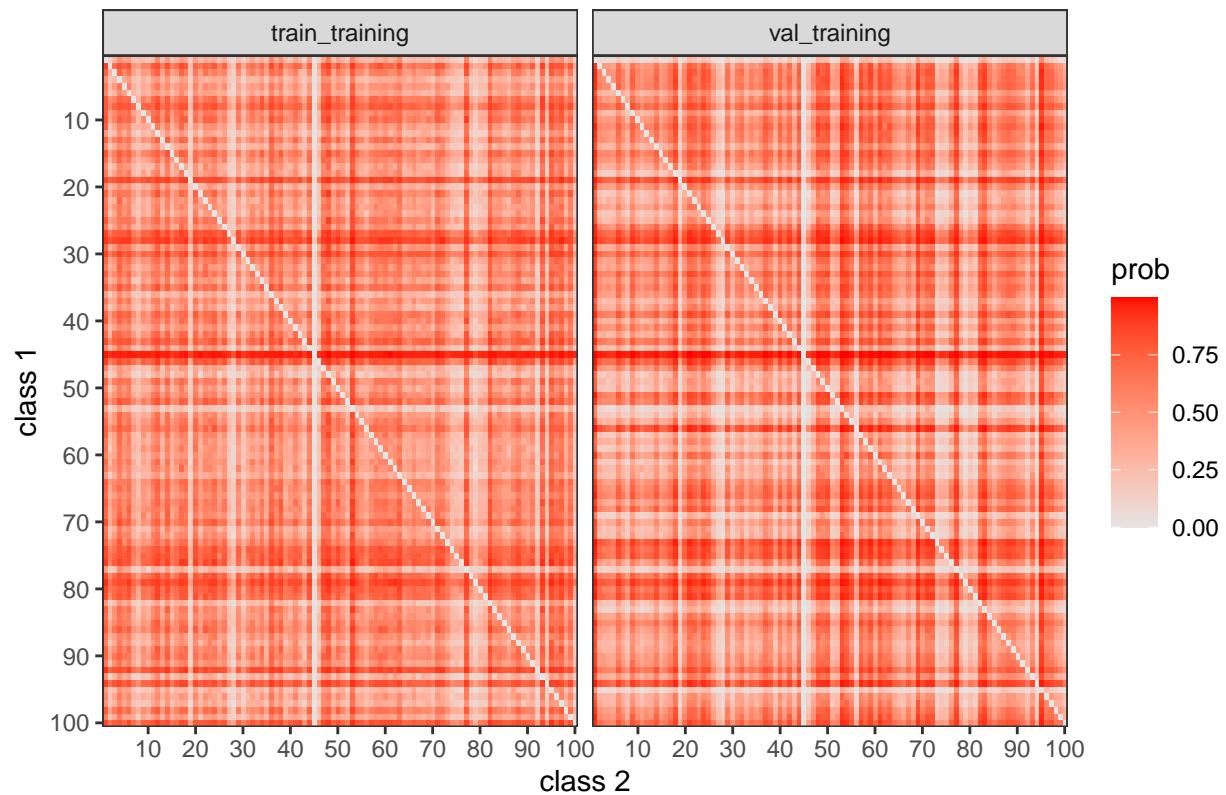
Average pairwise probabilities – class 43



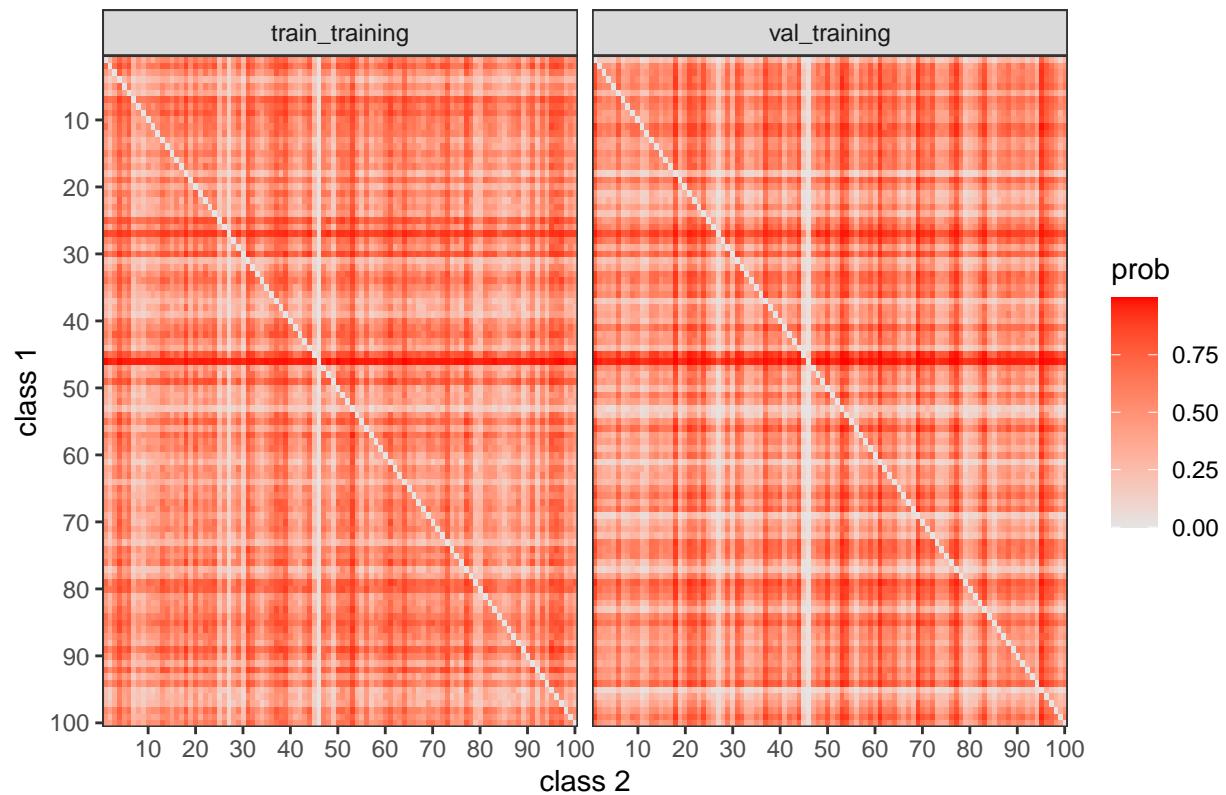
Average pairwise probabilities – class 44



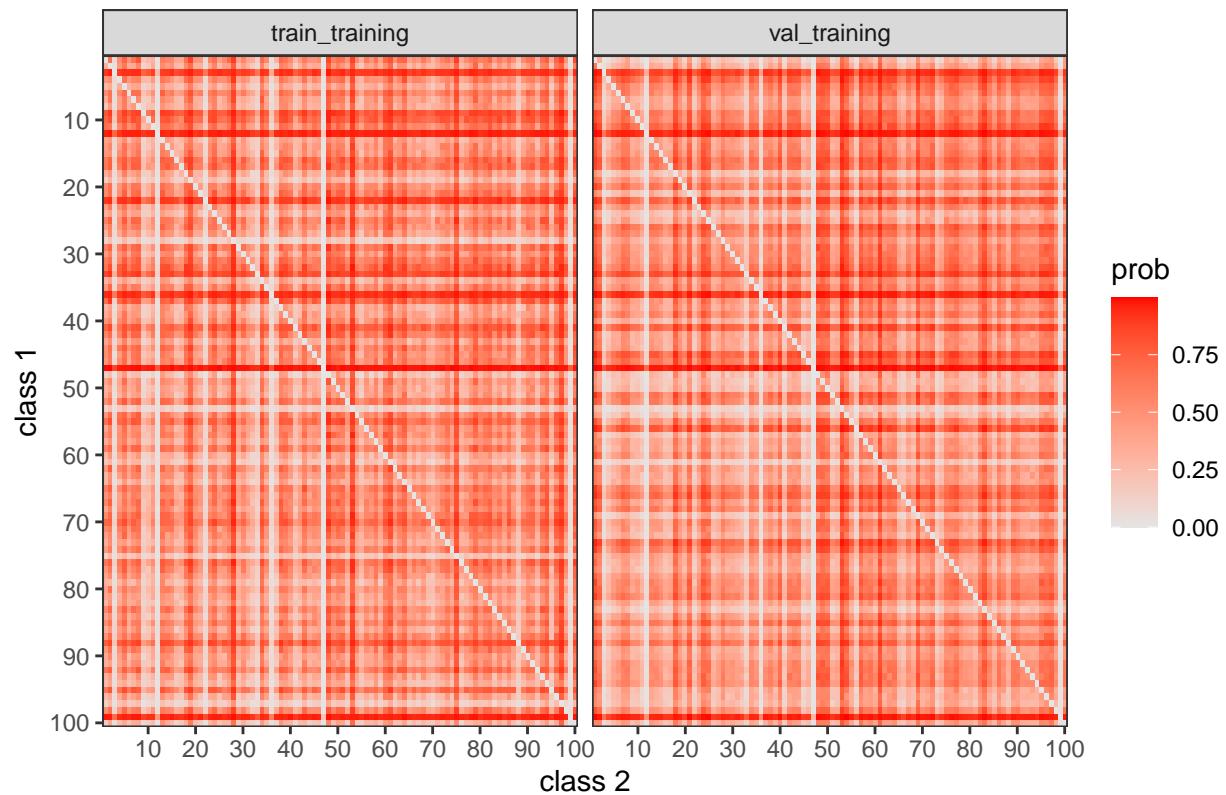
Average pairwise probabilities – class 45



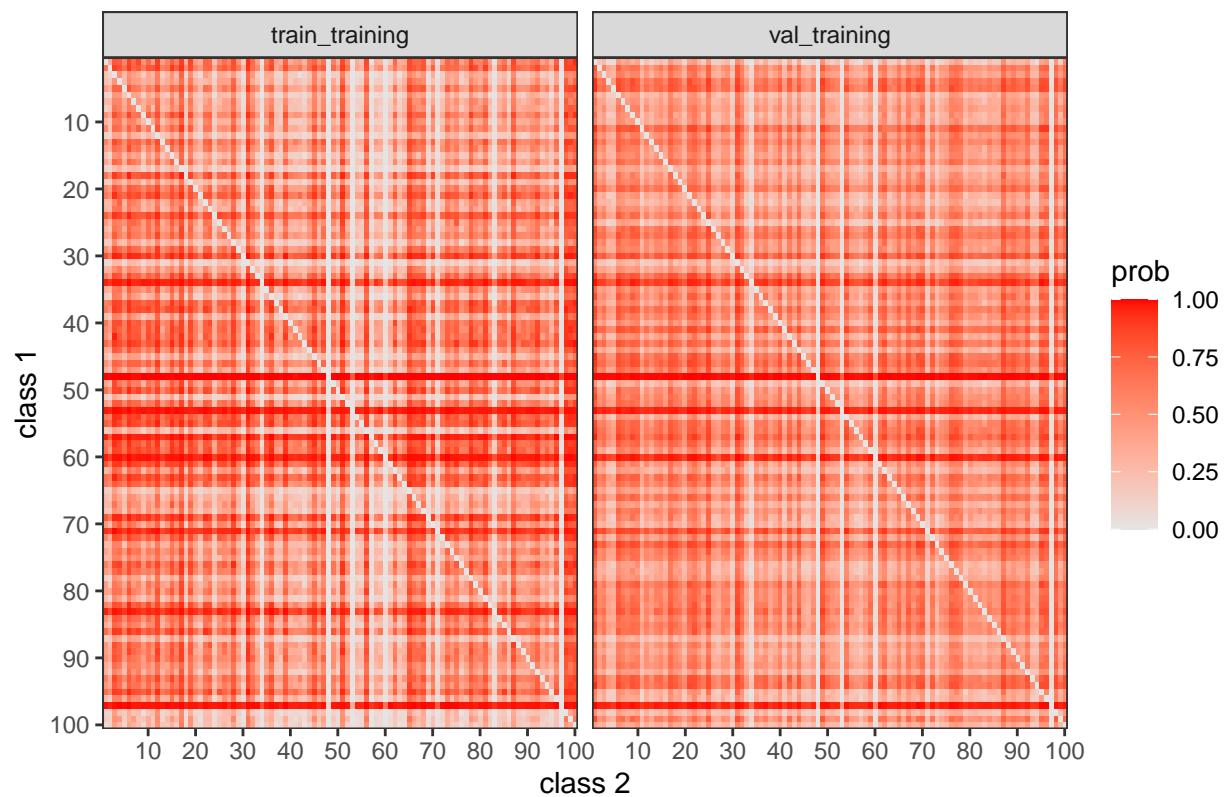
Average pairwise probabilities – class 46



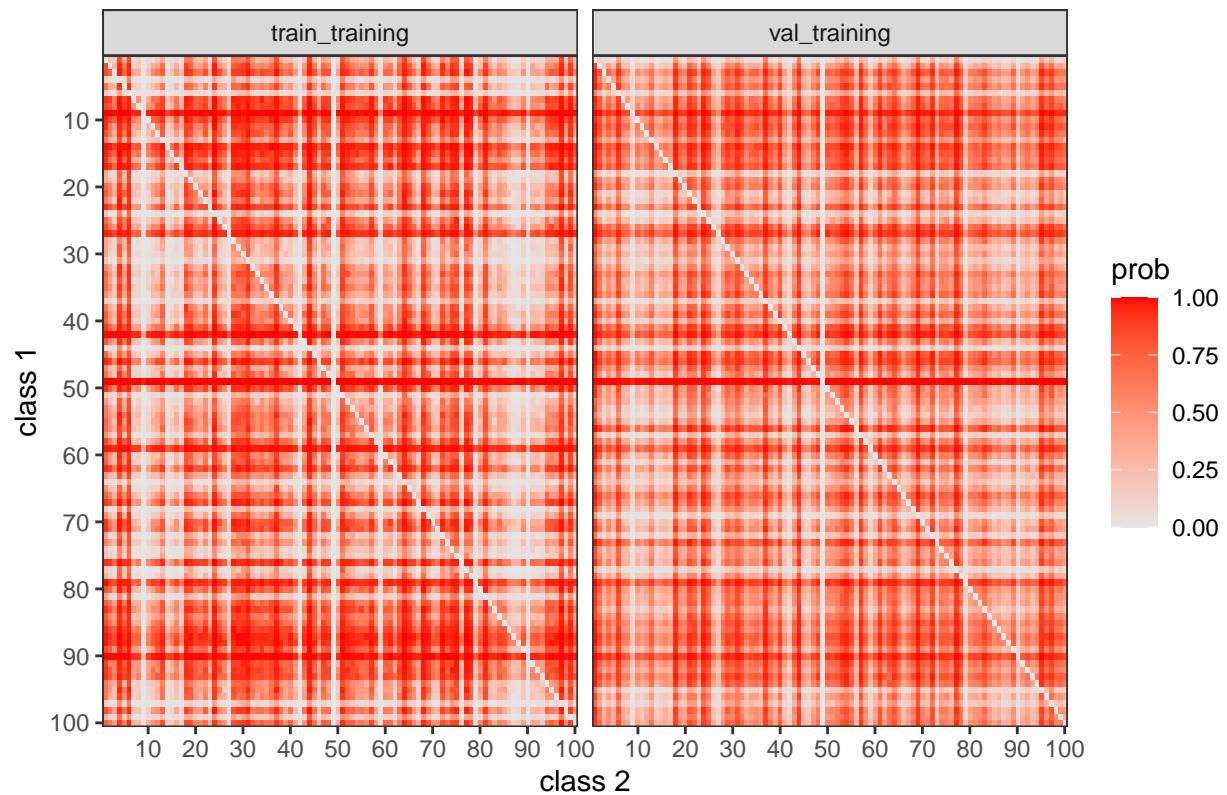
Average pairwise probabilities – class 47



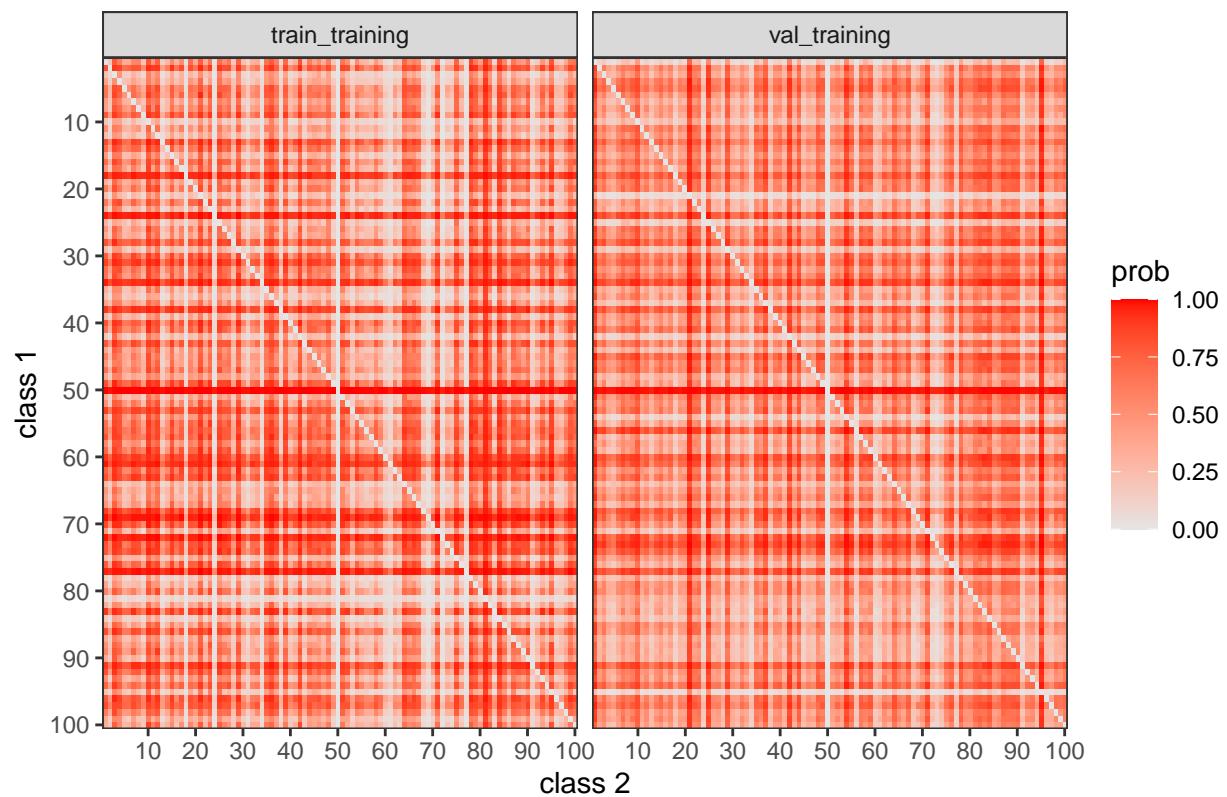
Average pairwise probabilities – class 48



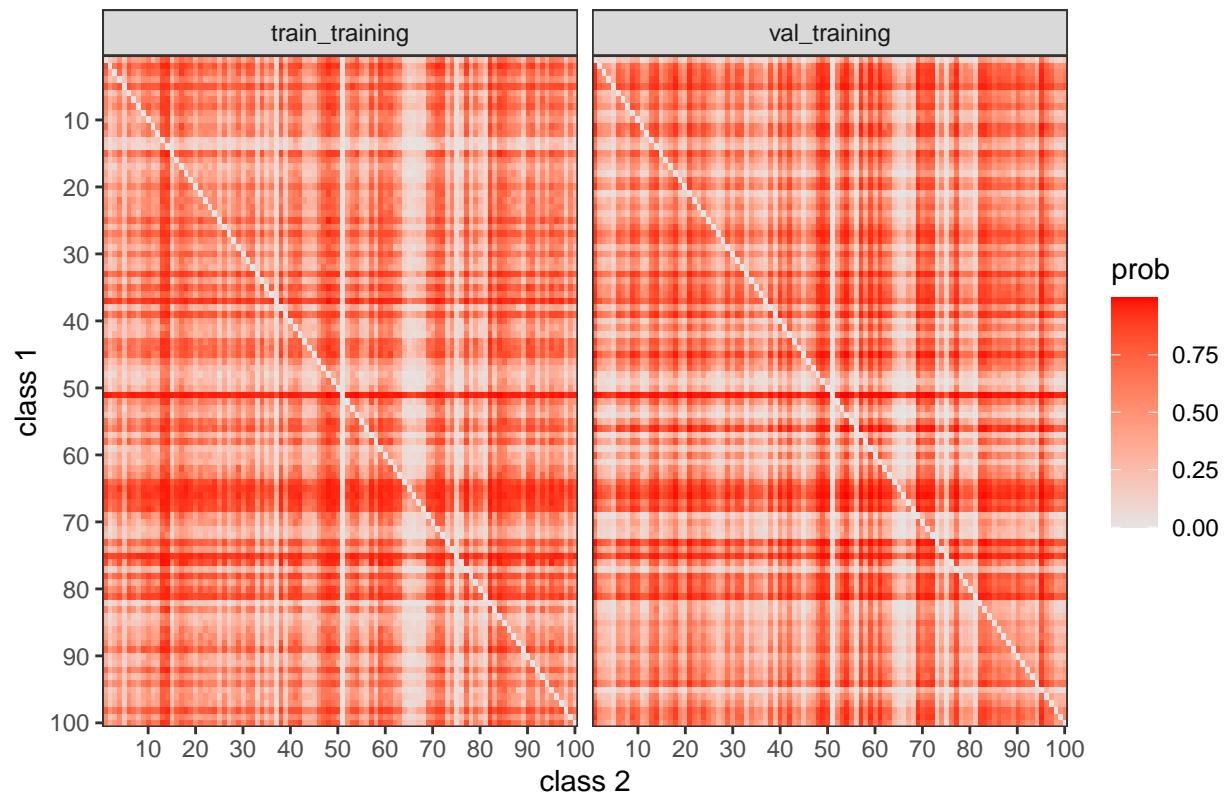
Average pairwise probabilities – class 49



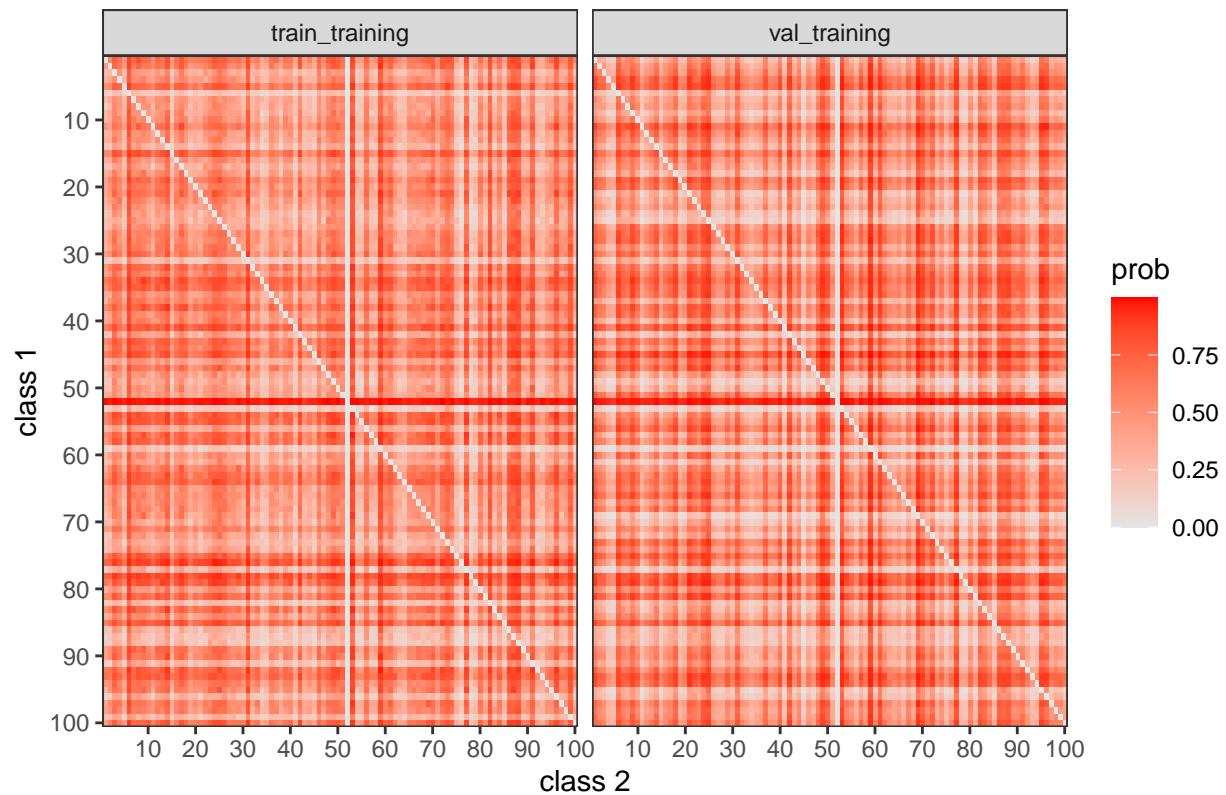
Average pairwise probabilities – class 50



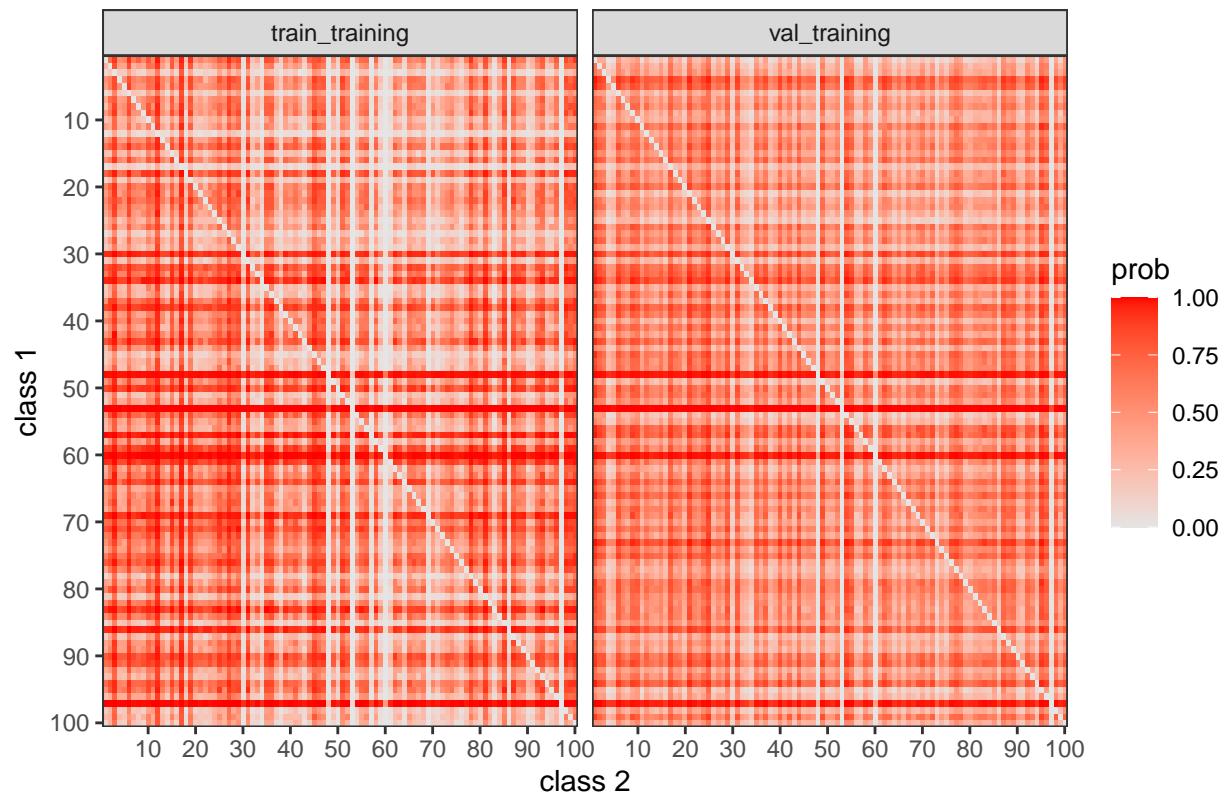
Average pairwise probabilities – class 51



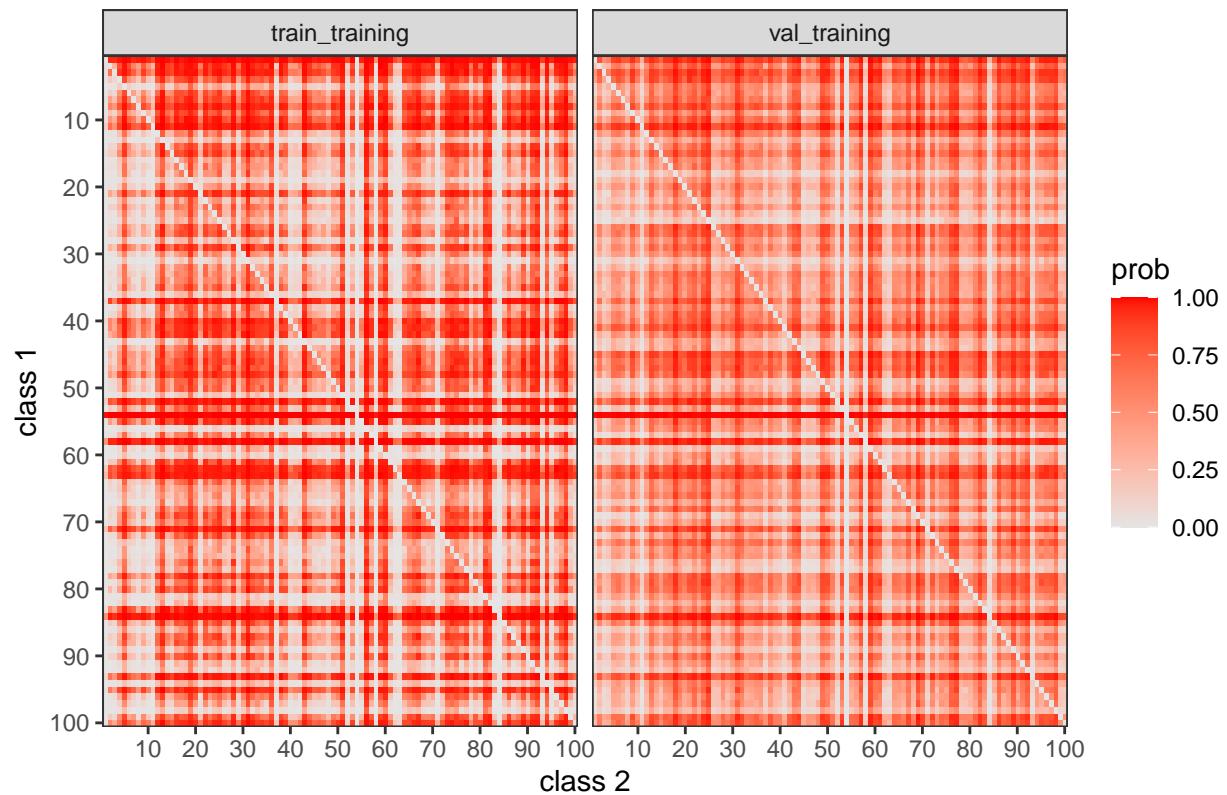
Average pairwise probabilities – class 52



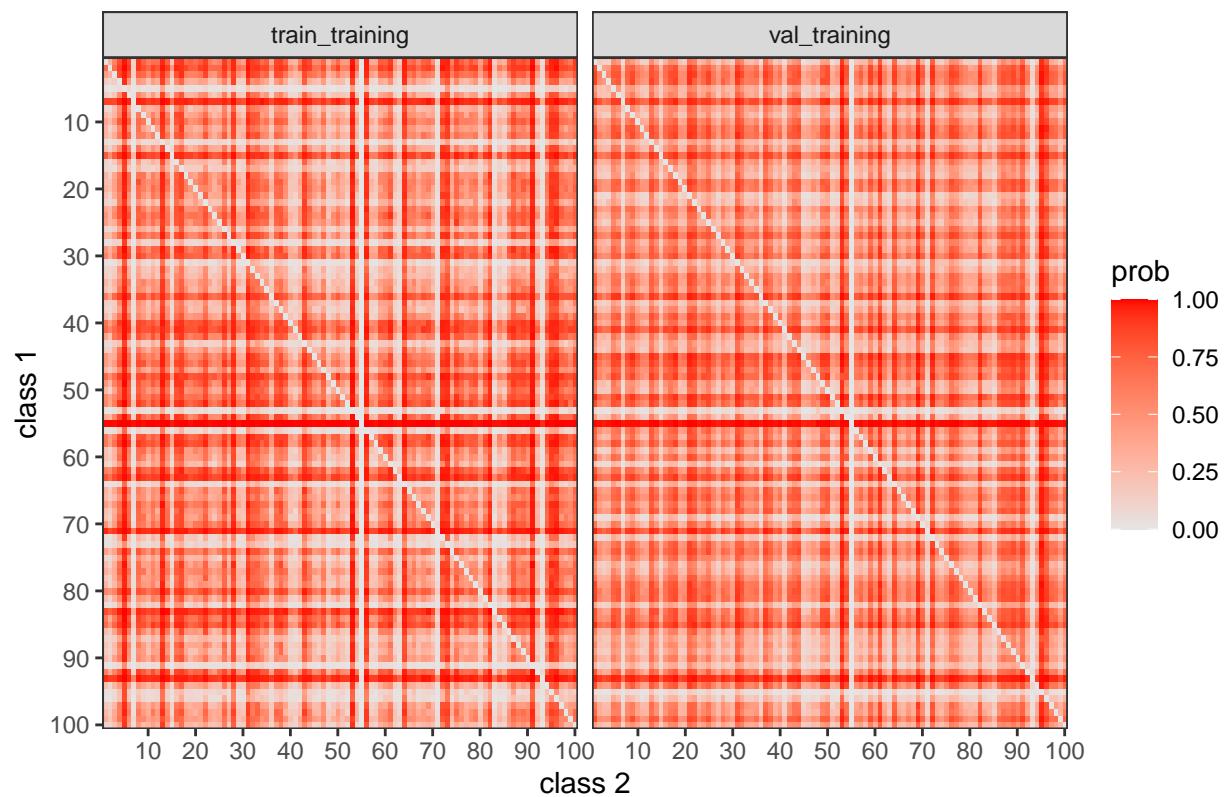
Average pairwise probabilities – class 53



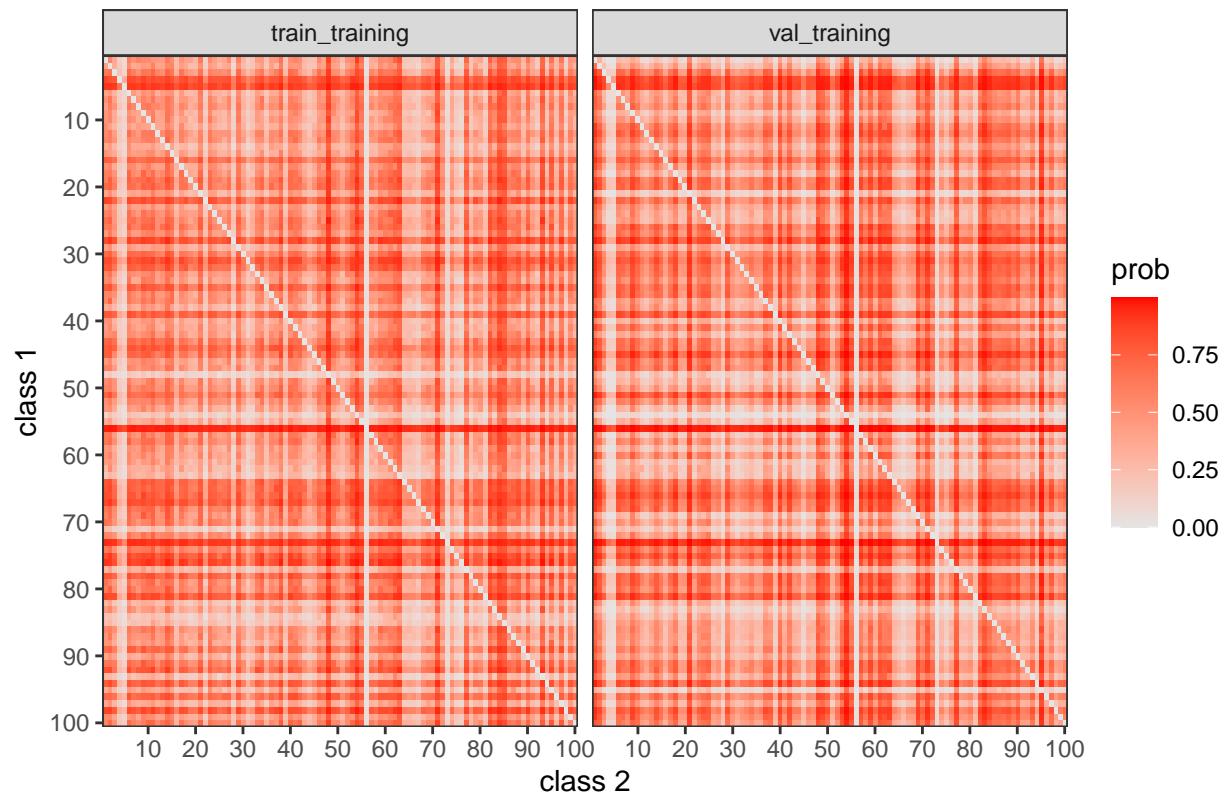
Average pairwise probabilities – class 54



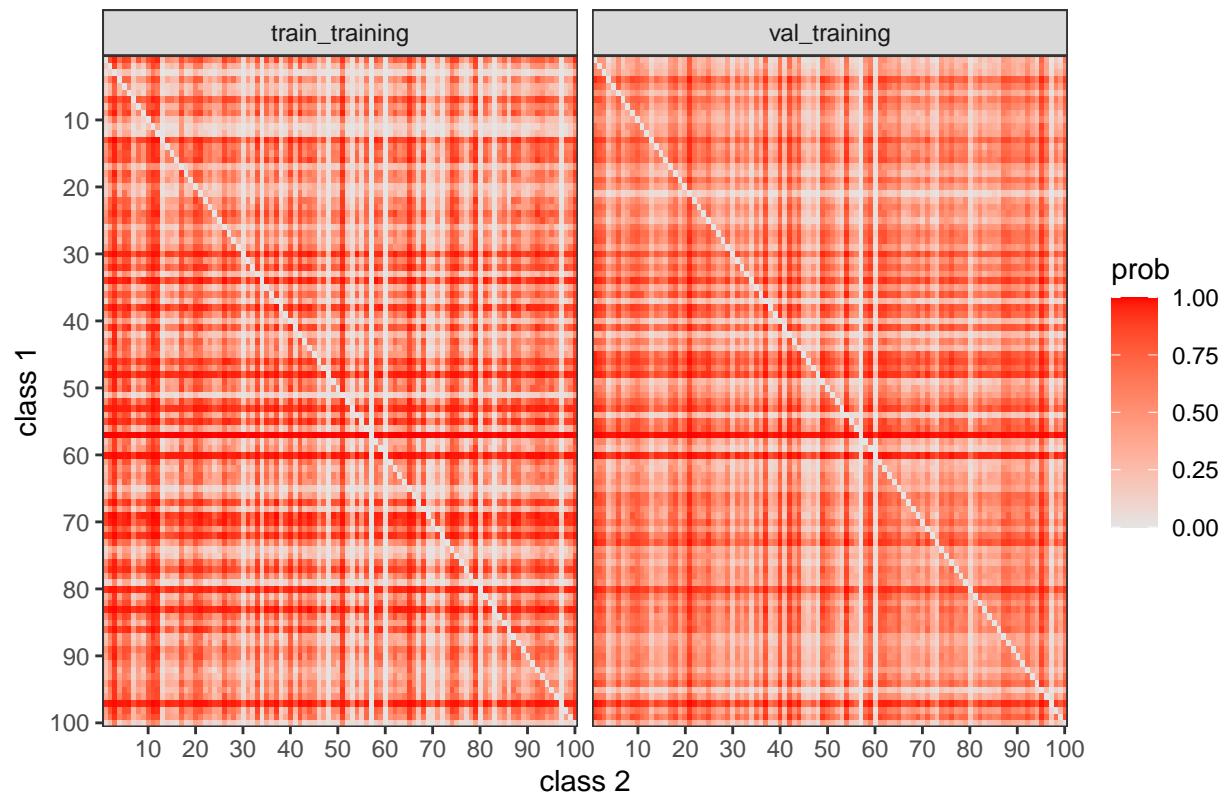
Average pairwise probabilities – class 55



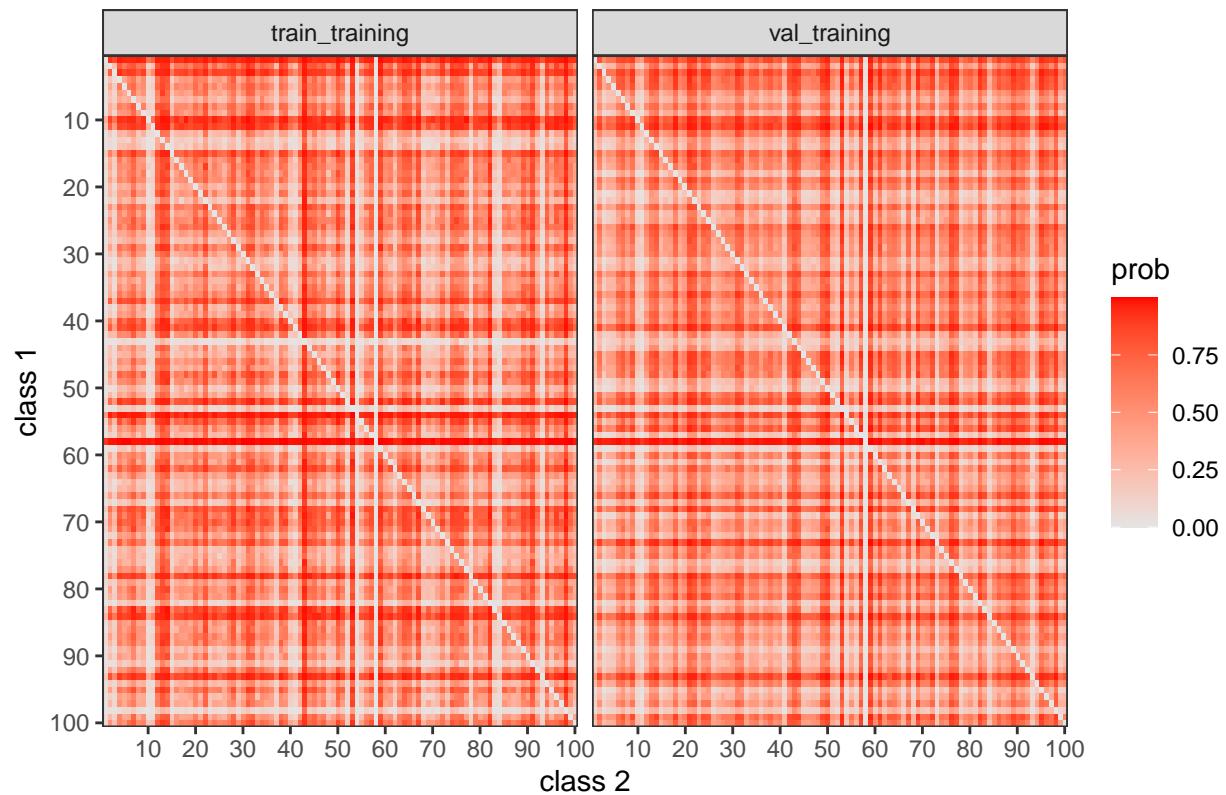
Average pairwise probabilities – class 56



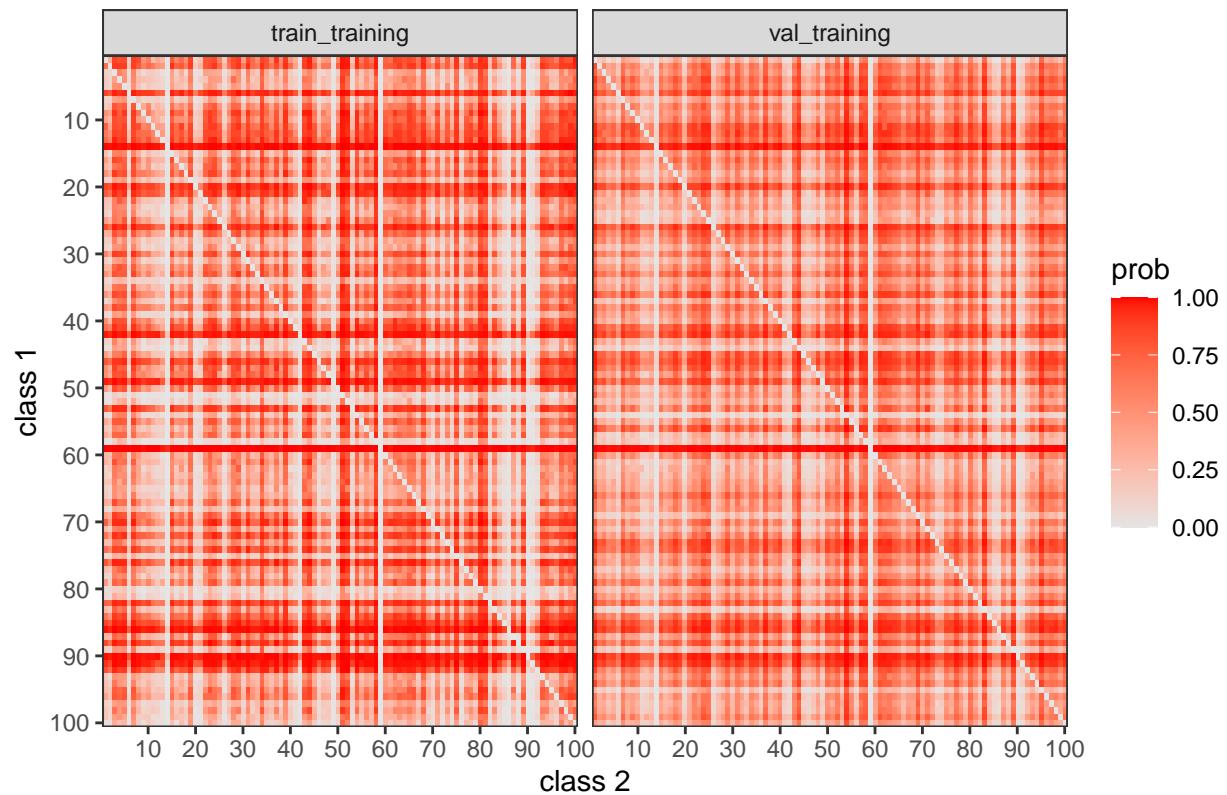
Average pairwise probabilities – class 57



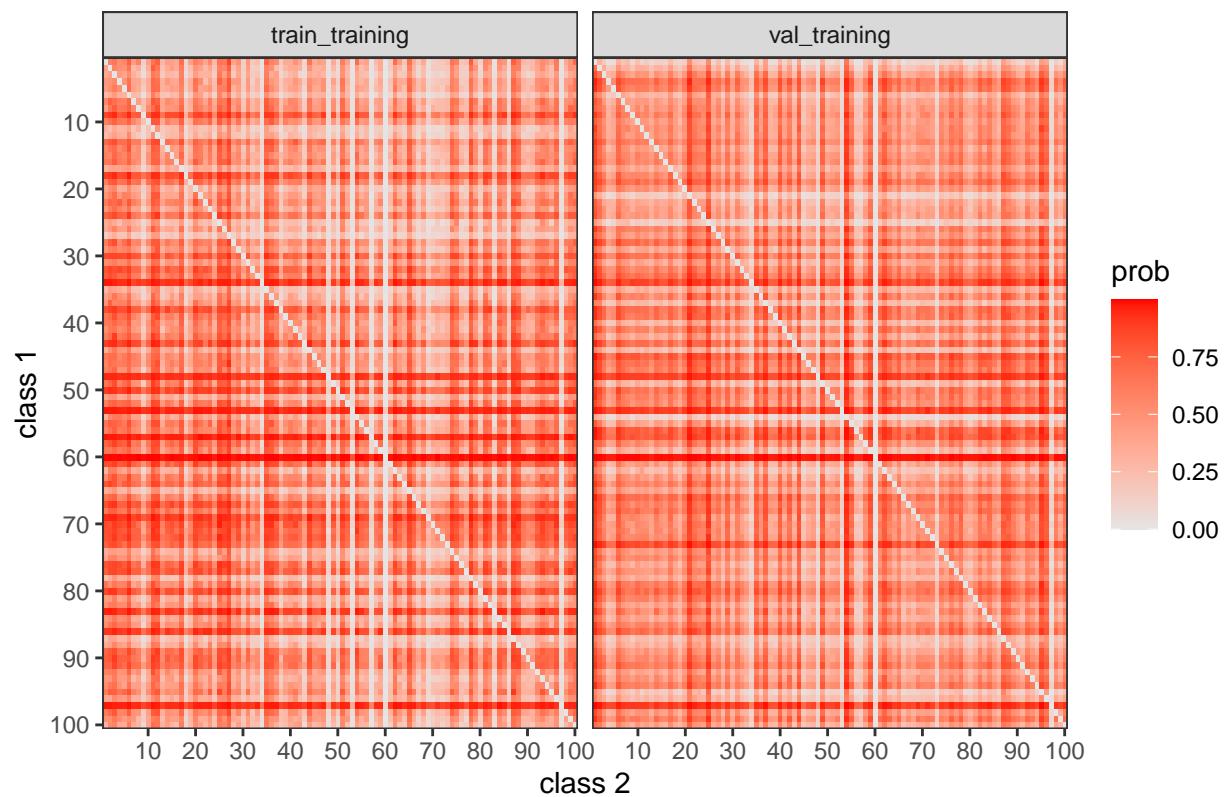
Average pairwise probabilities – class 58



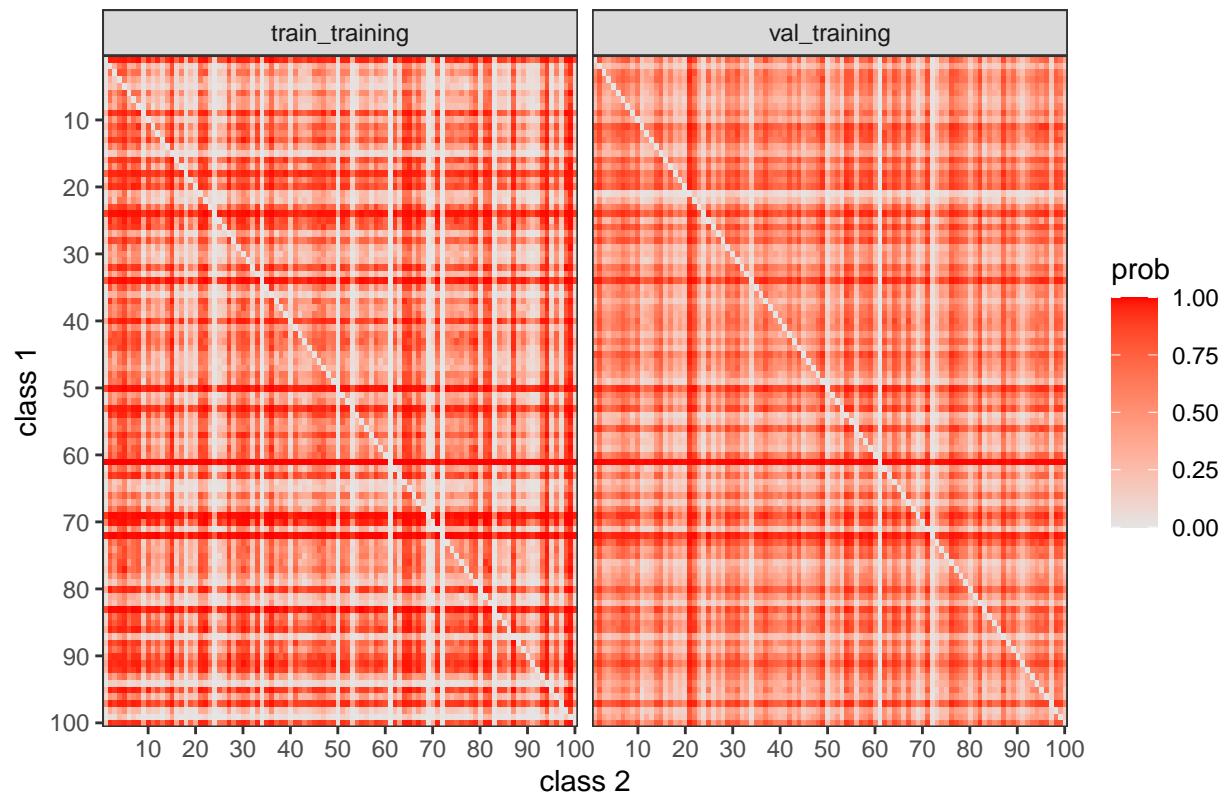
Average pairwise probabilities – class 59



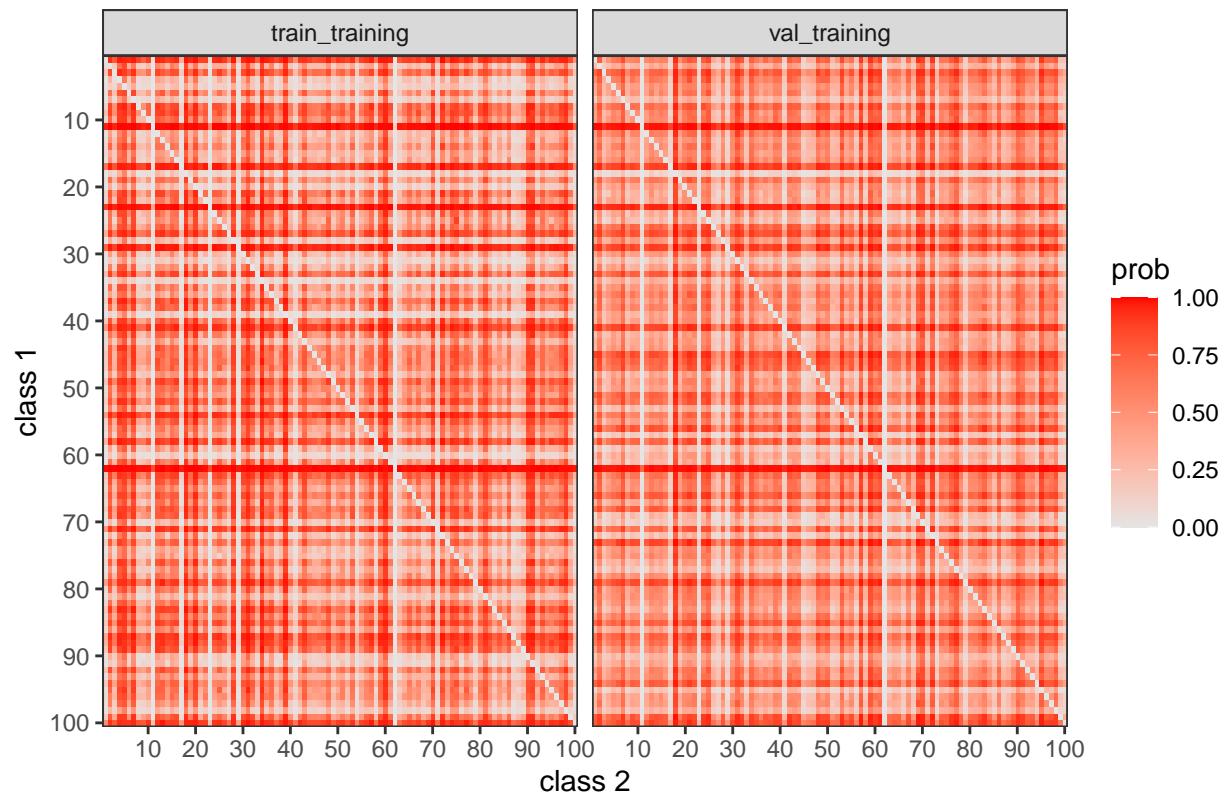
Average pairwise probabilities – class 60



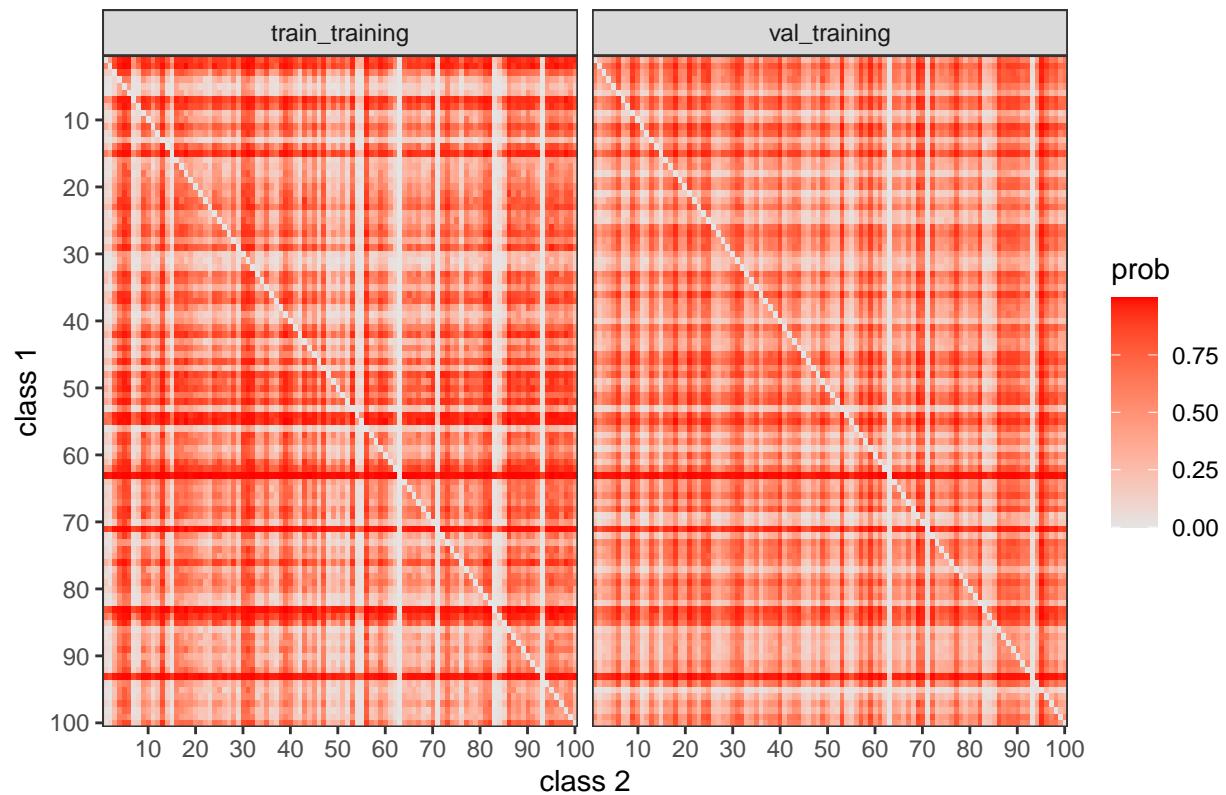
Average pairwise probabilities – class 61



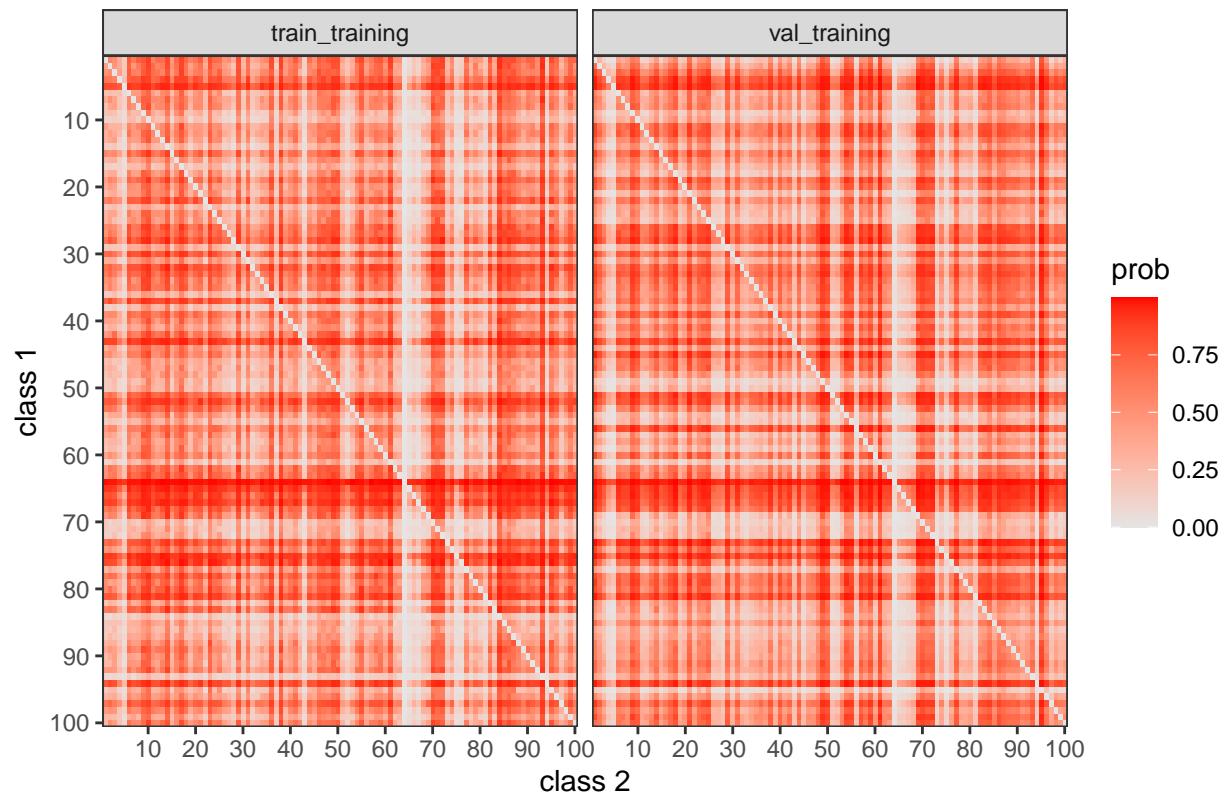
Average pairwise probabilities – class 62



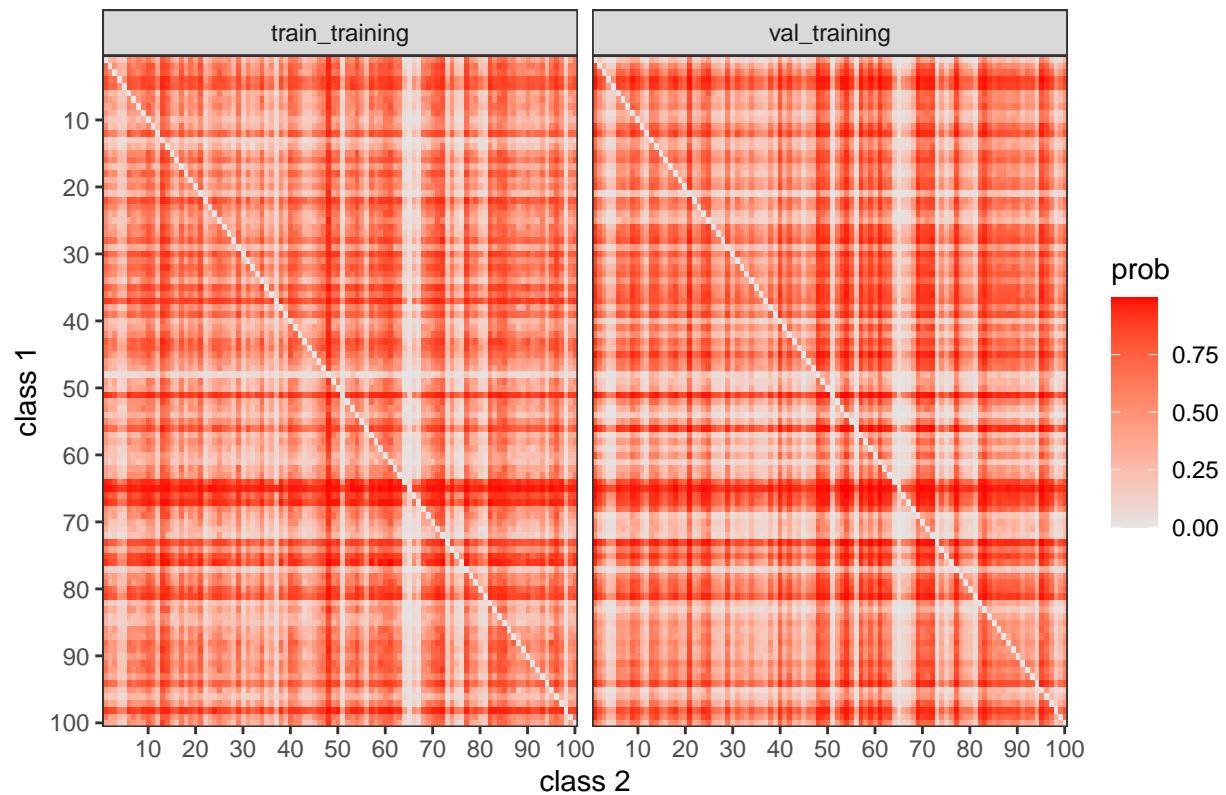
Average pairwise probabilities – class 63



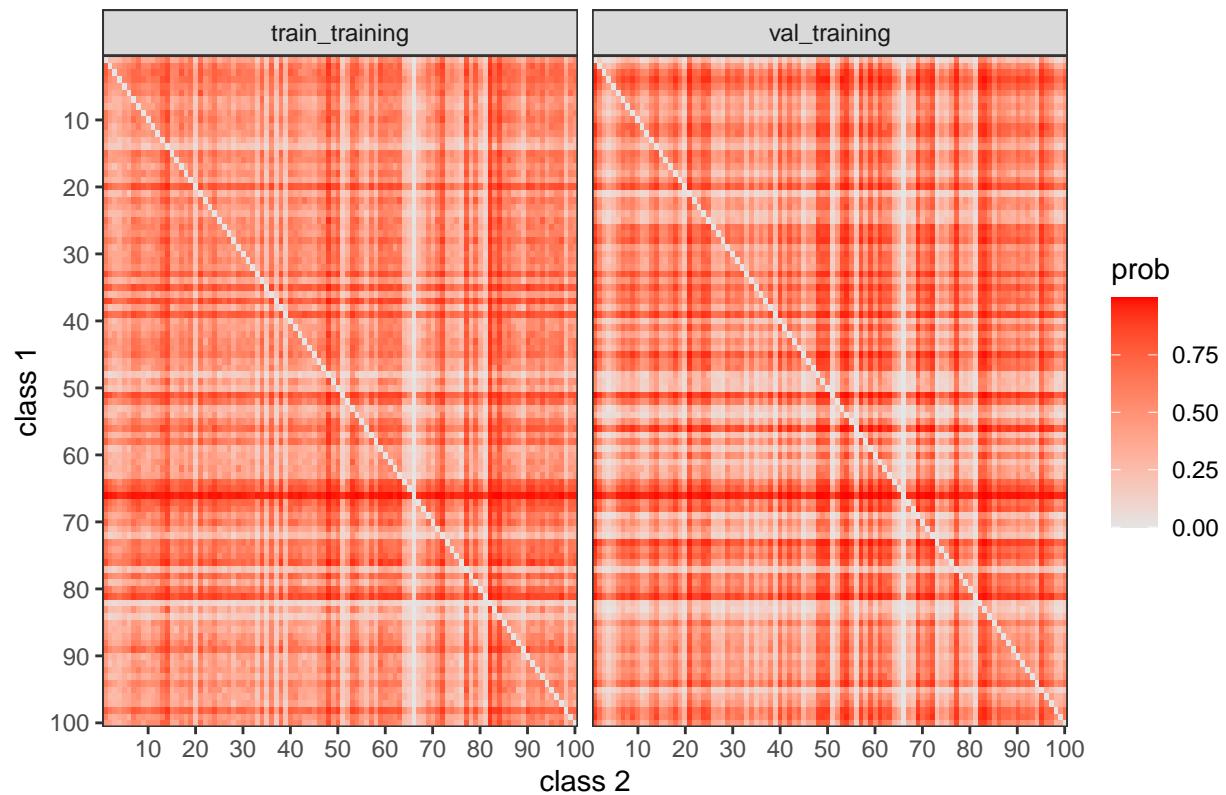
Average pairwise probabilities – class 64



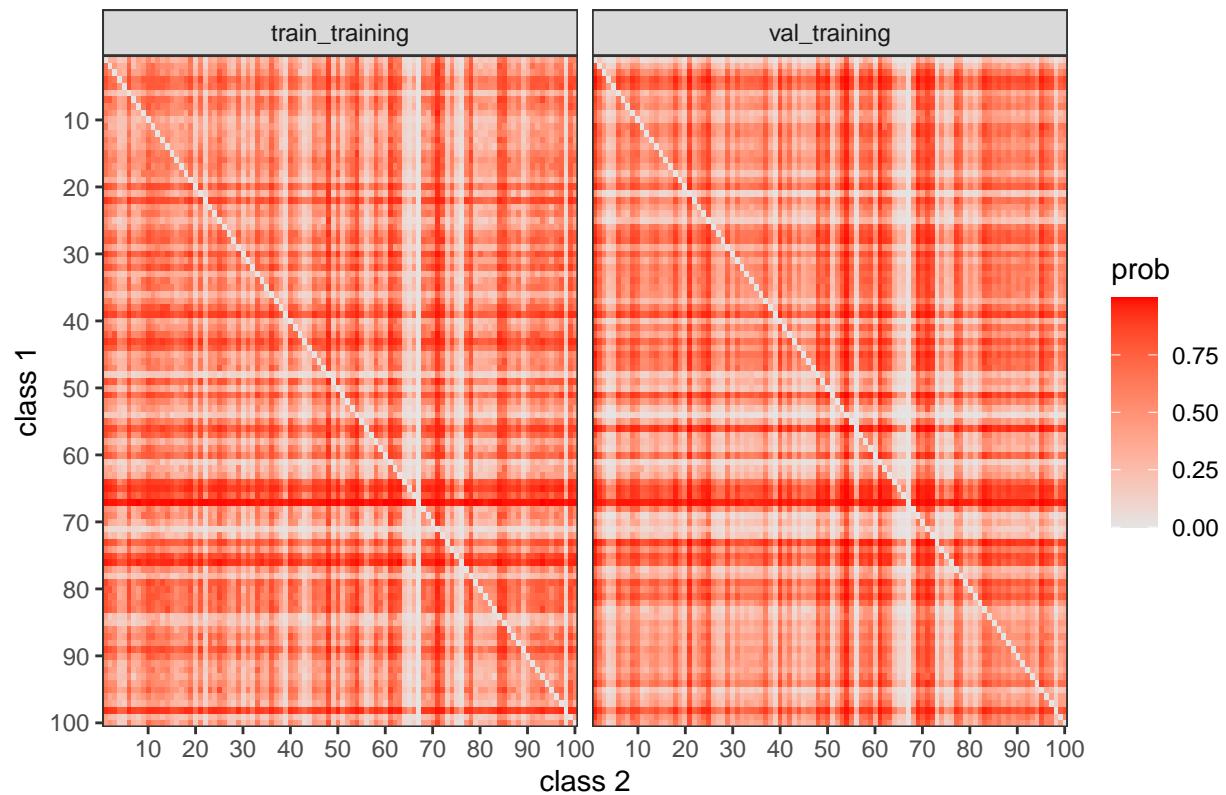
Average pairwise probabilities – class 65



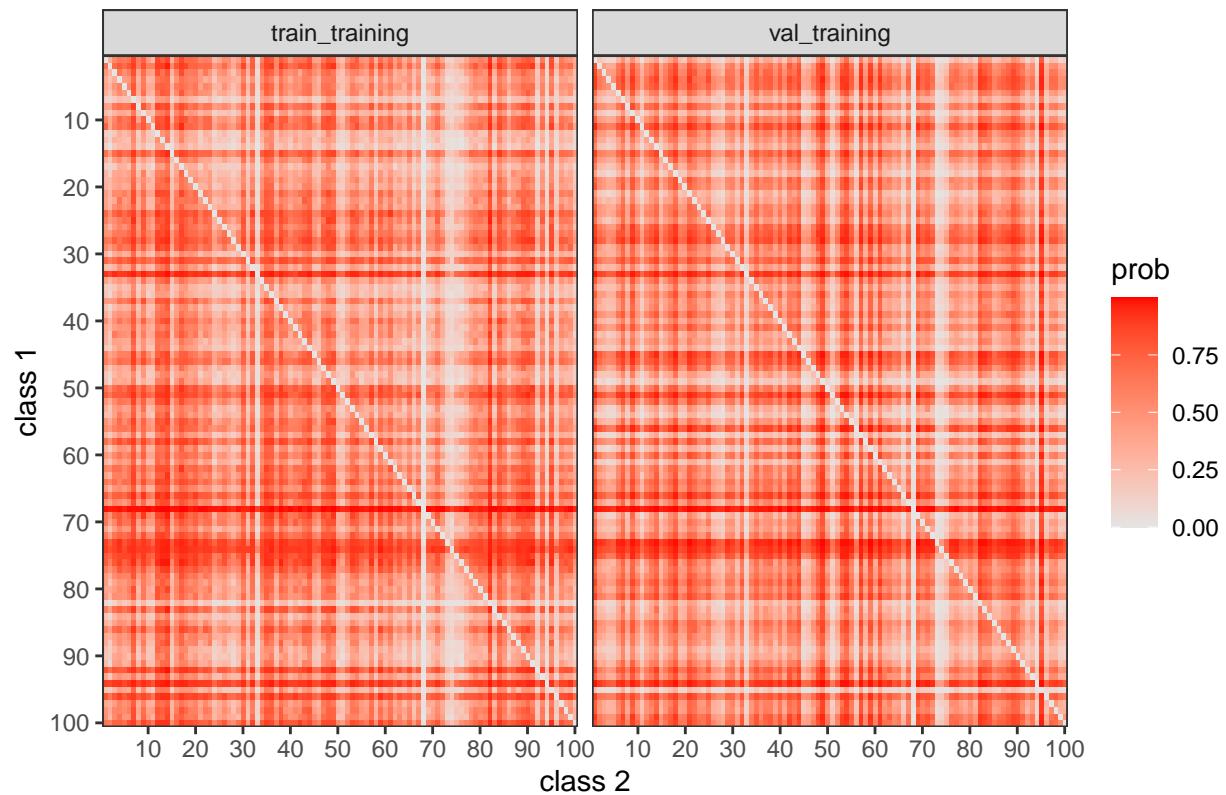
Average pairwise probabilities – class 66



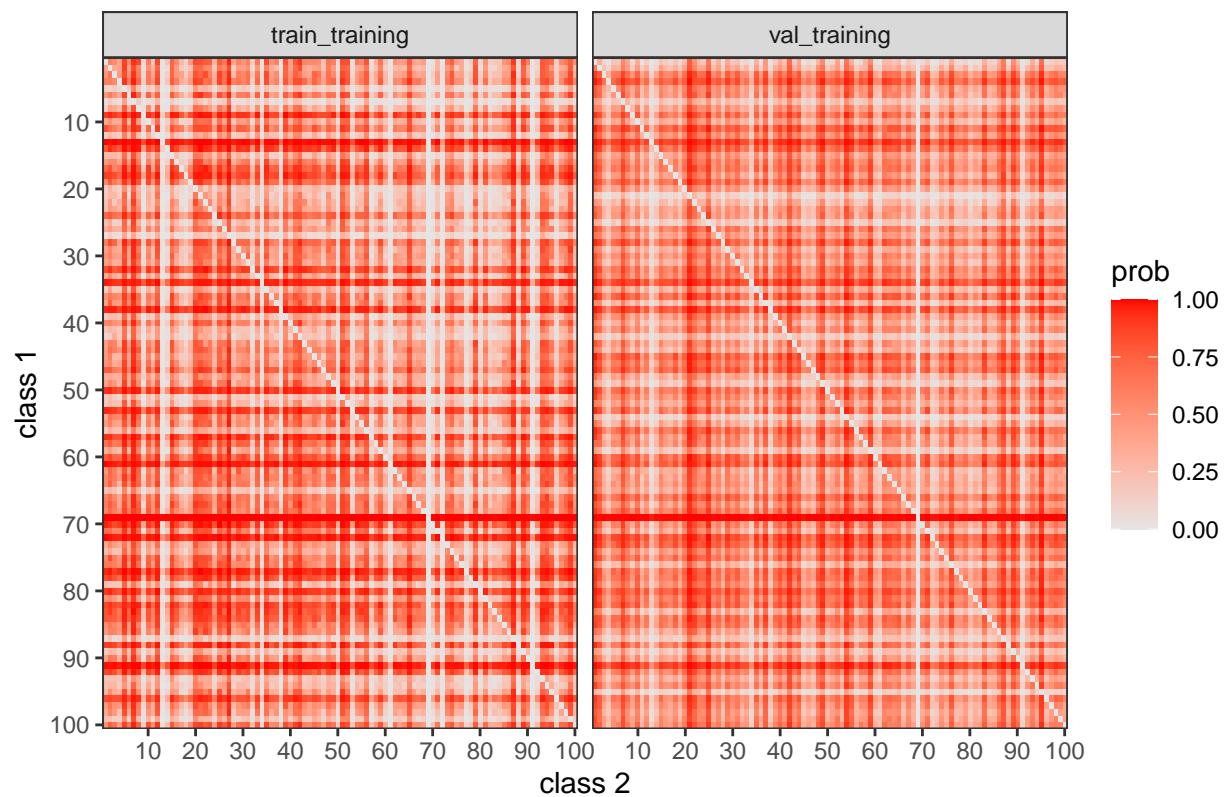
Average pairwise probabilities – class 67



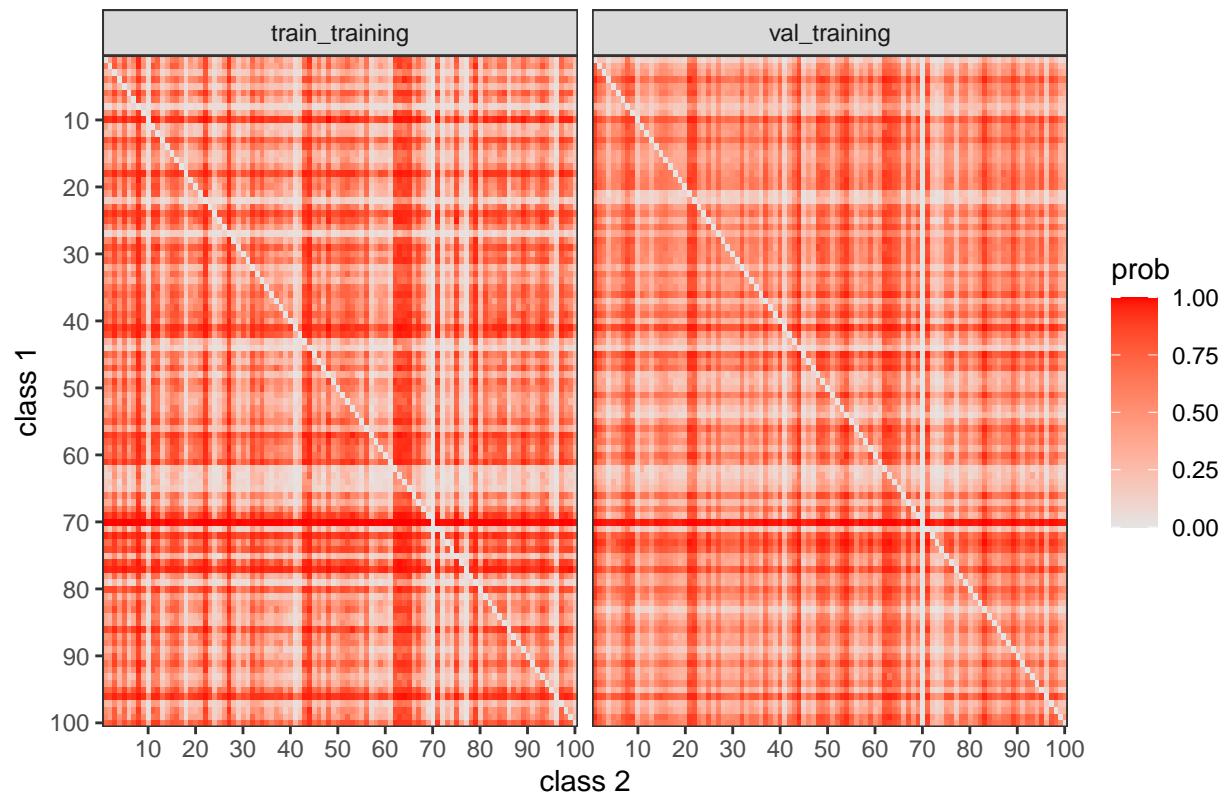
Average pairwise probabilities – class 68



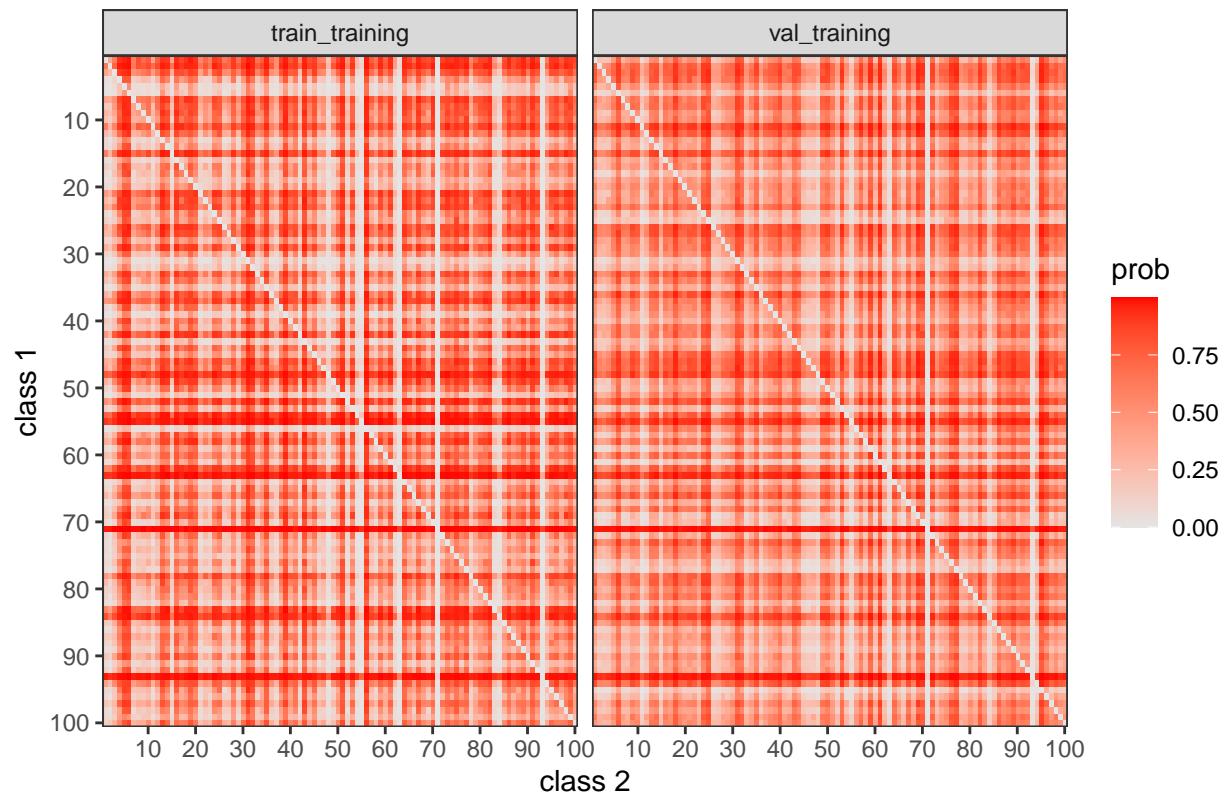
Average pairwise probabilities – class 69



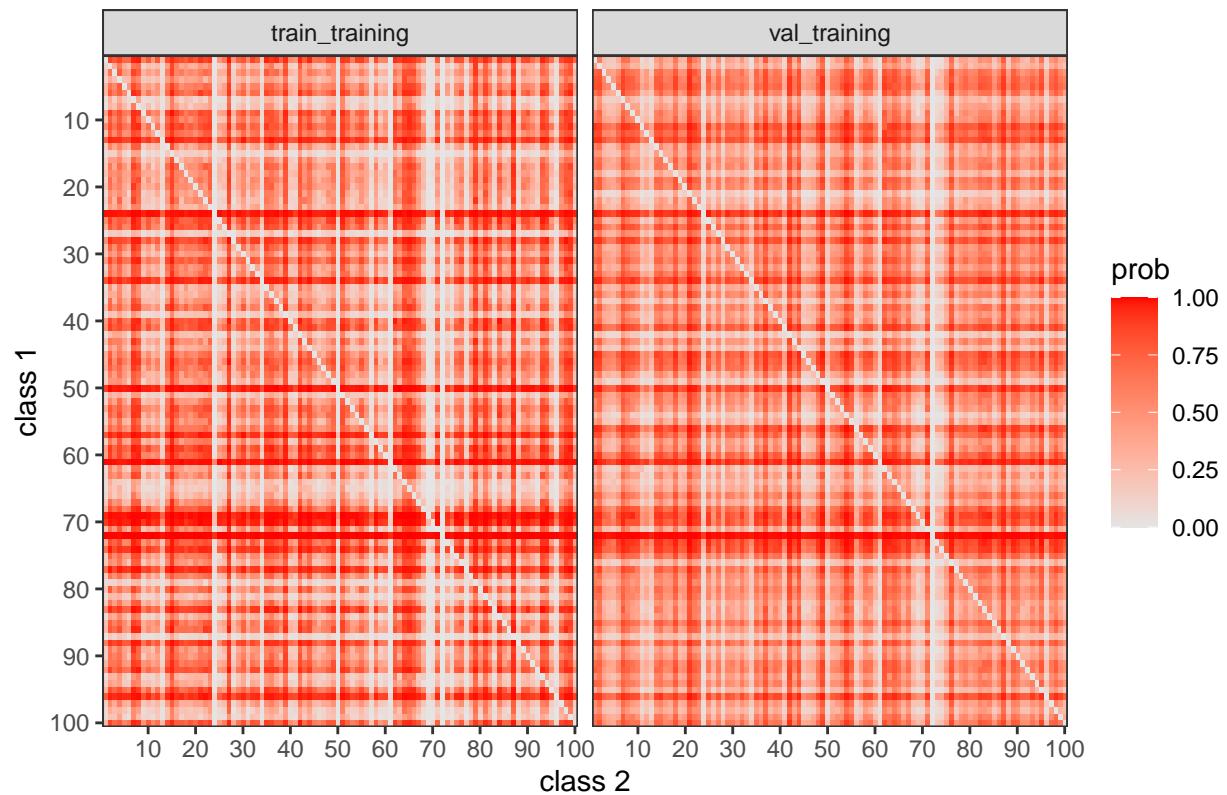
Average pairwise probabilities – class 70



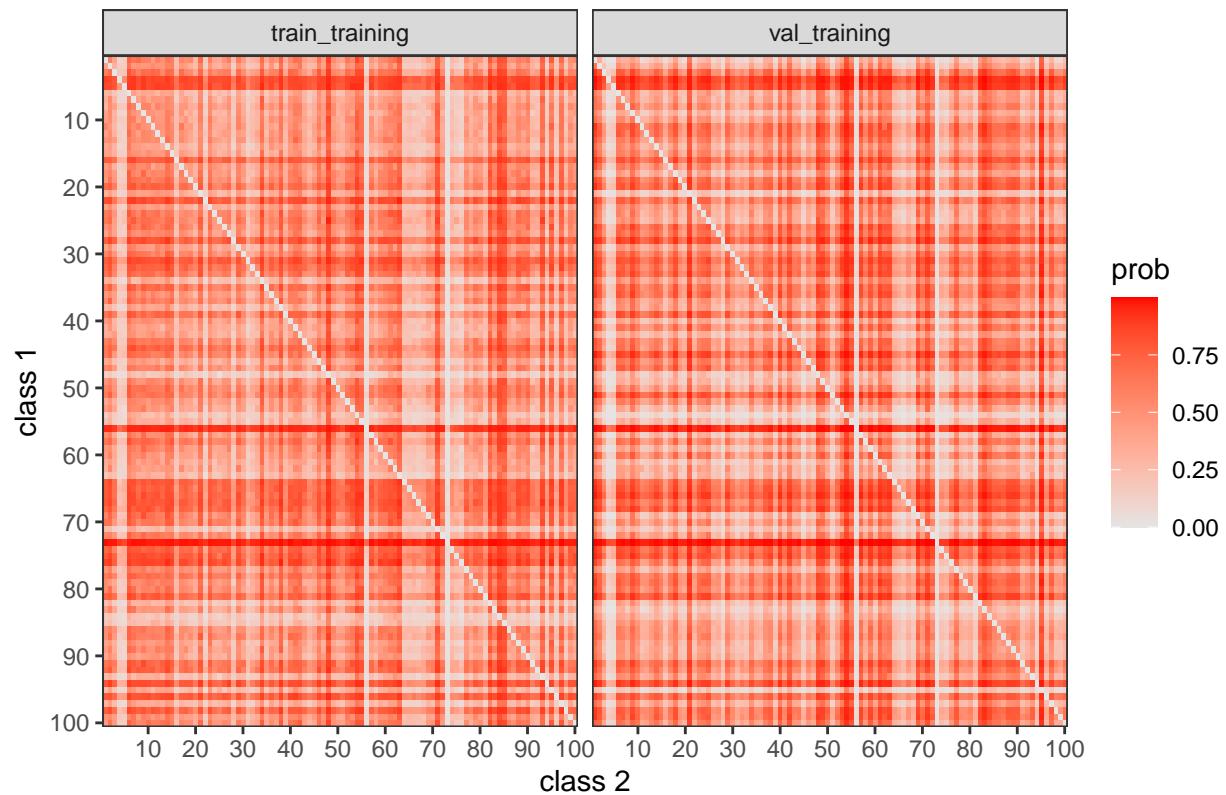
Average pairwise probabilities – class 71



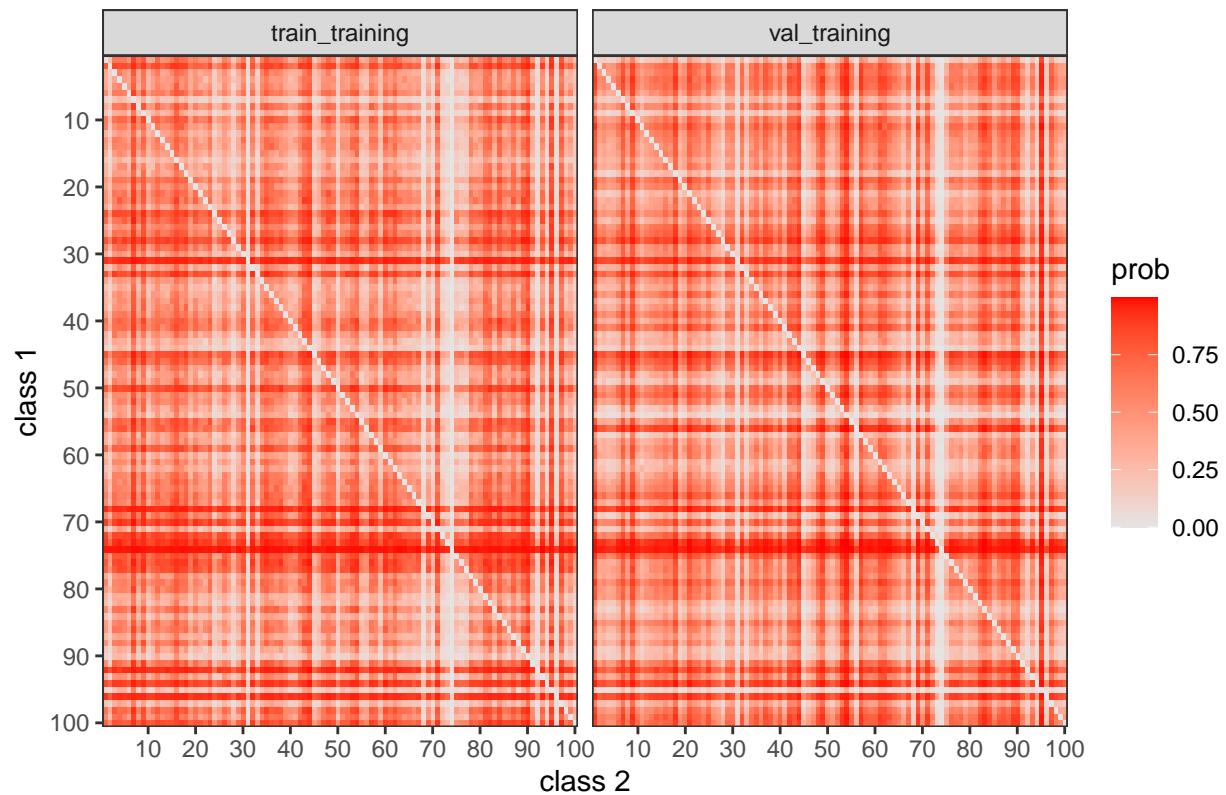
Average pairwise probabilities – class 72



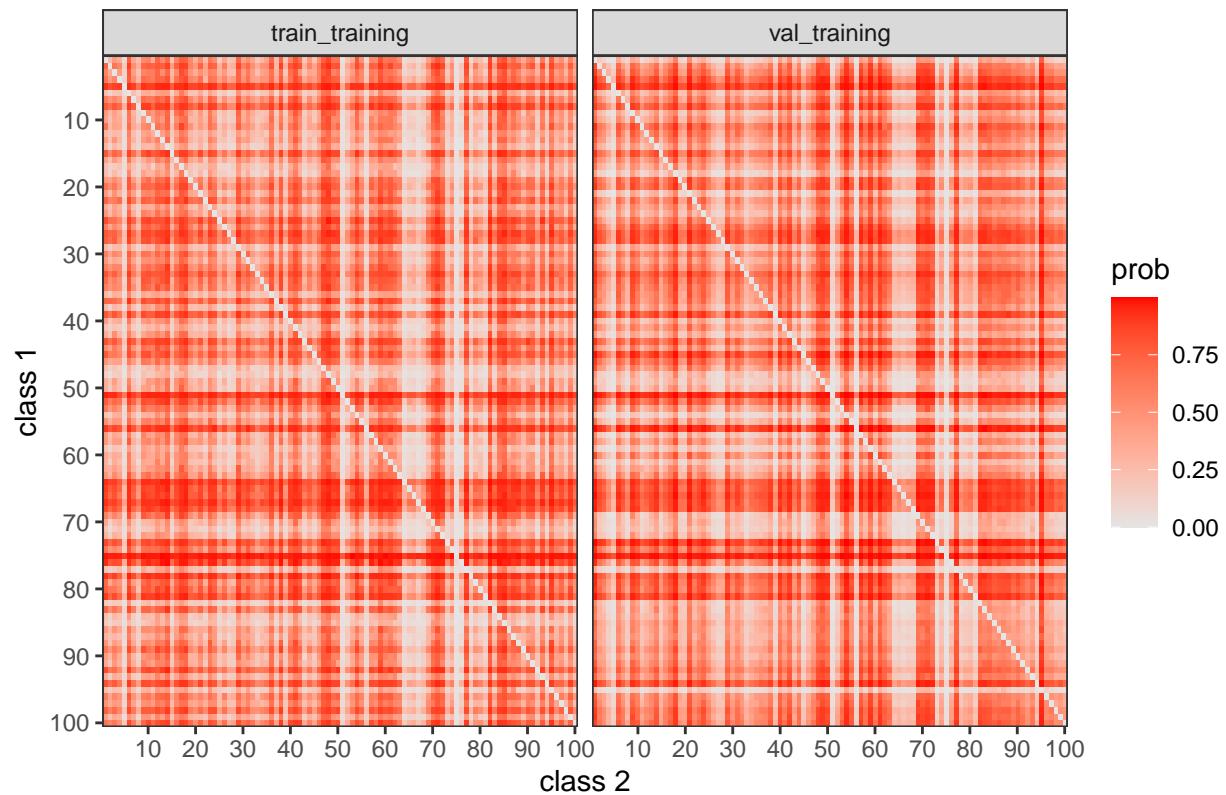
Average pairwise probabilities – class 73



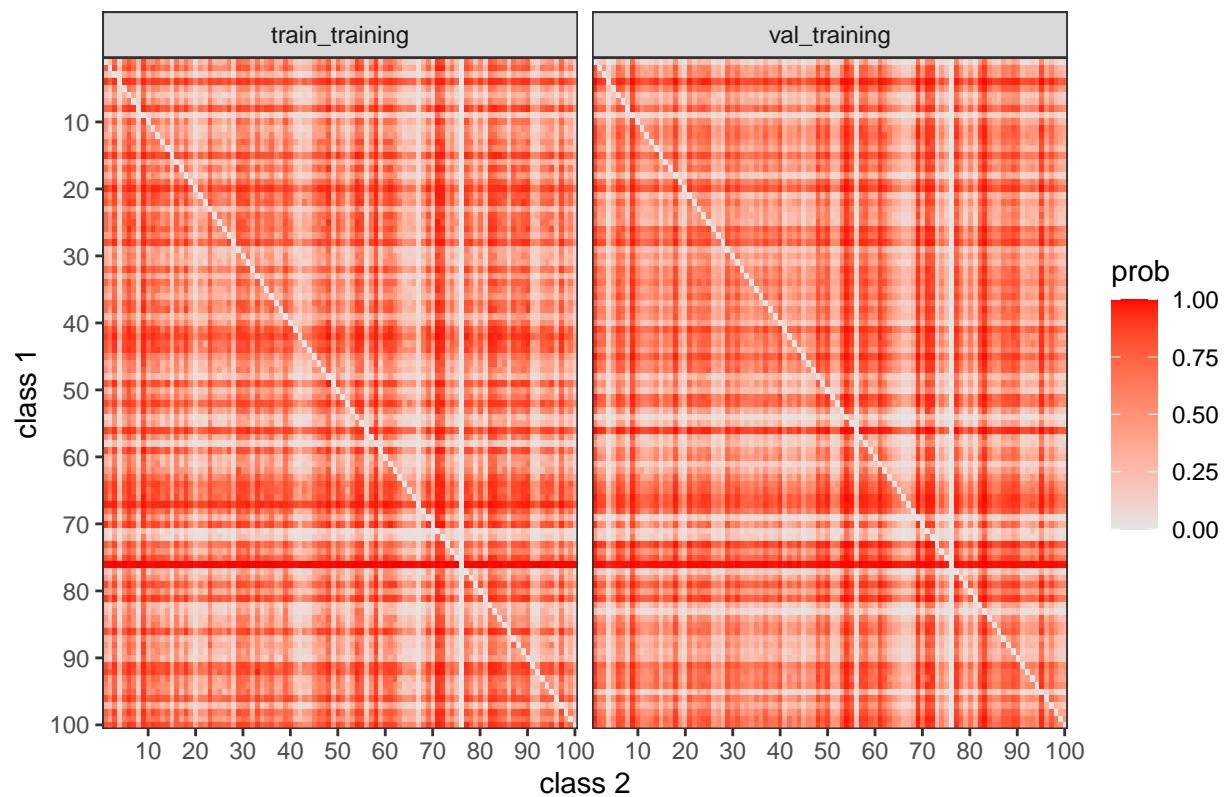
Average pairwise probabilities – class 74



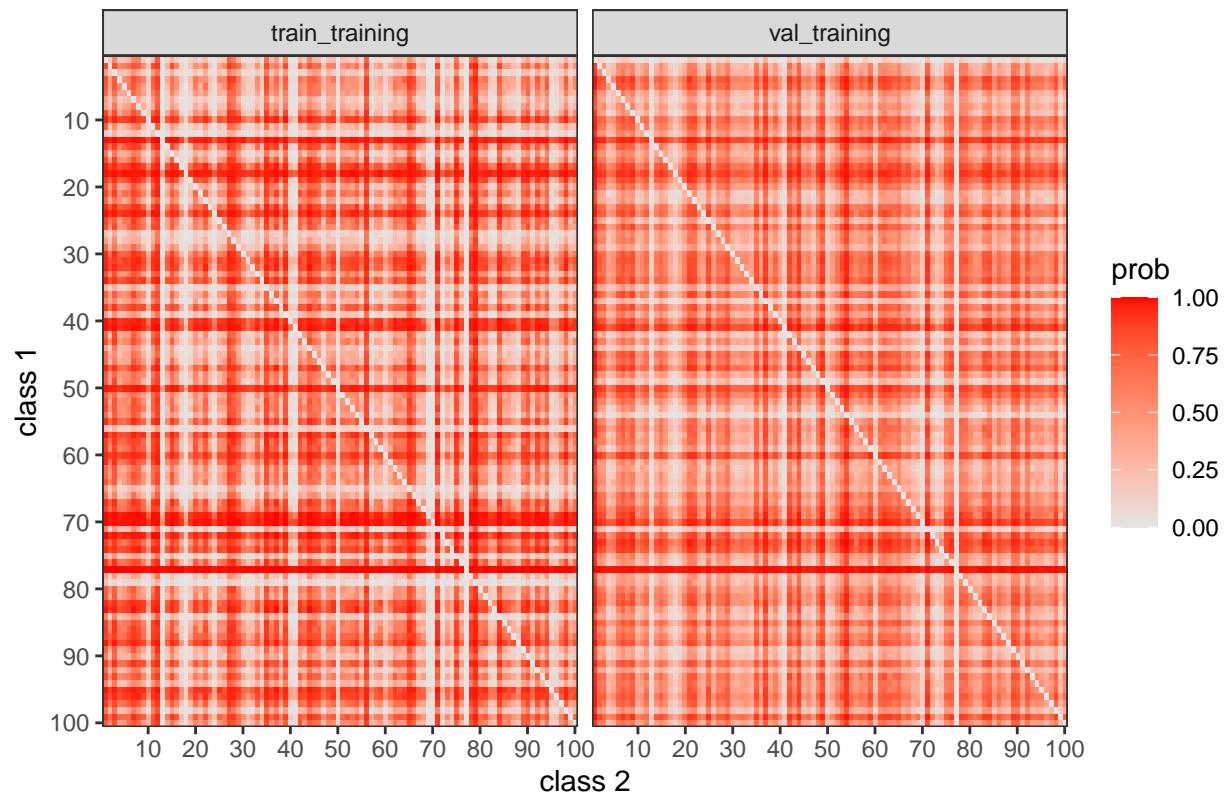
Average pairwise probabilities – class 75



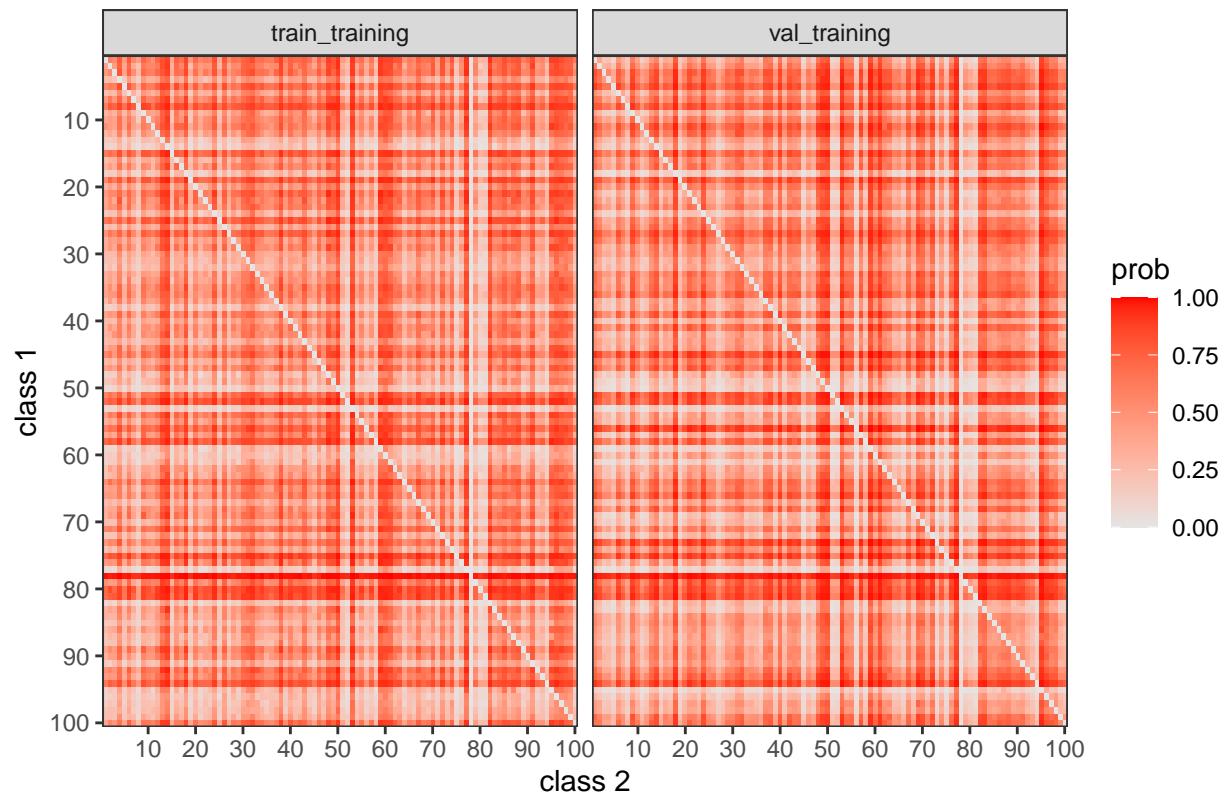
Average pairwise probabilities – class 76



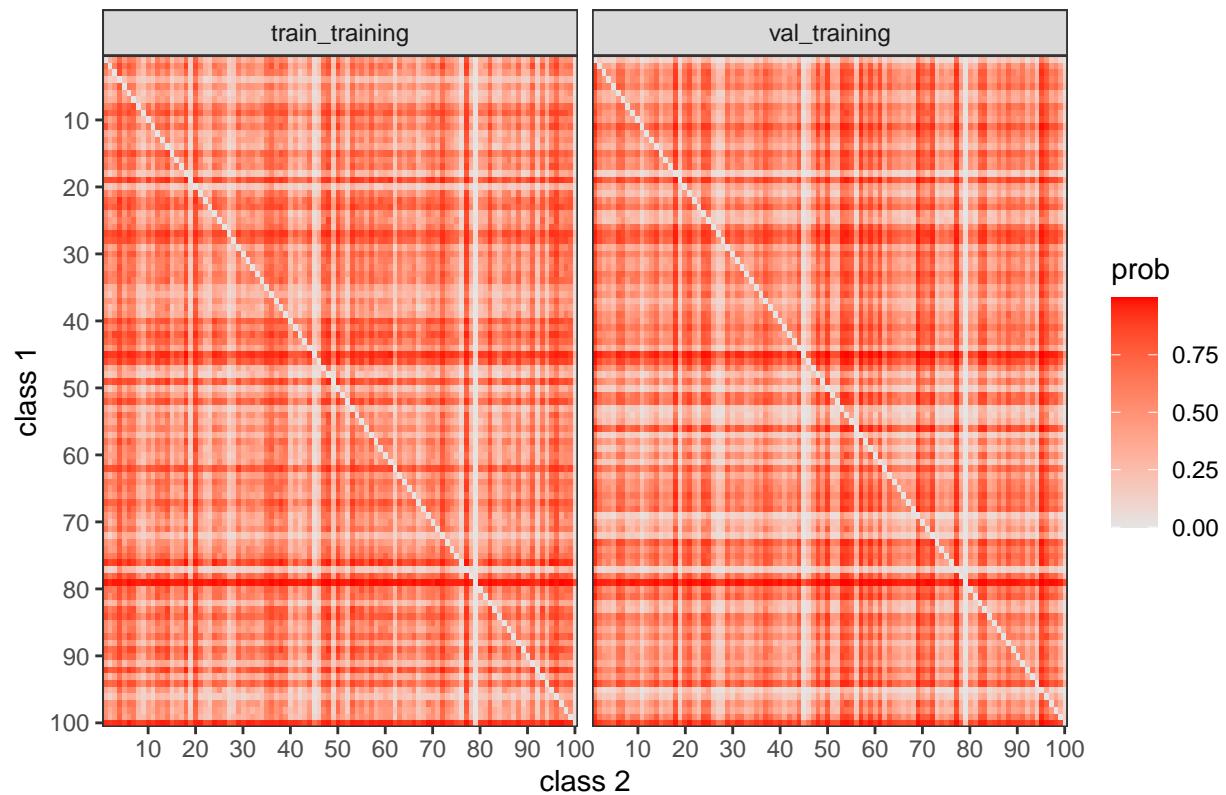
Average pairwise probabilities – class 77



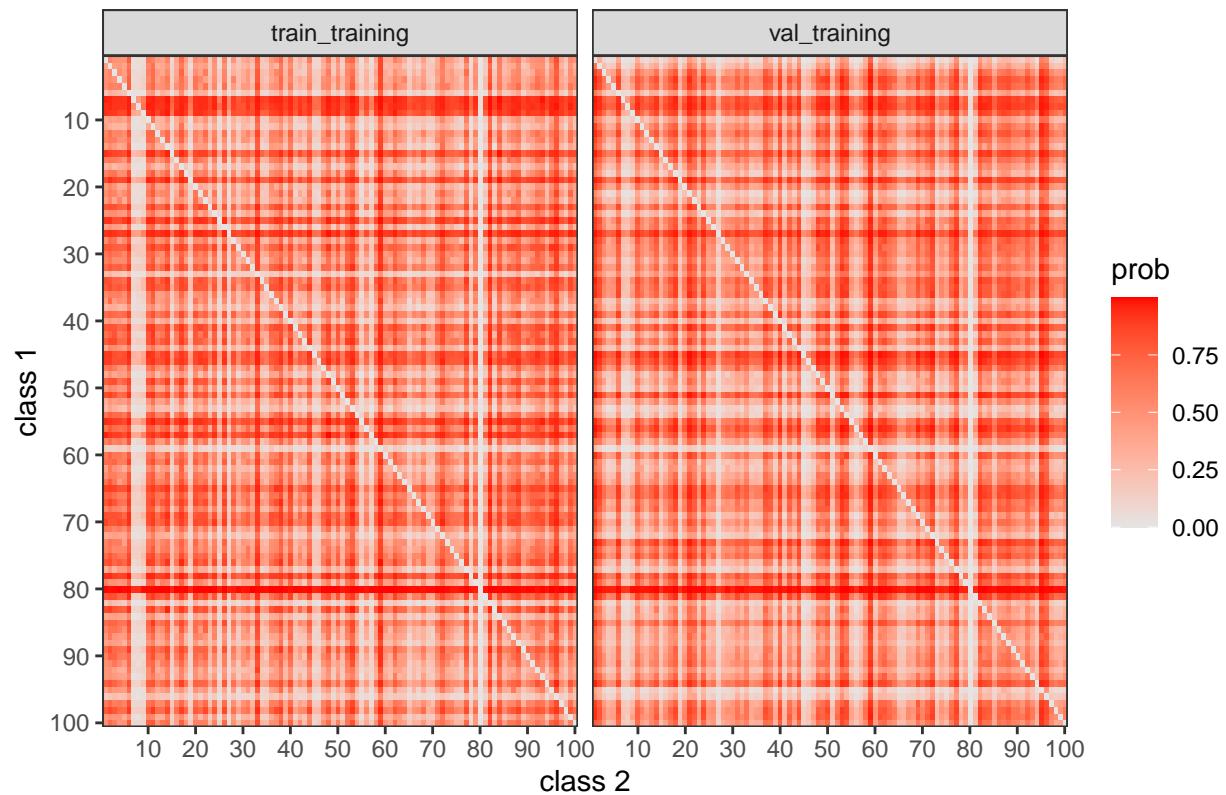
Average pairwise probabilities – class 78



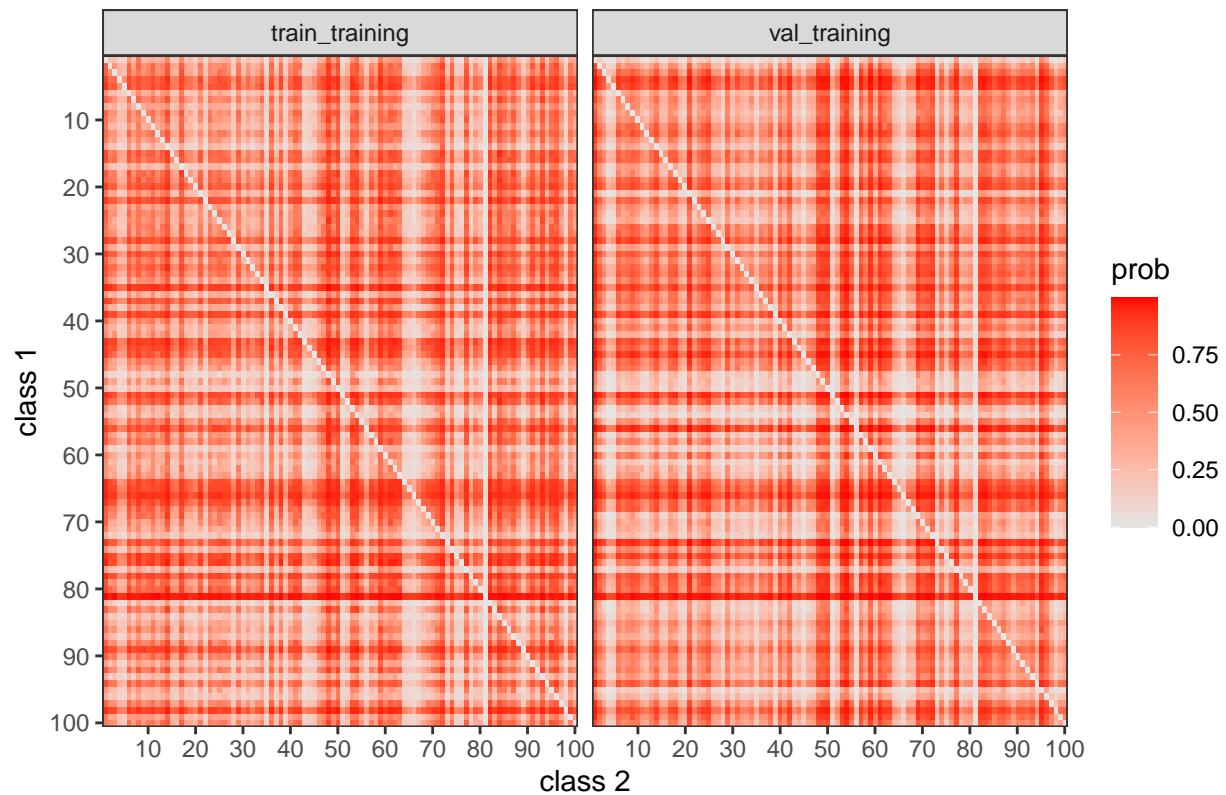
Average pairwise probabilities – class 79



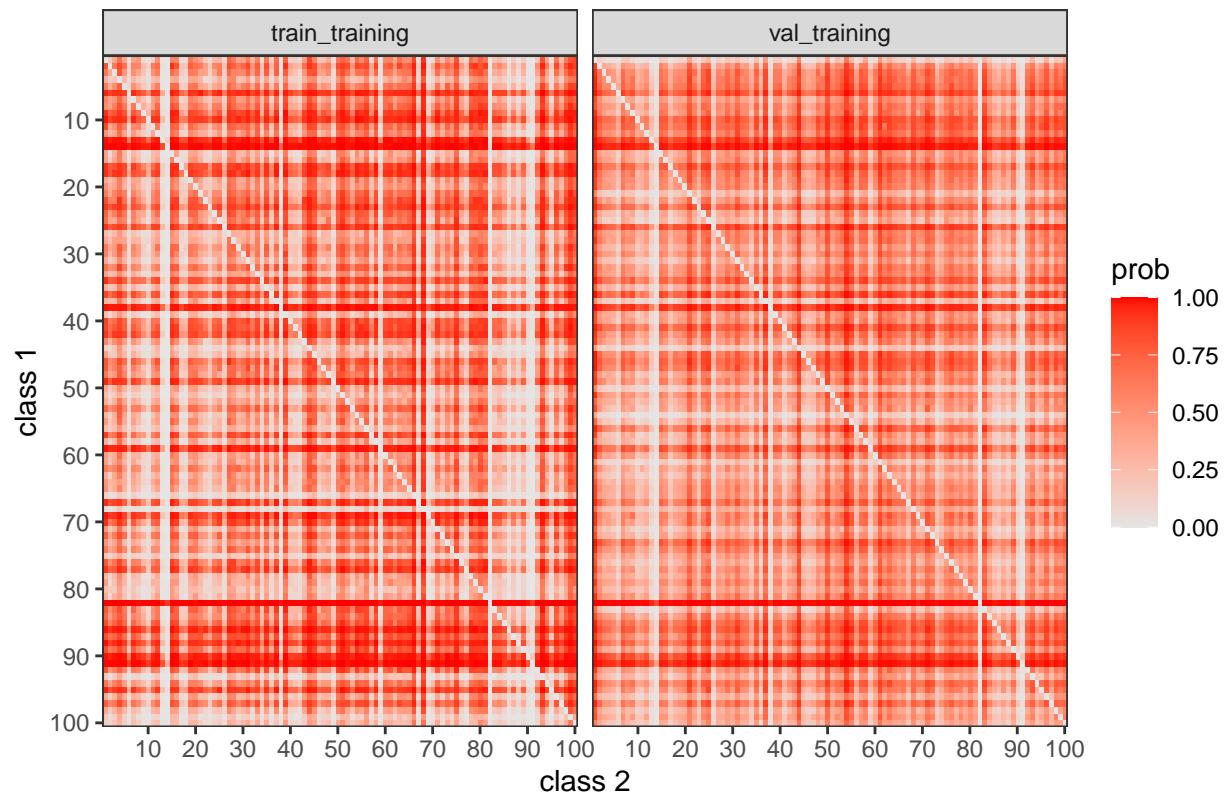
Average pairwise probabilities – class 80



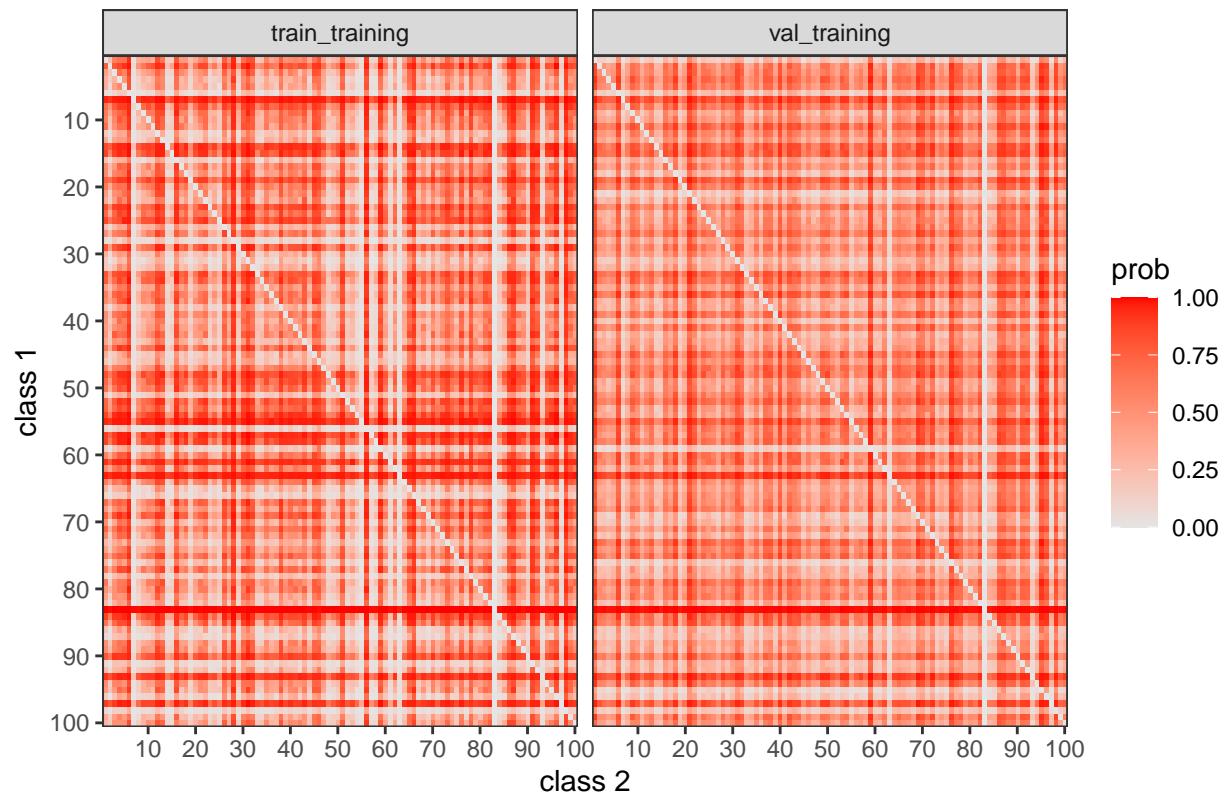
Average pairwise probabilities – class 81



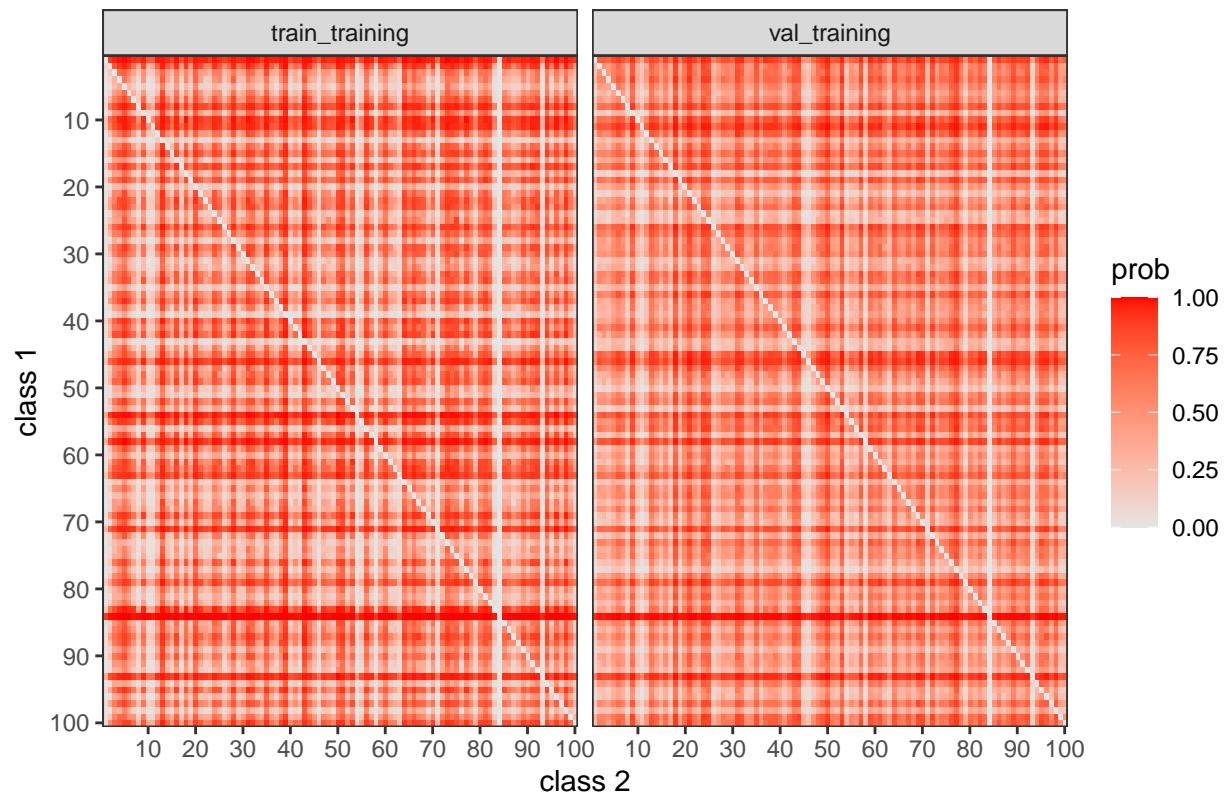
Average pairwise probabilities – class 82



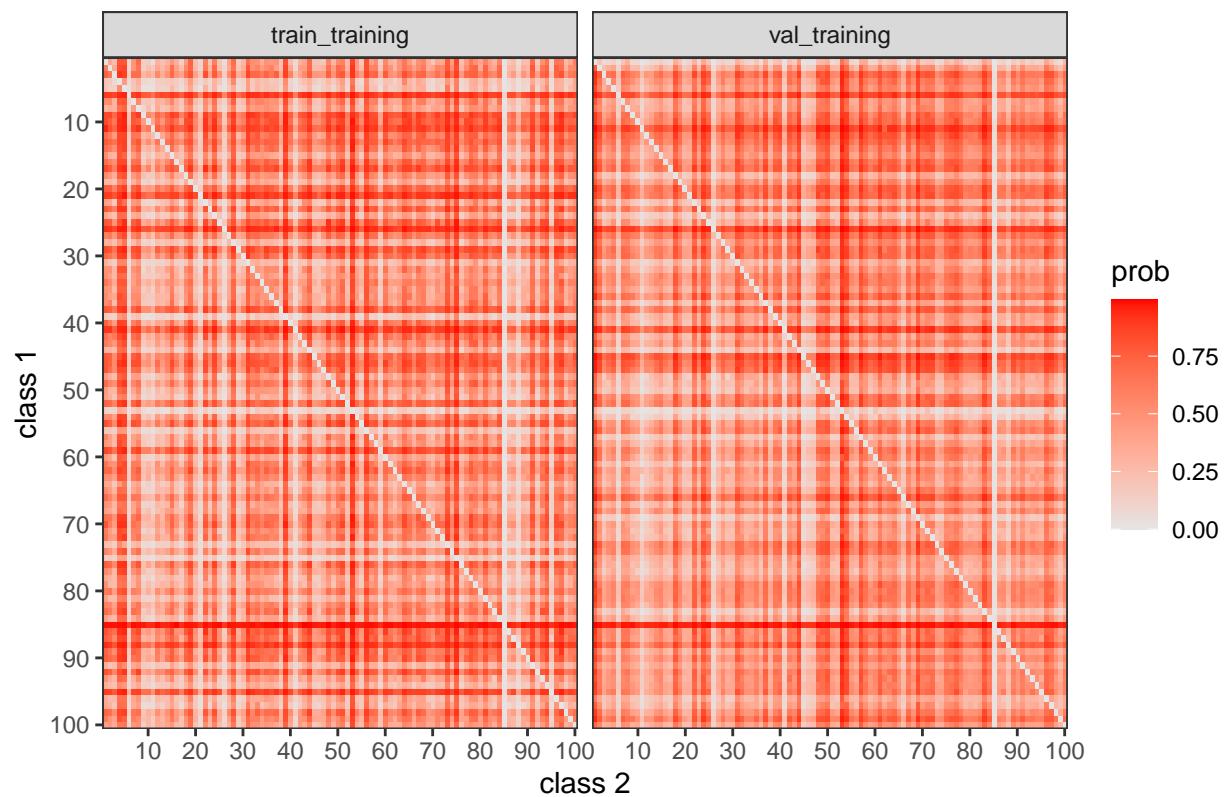
Average pairwise probabilities – class 83



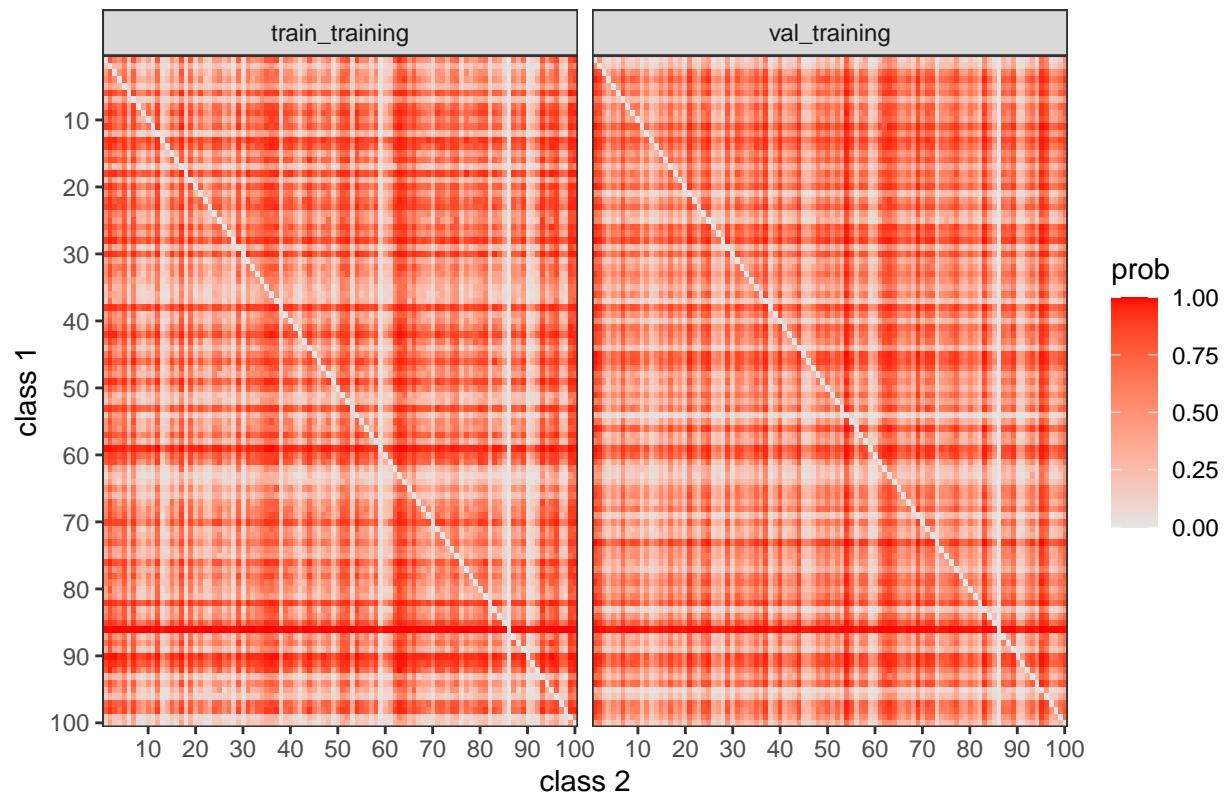
Average pairwise probabilities – class 84



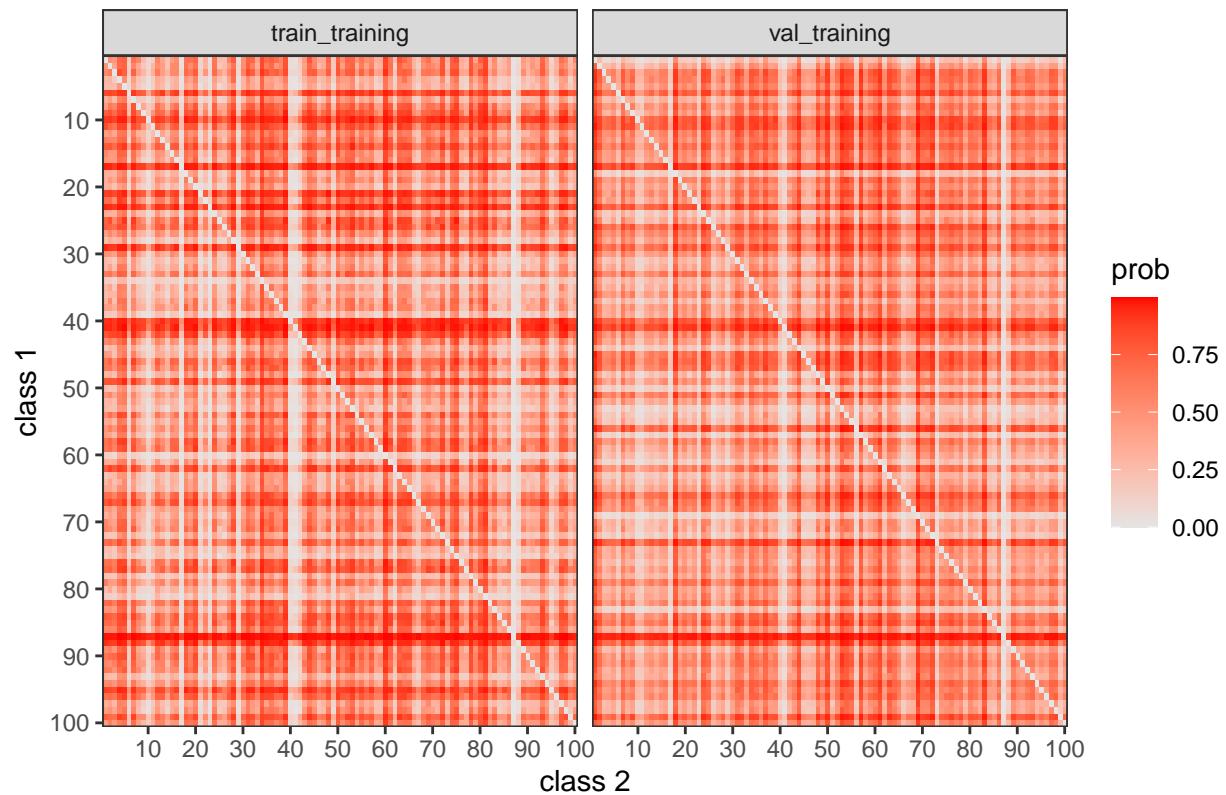
Average pairwise probabilities – class 85



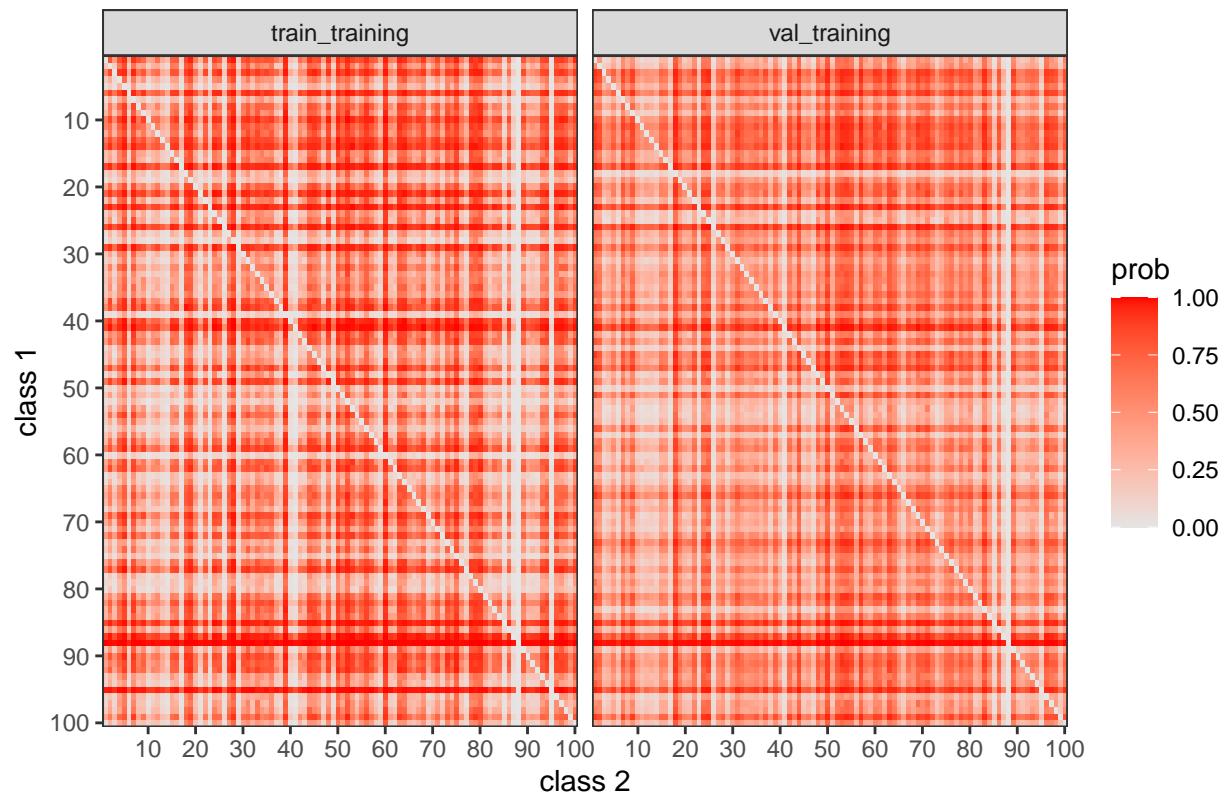
Average pairwise probabilities – class 86



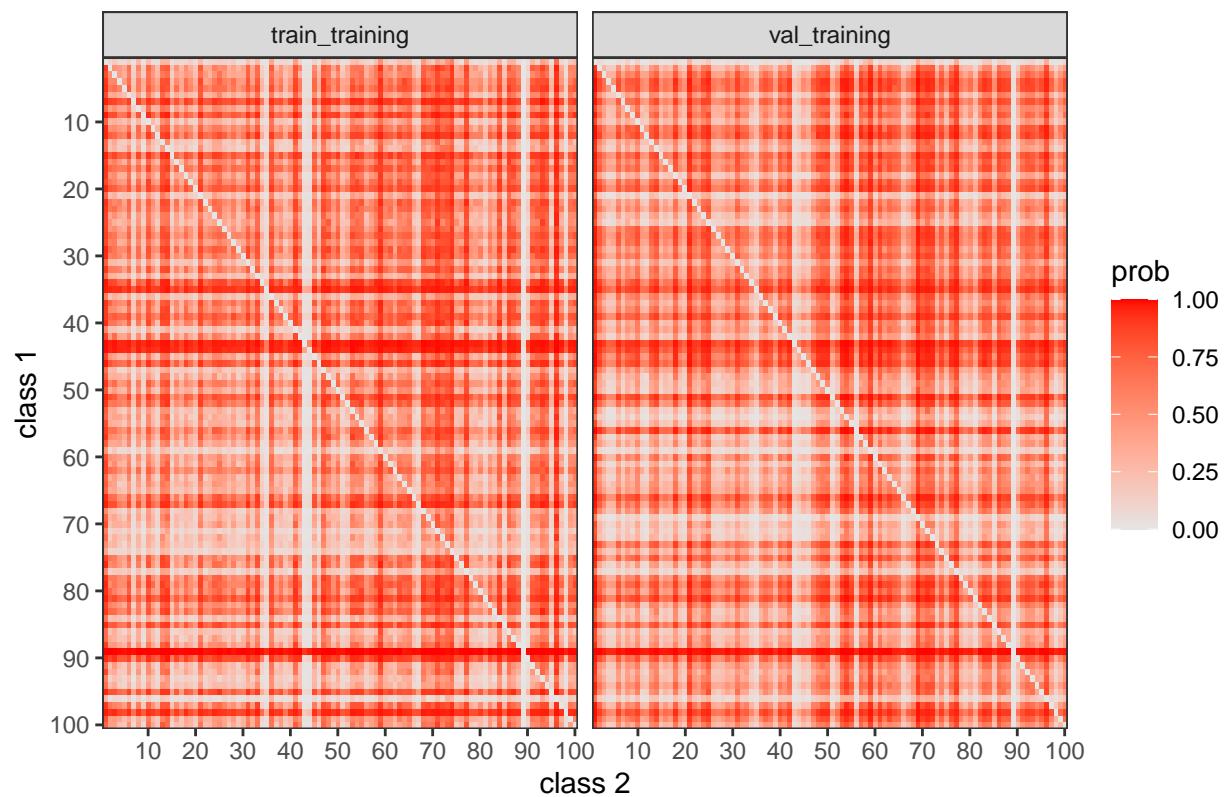
Average pairwise probabilities – class 87



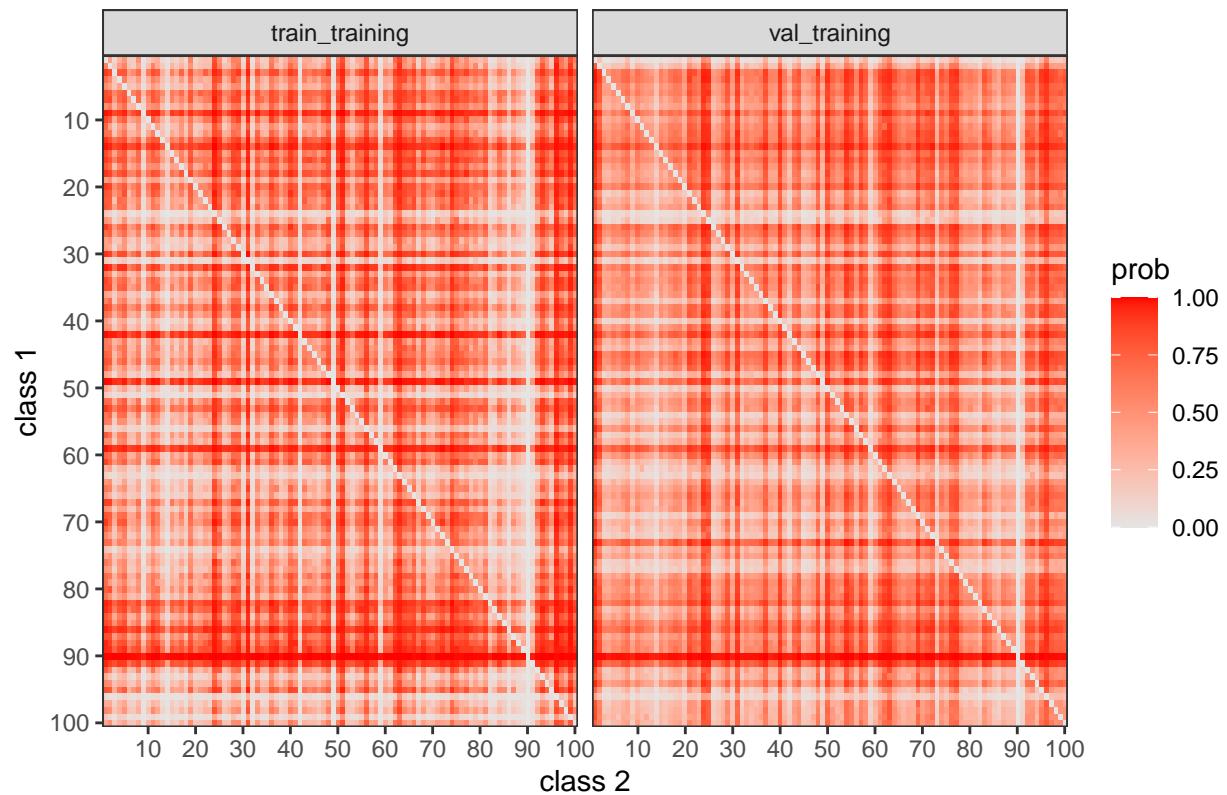
Average pairwise probabilities – class 88



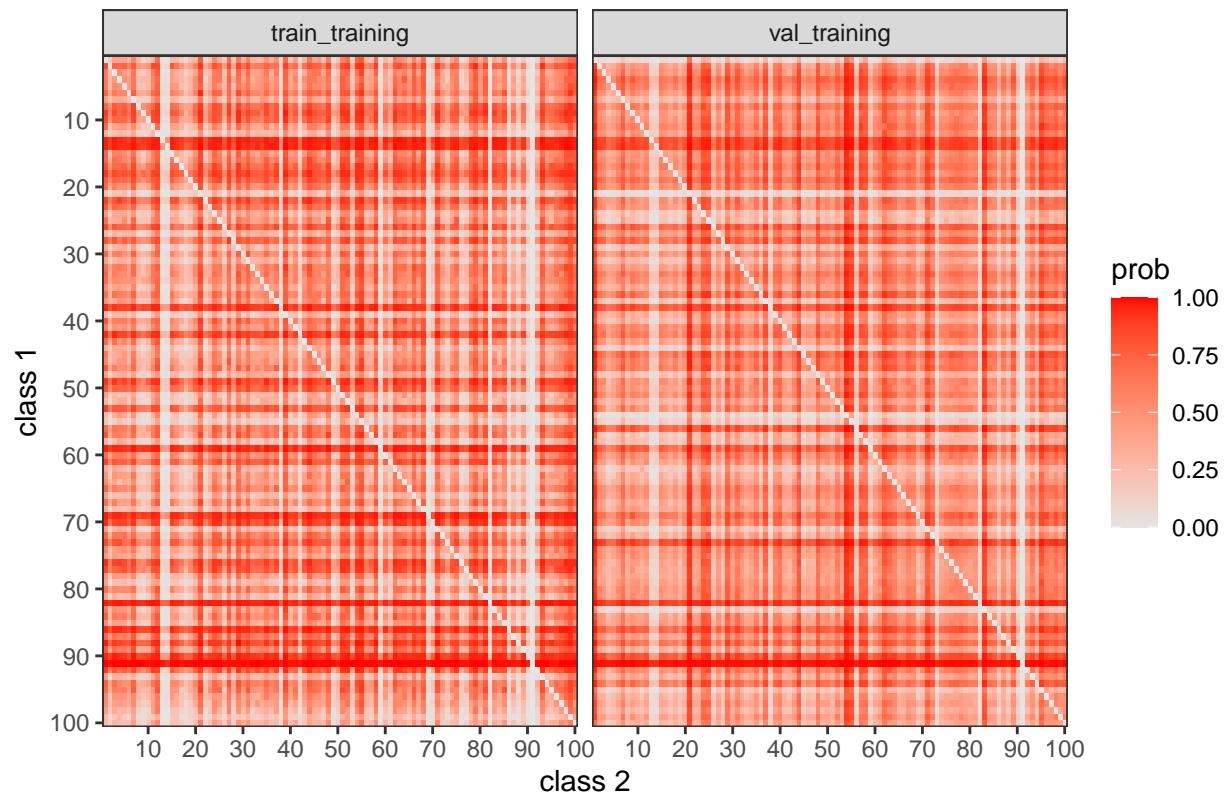
Average pairwise probabilities – class 89



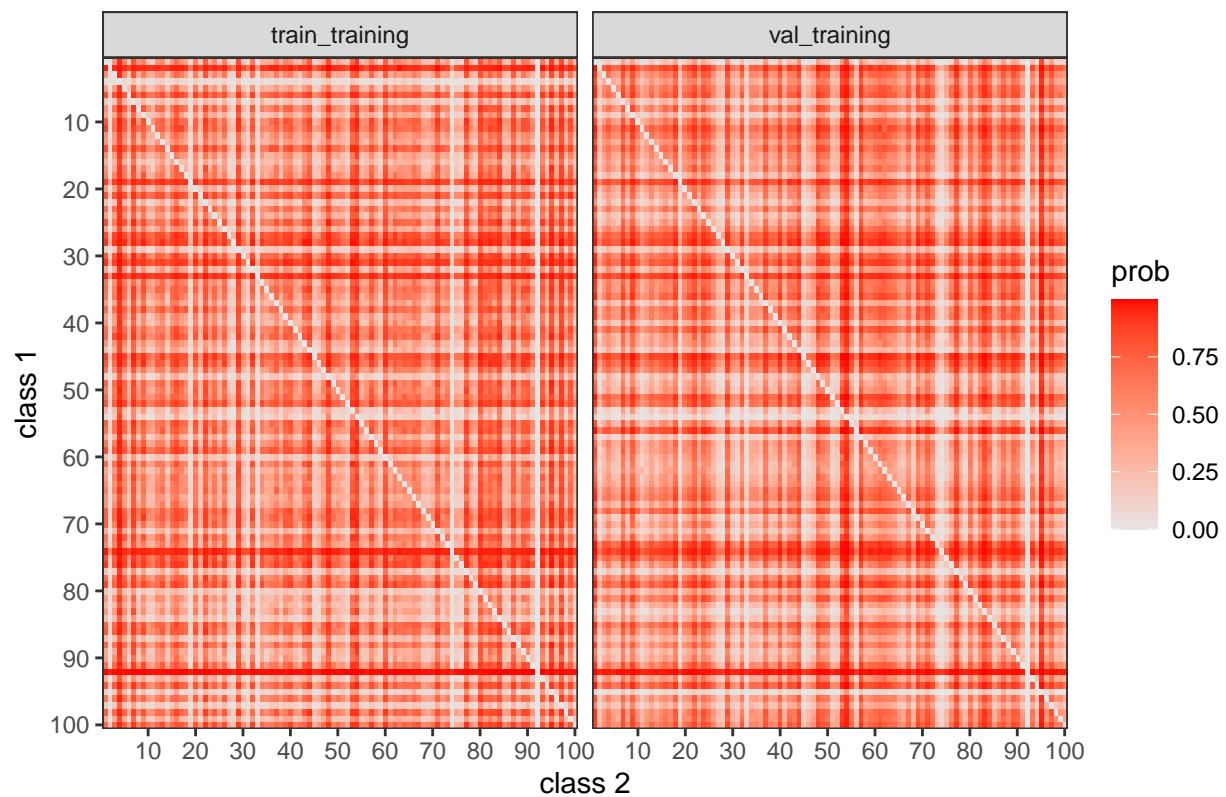
Average pairwise probabilities – class 90



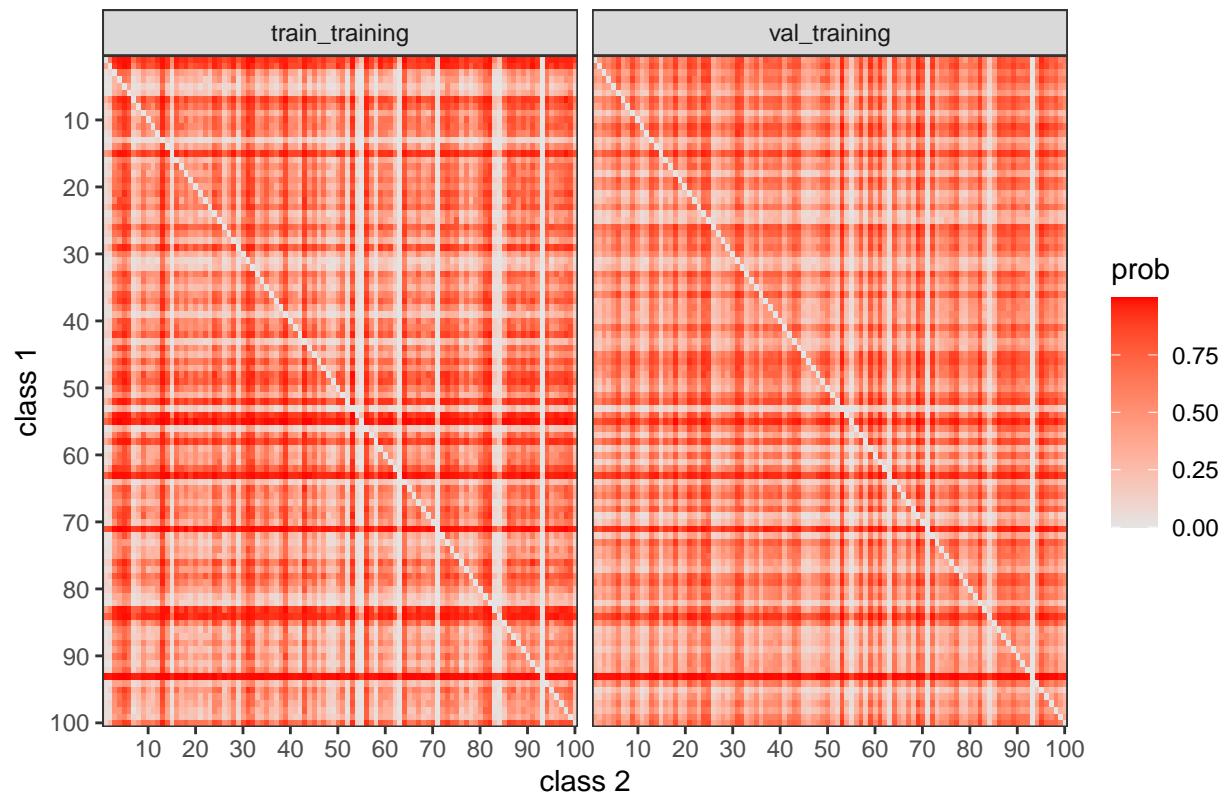
Average pairwise probabilities – class 91



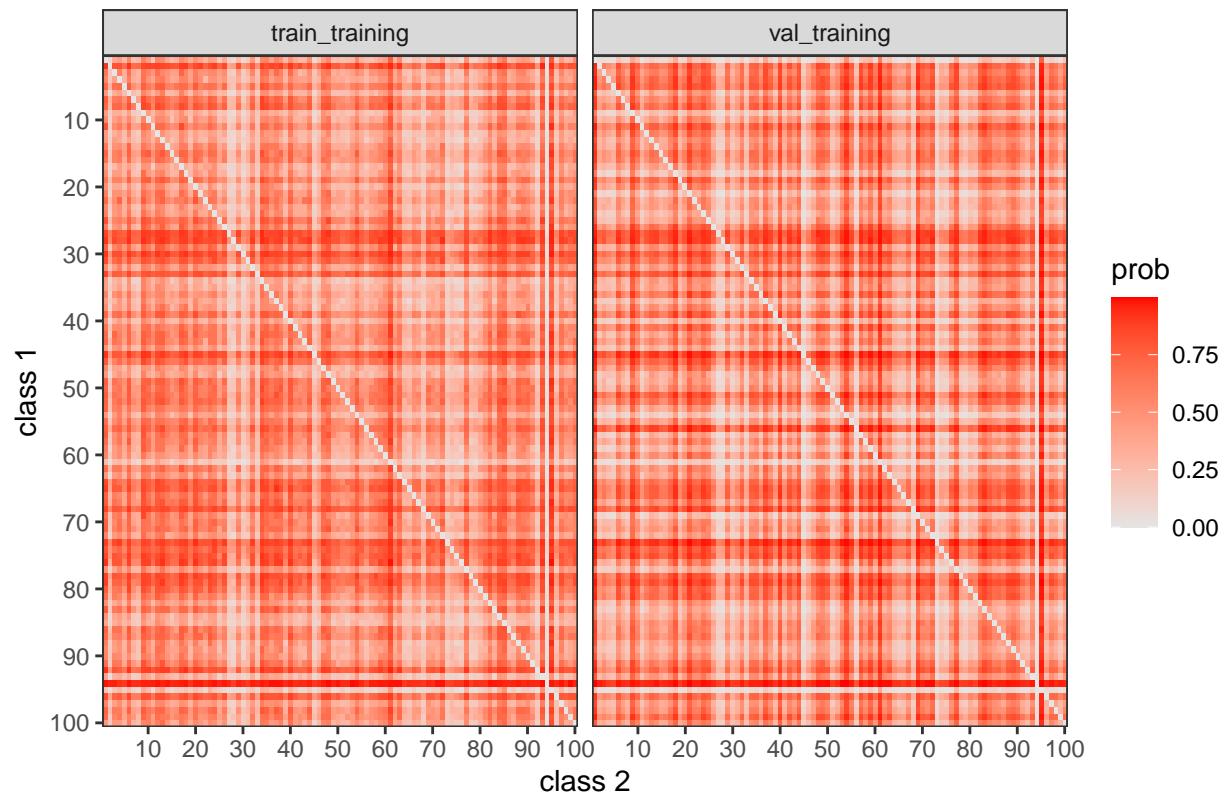
Average pairwise probabilities – class 92



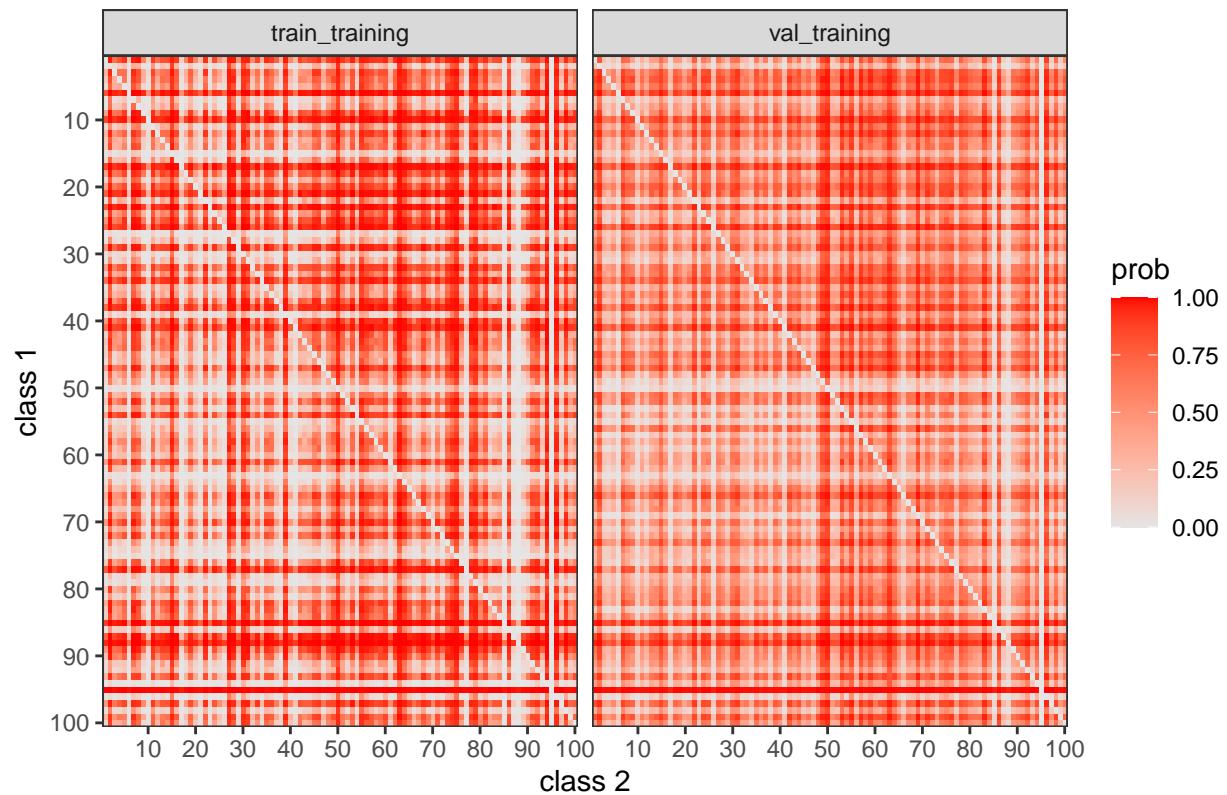
Average pairwise probabilities – class 93



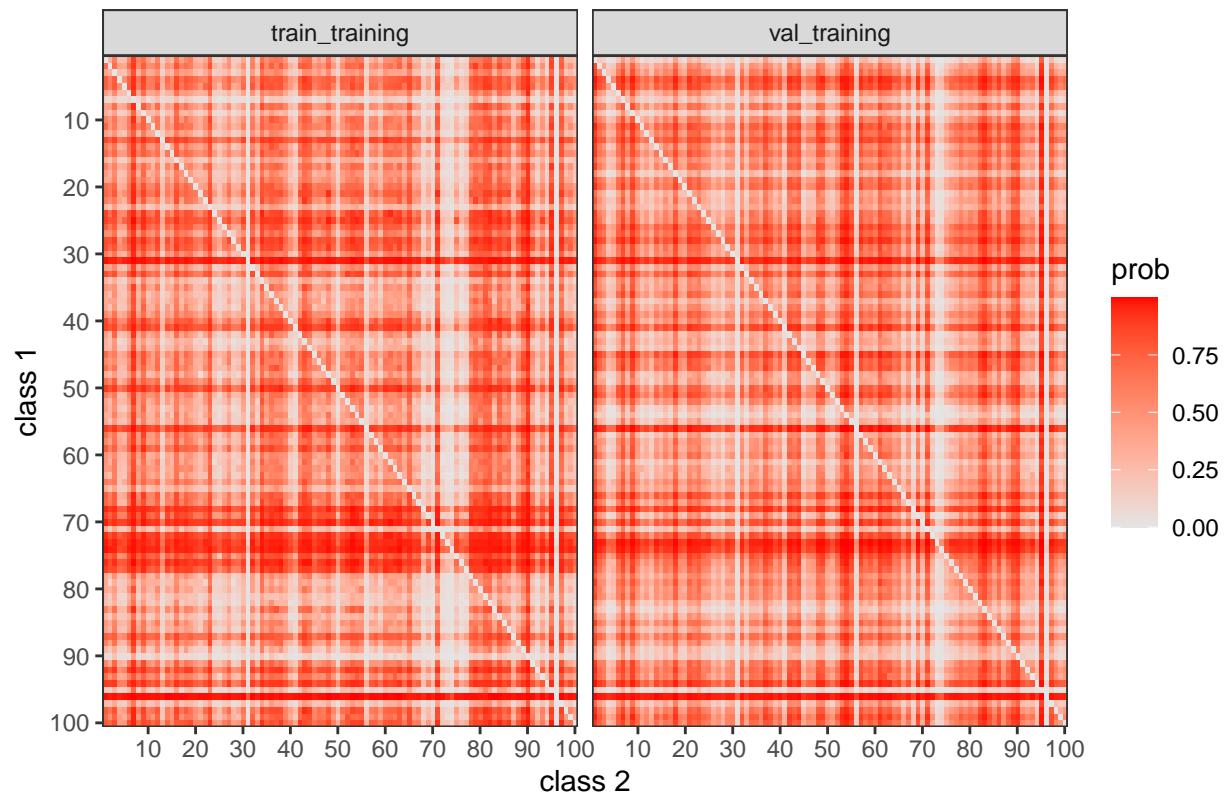
Average pairwise probabilities – class 94



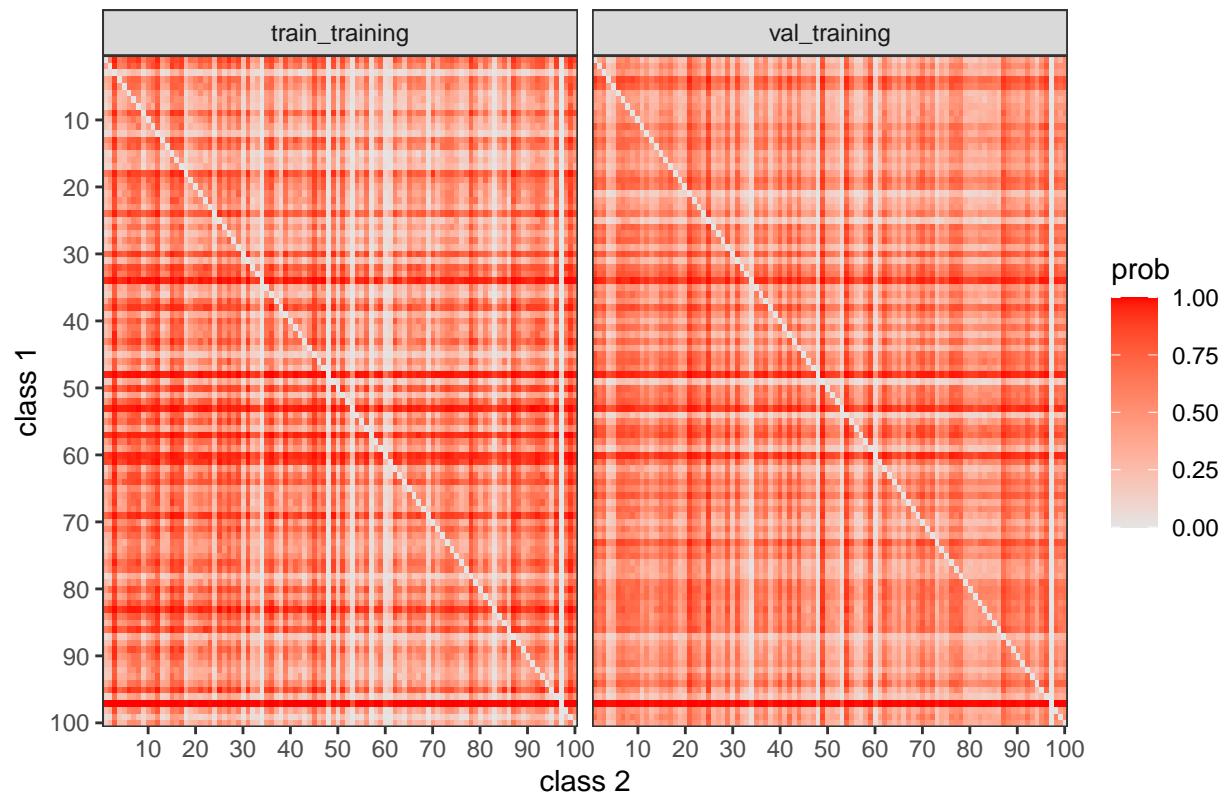
Average pairwise probabilities – class 95



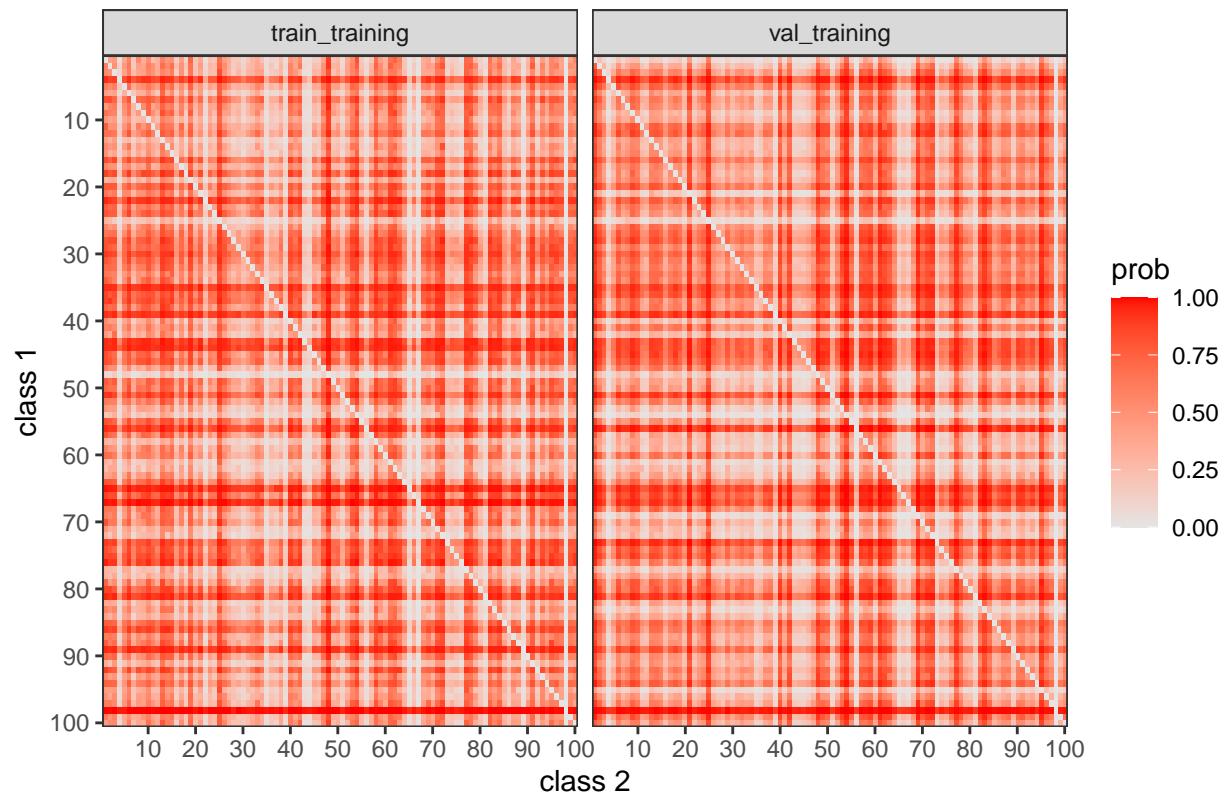
Average pairwise probabilities – class 96



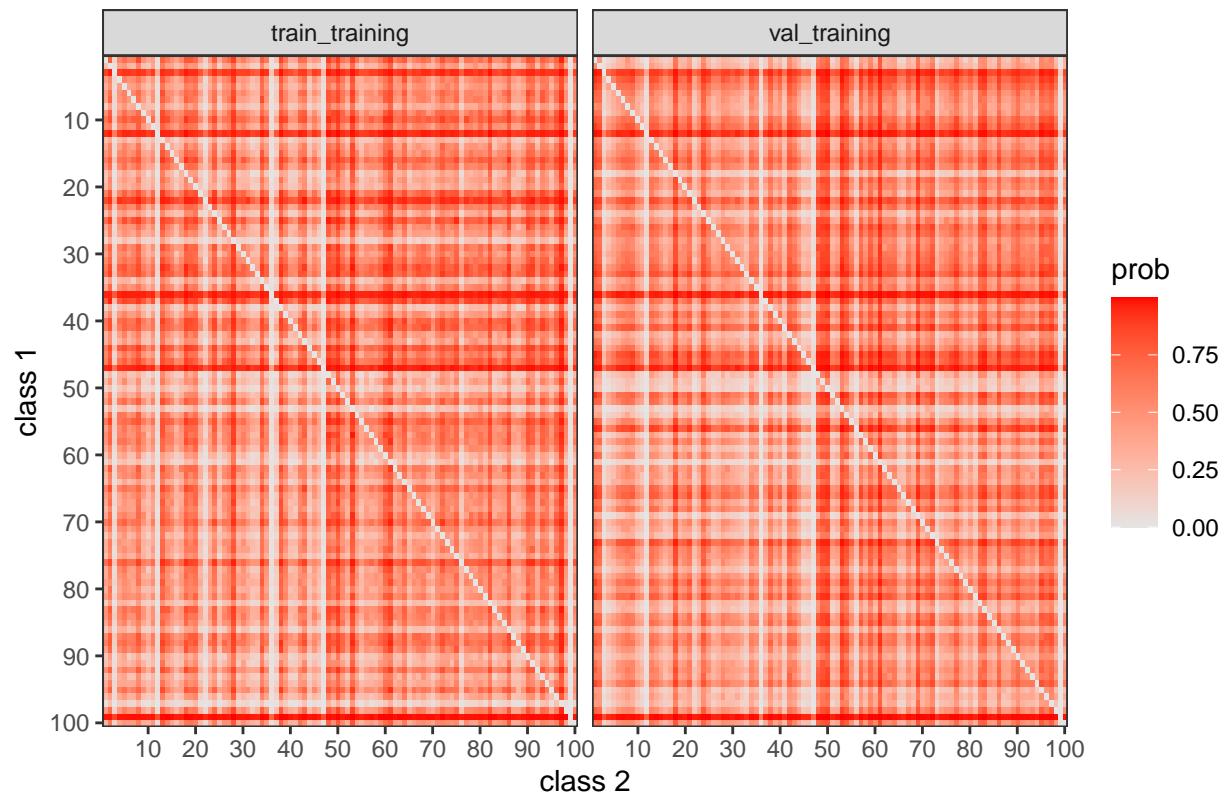
Average pairwise probabilities – class 97



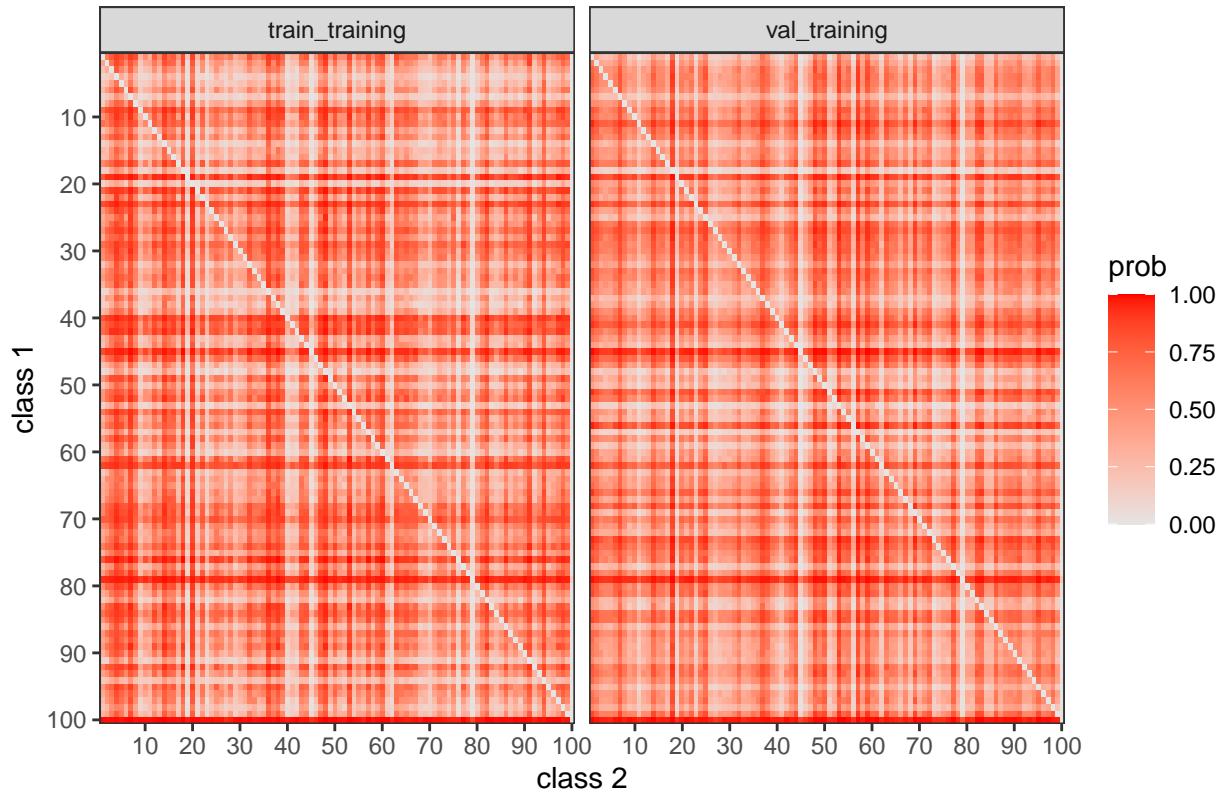
Average pairwise probabilities – class 98



Average pairwise probabilities – class 99



## Average pairwise probabilities – class 100

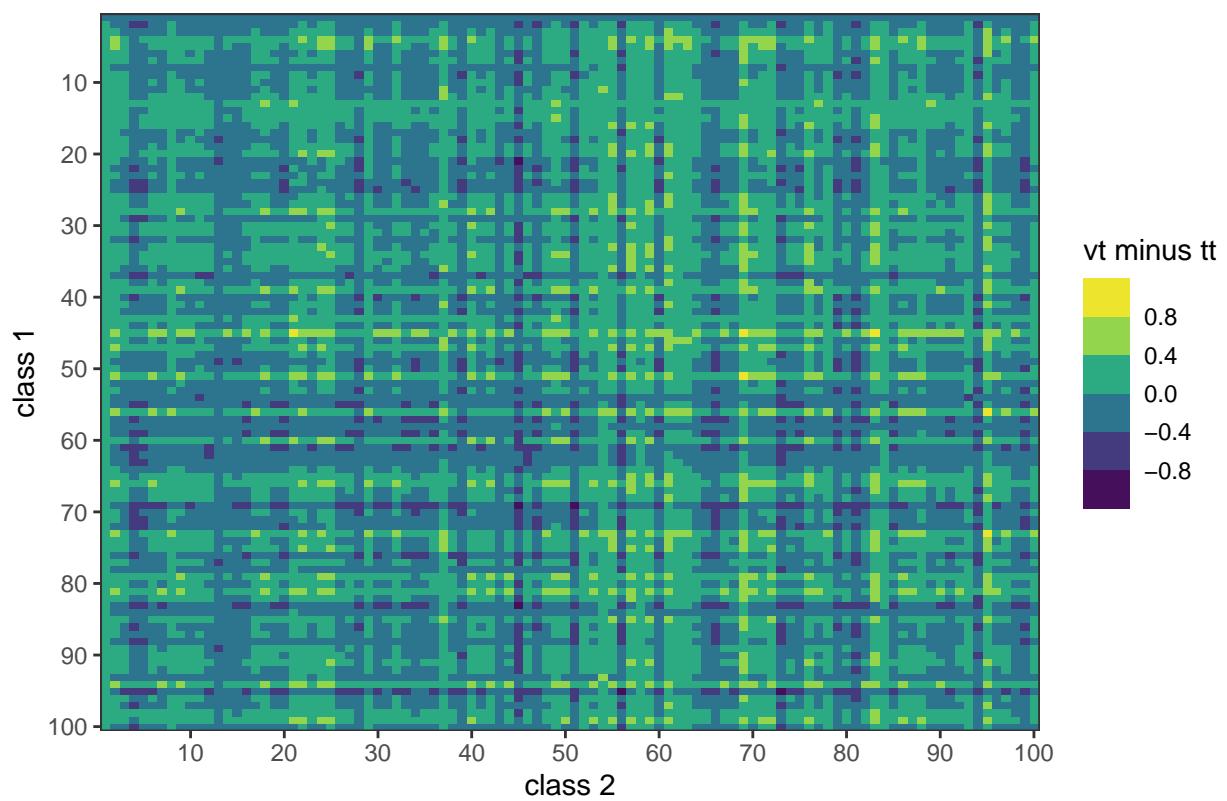


Difference between these two LDA training methodologies are not well visible, so we will plot just the differences.

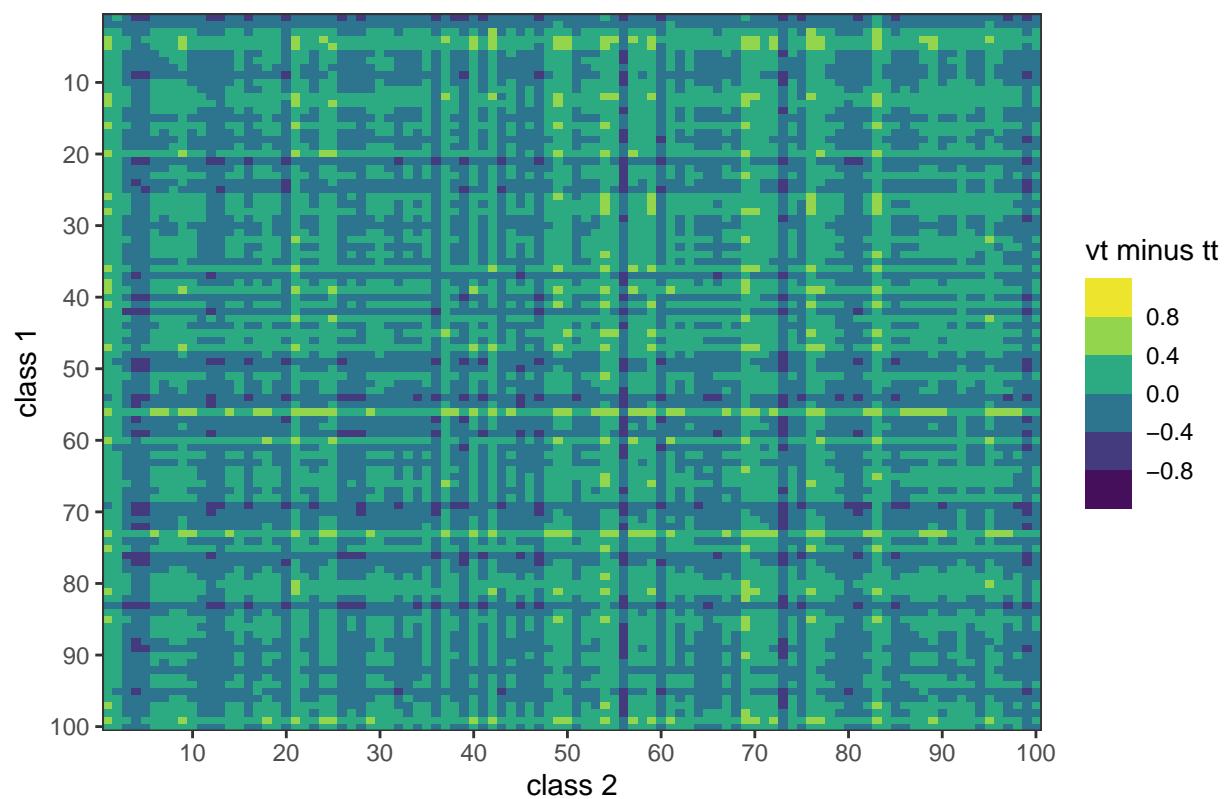
```
for (cls in 1:classes)
{
  cur_class_Rs <- df_aggr_Rs_diff %>% filter(class == cls)
  plot_cls <- ggplot(cur_class_Rs, aes(x = class2, y = class1)) +
    geom_raster(aes(fill=val_min_train)) +
    scale_fill_binned(type="viridis", limits=c(-0.9, 0.9), breaks=seq(-.8, .8, .4), name="vt minus tt")
    scale_y_discrete(limits=rev, breaks=seq(0, classes, 10)) +
    scale_x_discrete(breaks=seq(0, classes, 10)) +
    labs(x="class 2", y="class 1", title=paste("Differences between average pairwise probabilities - cl"))
    theme_bw()

  print(plot_cls)
}
```

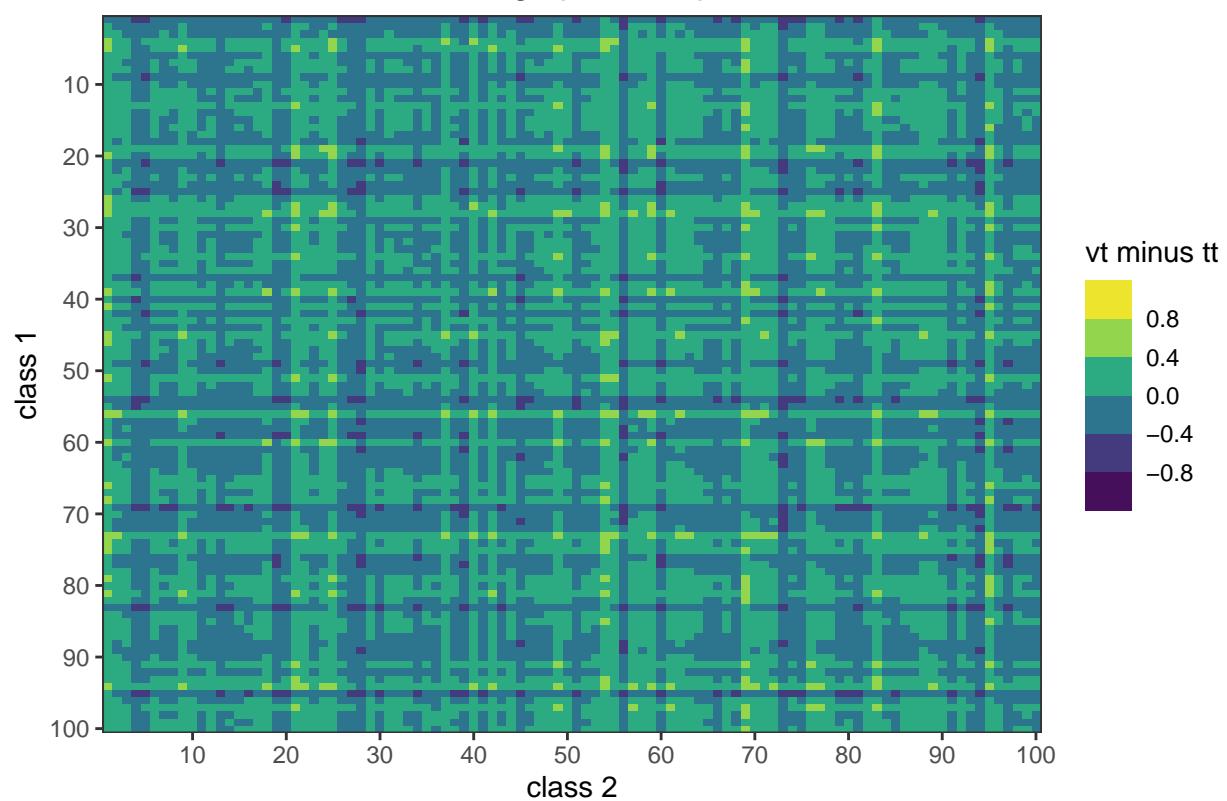
Differences between average pairwise probabilities – class 1



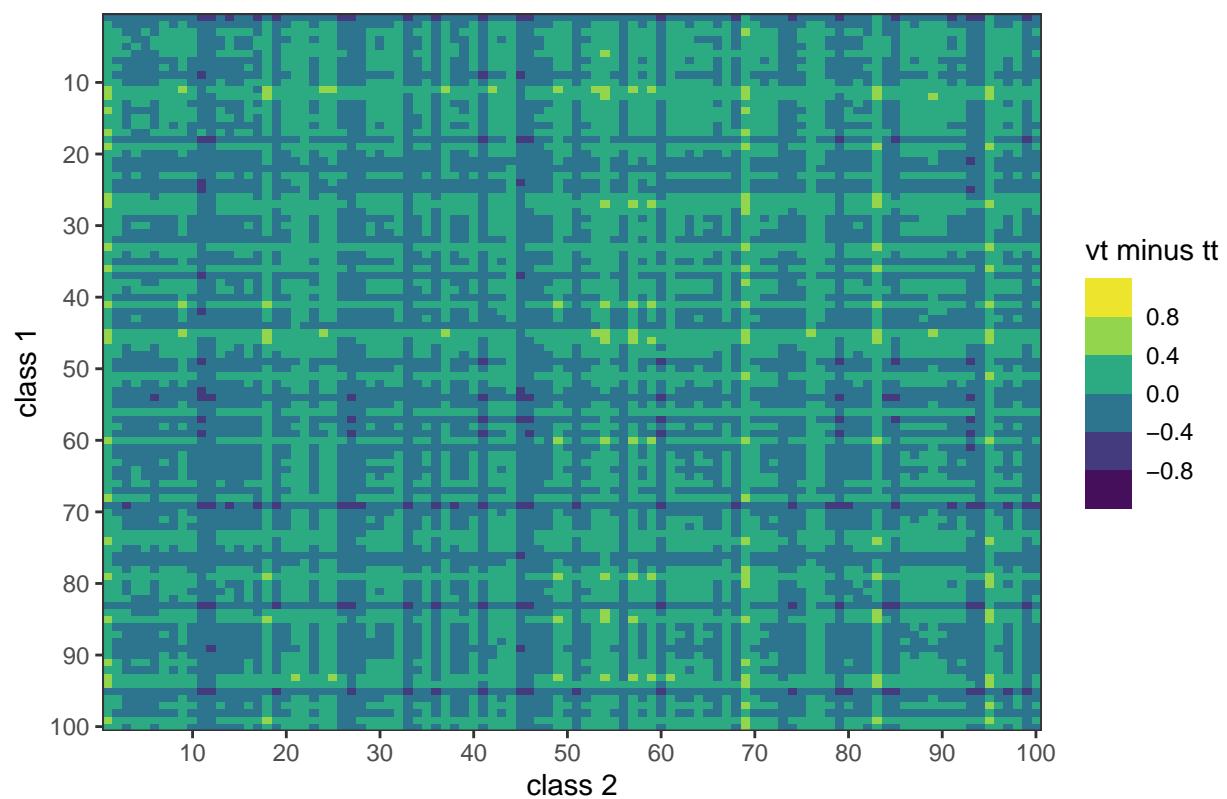
Differences between average pairwise probabilities – class 2



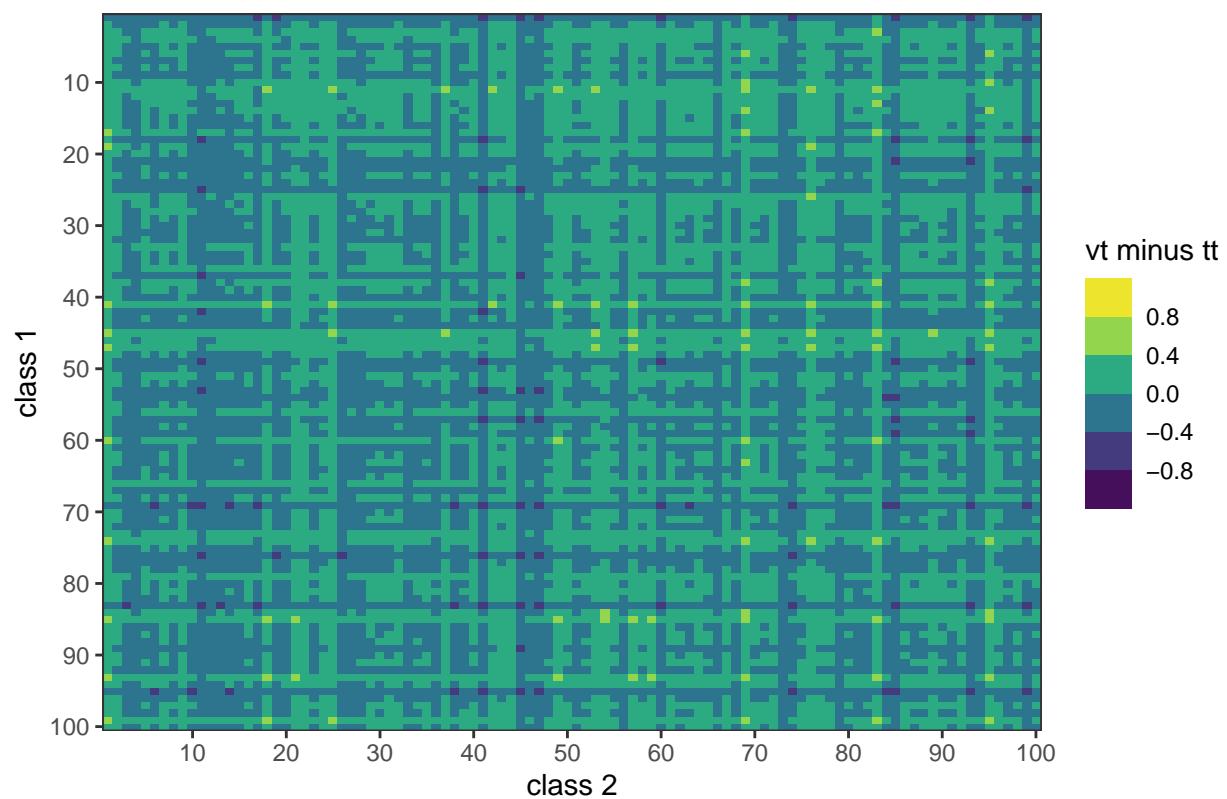
Differences between average pairwise probabilities – class 3



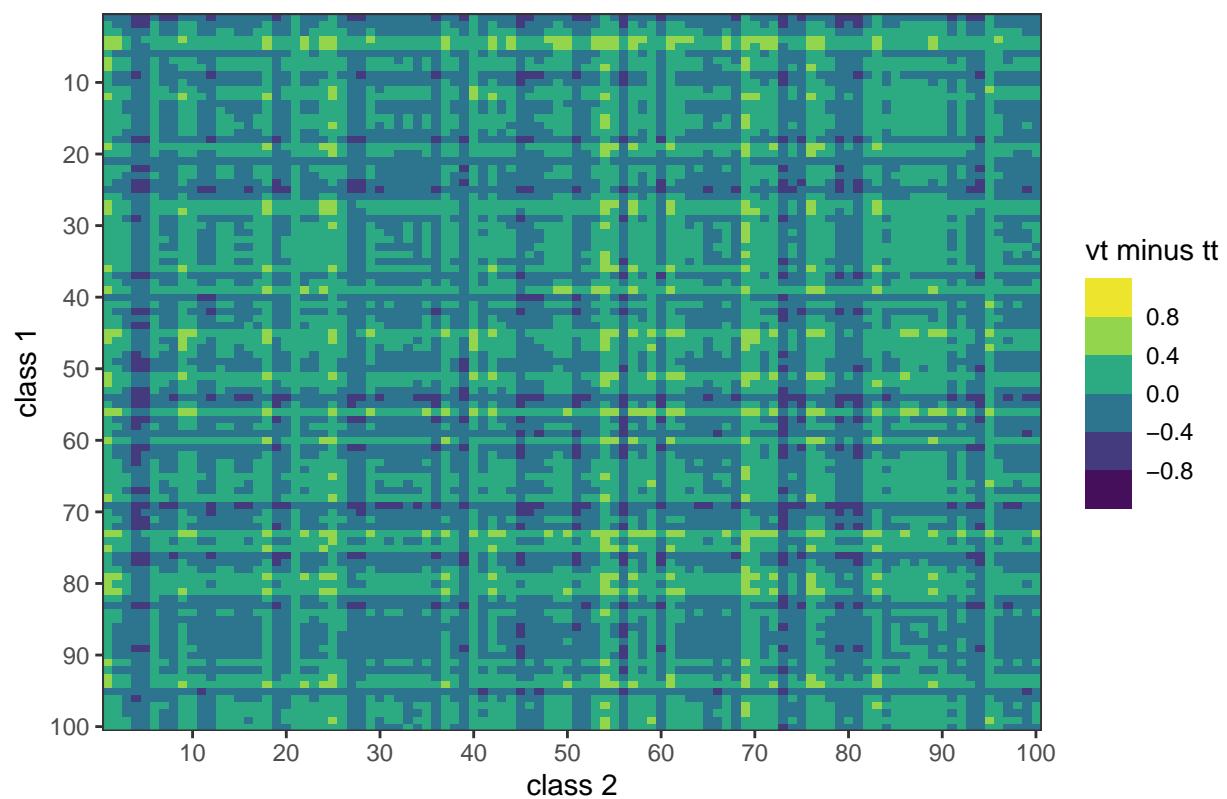
Differences between average pairwise probabilities – class 4



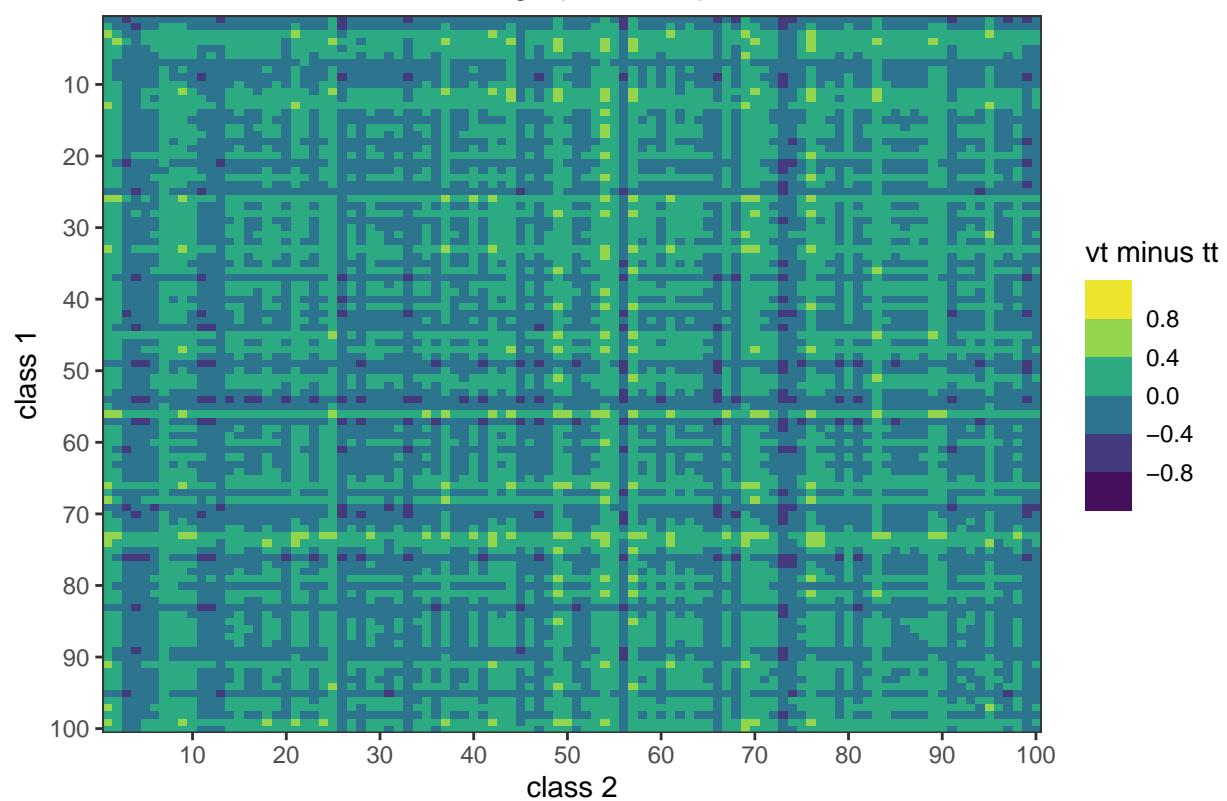
Differences between average pairwise probabilities – class 5



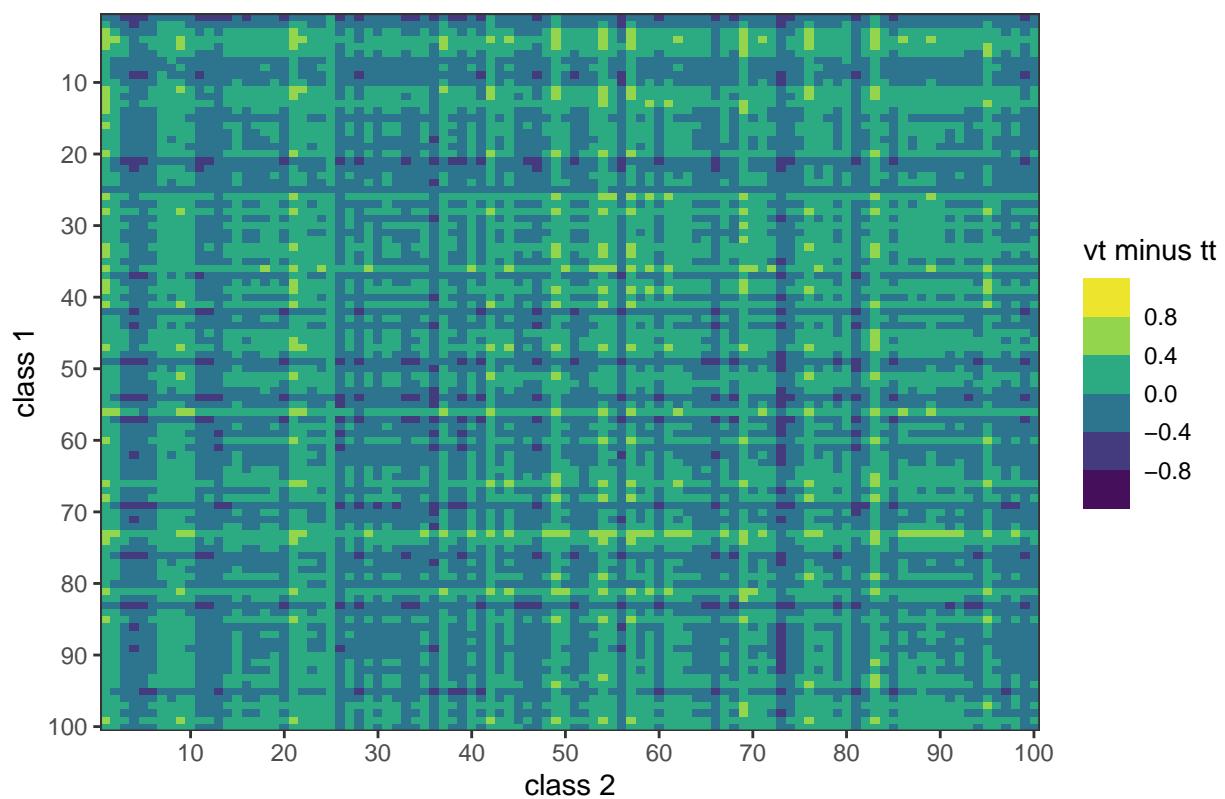
Differences between average pairwise probabilities – class 6



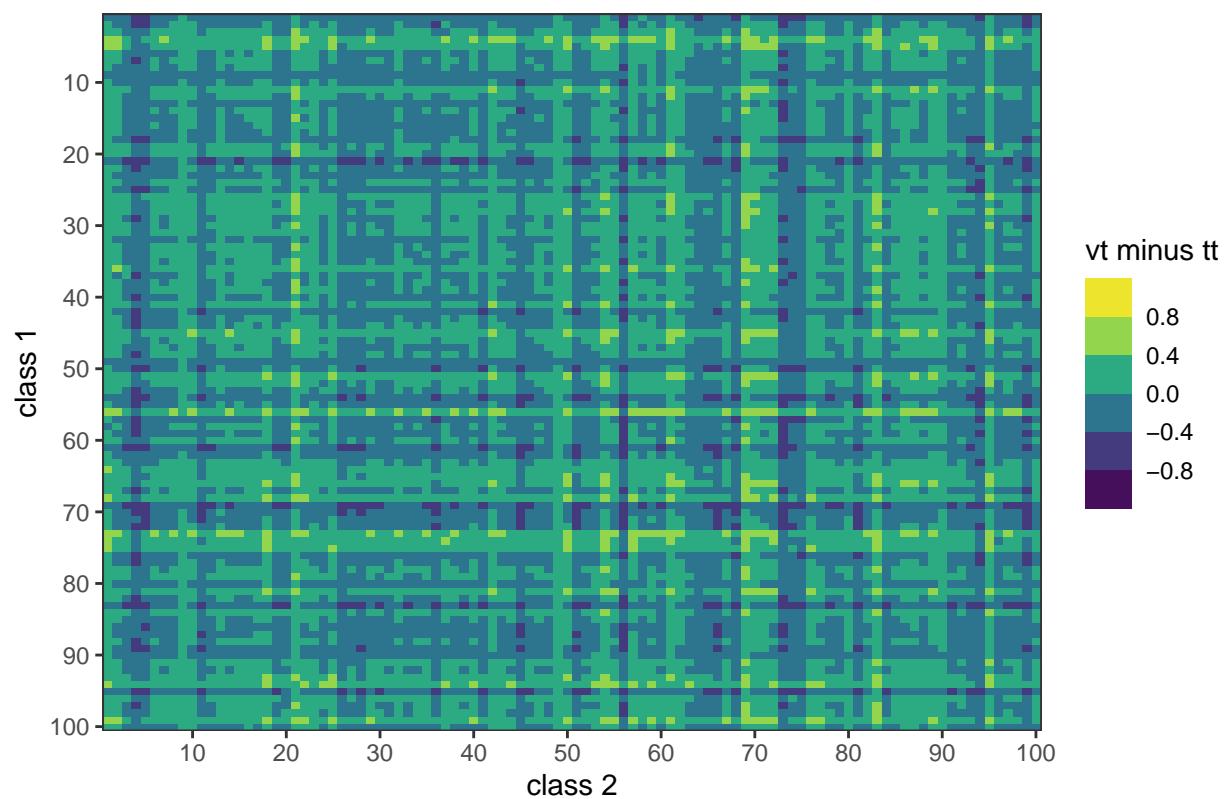
Differences between average pairwise probabilities – class 7



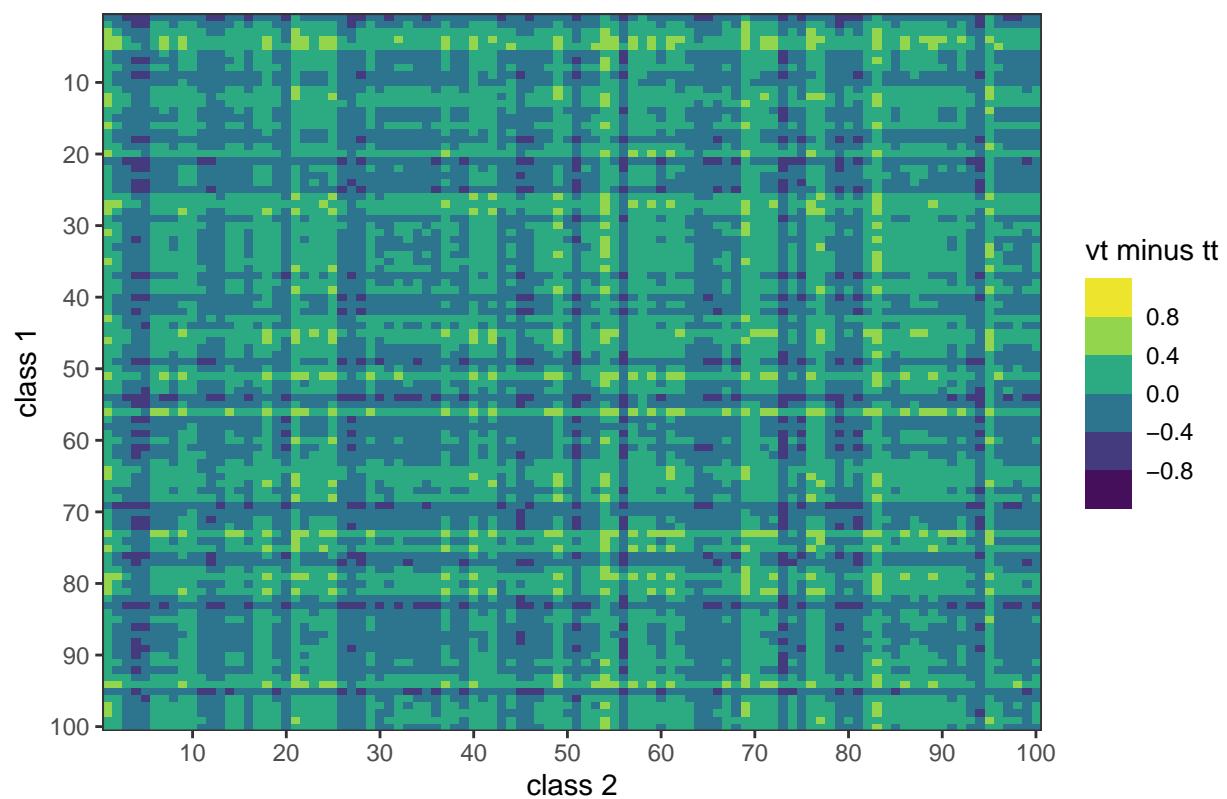
Differences between average pairwise probabilities – class 8



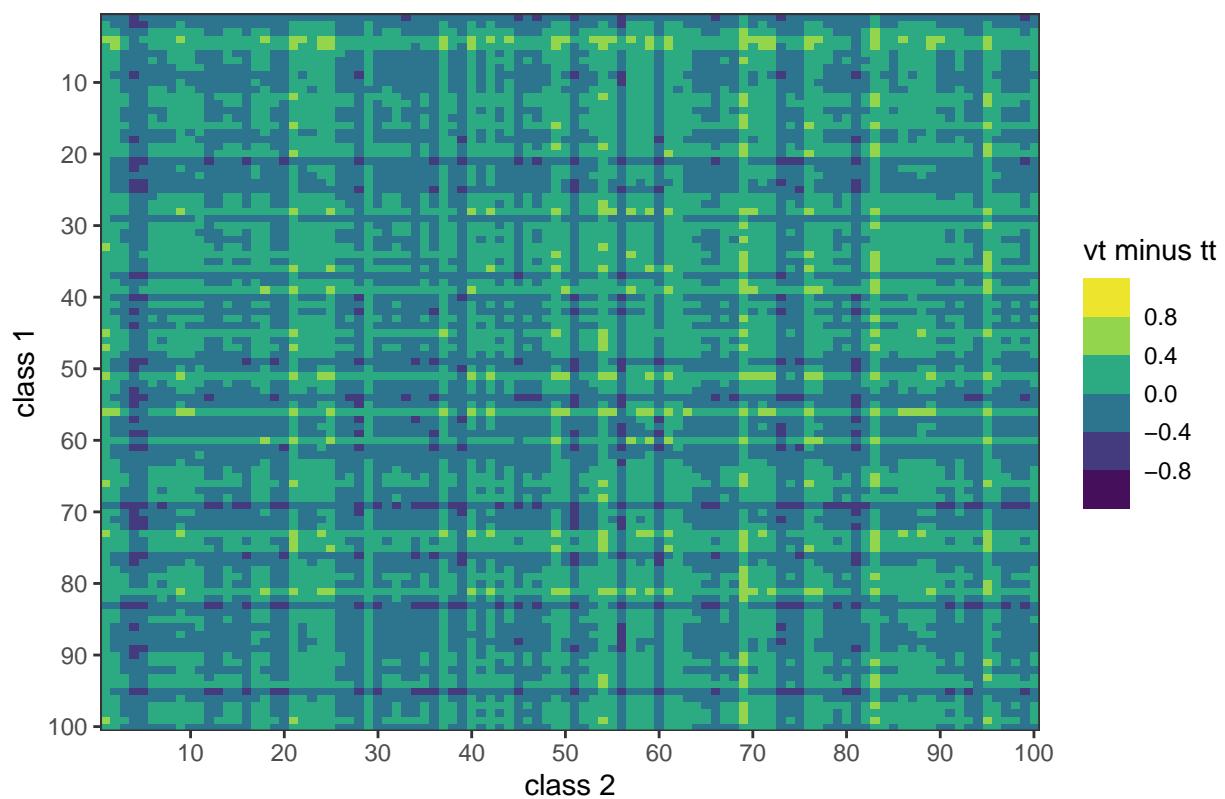
Differences between average pairwise probabilities – class 9



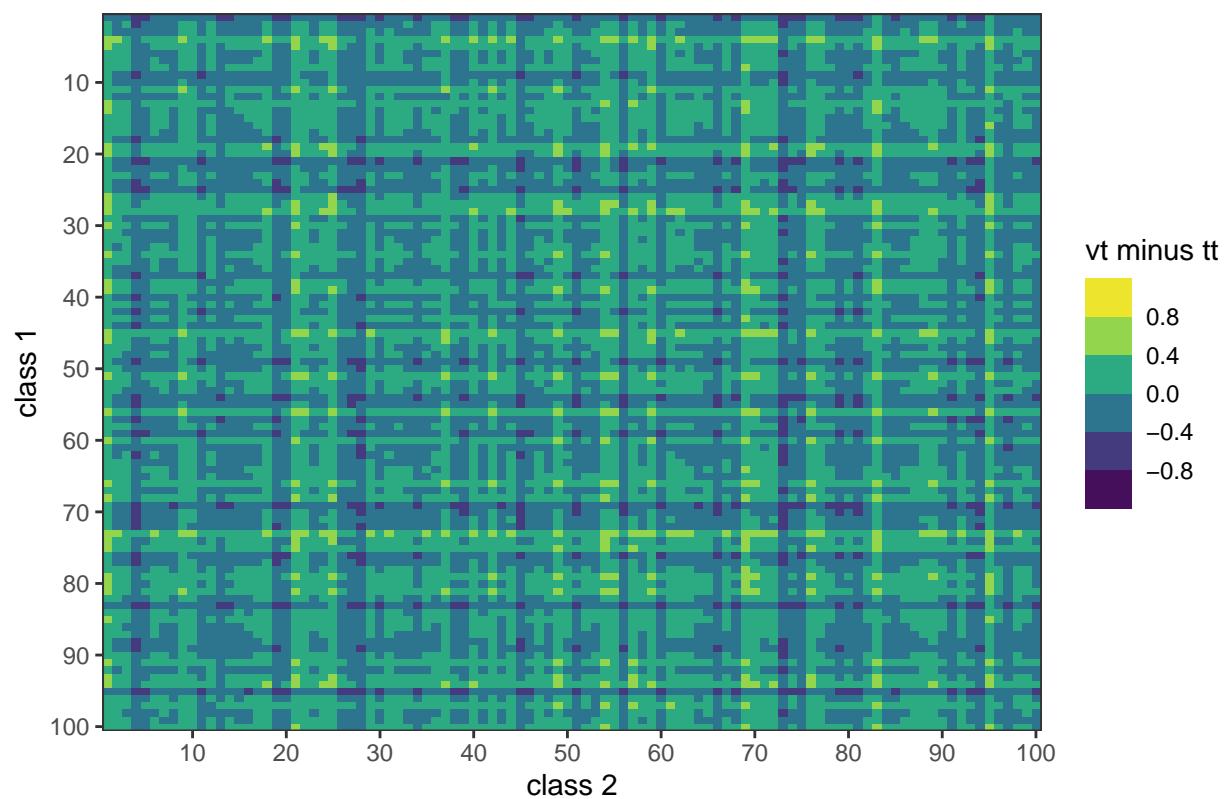
Differences between average pairwise probabilities – class 10



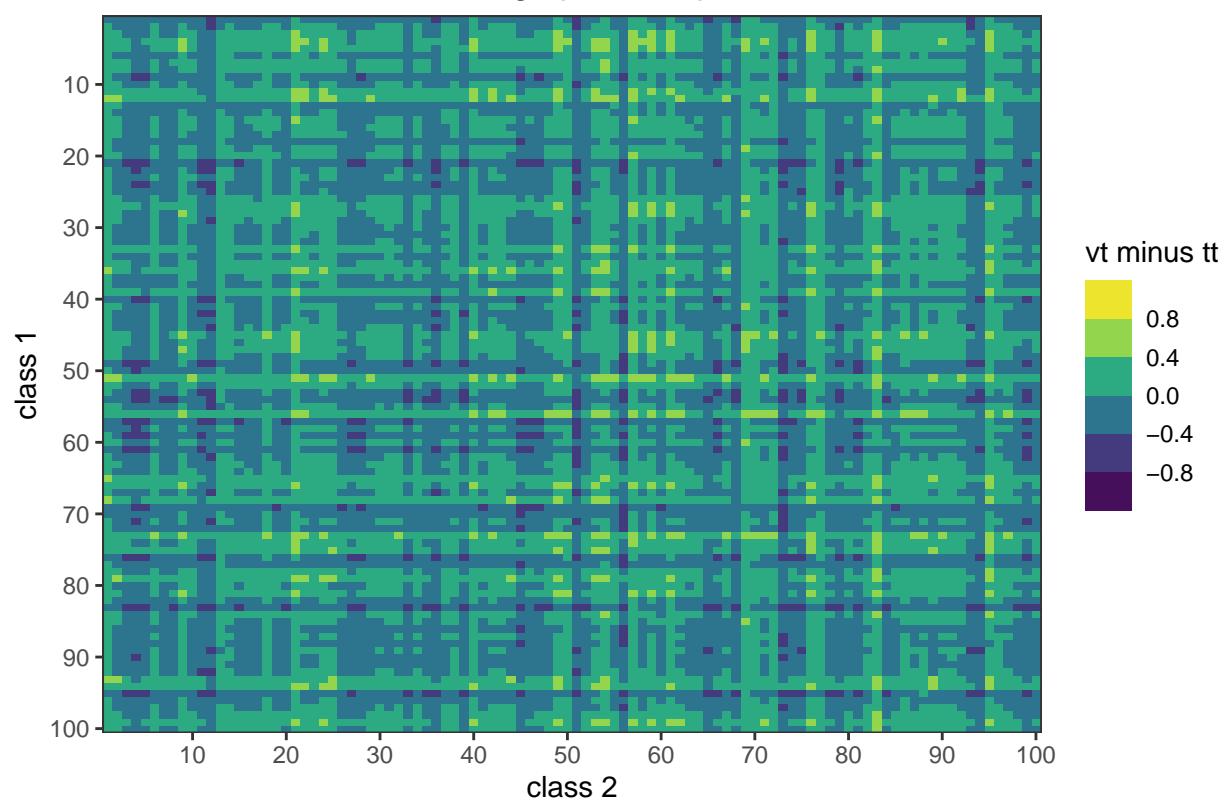
Differences between average pairwise probabilities – class 11



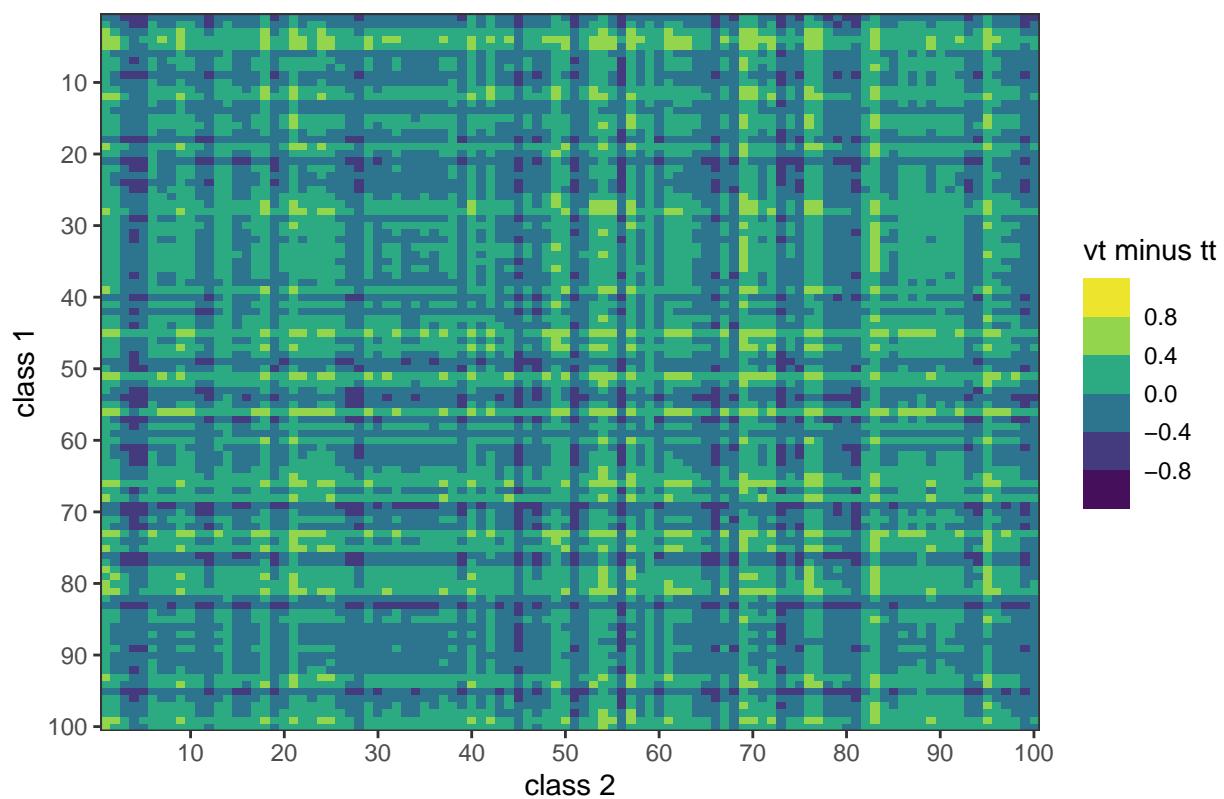
Differences between average pairwise probabilities – class 12



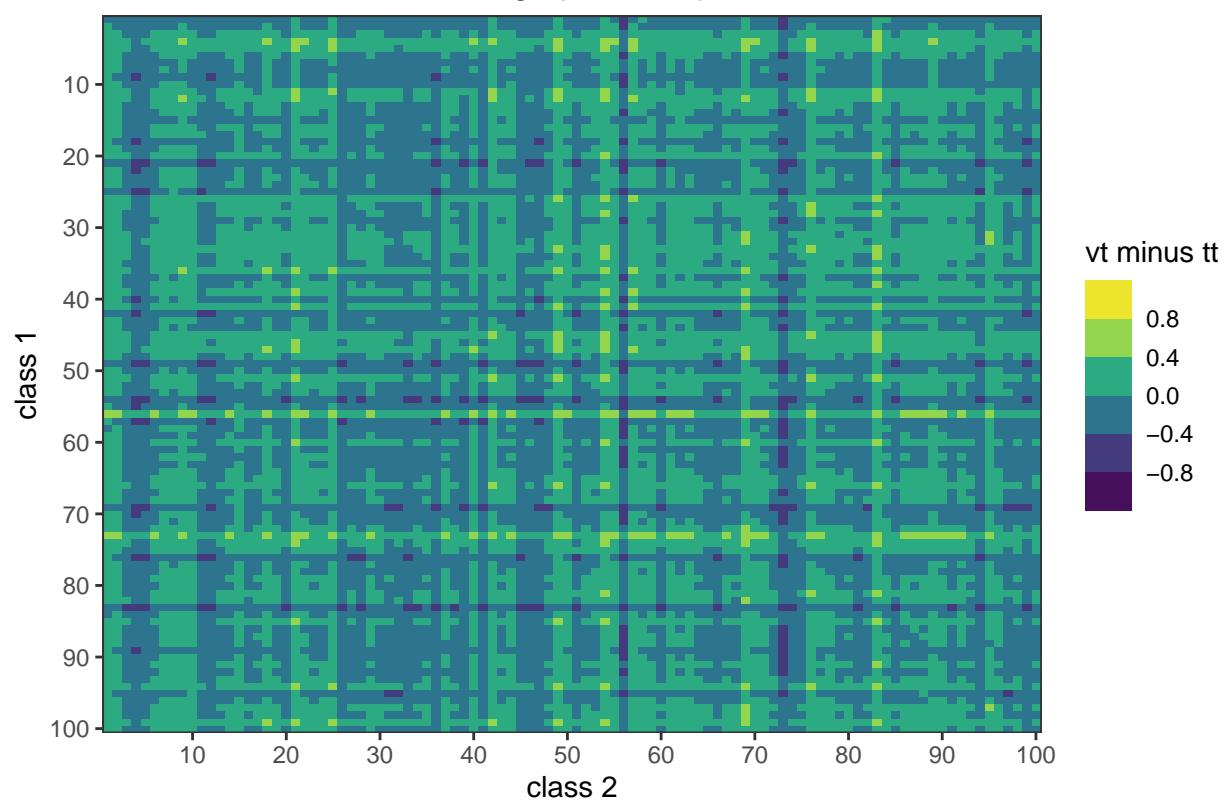
Differences between average pairwise probabilities – class 13



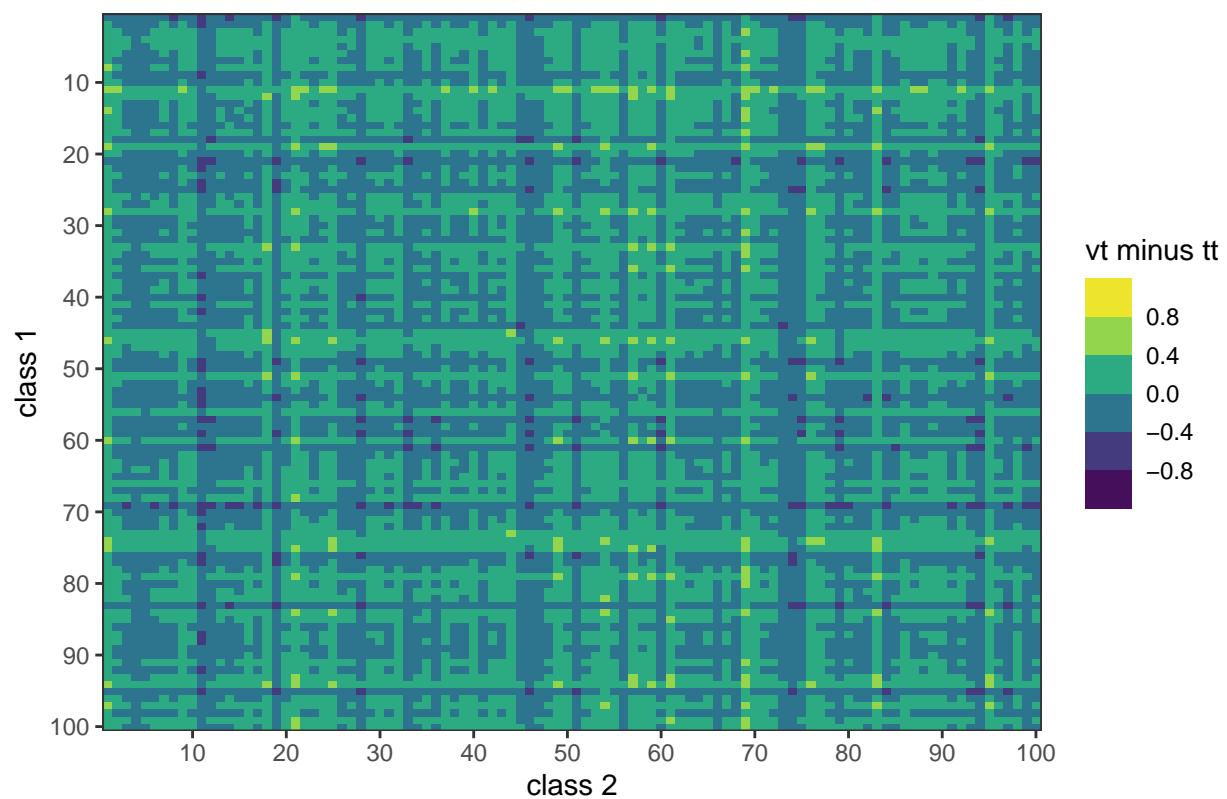
Differences between average pairwise probabilities – class 14



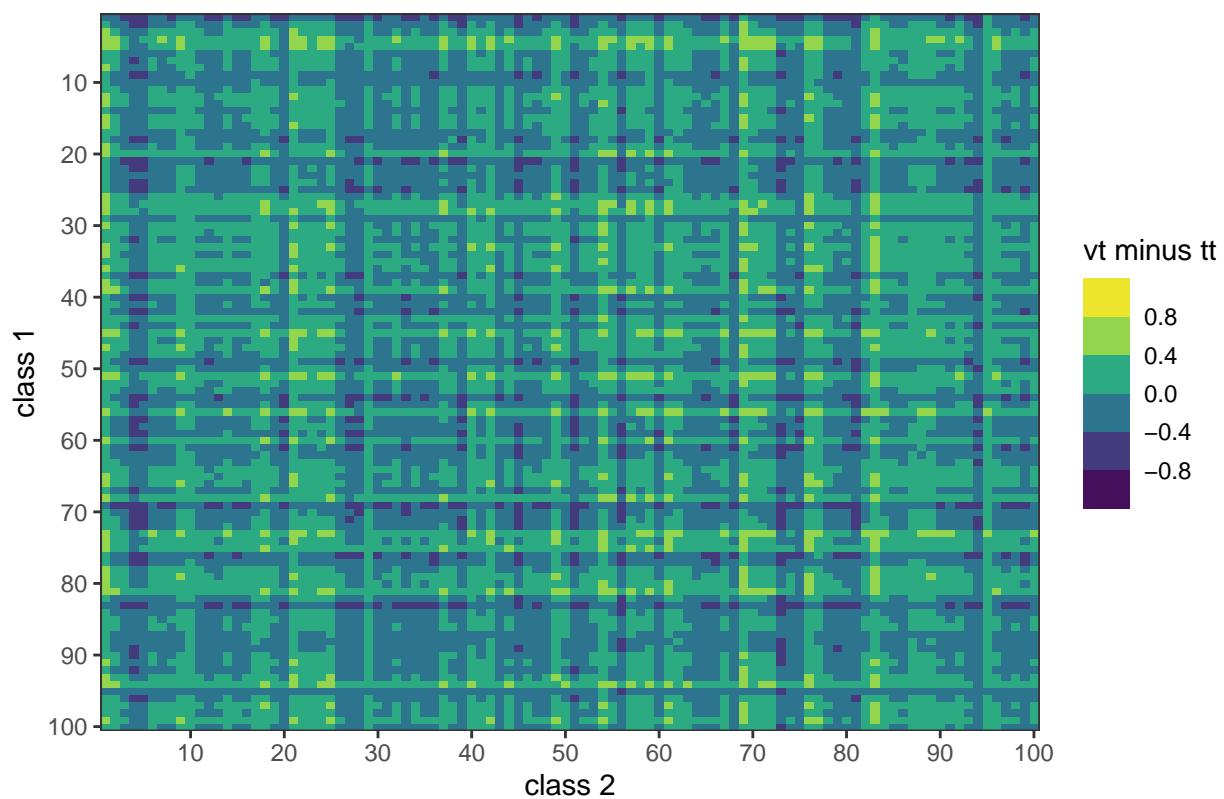
Differences between average pairwise probabilities – class 15



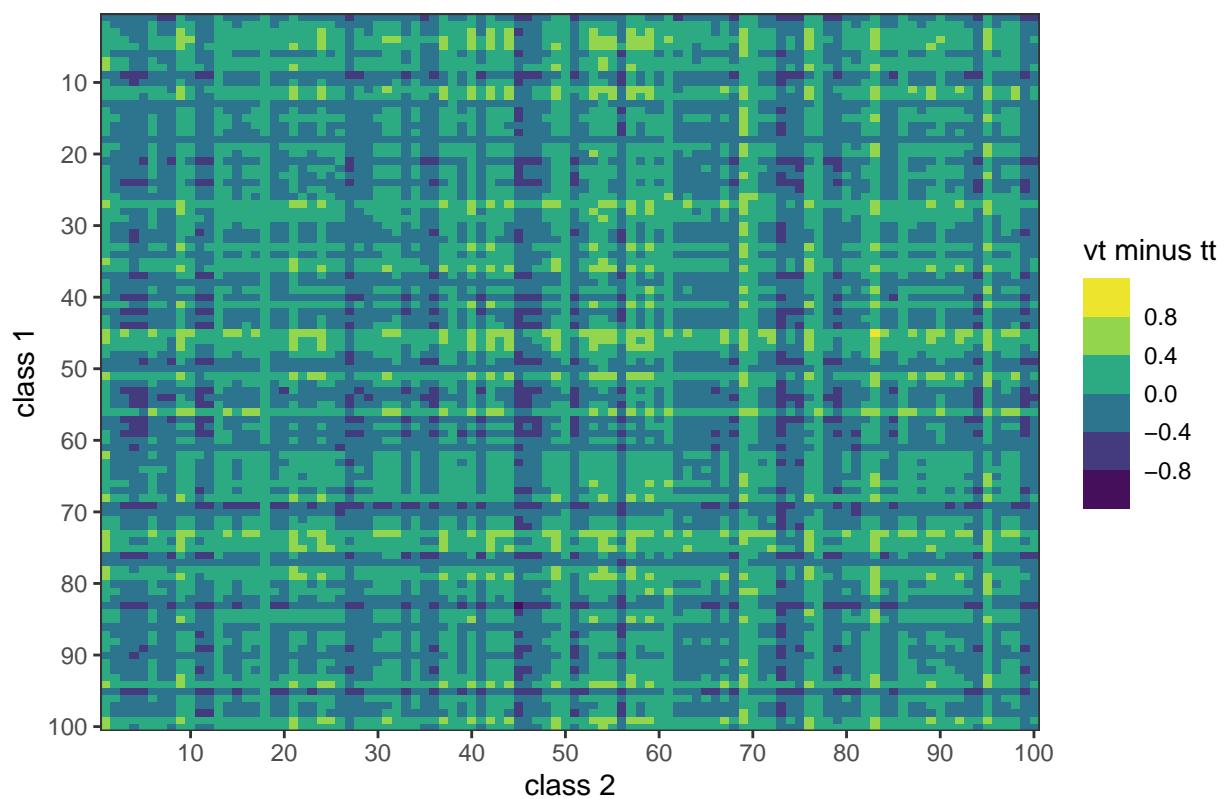
Differences between average pairwise probabilities – class 16



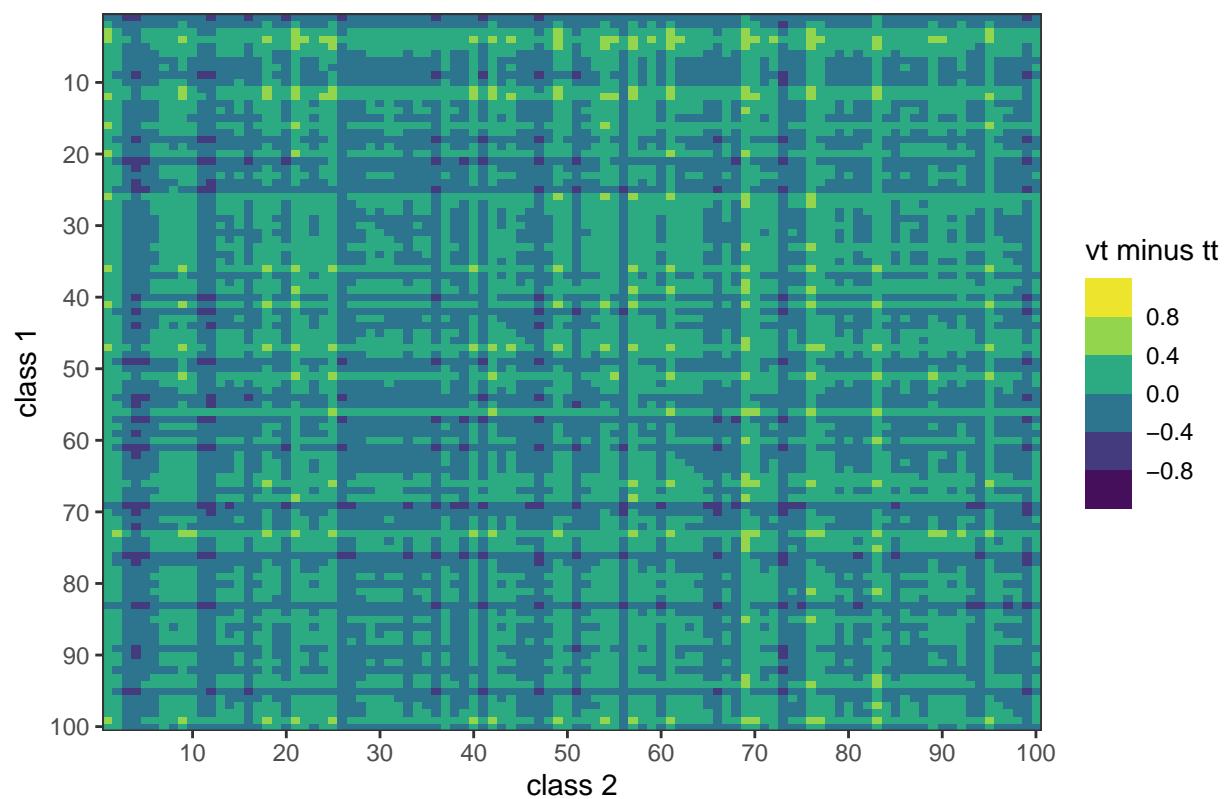
Differences between average pairwise probabilities – class 17



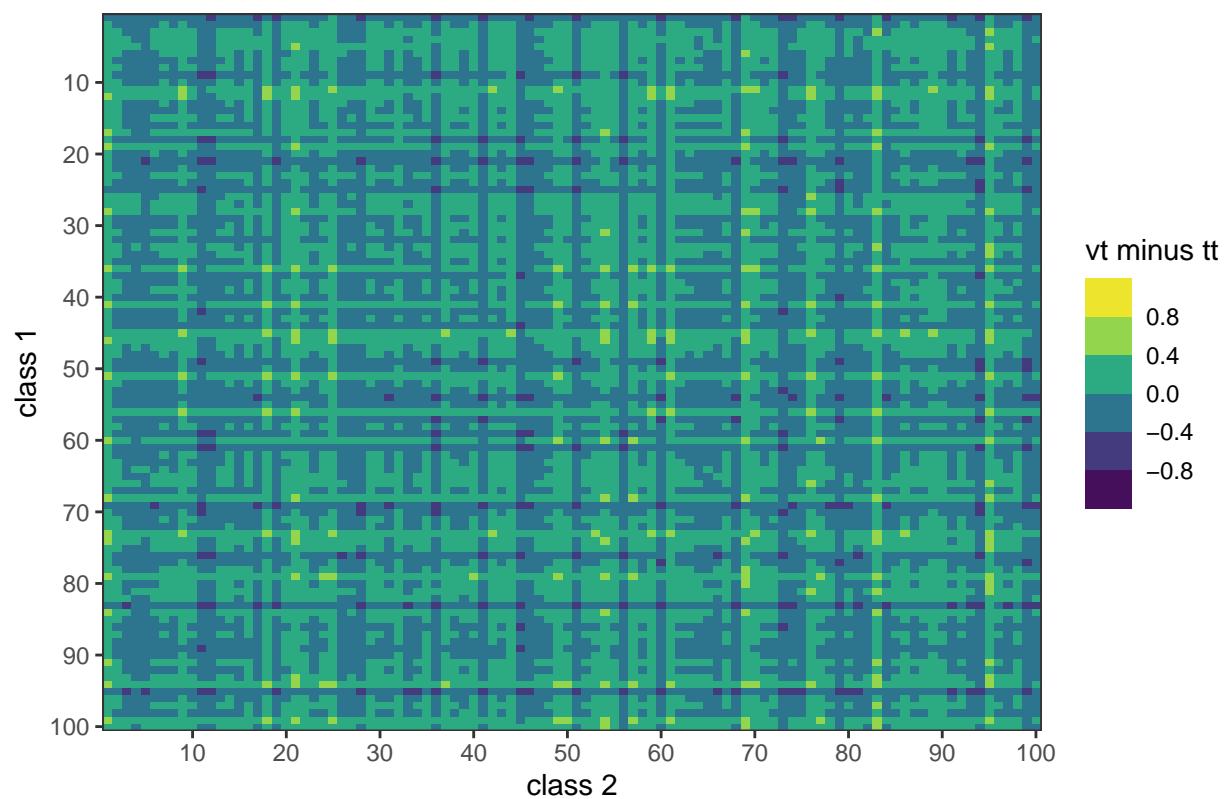
Differences between average pairwise probabilities – class 18



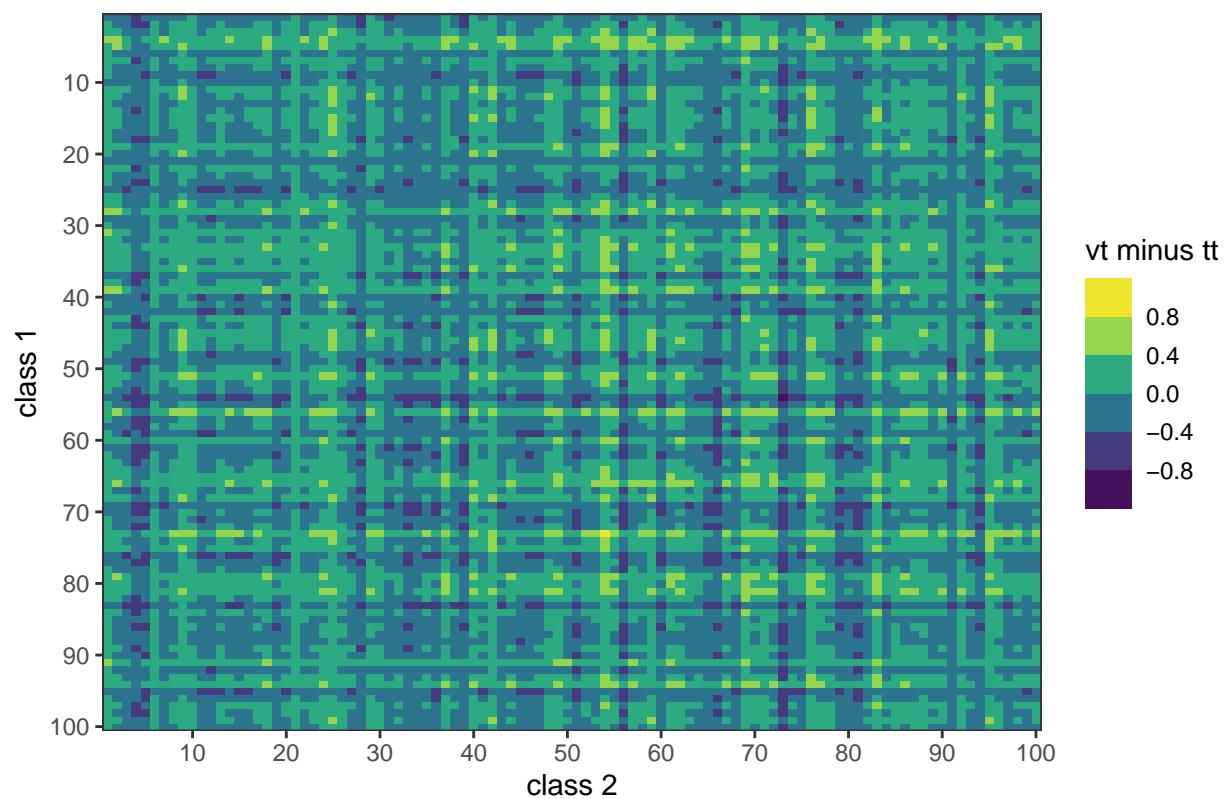
Differences between average pairwise probabilities – class 19



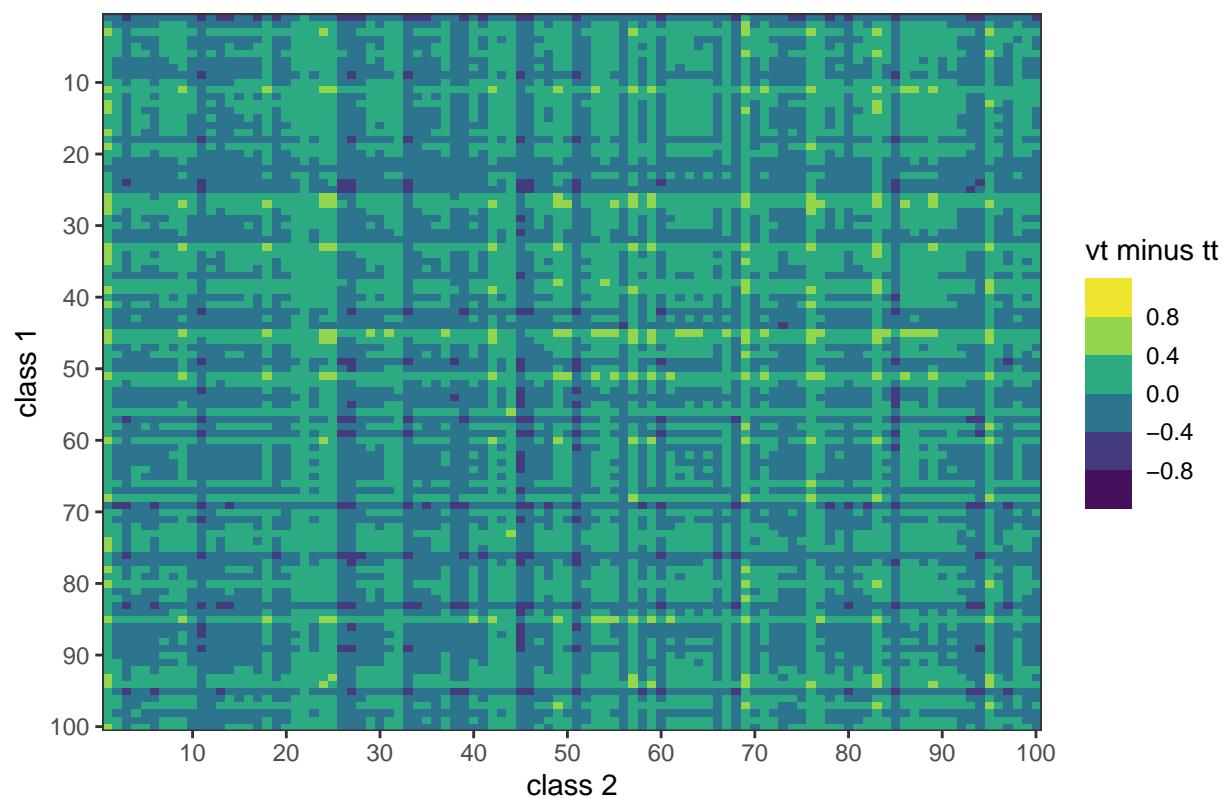
Differences between average pairwise probabilities – class 20



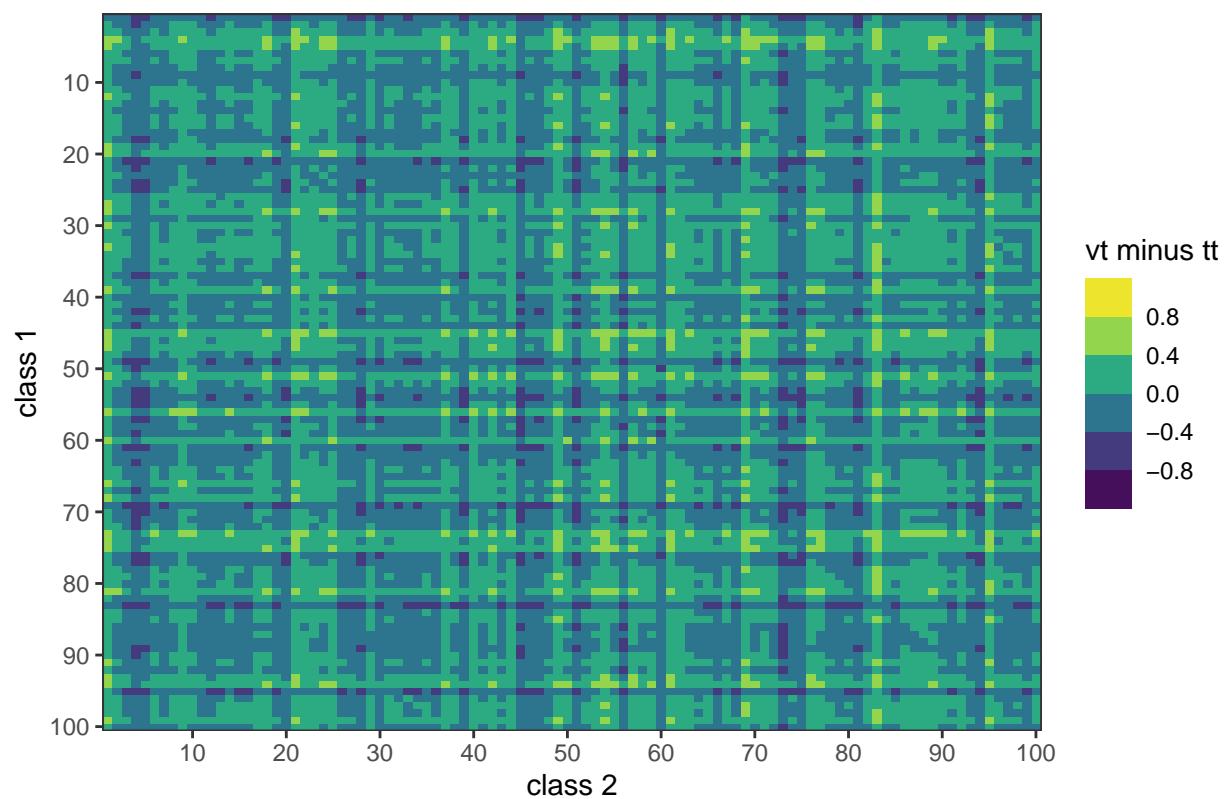
Differences between average pairwise probabilities – class 21



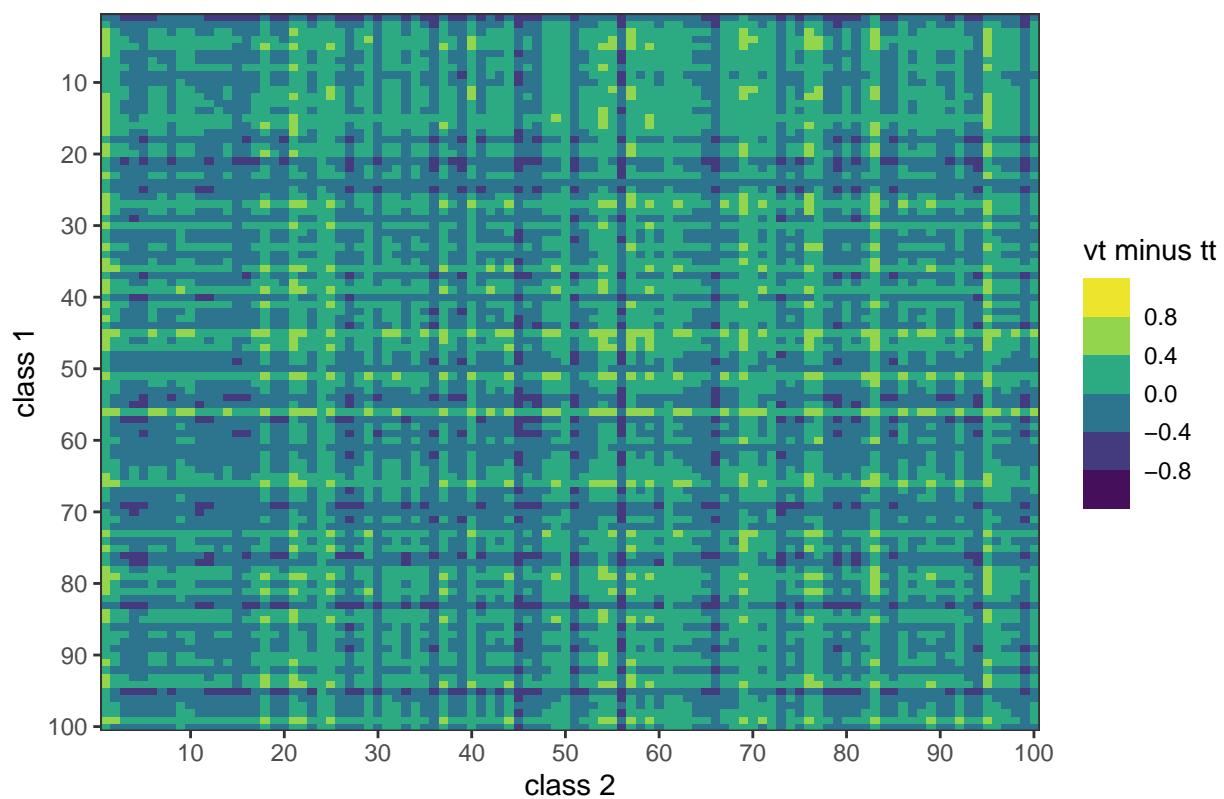
Differences between average pairwise probabilities – class 22



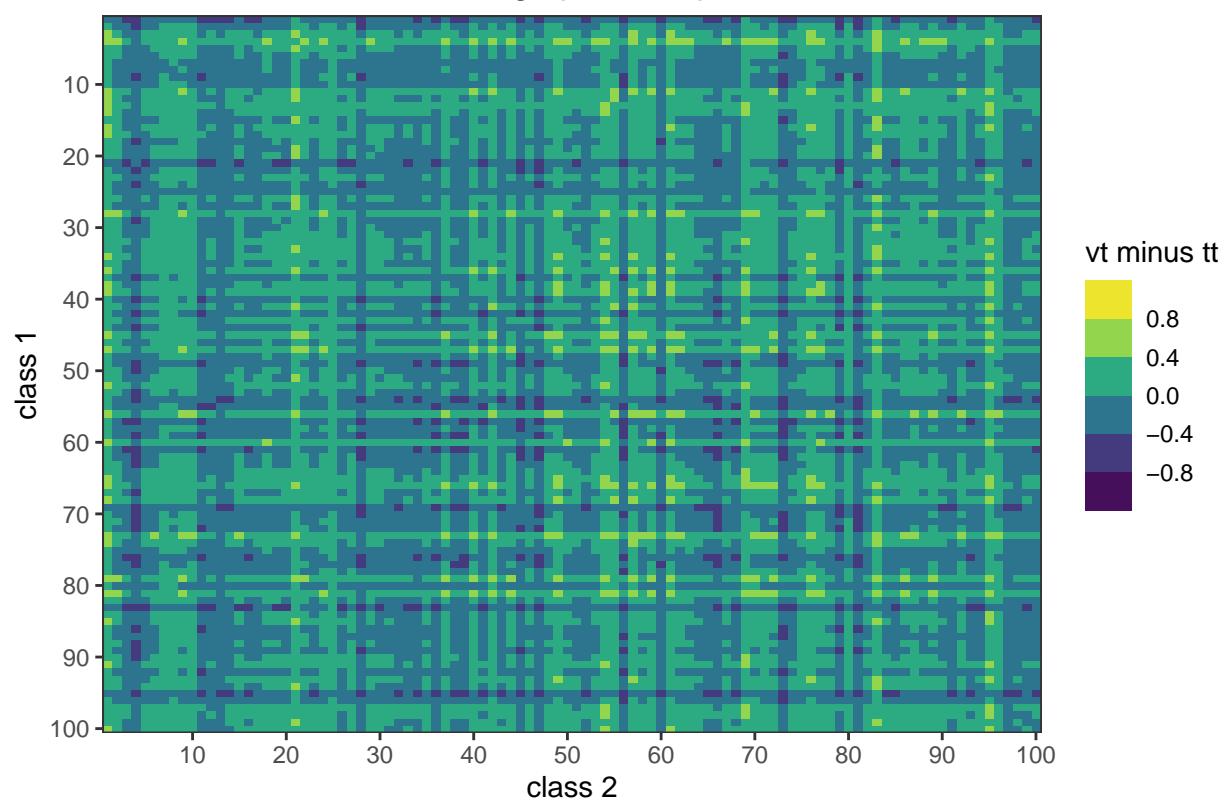
Differences between average pairwise probabilities – class 23



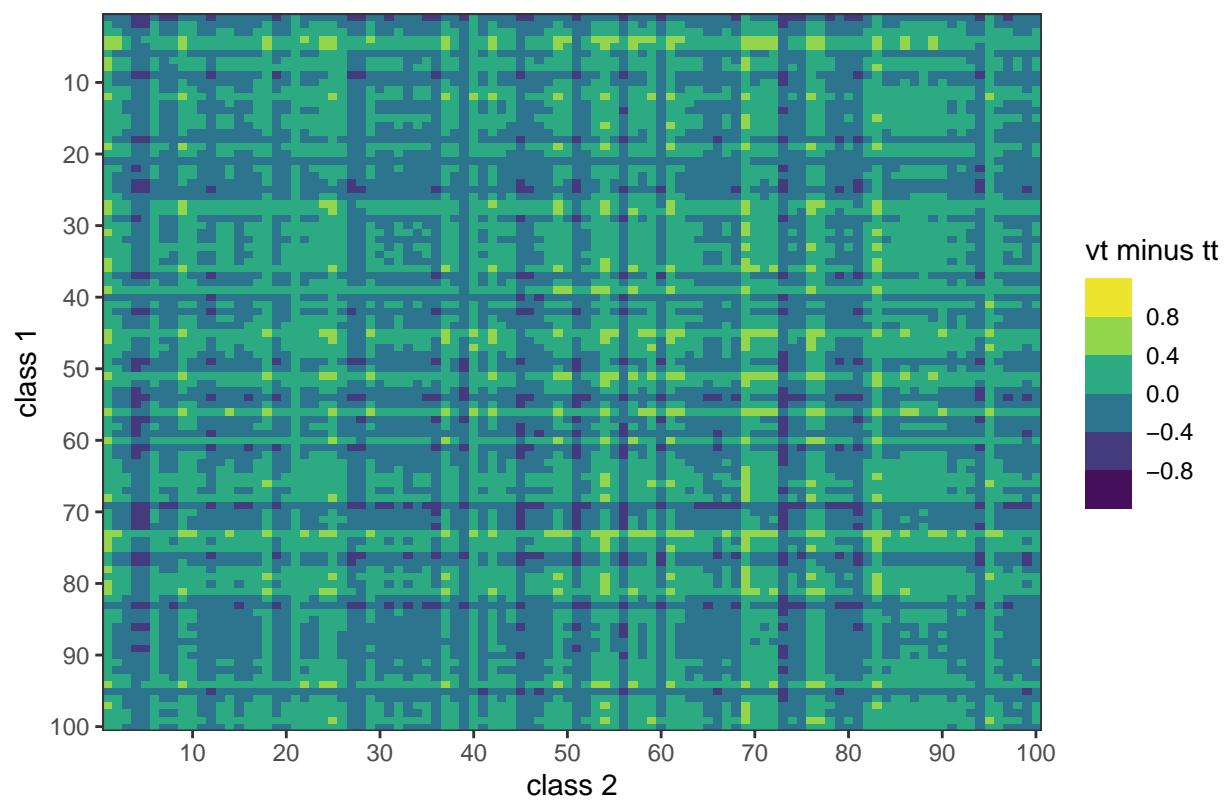
Differences between average pairwise probabilities – class 24



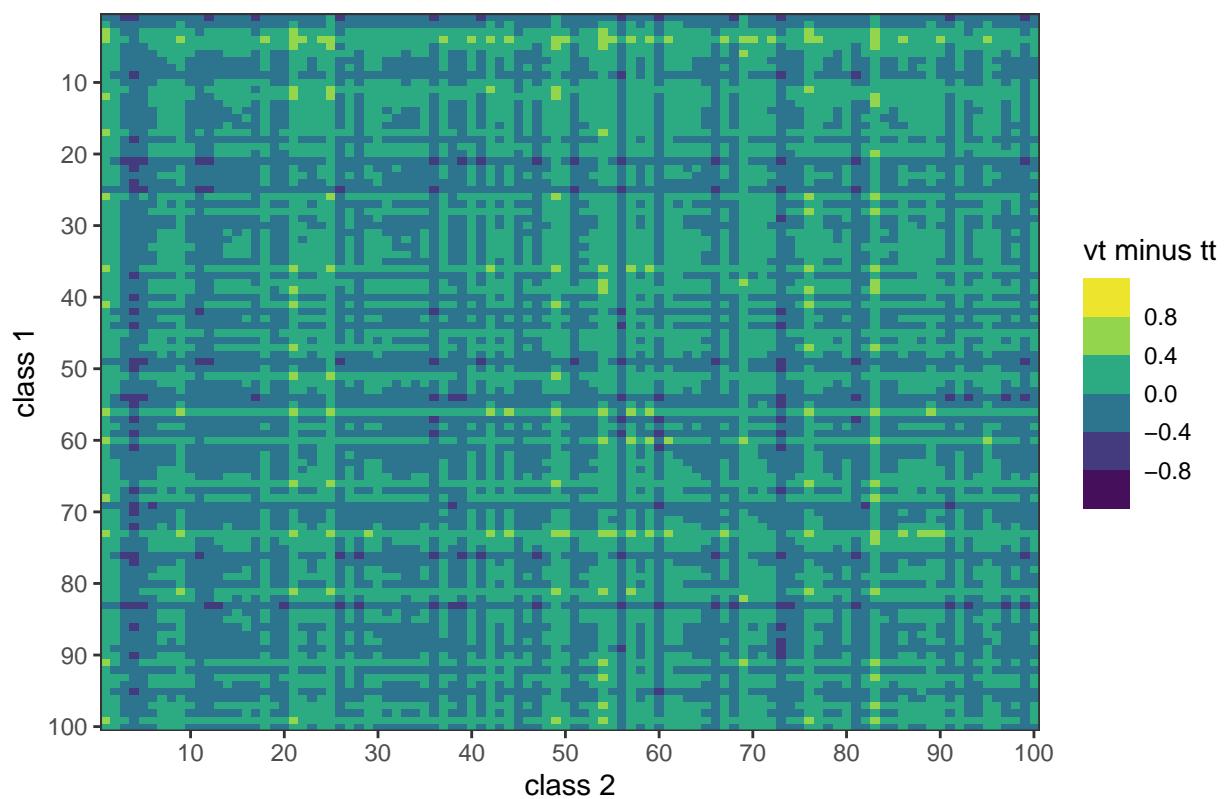
Differences between average pairwise probabilities – class 25



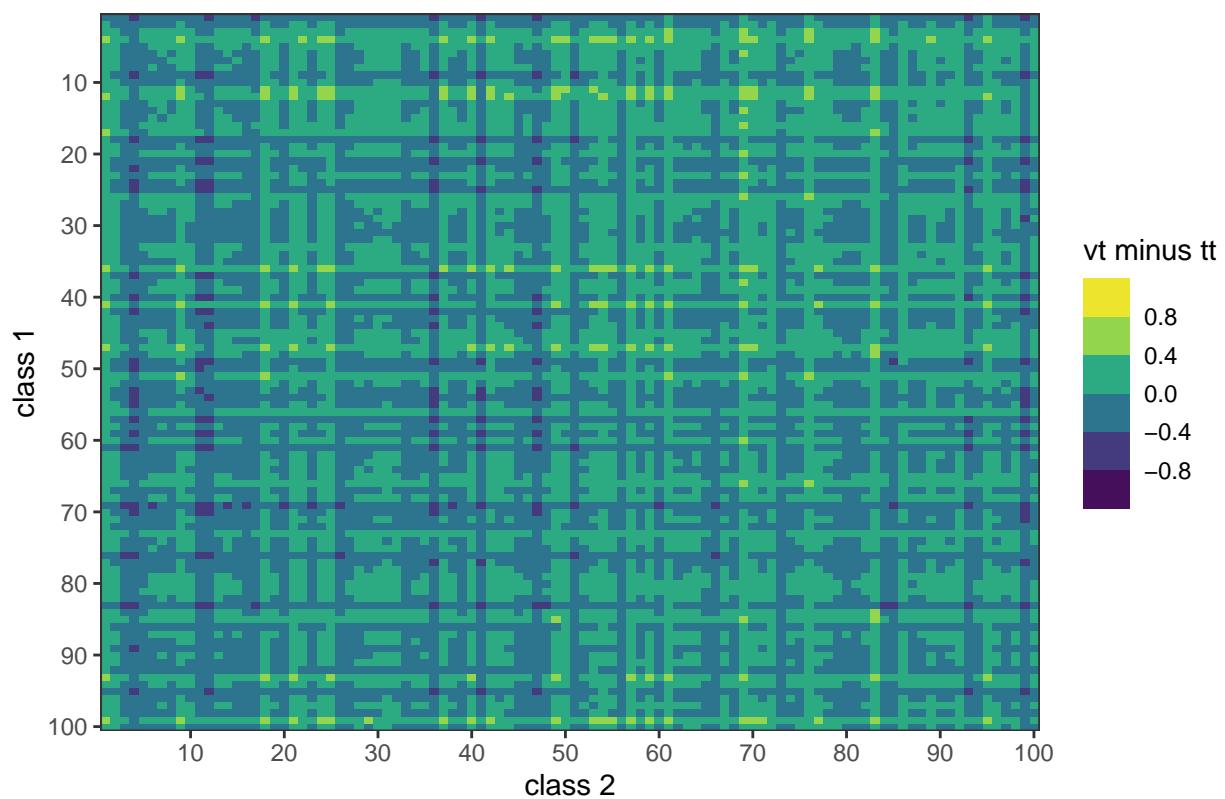
Differences between average pairwise probabilities – class 26



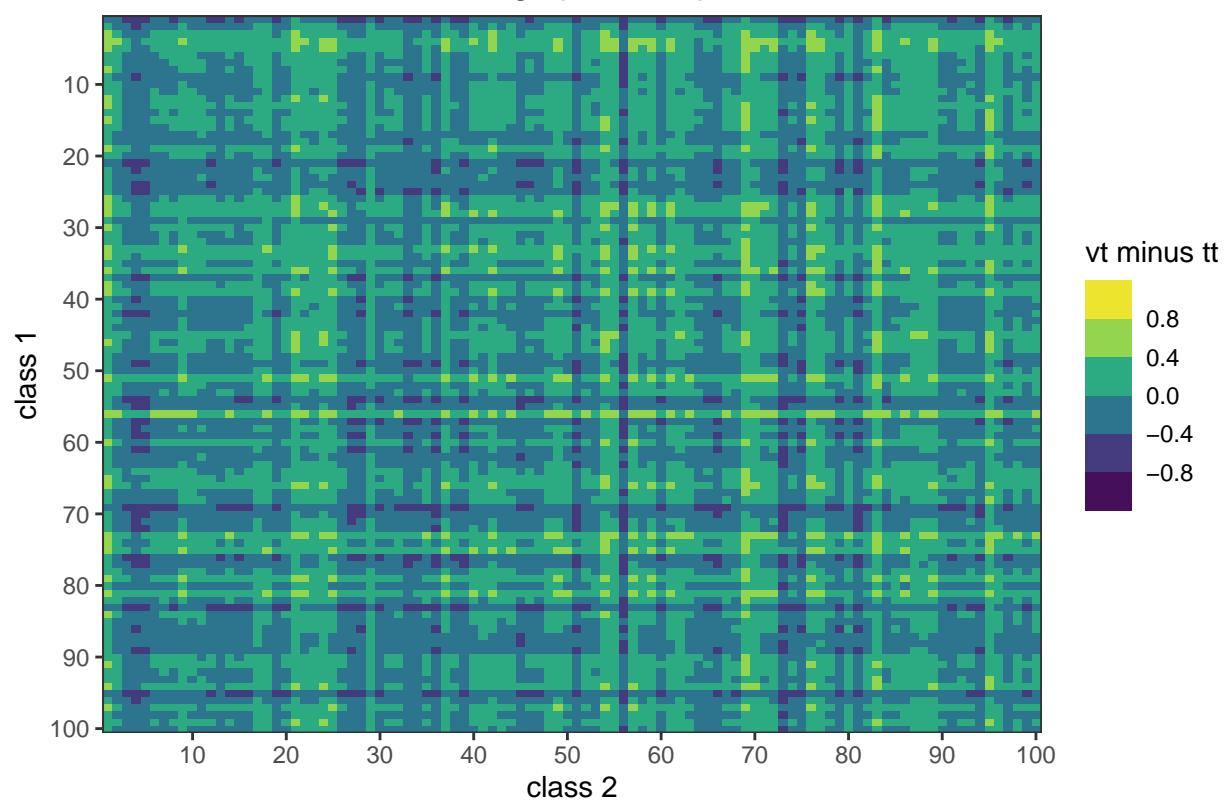
Differences between average pairwise probabilities – class 27



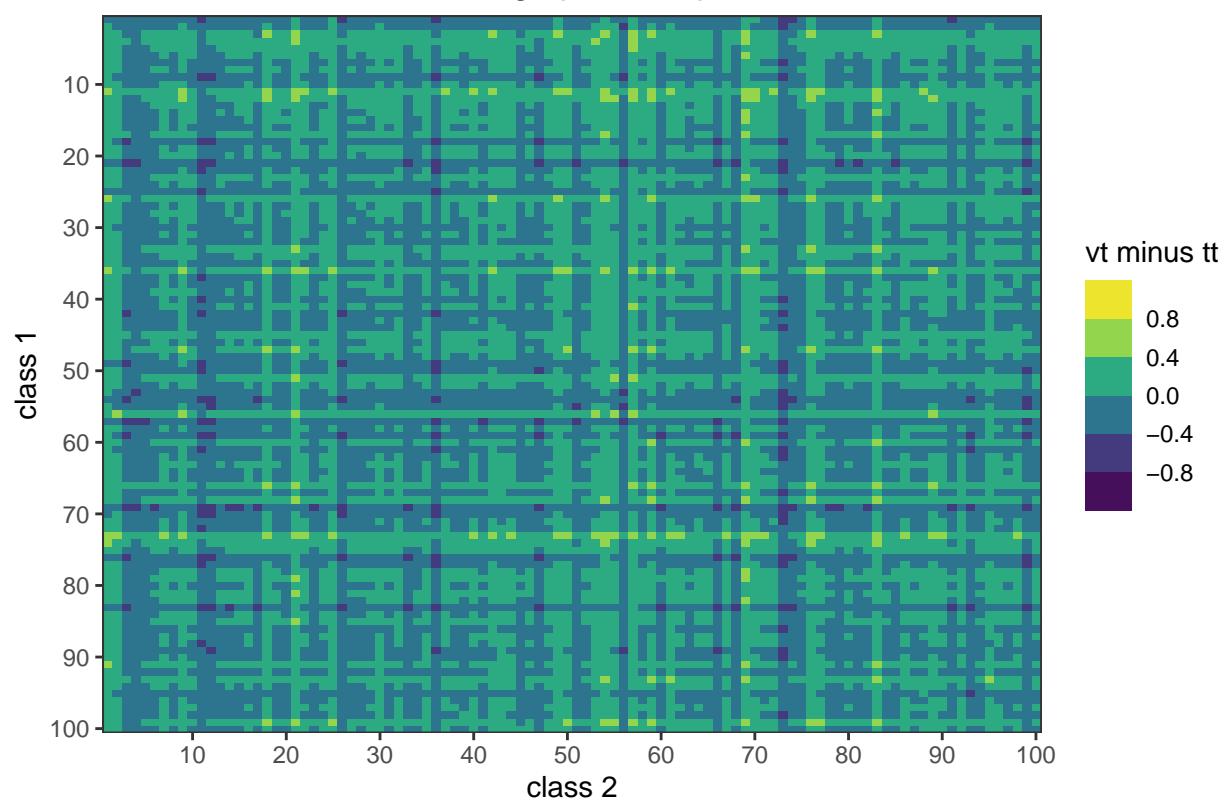
Differences between average pairwise probabilities – class 28



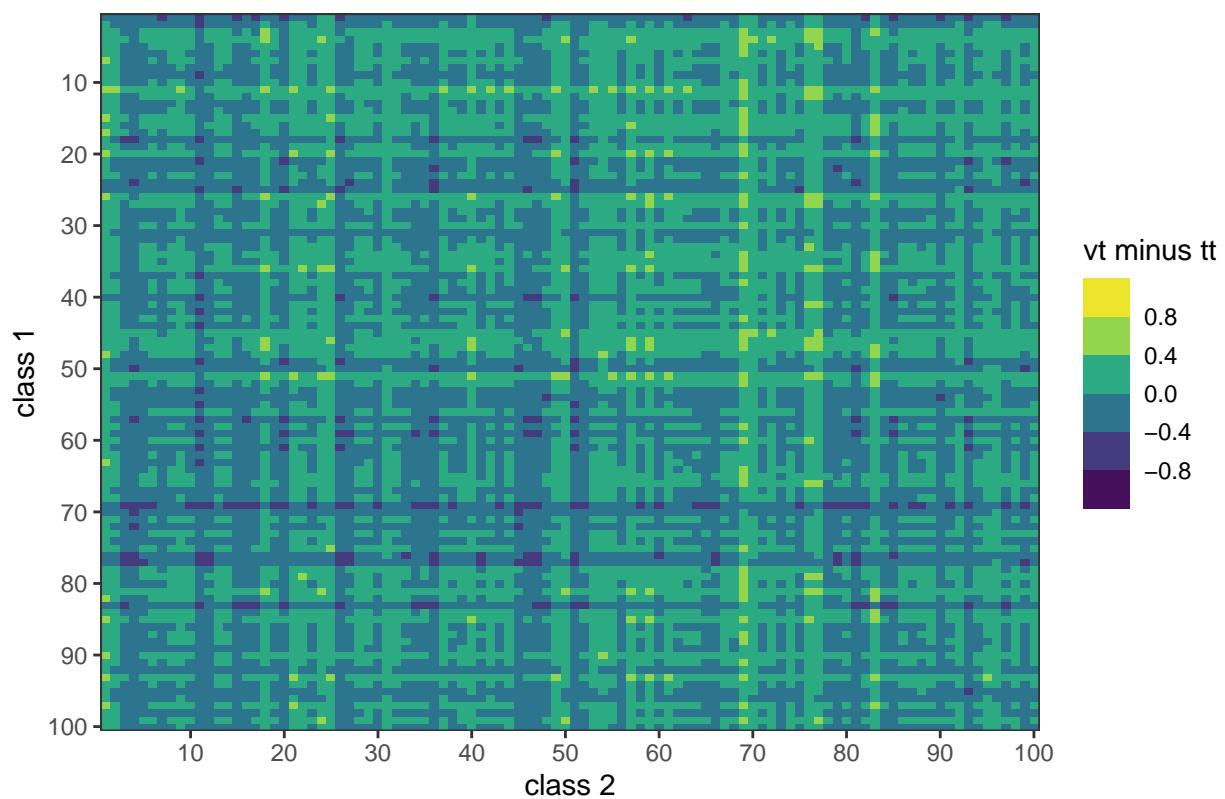
Differences between average pairwise probabilities – class 29



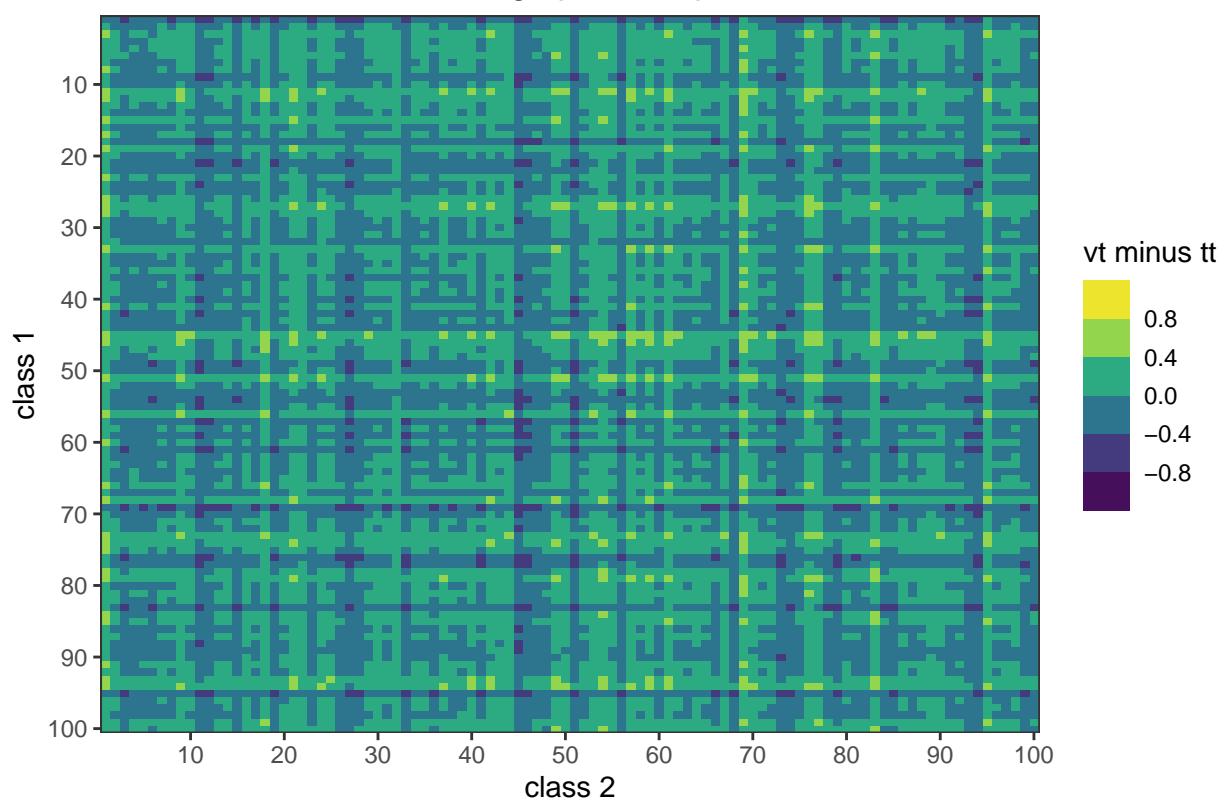
Differences between average pairwise probabilities – class 30



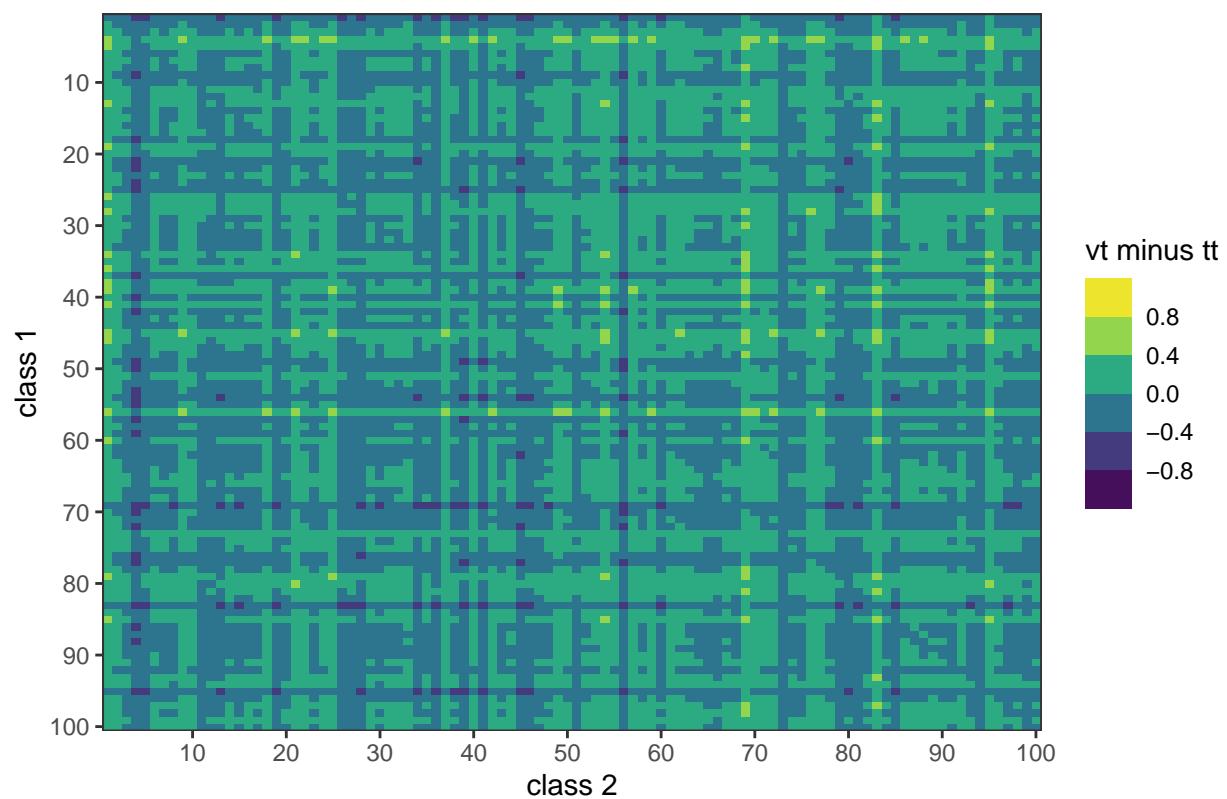
Differences between average pairwise probabilities – class 31



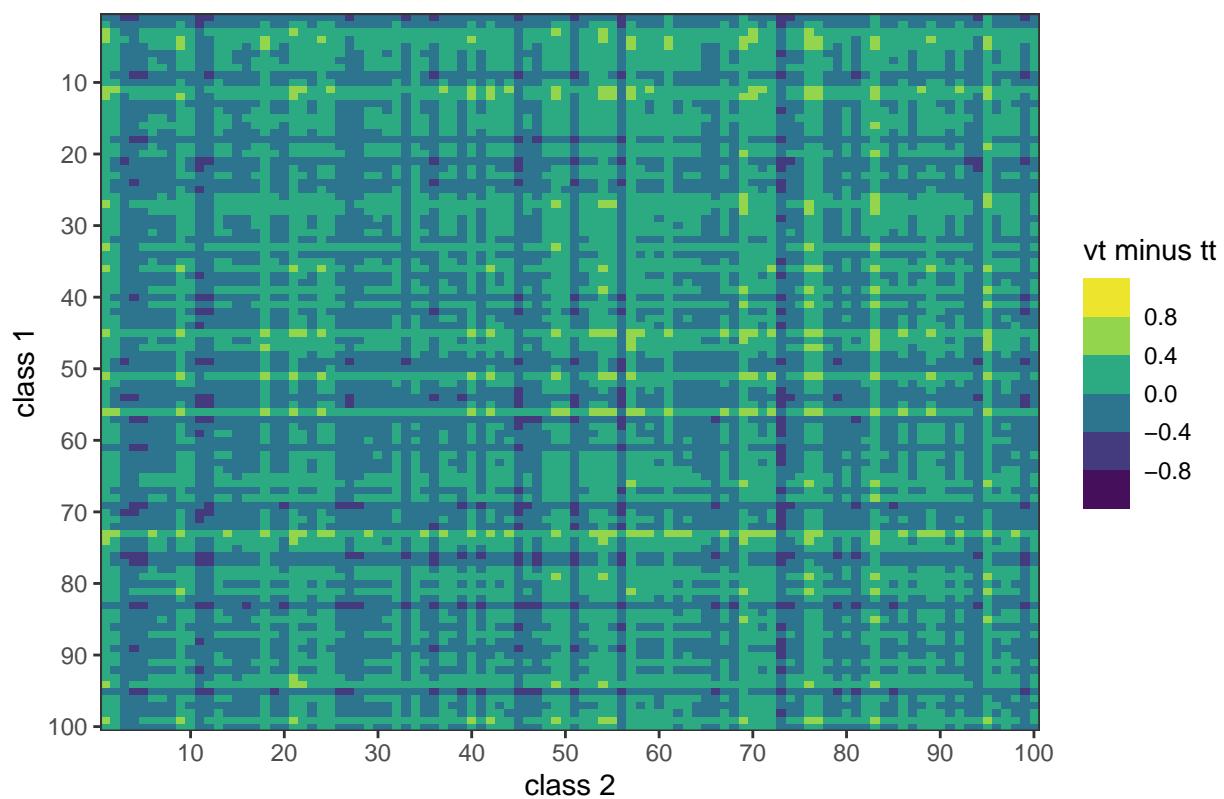
Differences between average pairwise probabilities – class 32



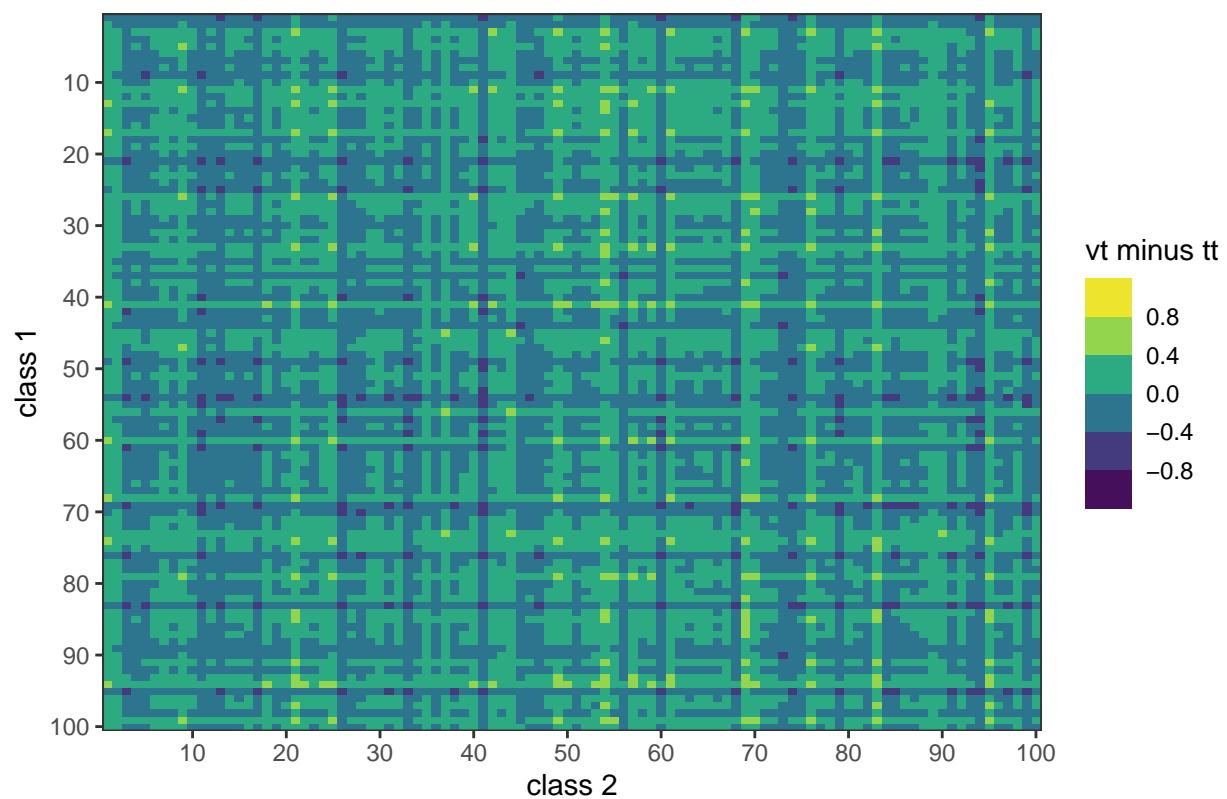
Differences between average pairwise probabilities – class 33



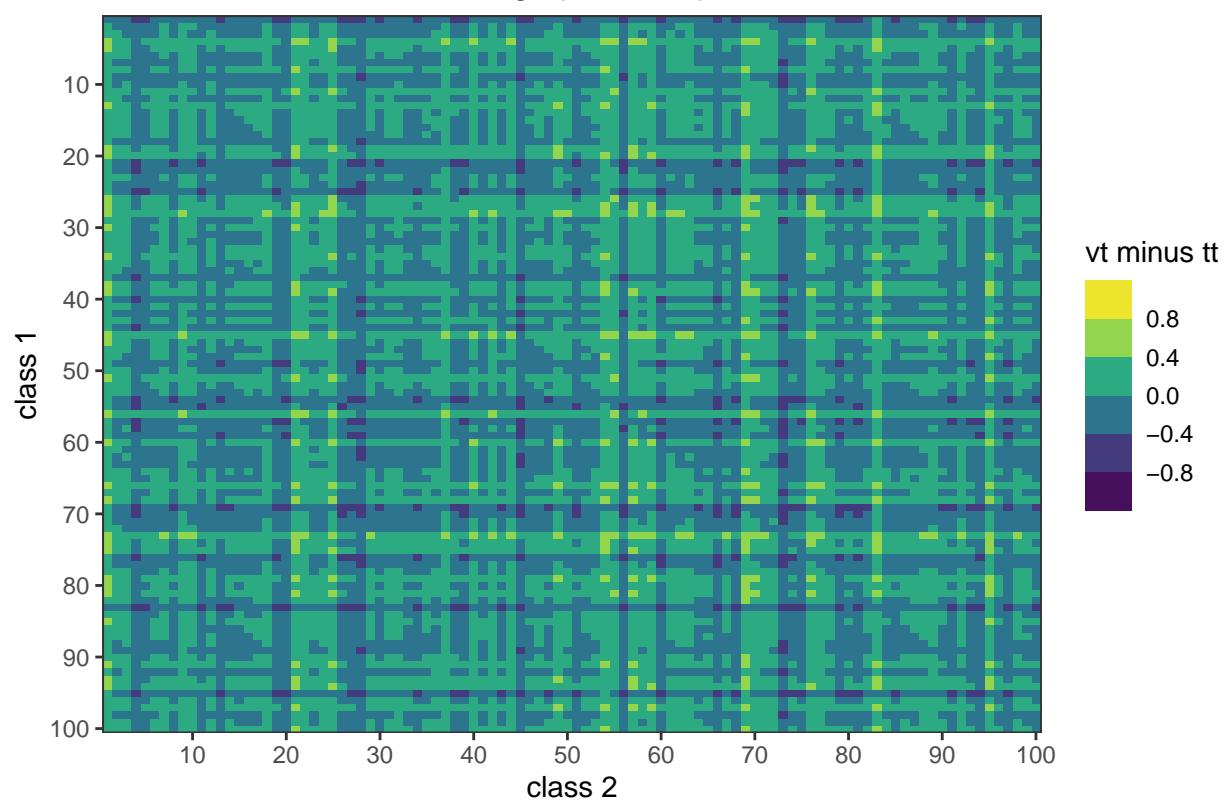
Differences between average pairwise probabilities – class 34



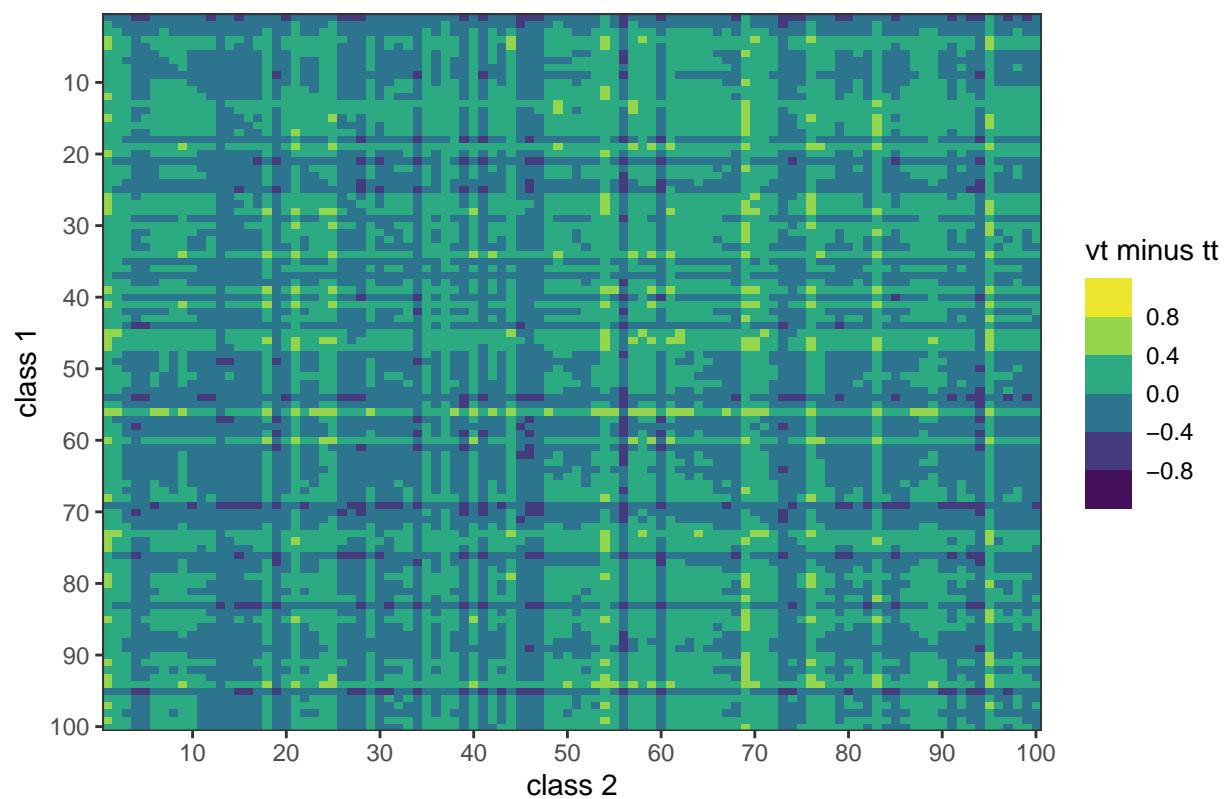
Differences between average pairwise probabilities – class 35



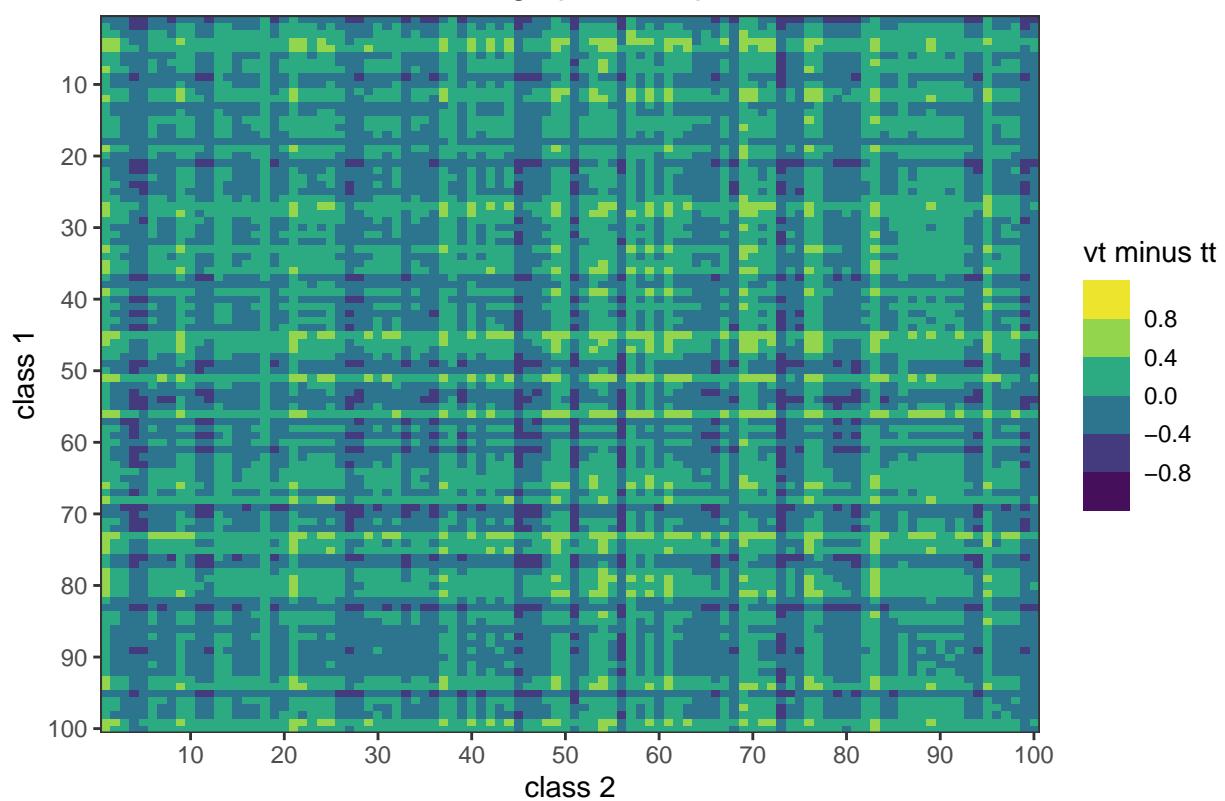
Differences between average pairwise probabilities – class 36



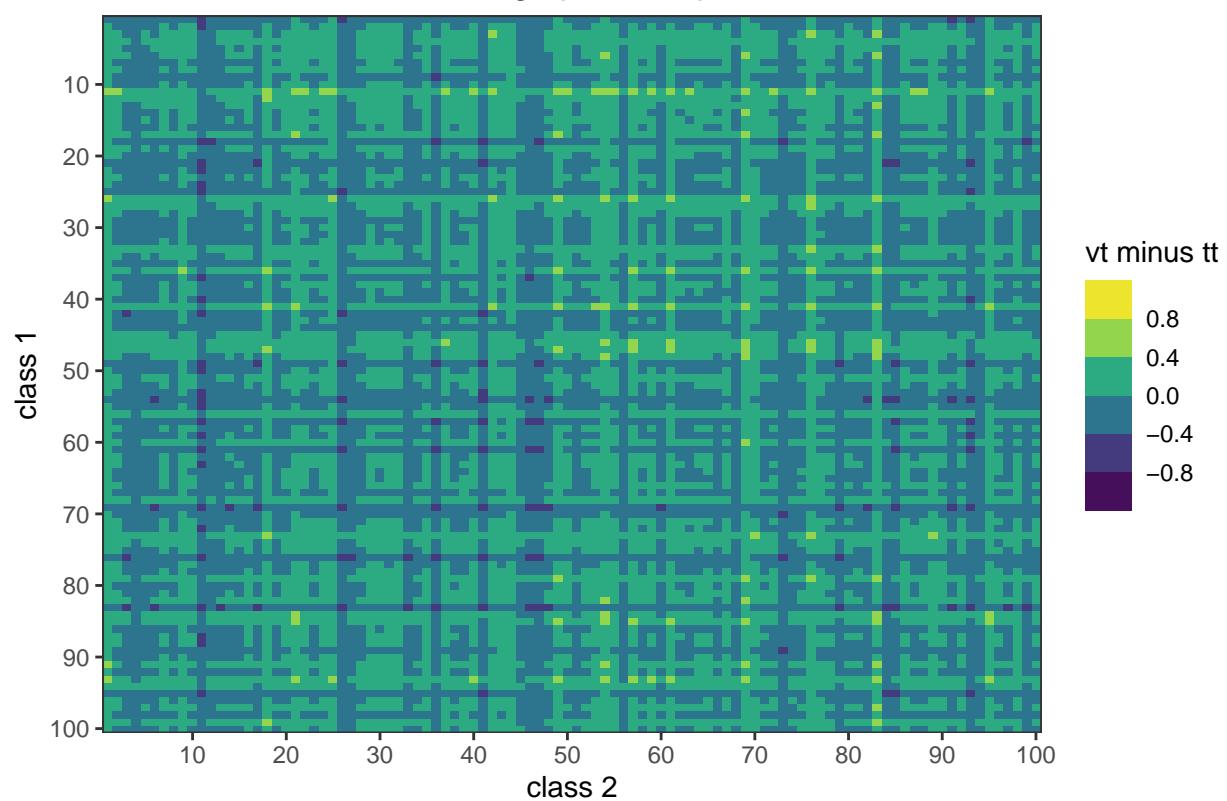
Differences between average pairwise probabilities – class 37



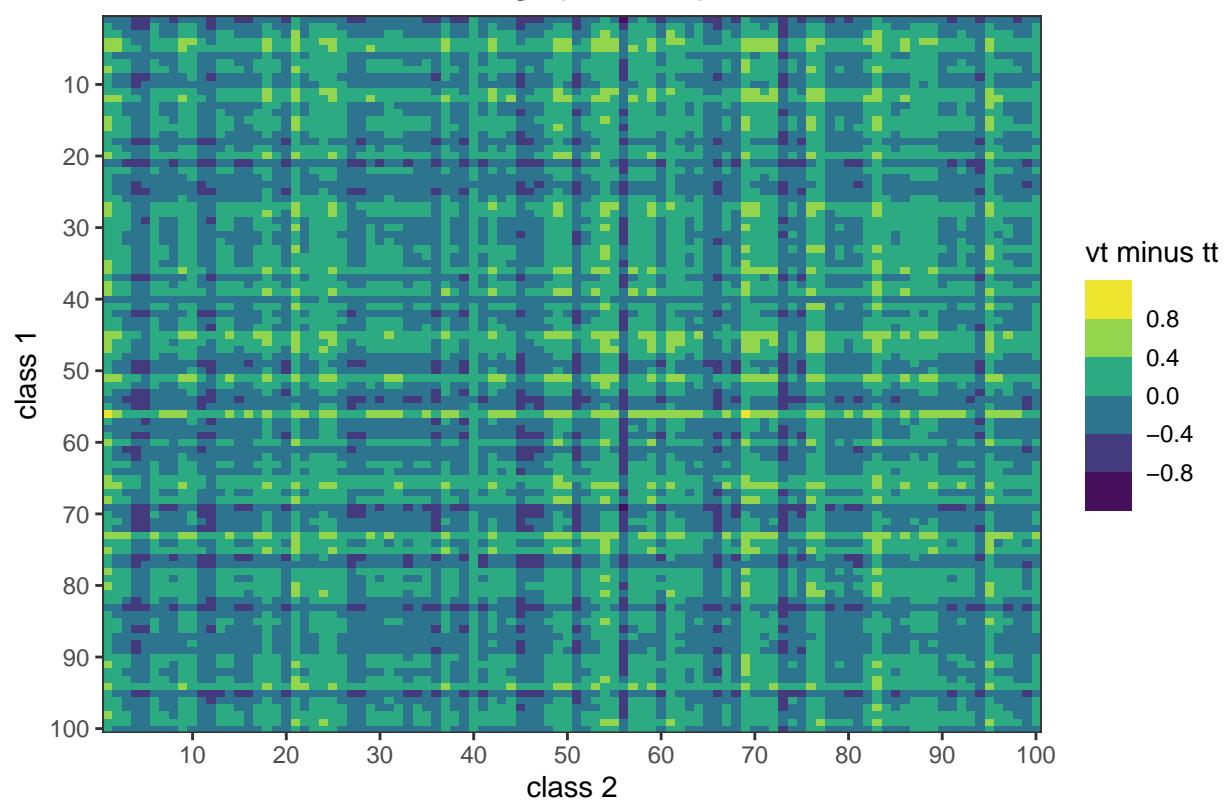
Differences between average pairwise probabilities – class 38



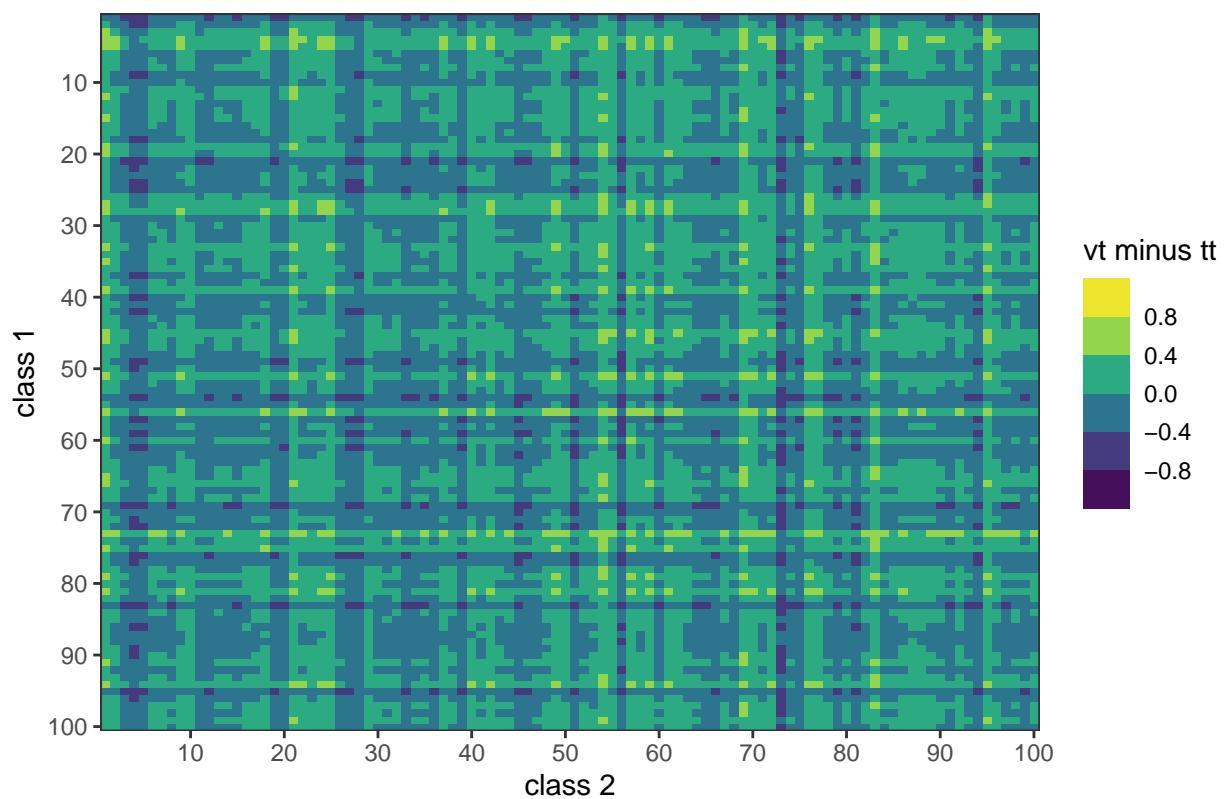
Differences between average pairwise probabilities – class 39



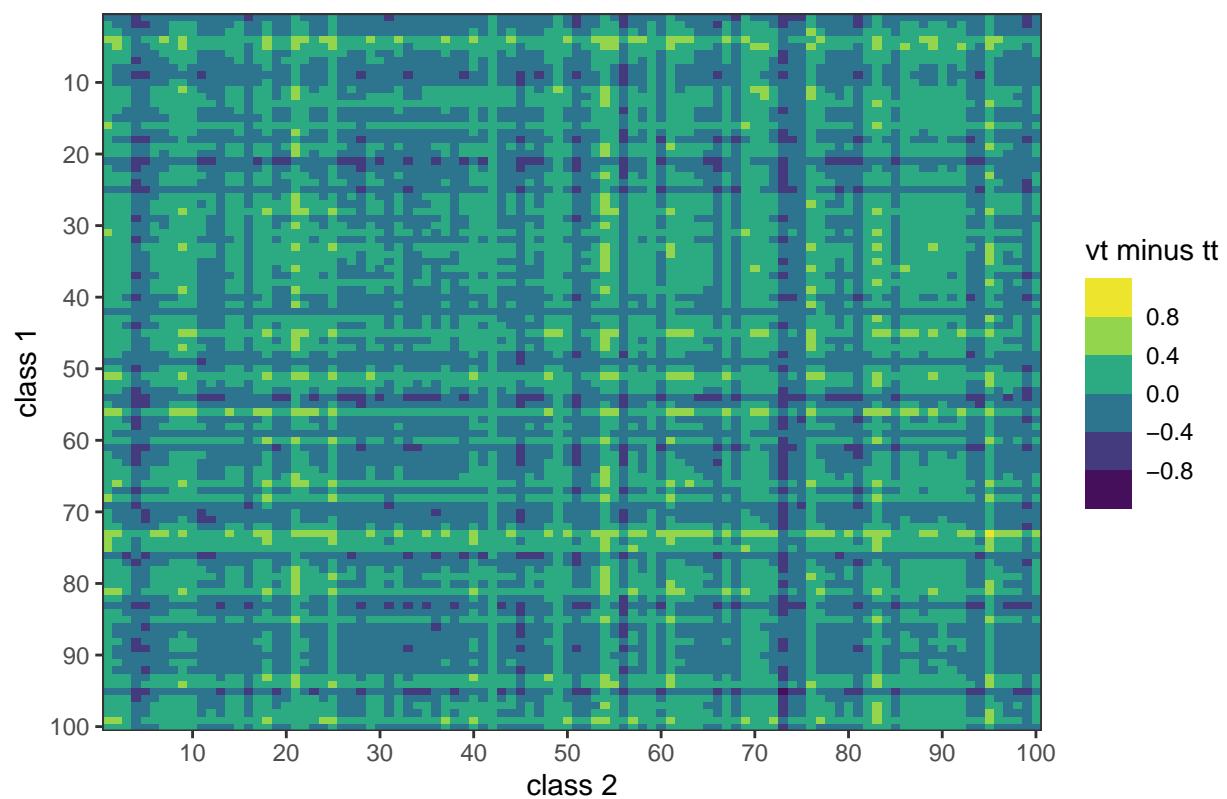
Differences between average pairwise probabilities – class 40



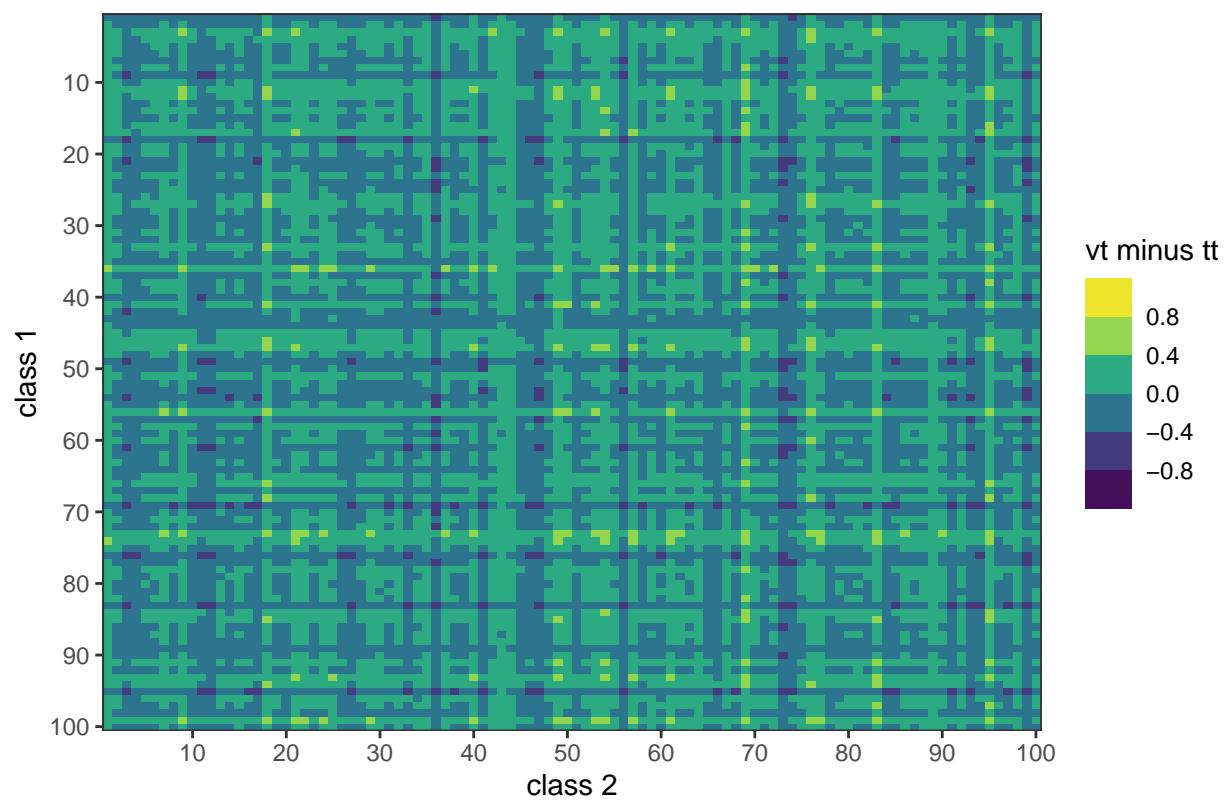
Differences between average pairwise probabilities – class 41



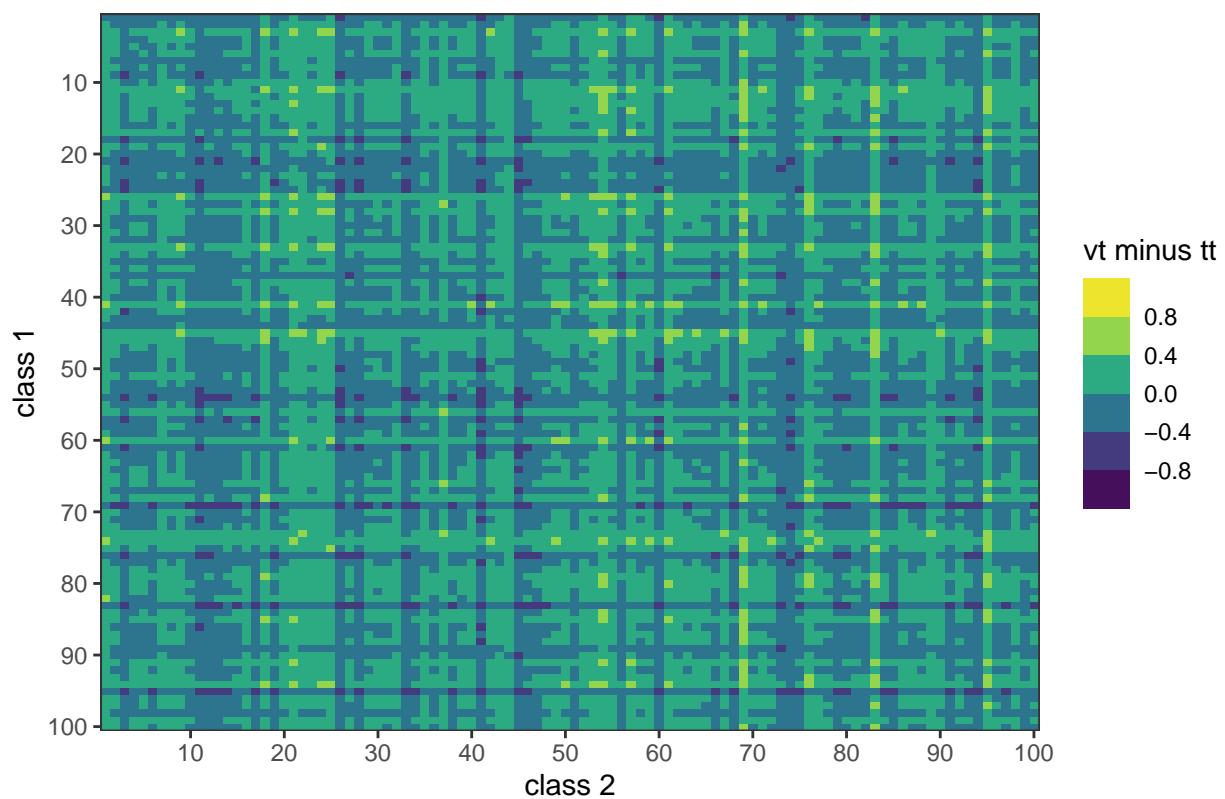
Differences between average pairwise probabilities – class 42



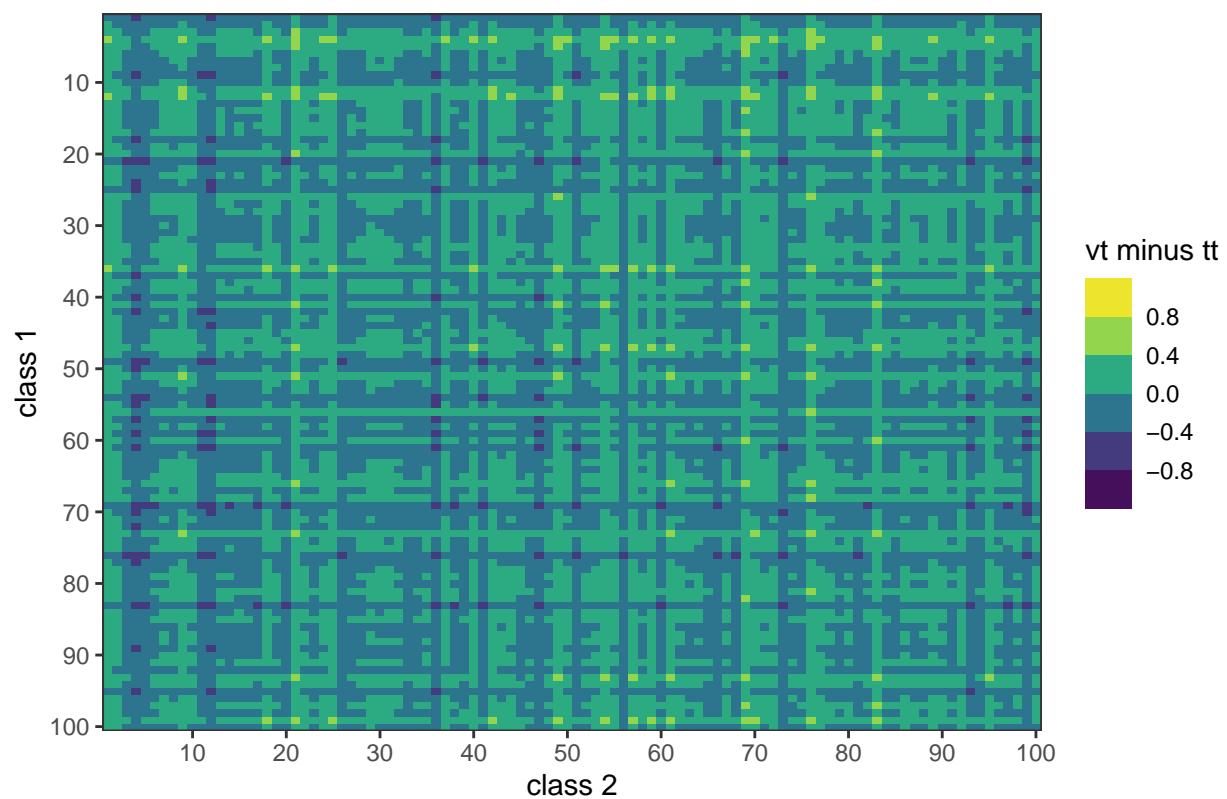
Differences between average pairwise probabilities – class 43



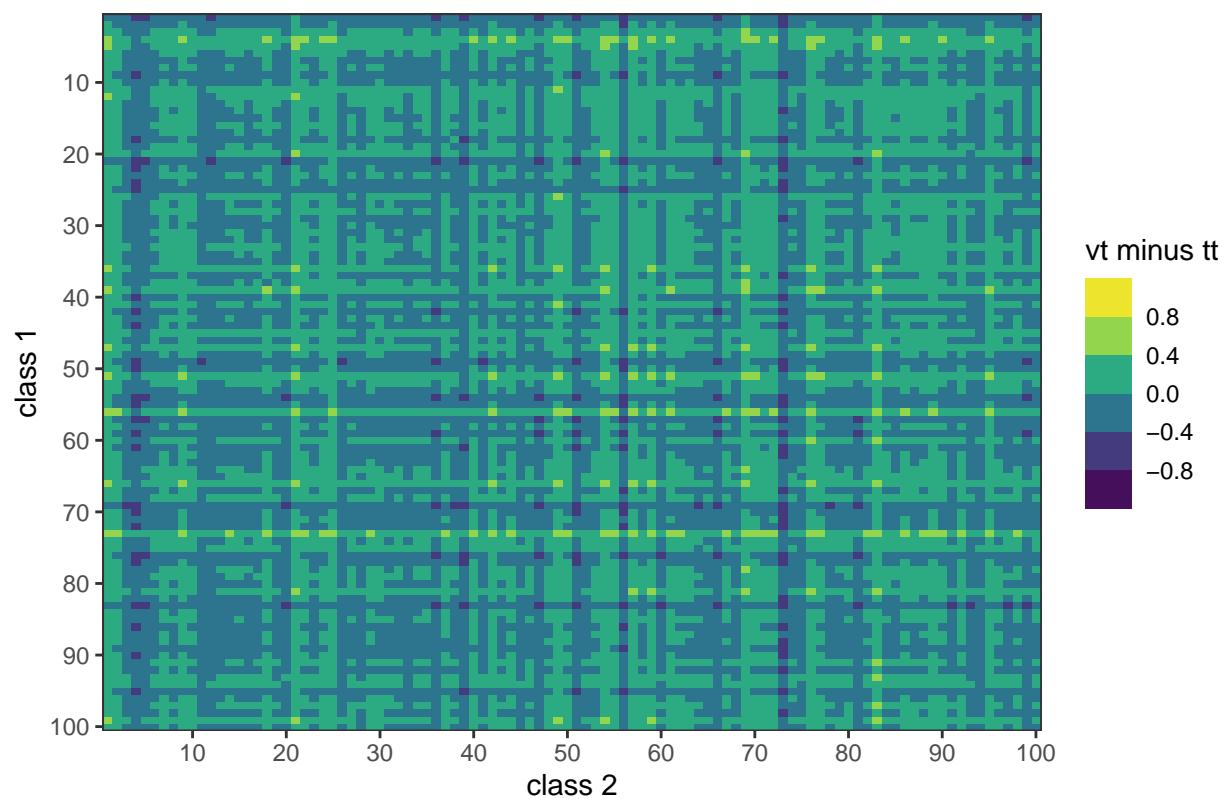
Differences between average pairwise probabilities – class 44



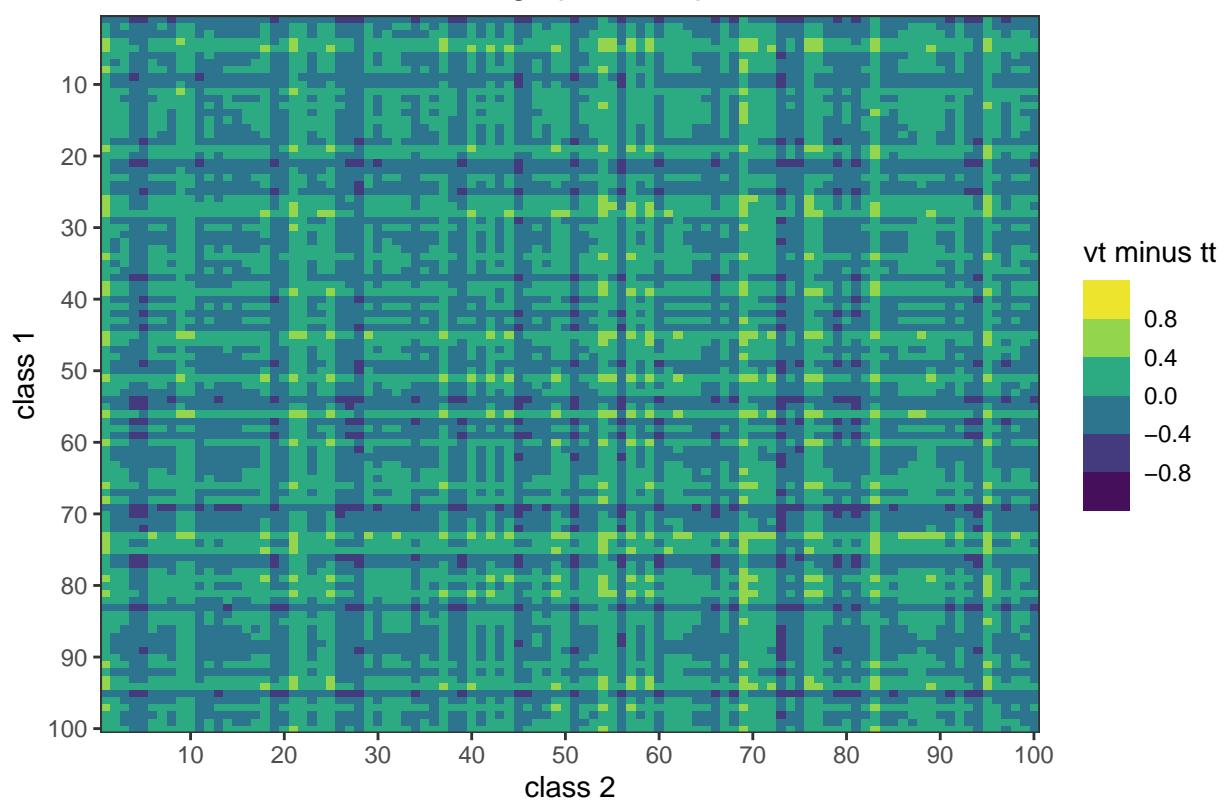
Differences between average pairwise probabilities – class 45



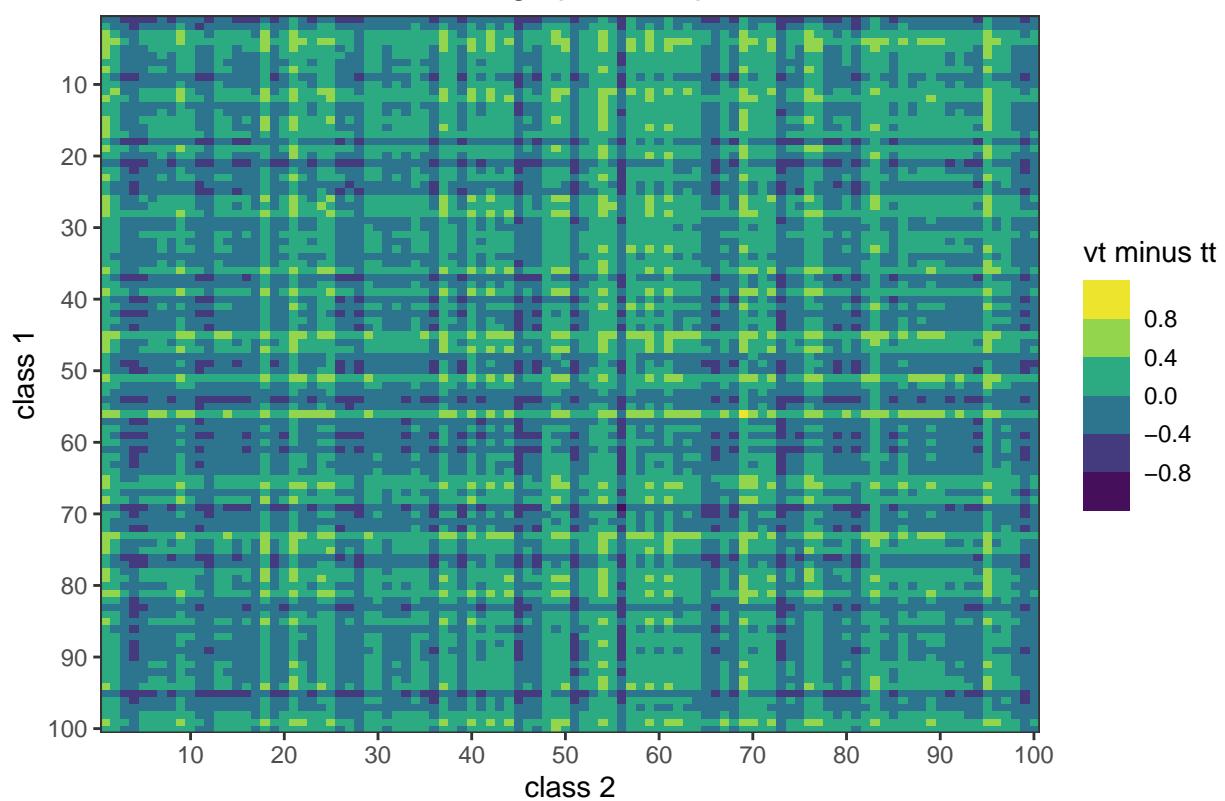
Differences between average pairwise probabilities – class 46



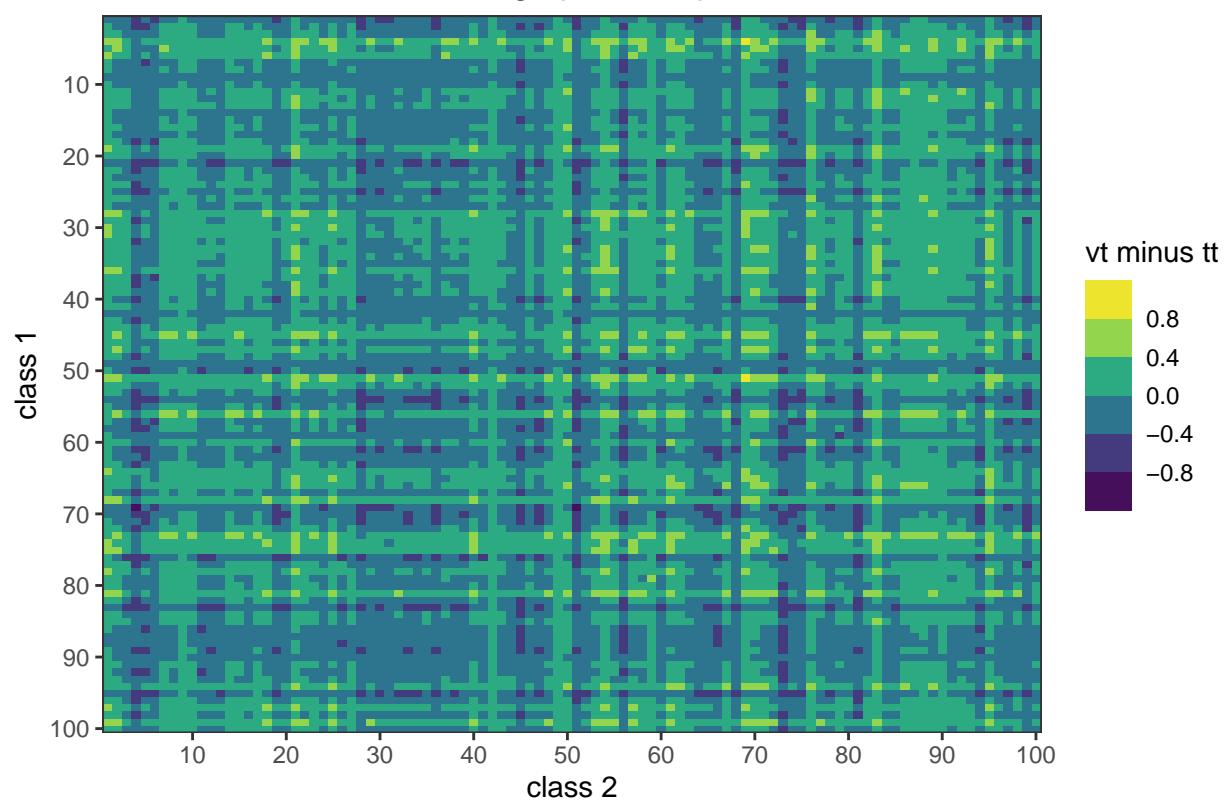
Differences between average pairwise probabilities – class 47



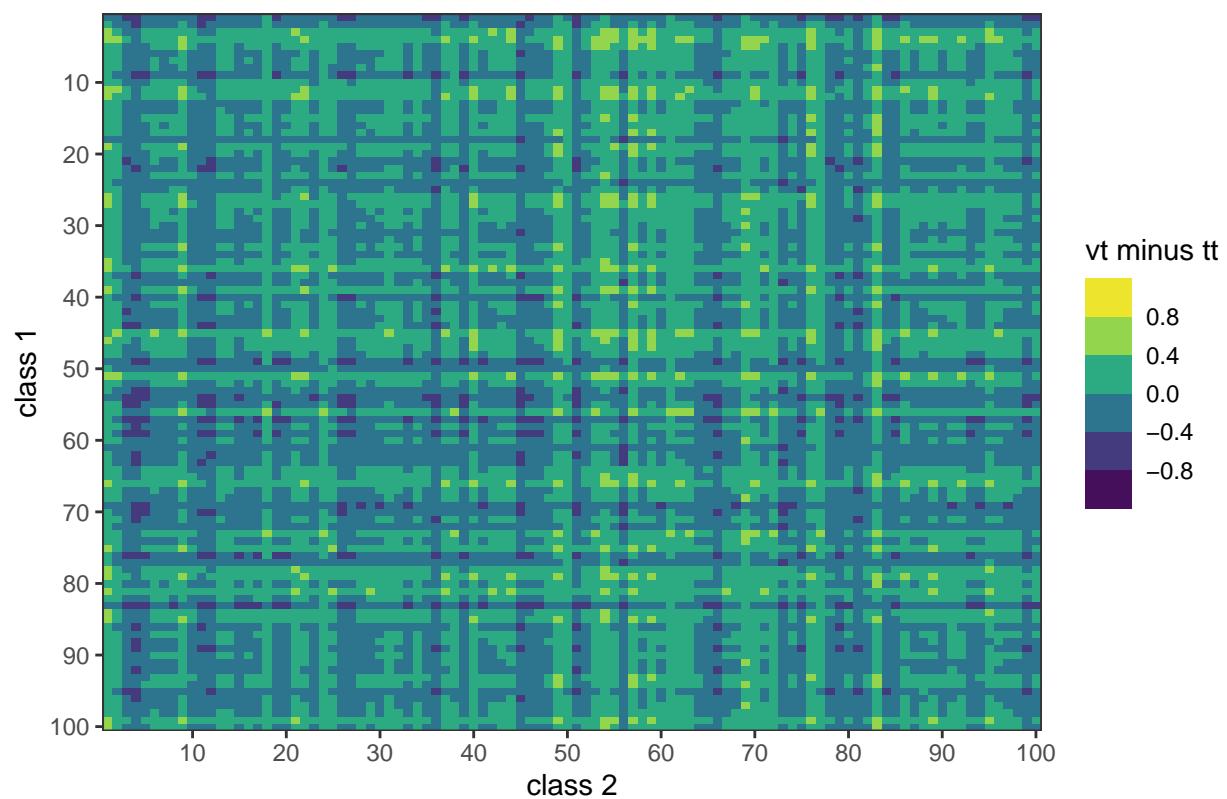
Differences between average pairwise probabilities – class 48



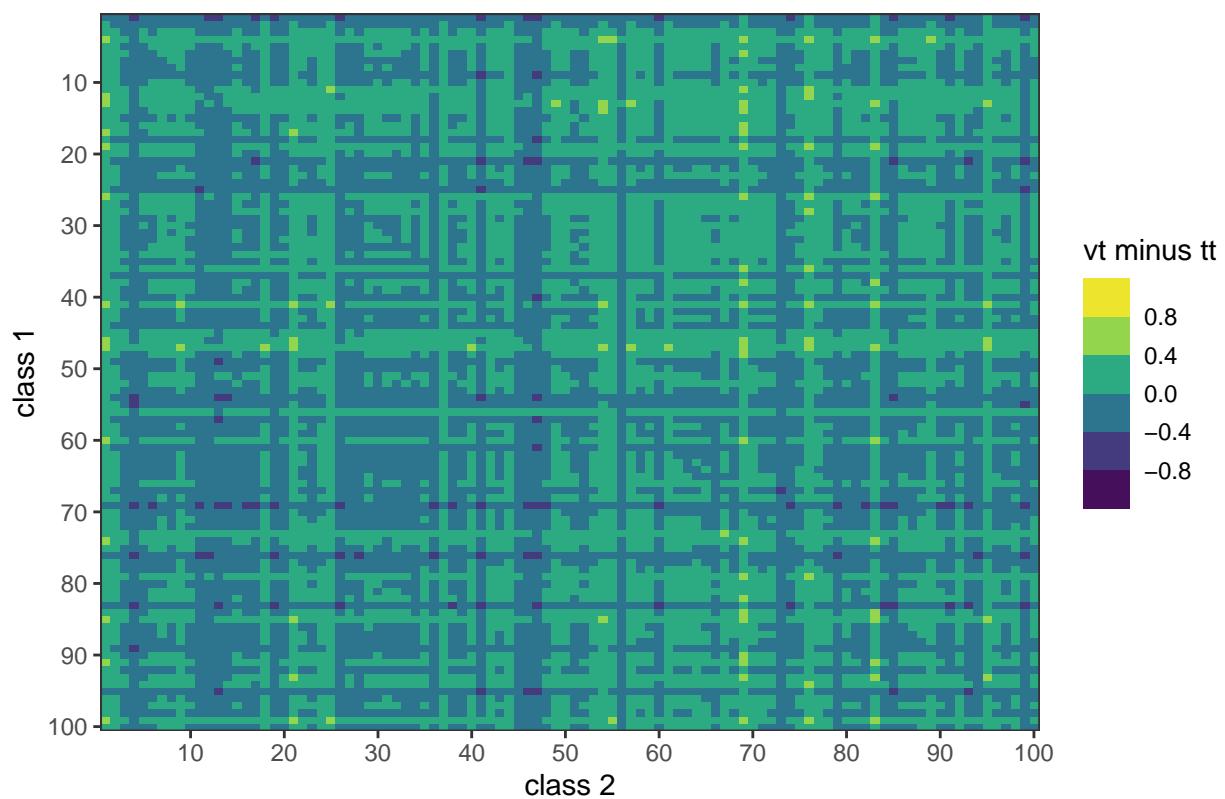
Differences between average pairwise probabilities – class 49



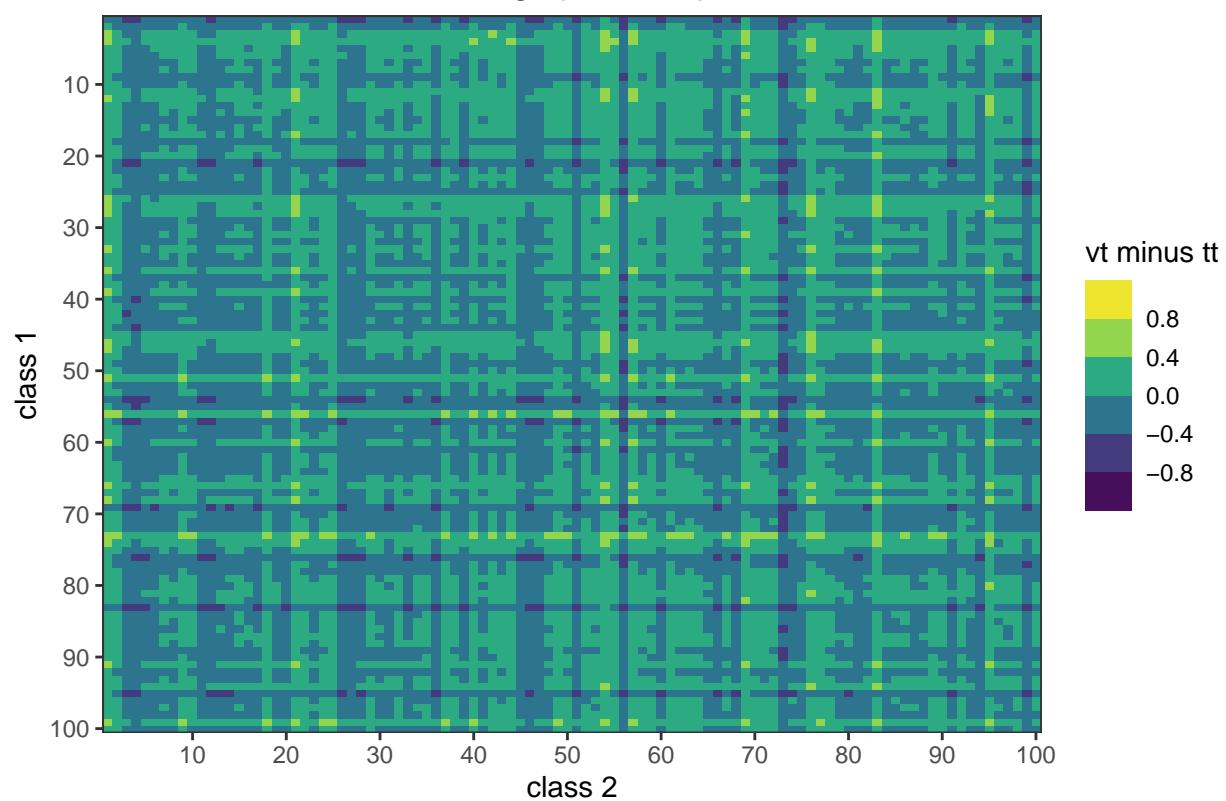
Differences between average pairwise probabilities – class 50



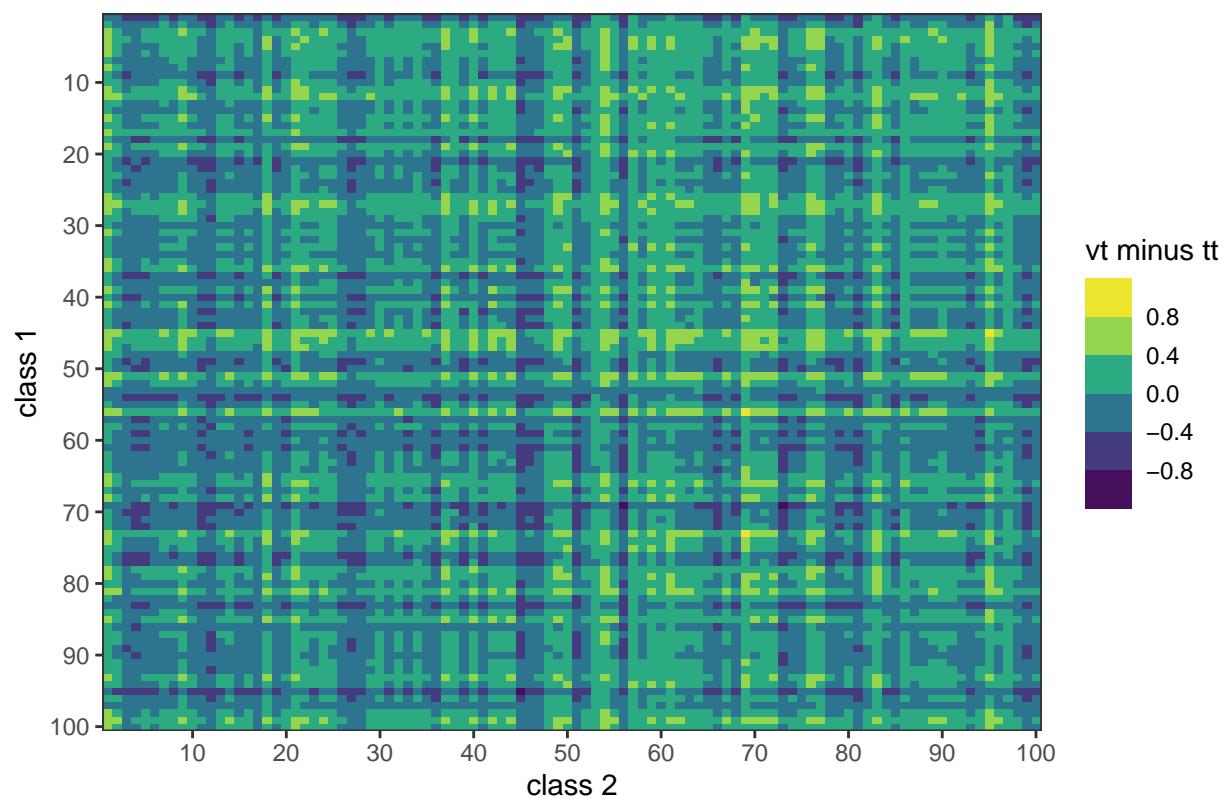
Differences between average pairwise probabilities – class 51



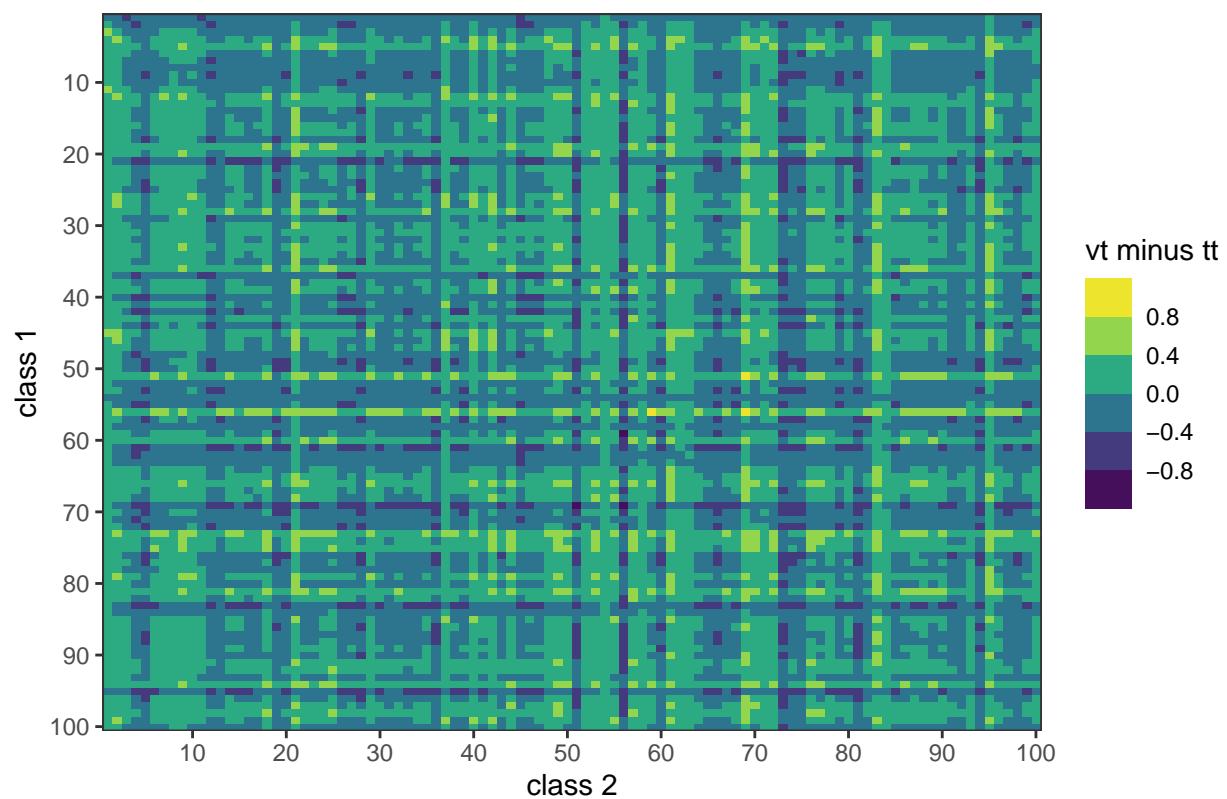
Differences between average pairwise probabilities – class 52



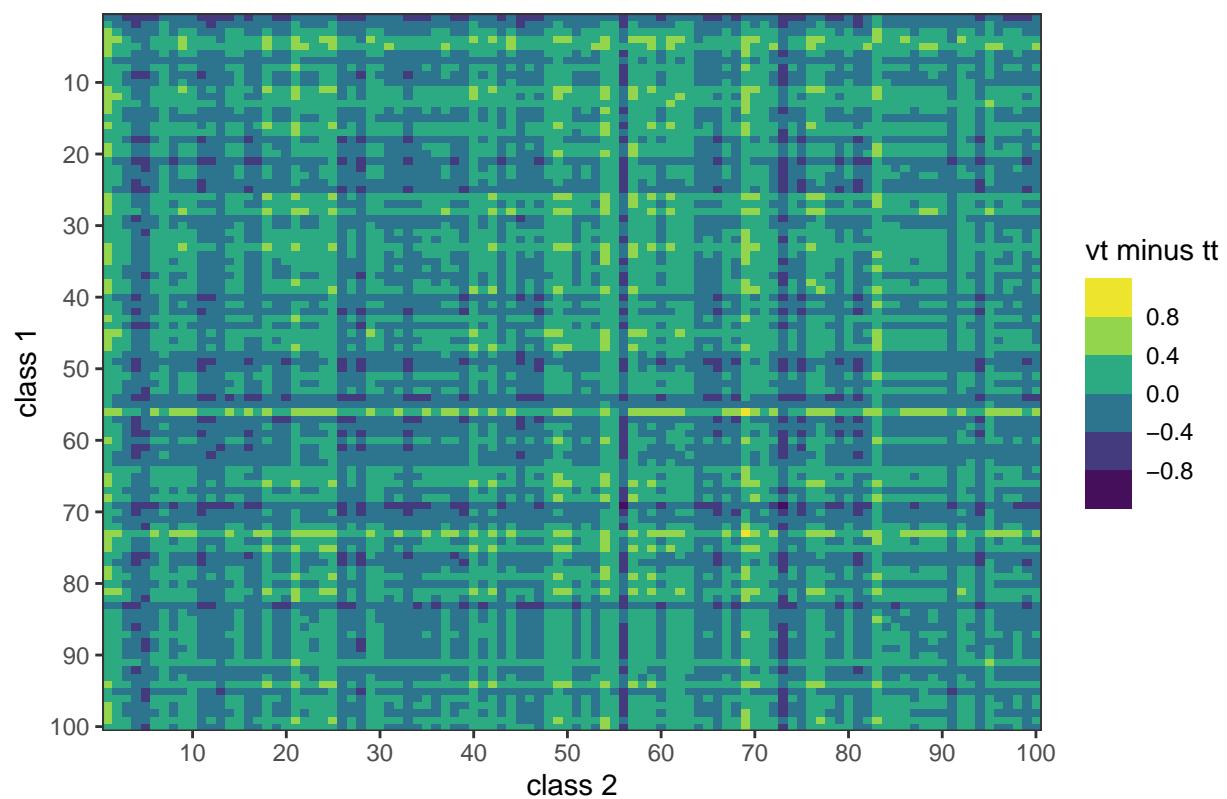
Differences between average pairwise probabilities – class 53



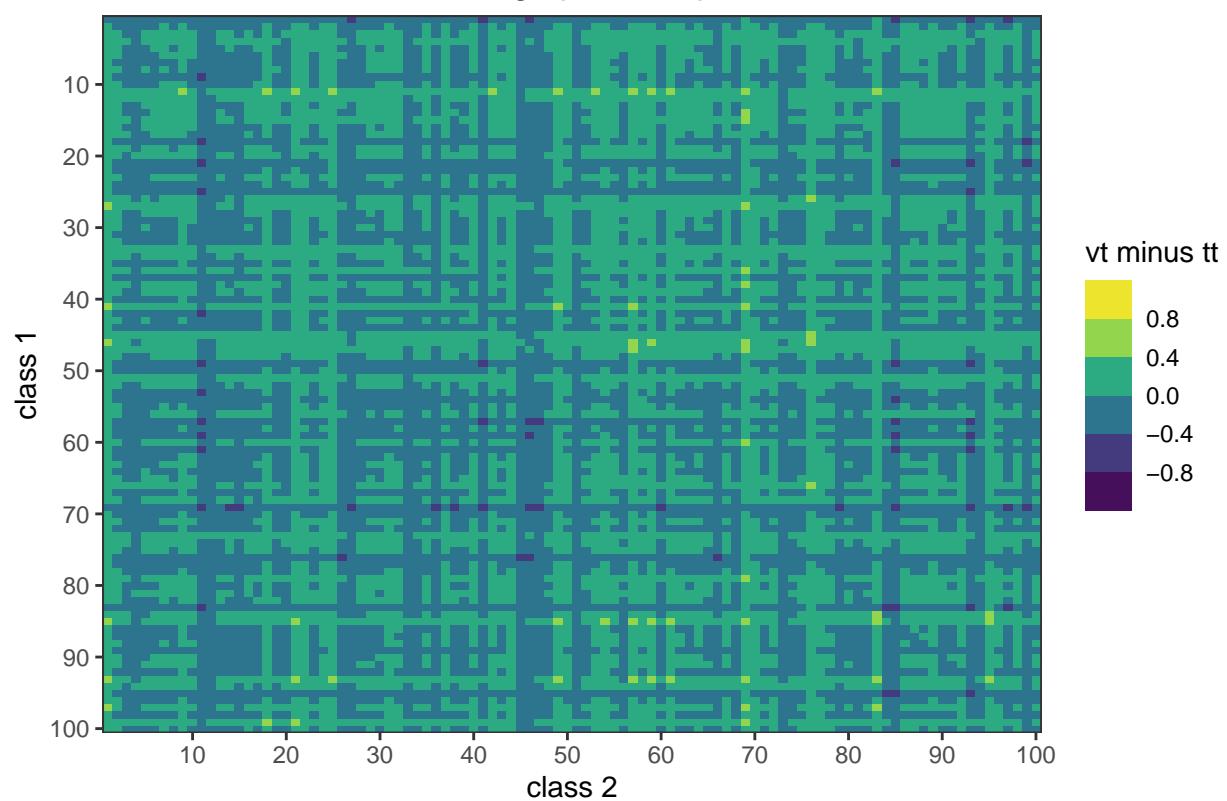
Differences between average pairwise probabilities – class 54



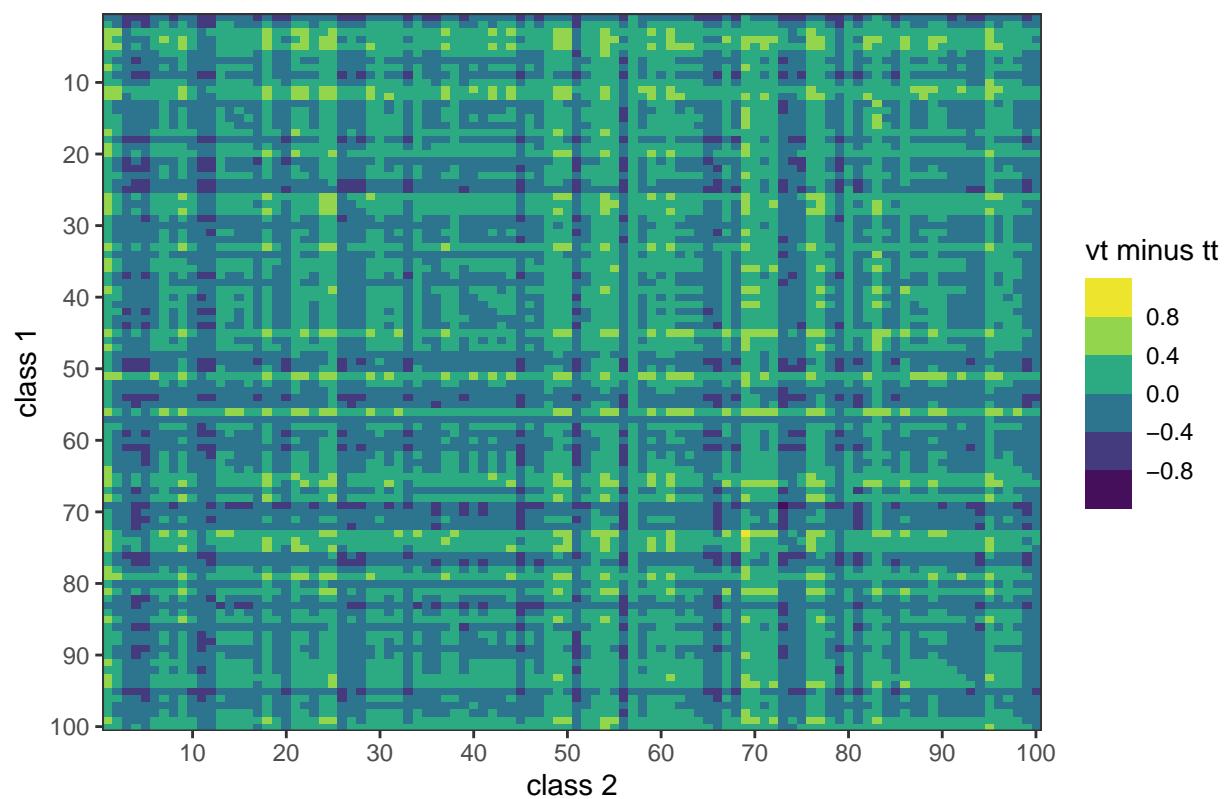
Differences between average pairwise probabilities – class 55



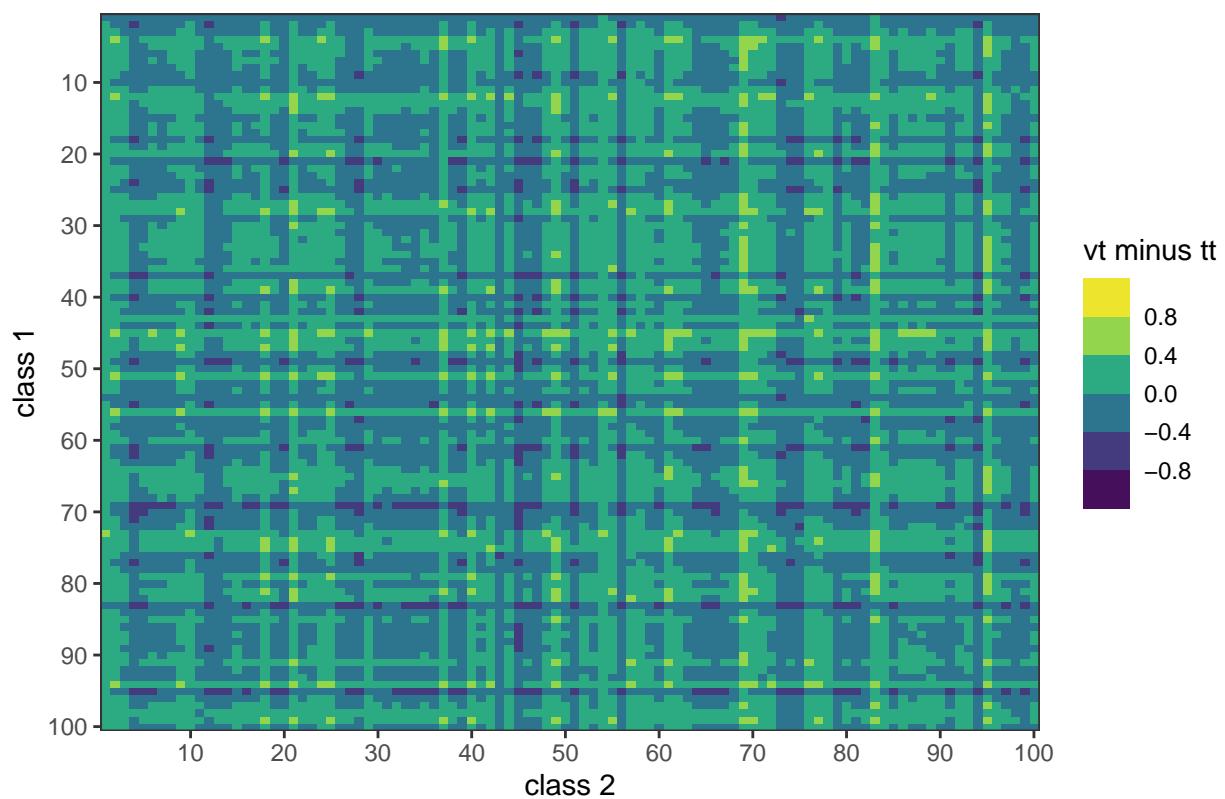
Differences between average pairwise probabilities – class 56



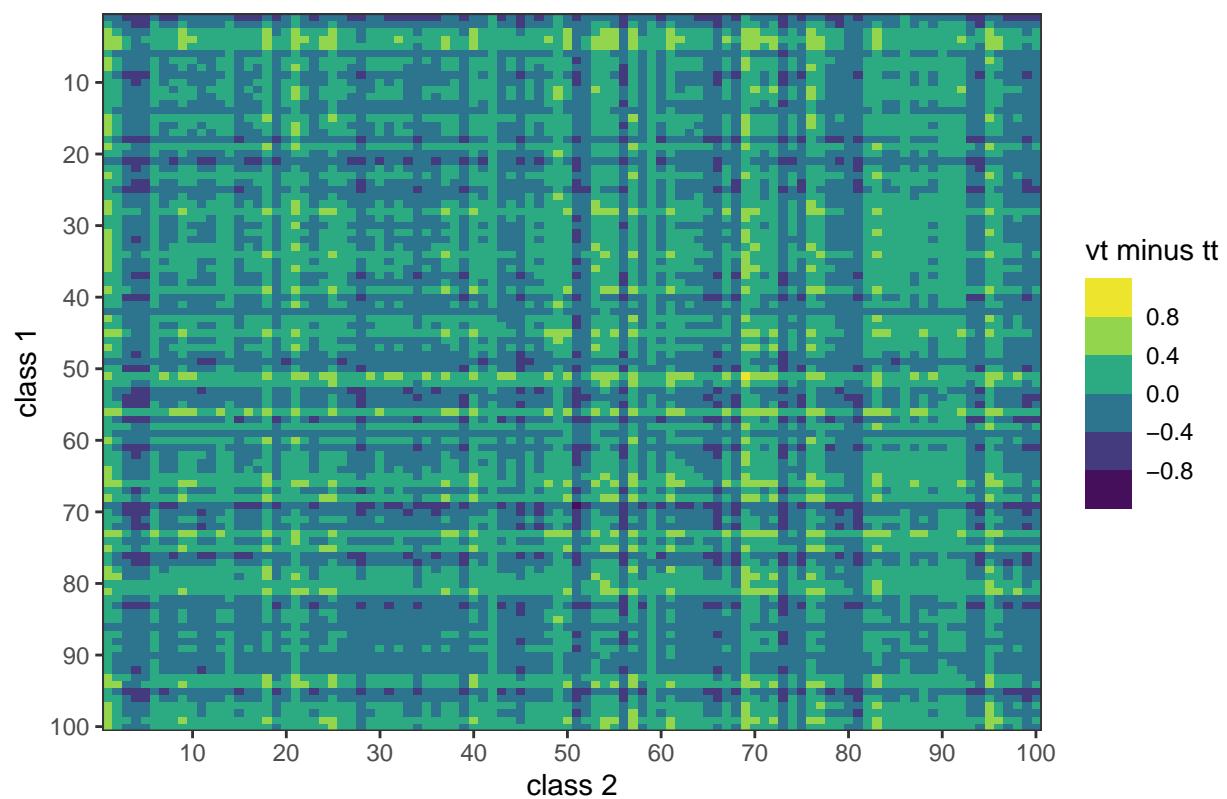
Differences between average pairwise probabilities – class 57



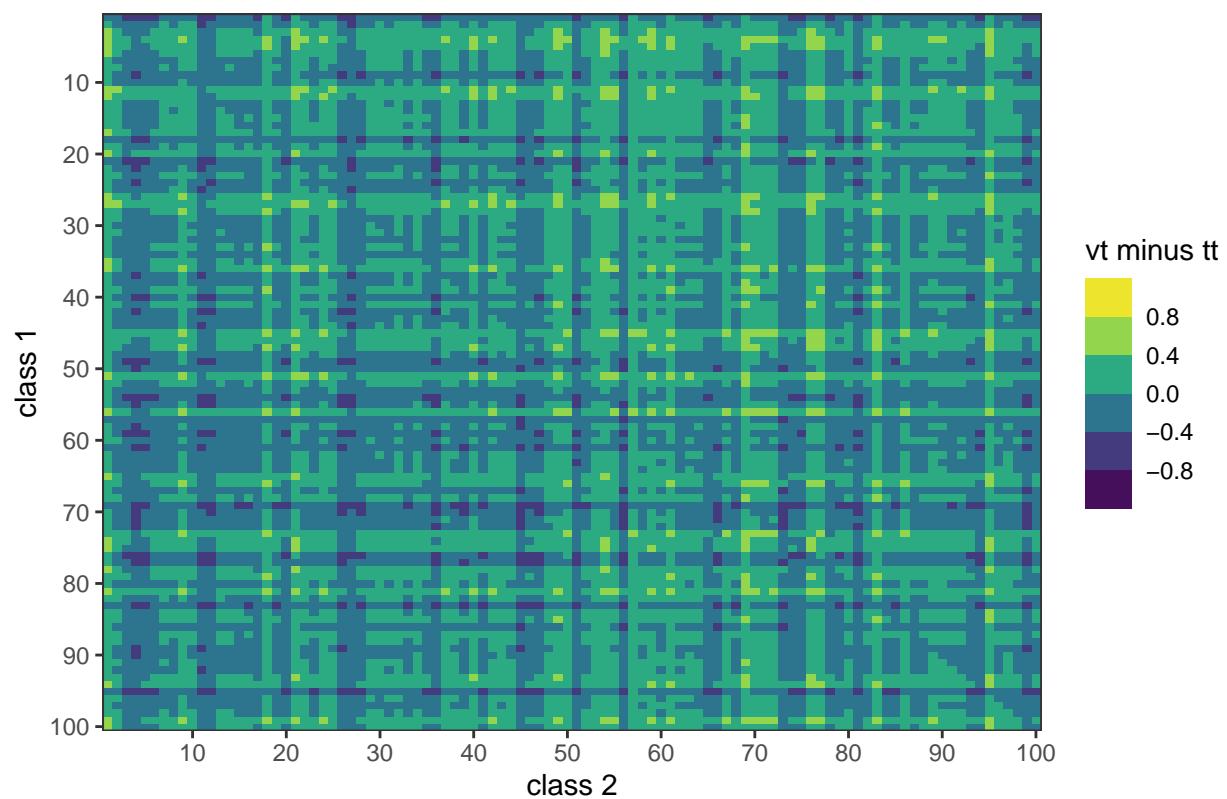
Differences between average pairwise probabilities – class 58



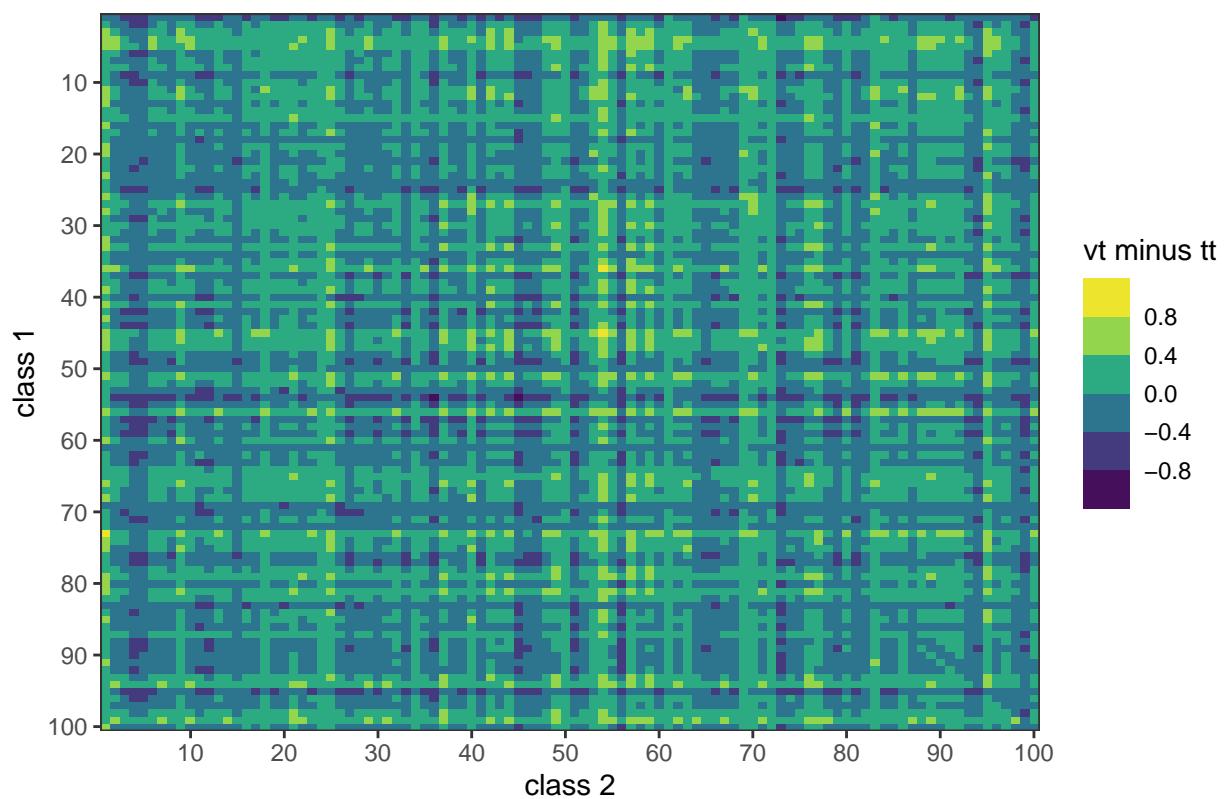
Differences between average pairwise probabilities – class 59



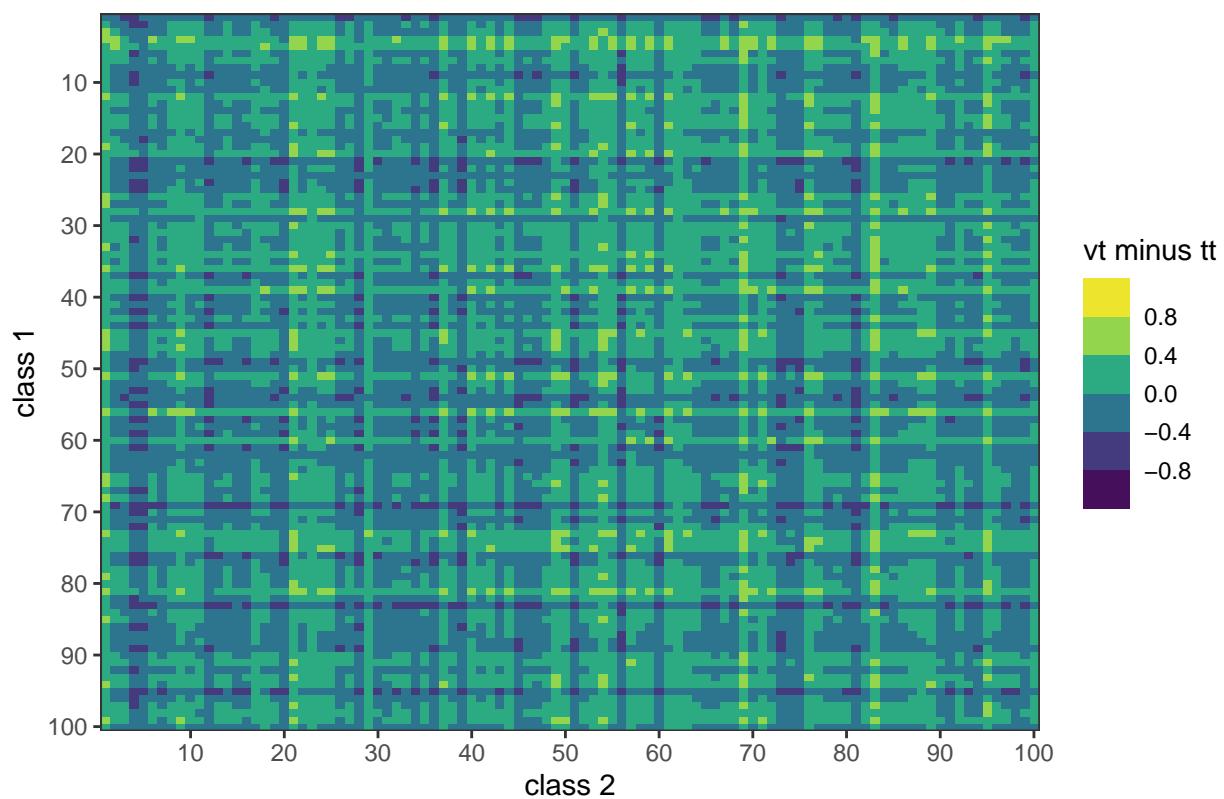
Differences between average pairwise probabilities – class 60



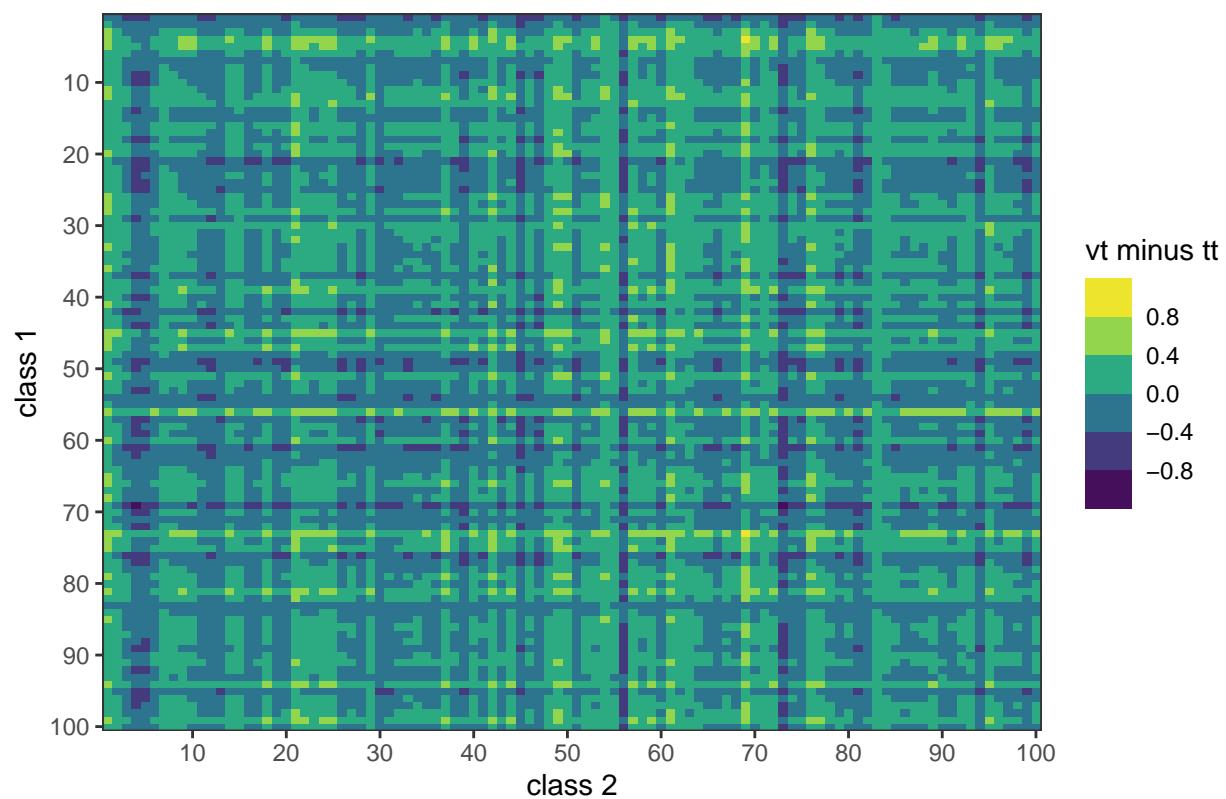
Differences between average pairwise probabilities – class 61



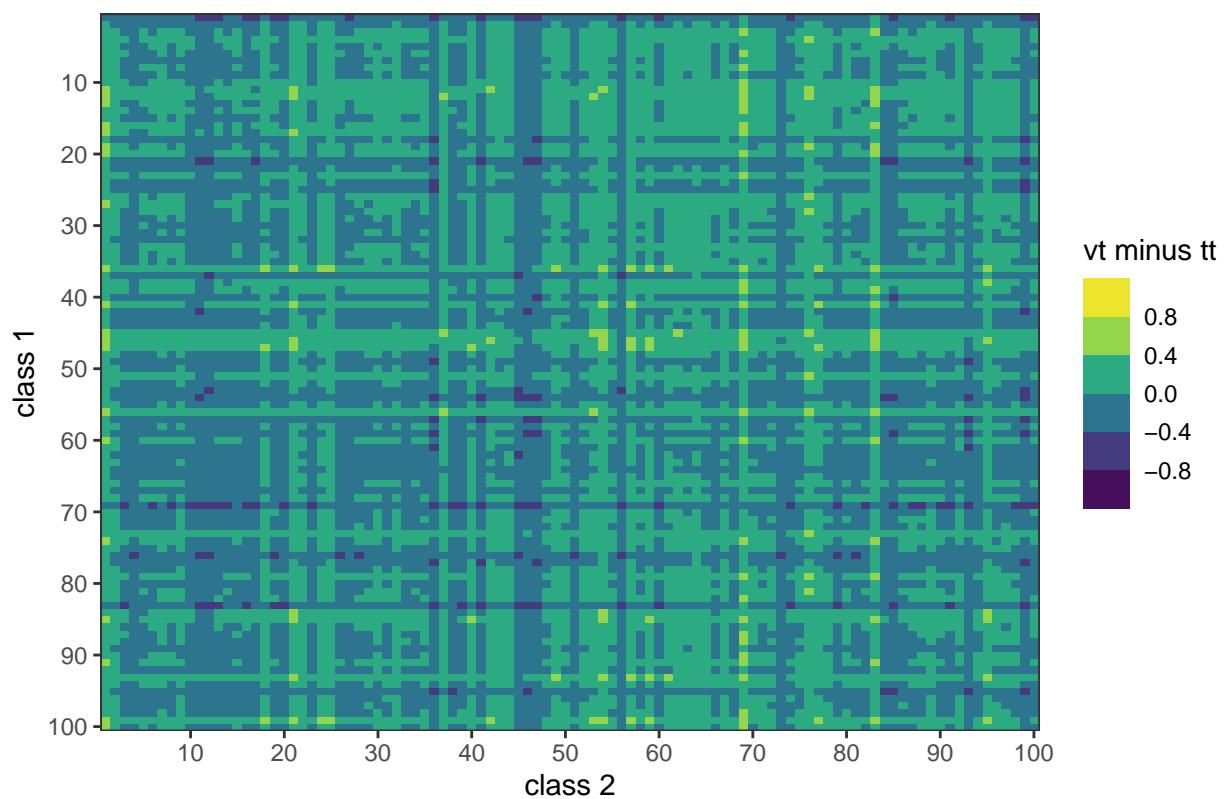
Differences between average pairwise probabilities – class 62



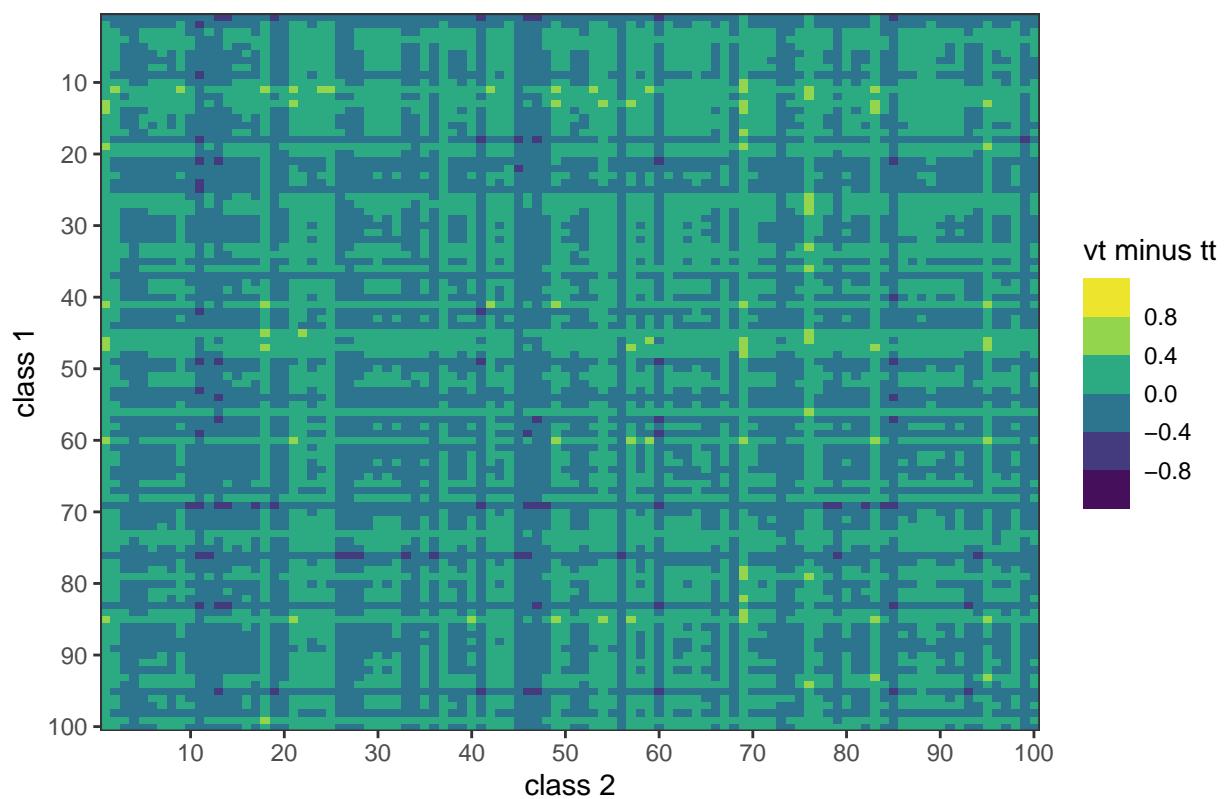
Differences between average pairwise probabilities – class 63



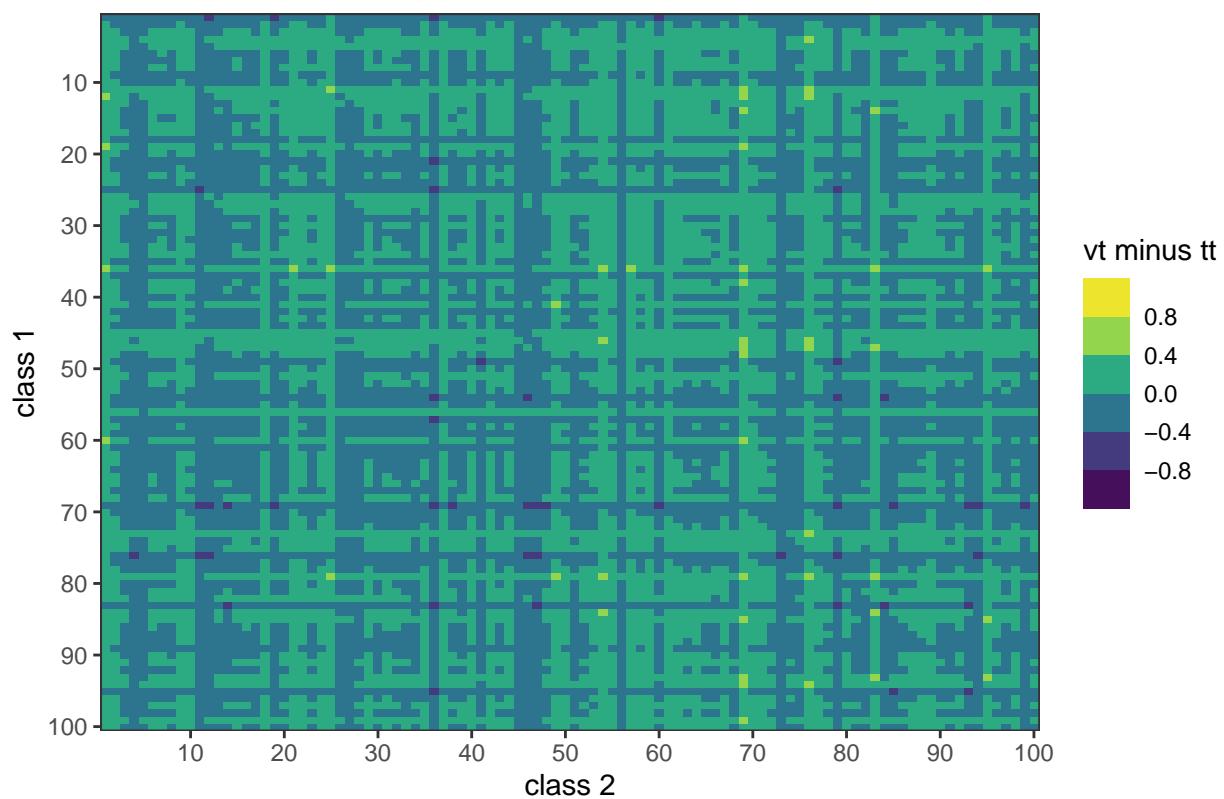
Differences between average pairwise probabilities – class 64



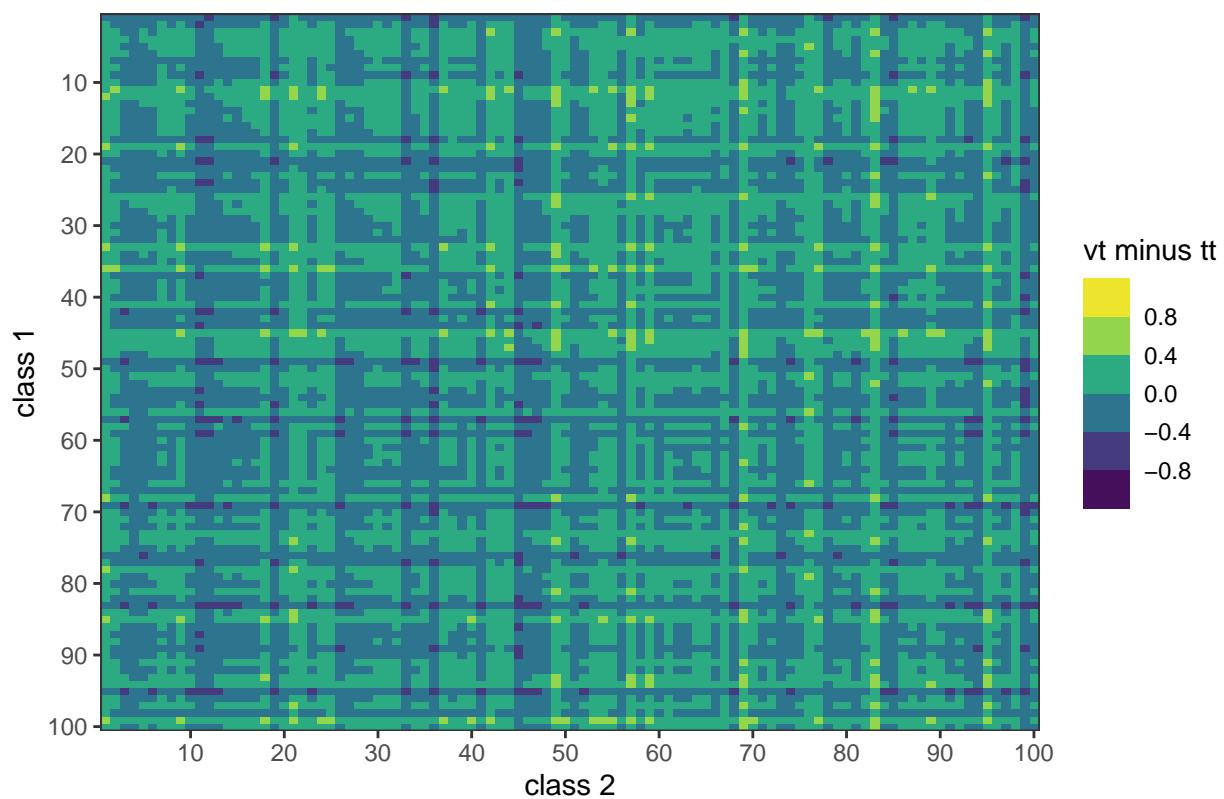
Differences between average pairwise probabilities – class 65



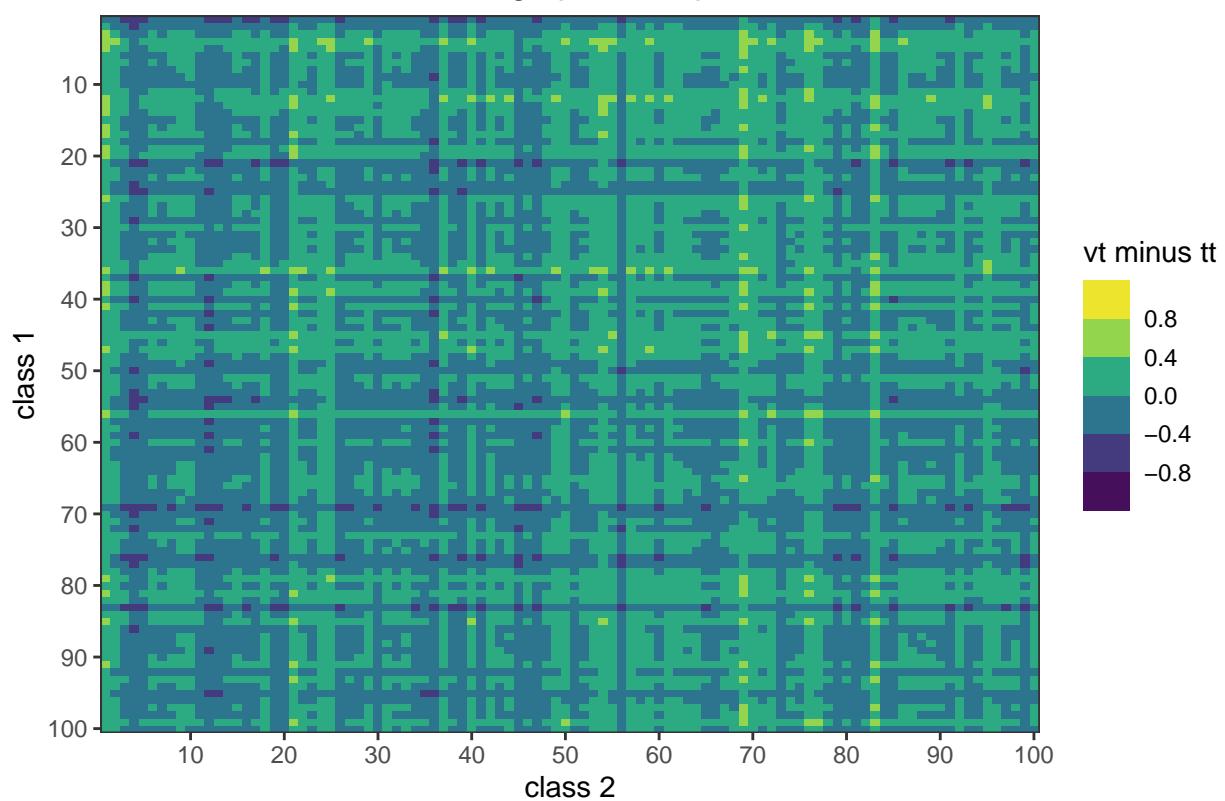
Differences between average pairwise probabilities – class 66



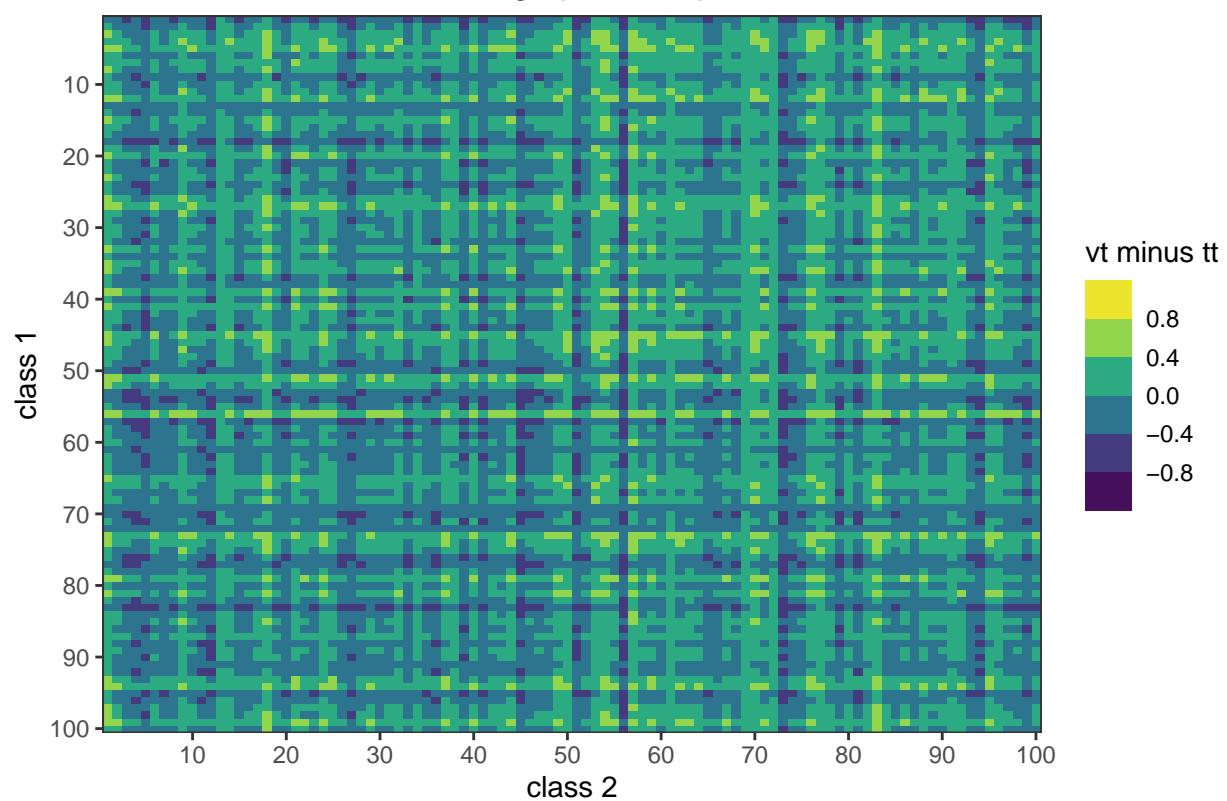
Differences between average pairwise probabilities – class 67



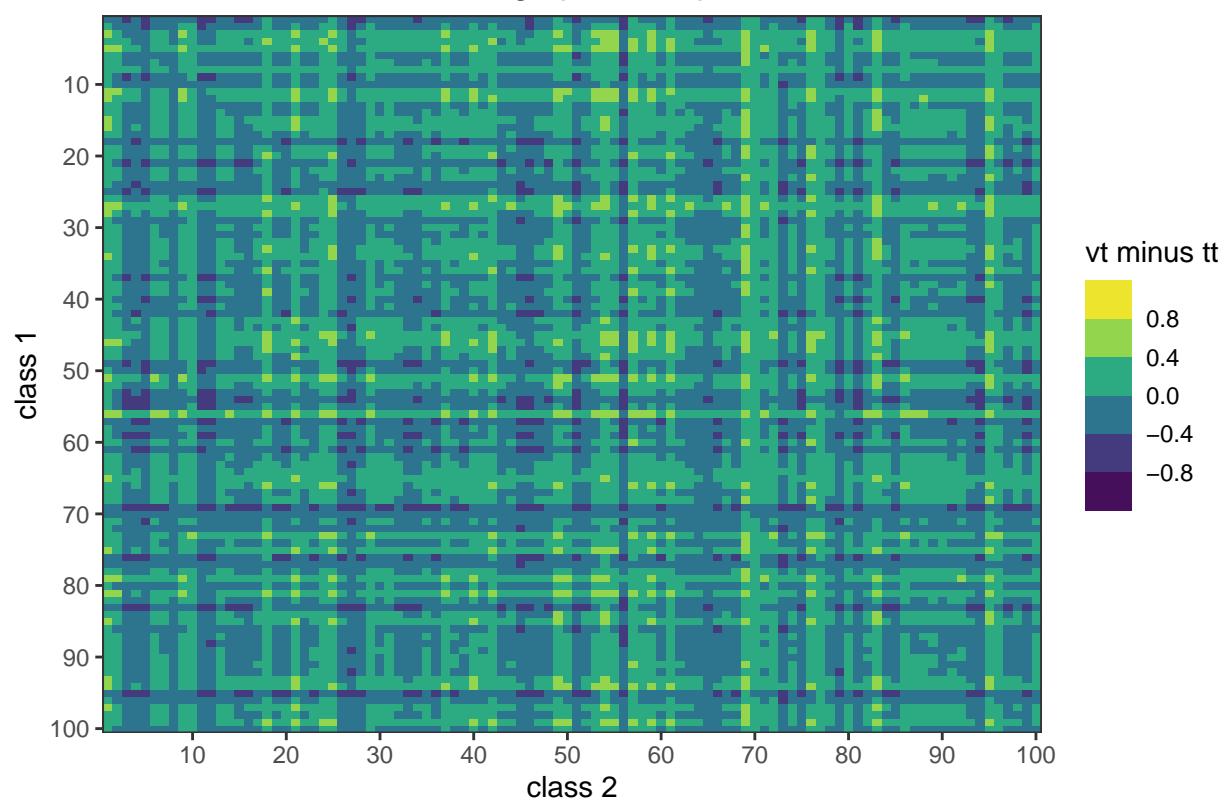
Differences between average pairwise probabilities – class 68



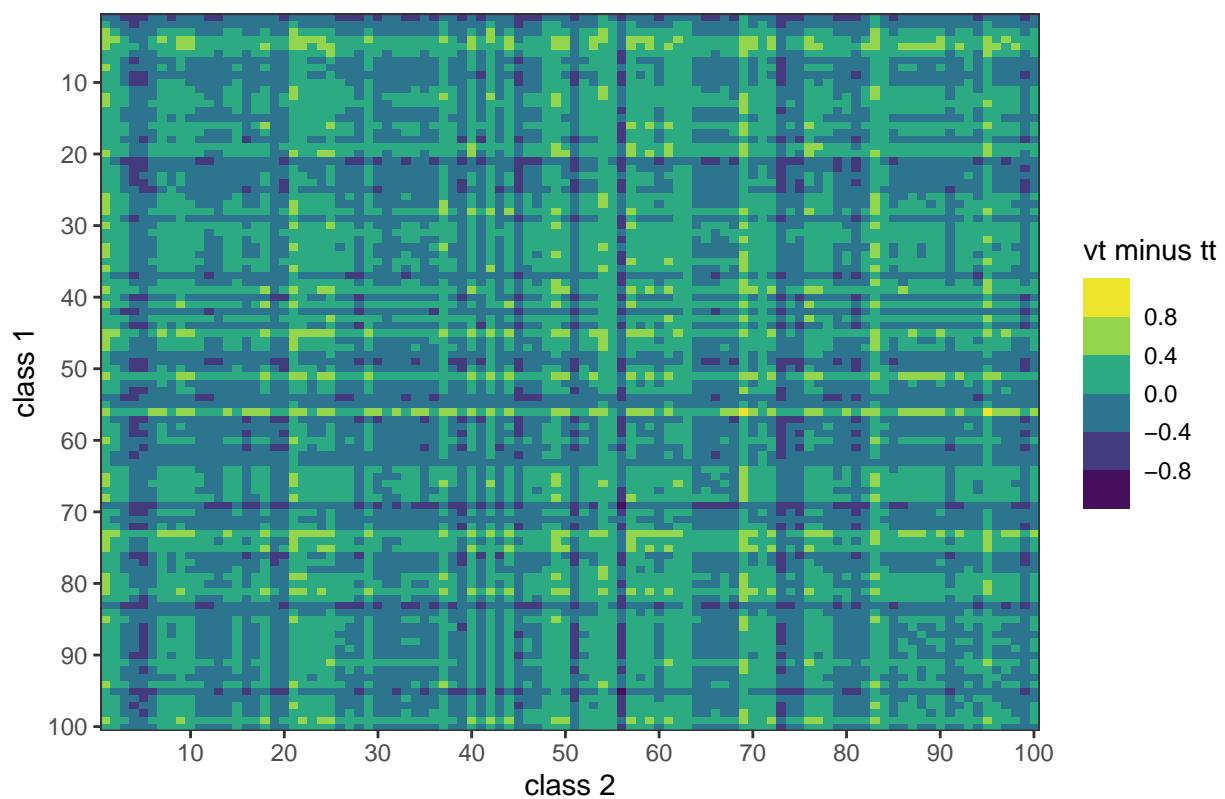
Differences between average pairwise probabilities – class 69



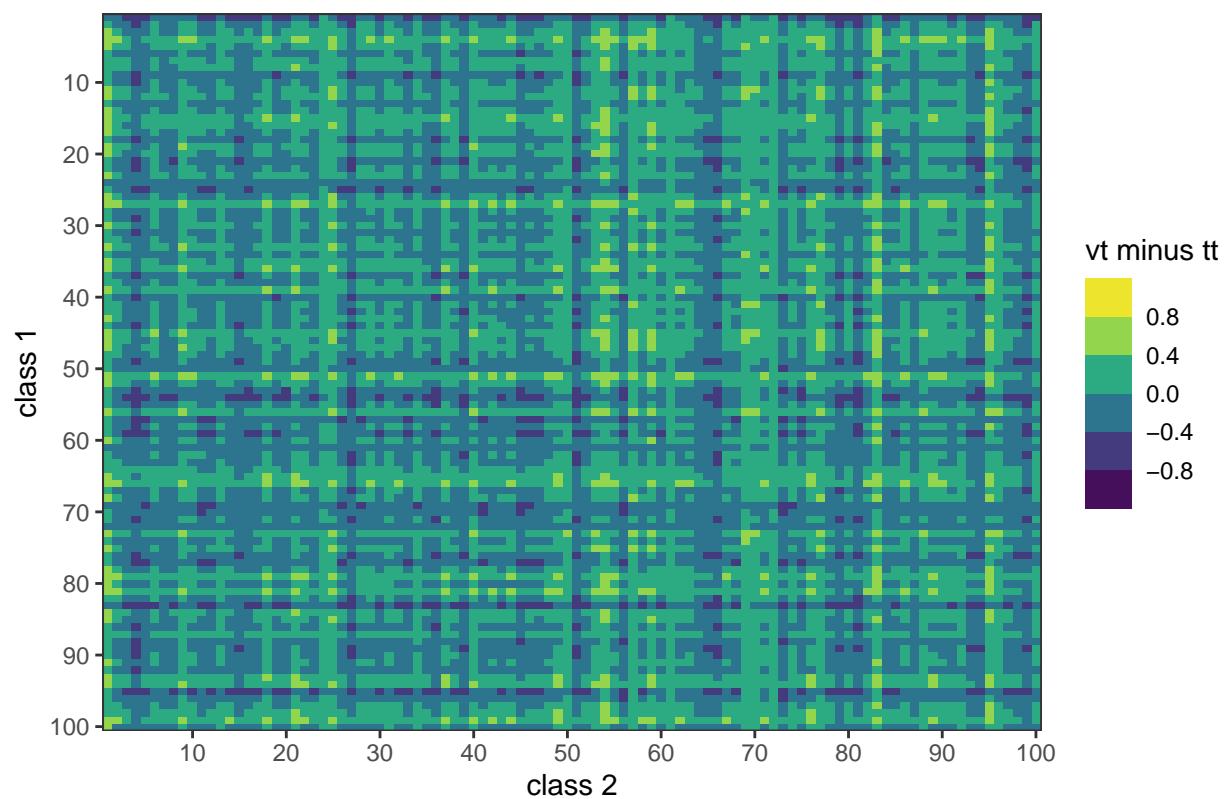
Differences between average pairwise probabilities – class 70



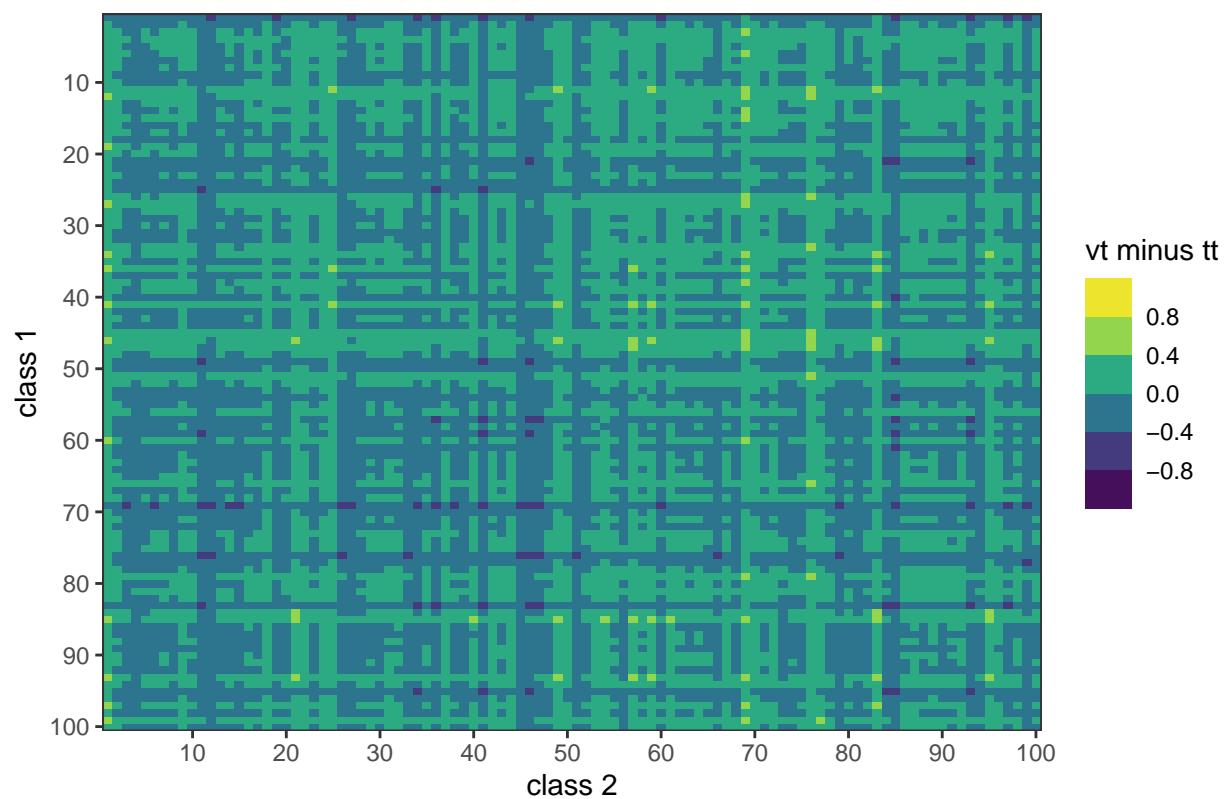
Differences between average pairwise probabilities – class 71



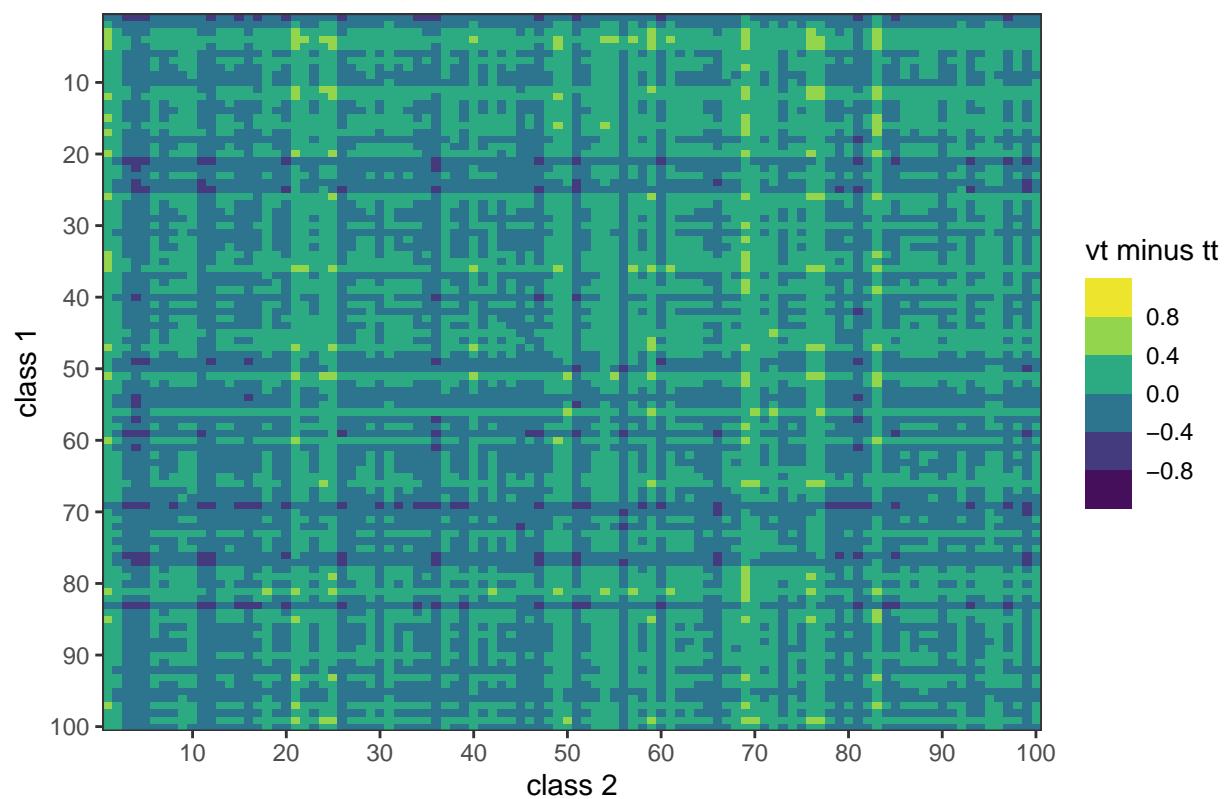
Differences between average pairwise probabilities – class 72



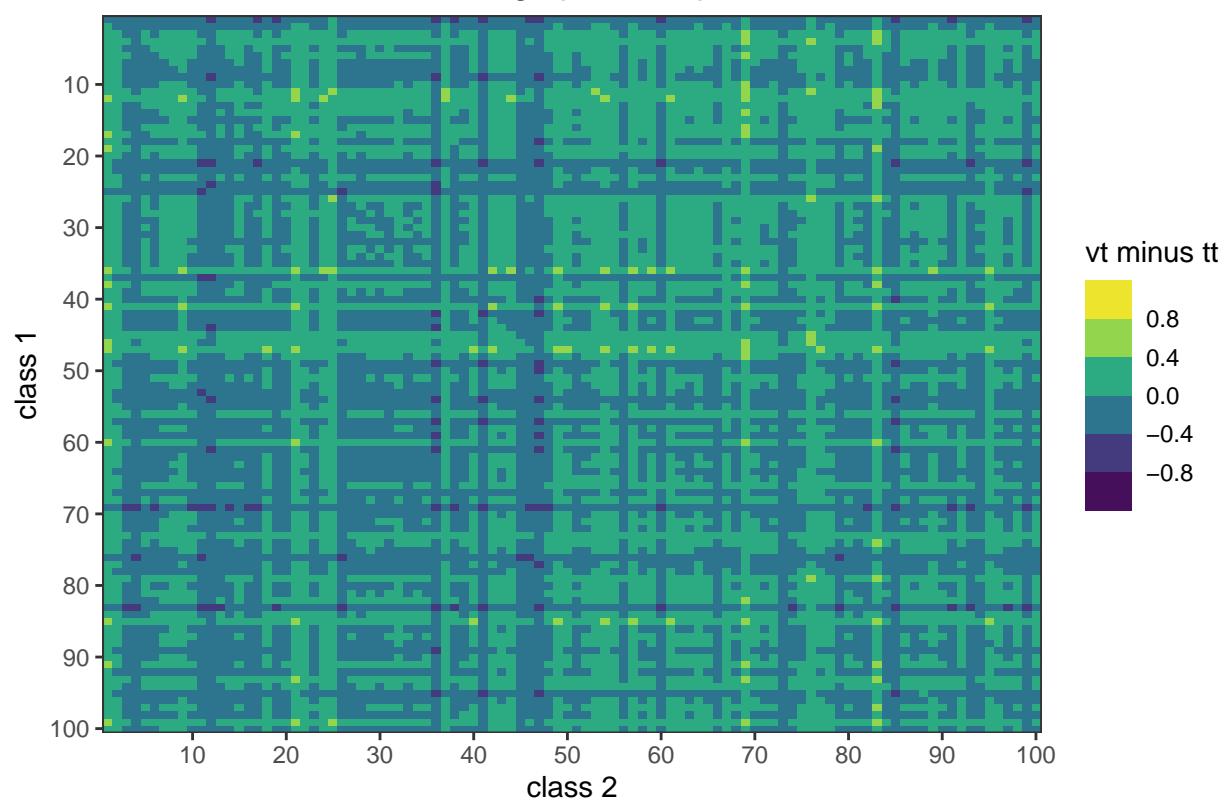
Differences between average pairwise probabilities – class 73



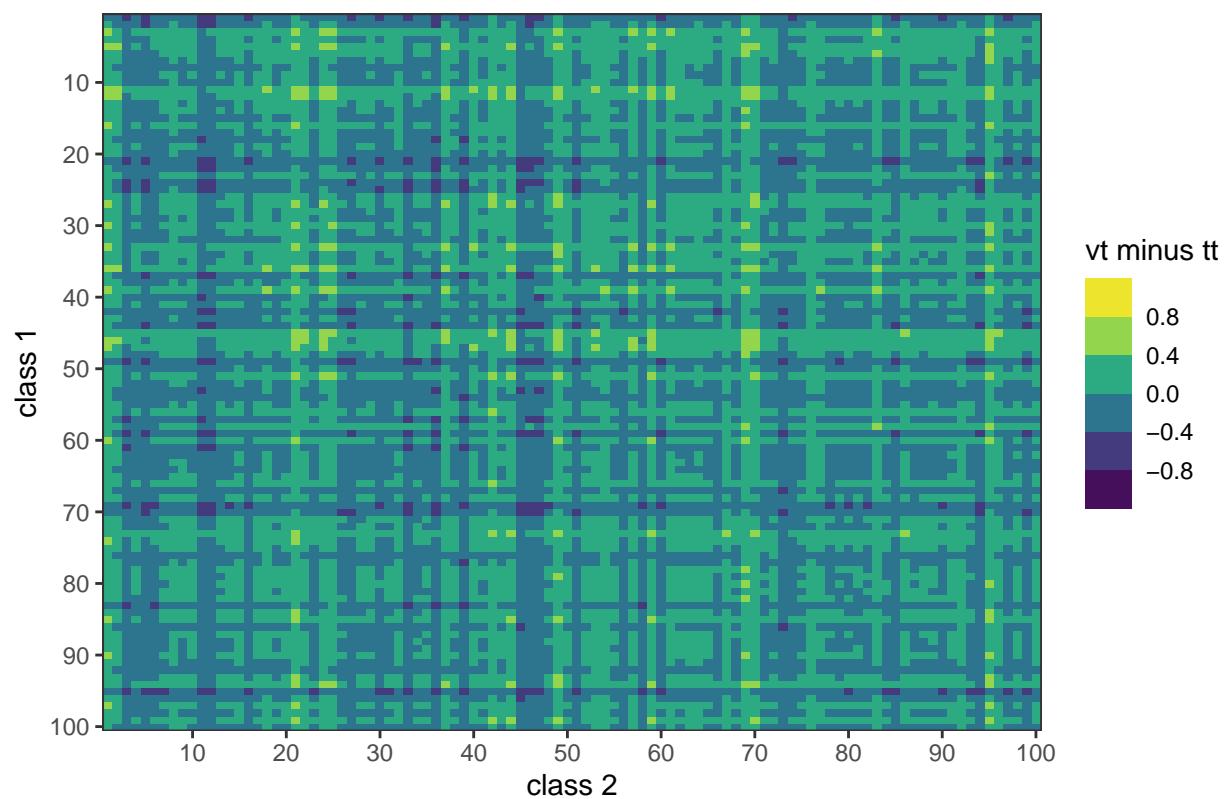
Differences between average pairwise probabilities – class 74



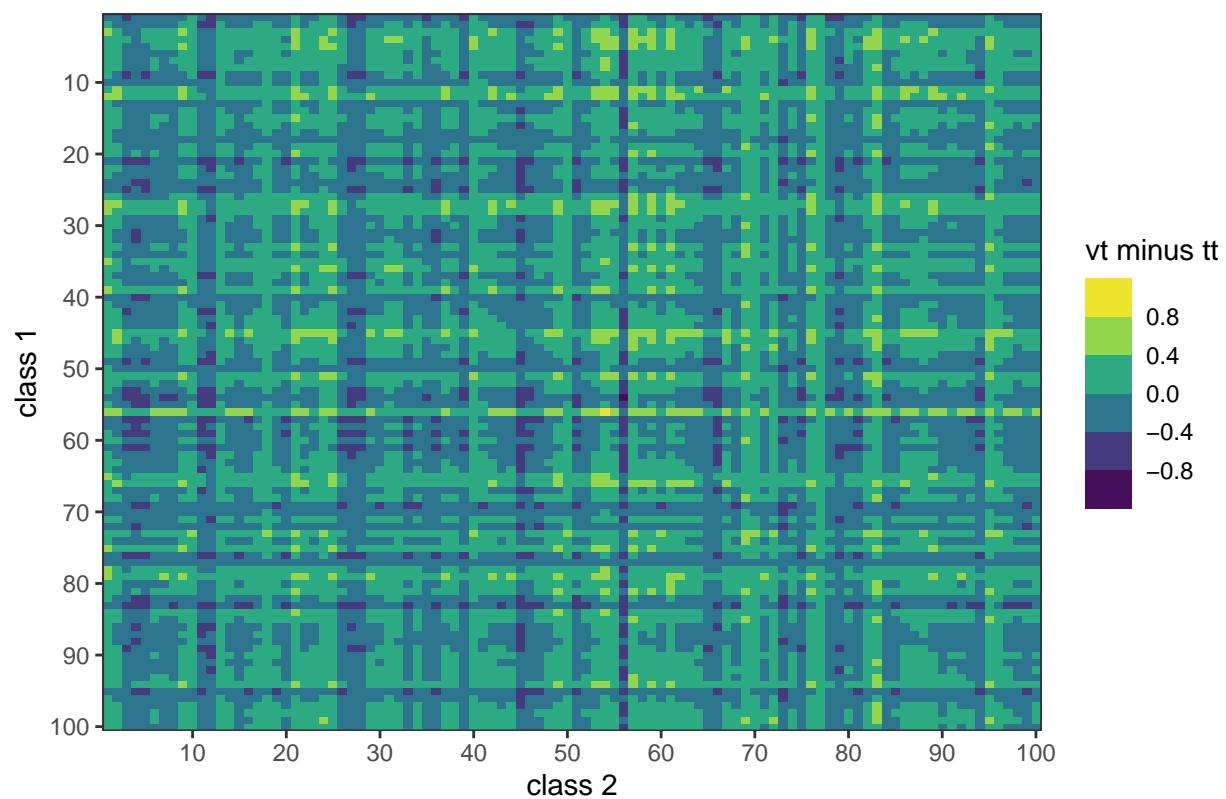
Differences between average pairwise probabilities – class 75



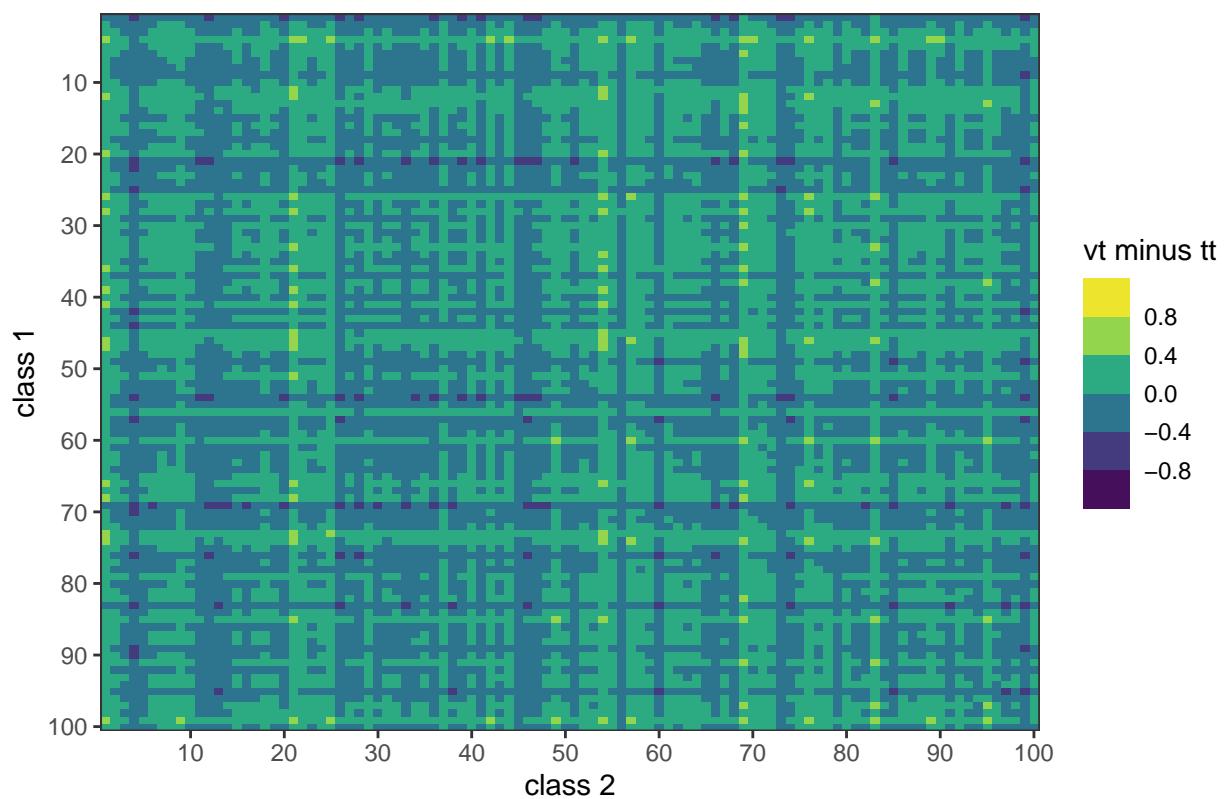
Differences between average pairwise probabilities – class 76



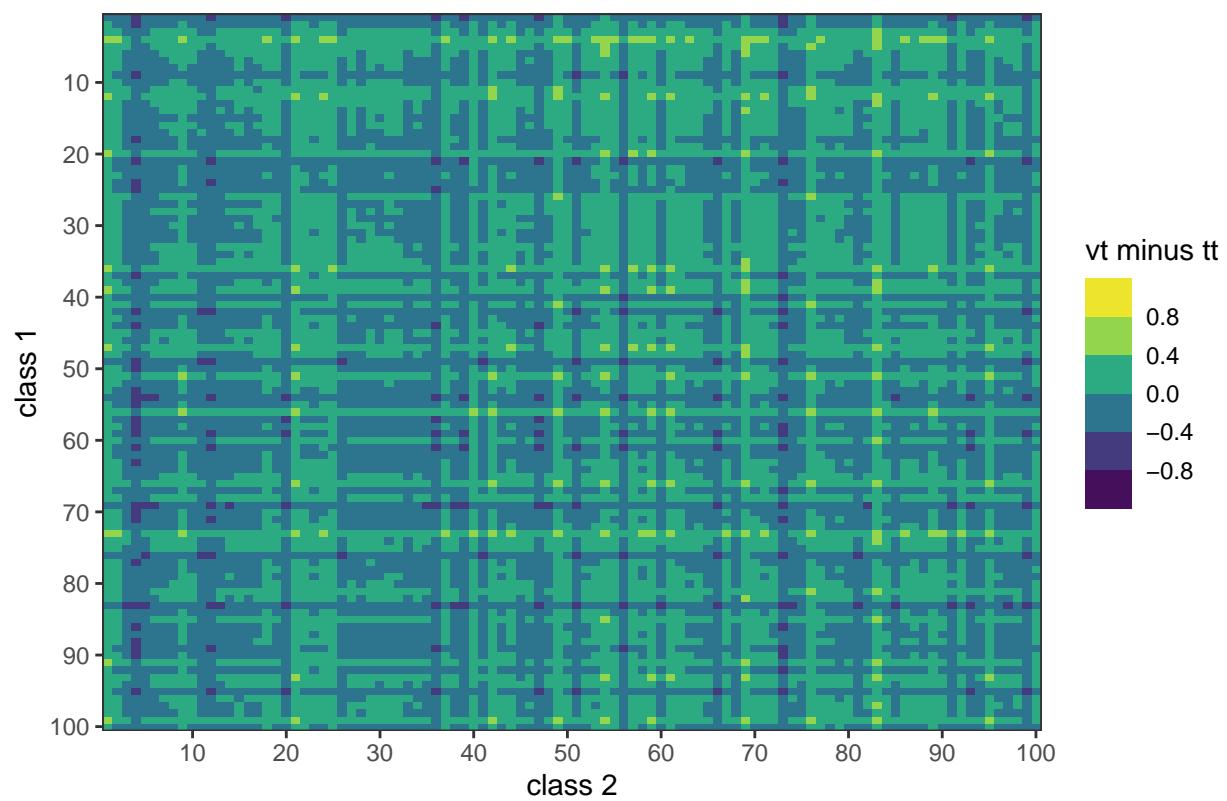
Differences between average pairwise probabilities – class 77



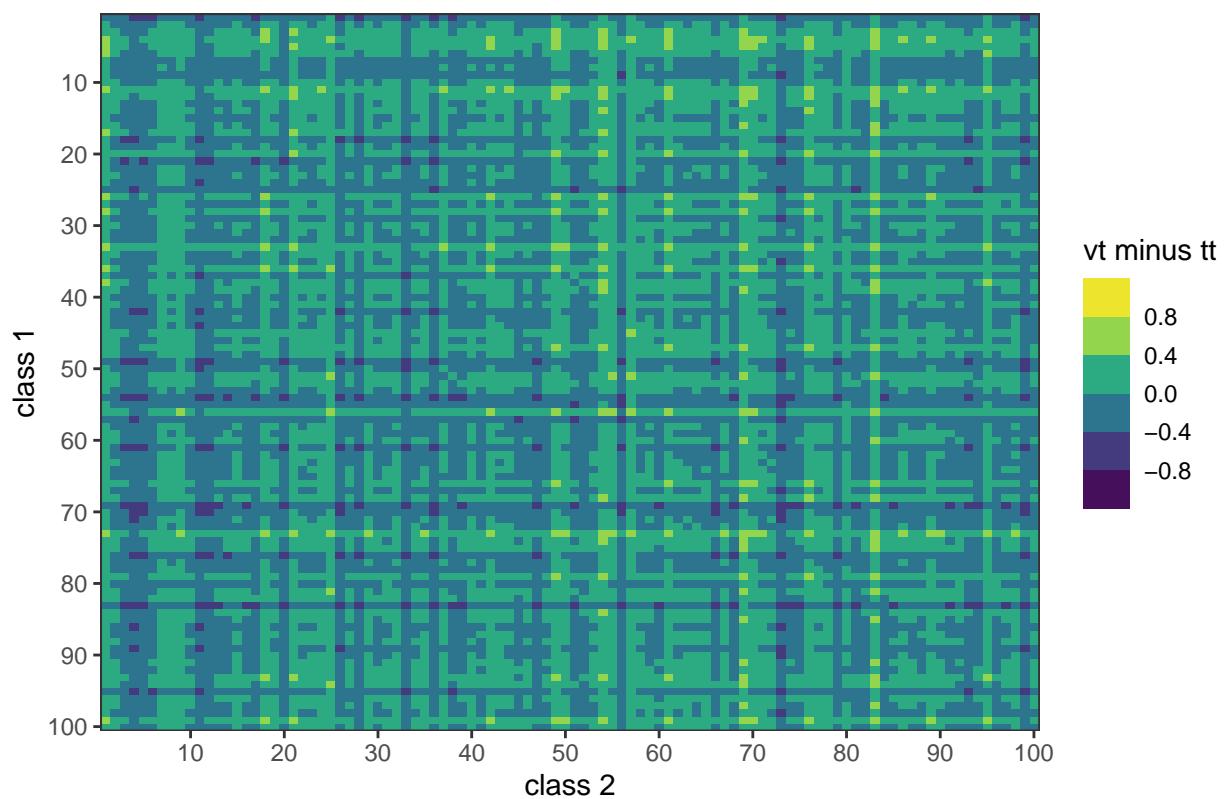
Differences between average pairwise probabilities – class 78



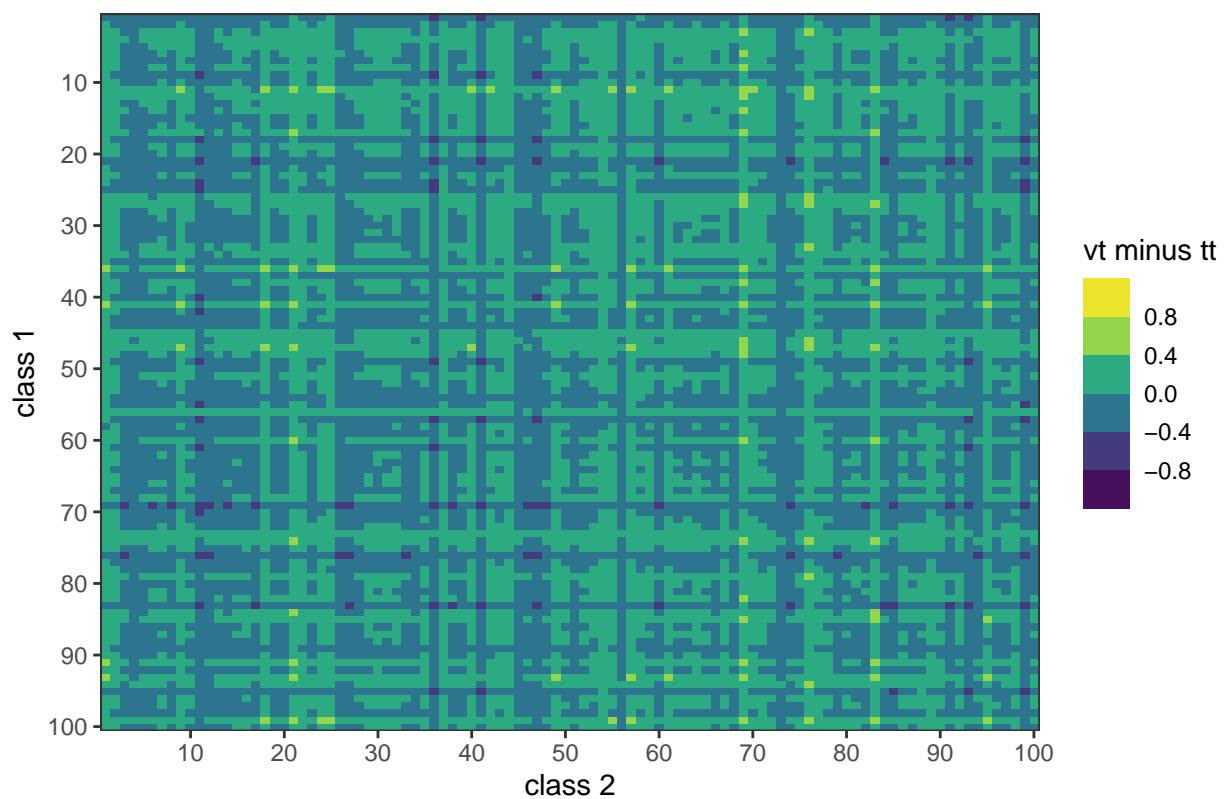
Differences between average pairwise probabilities – class 79



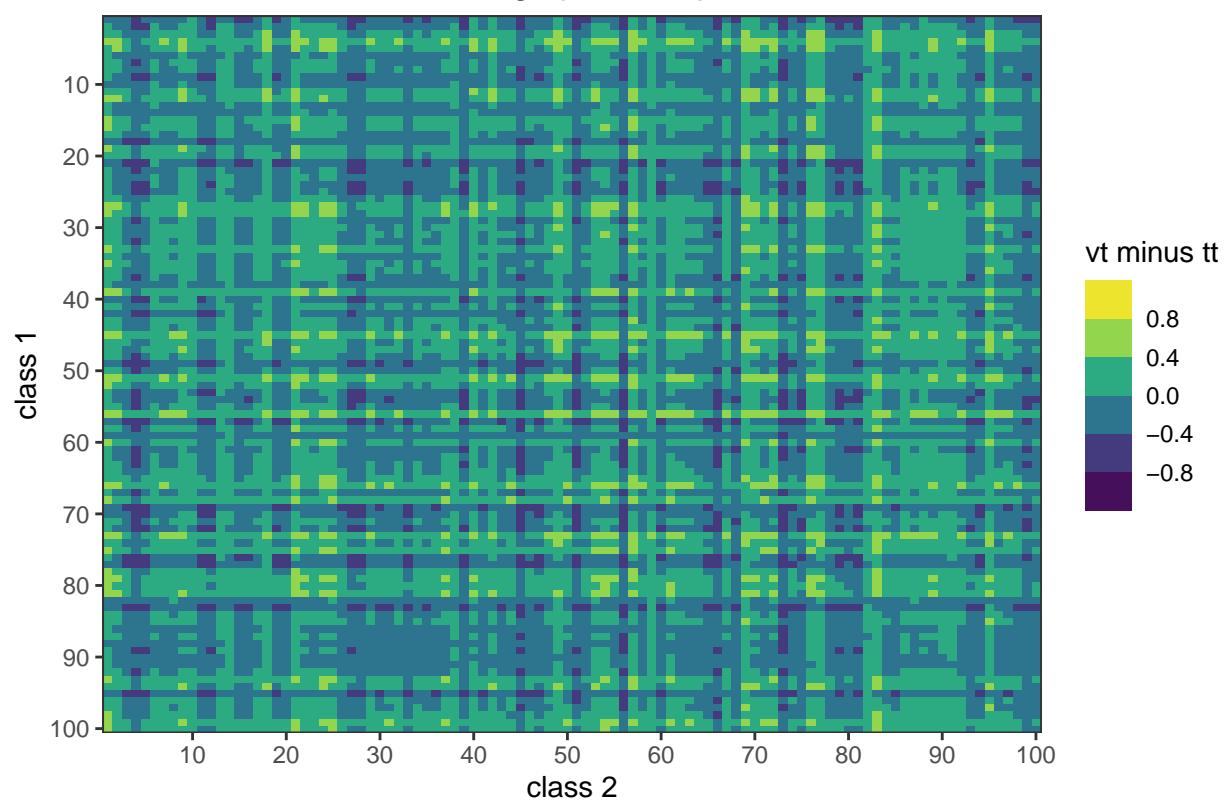
Differences between average pairwise probabilities – class 80



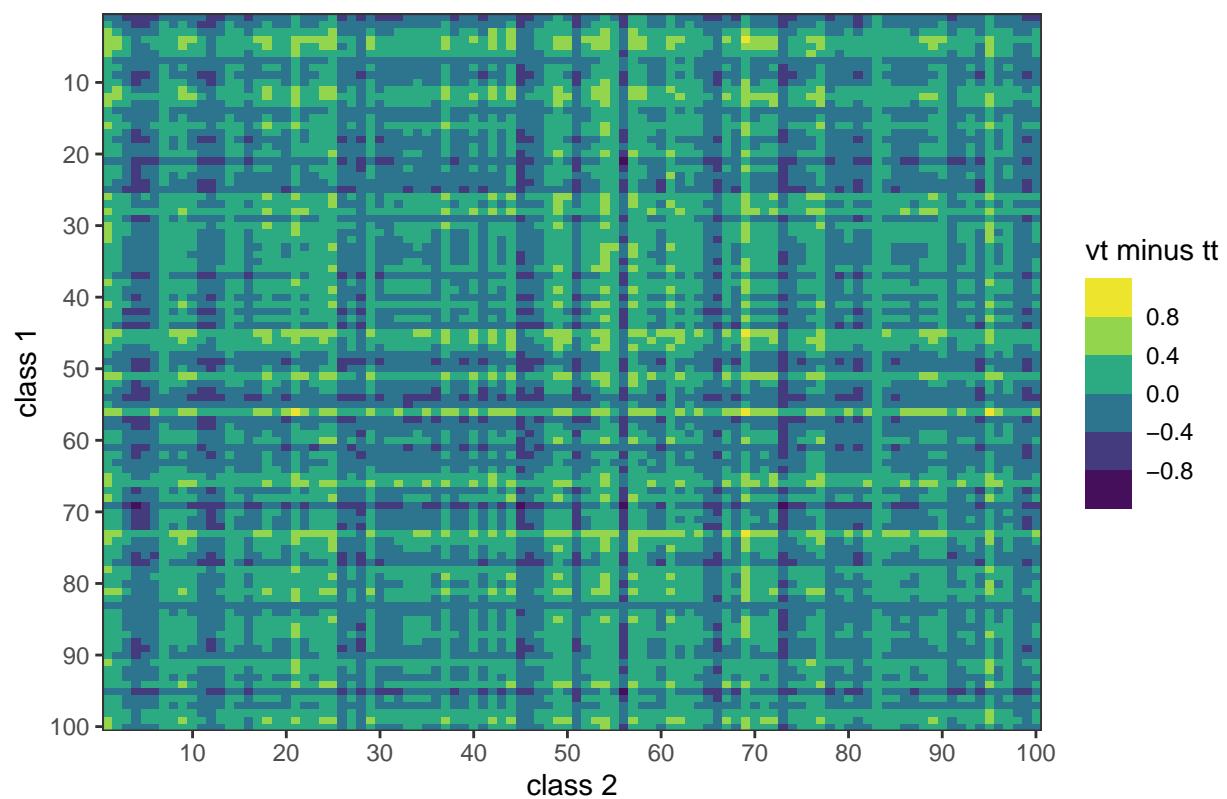
Differences between average pairwise probabilities – class 81



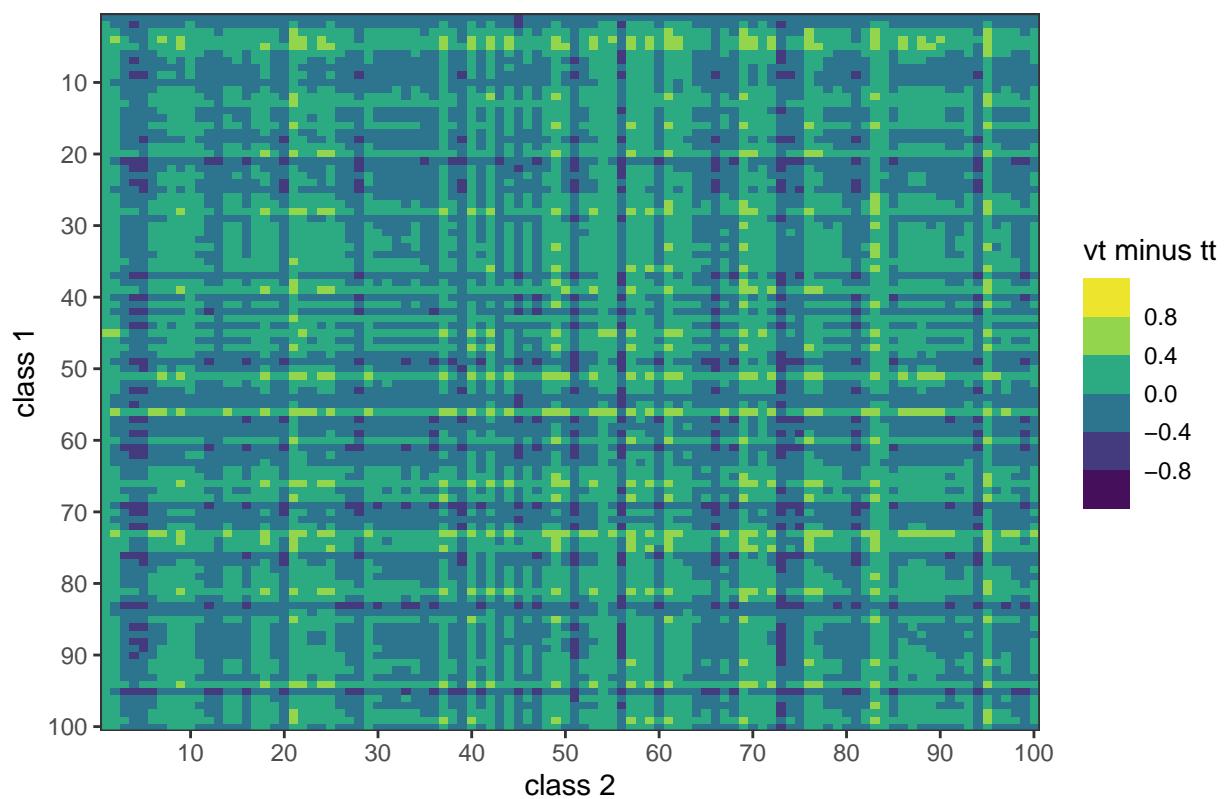
Differences between average pairwise probabilities – class 82



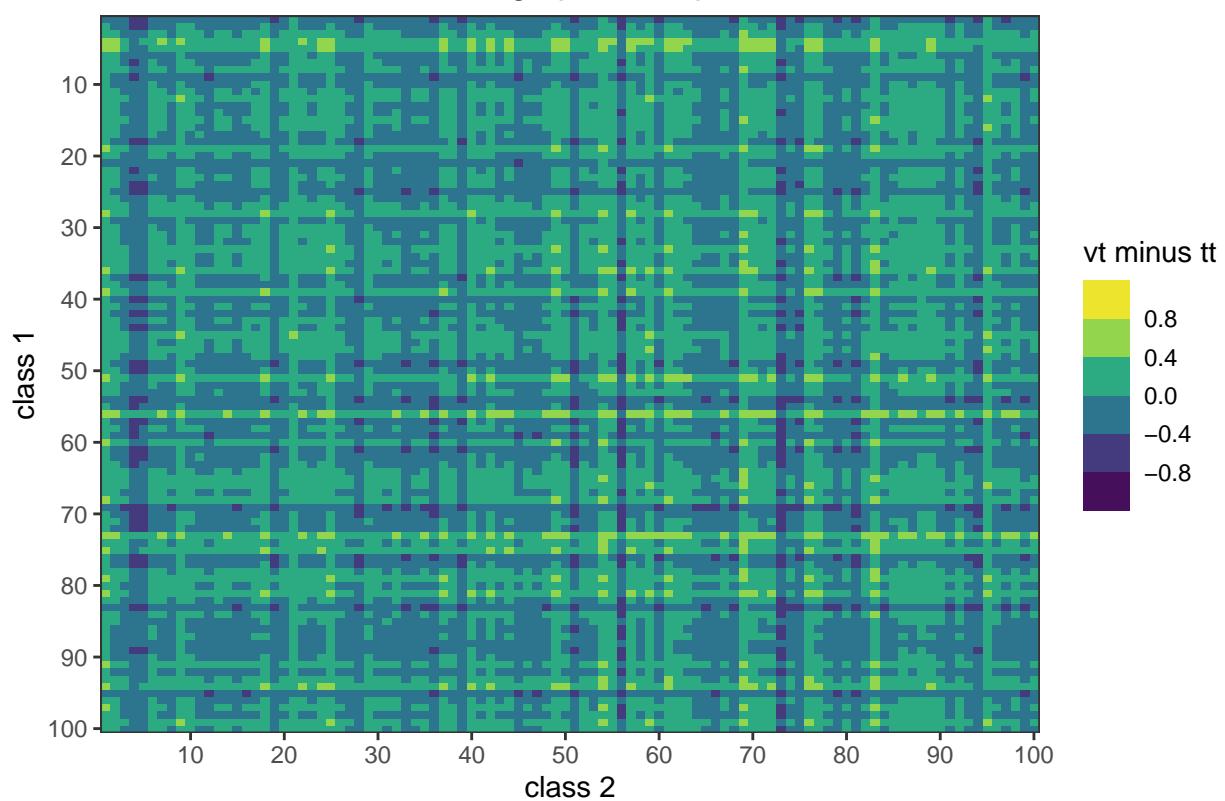
Differences between average pairwise probabilities – class 83



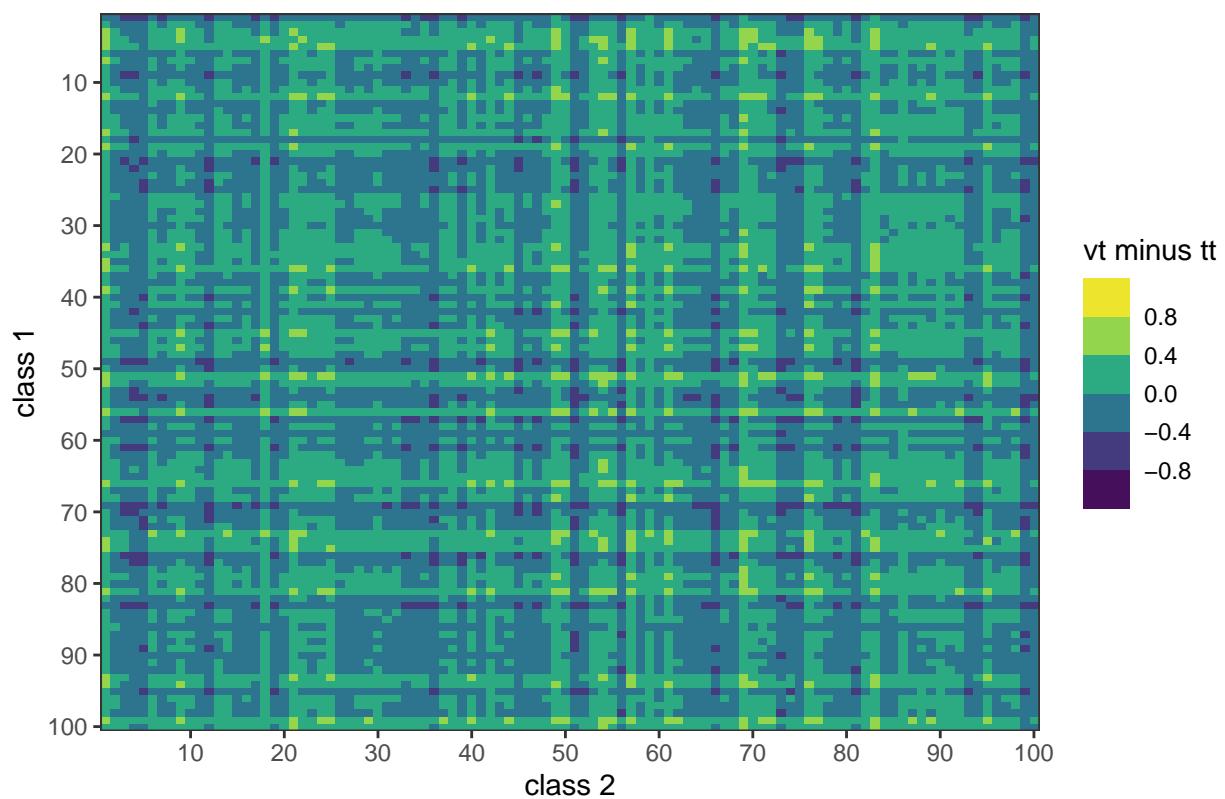
Differences between average pairwise probabilities – class 84



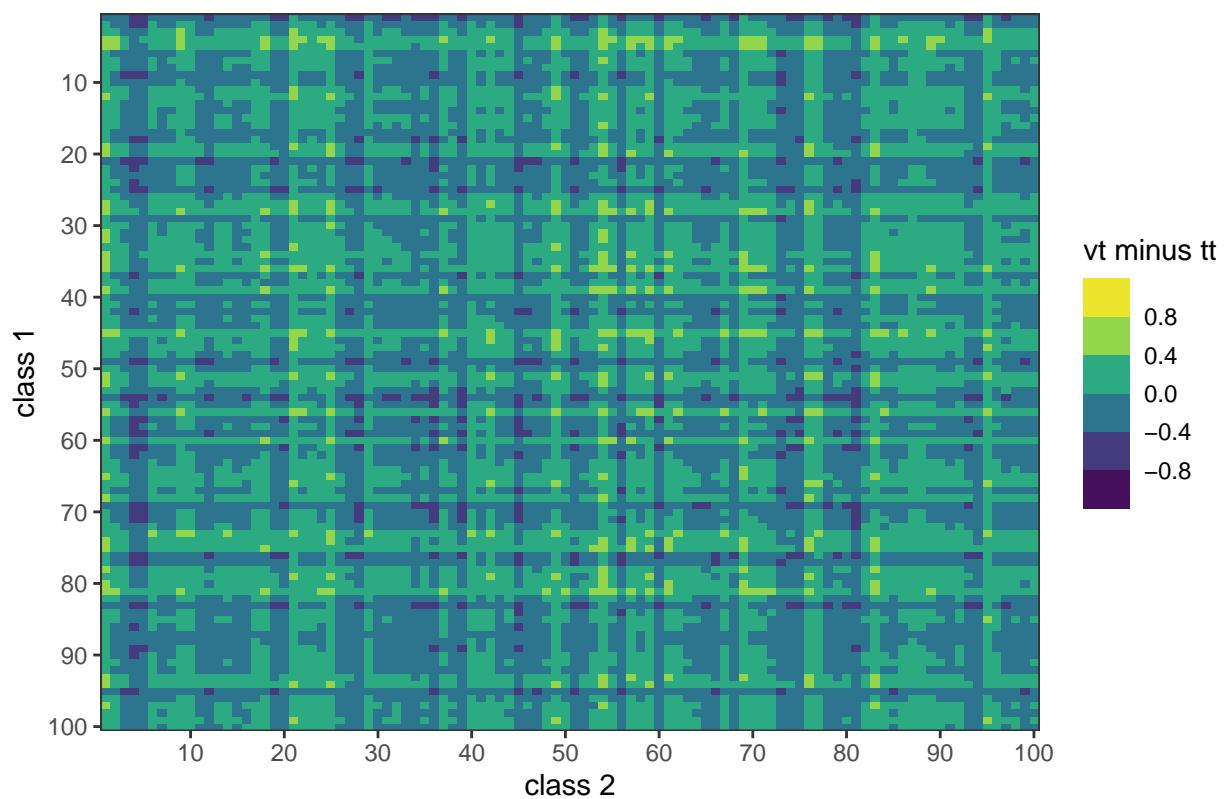
Differences between average pairwise probabilities – class 85



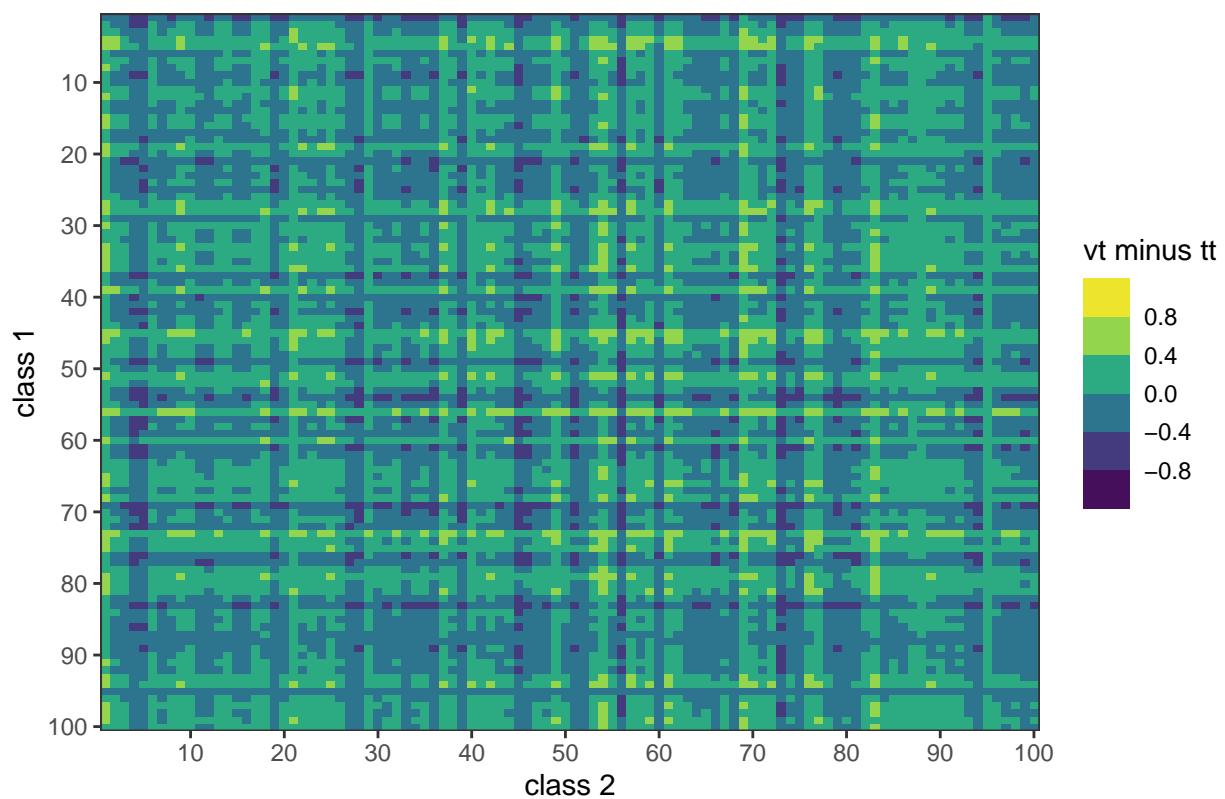
Differences between average pairwise probabilities – class 86



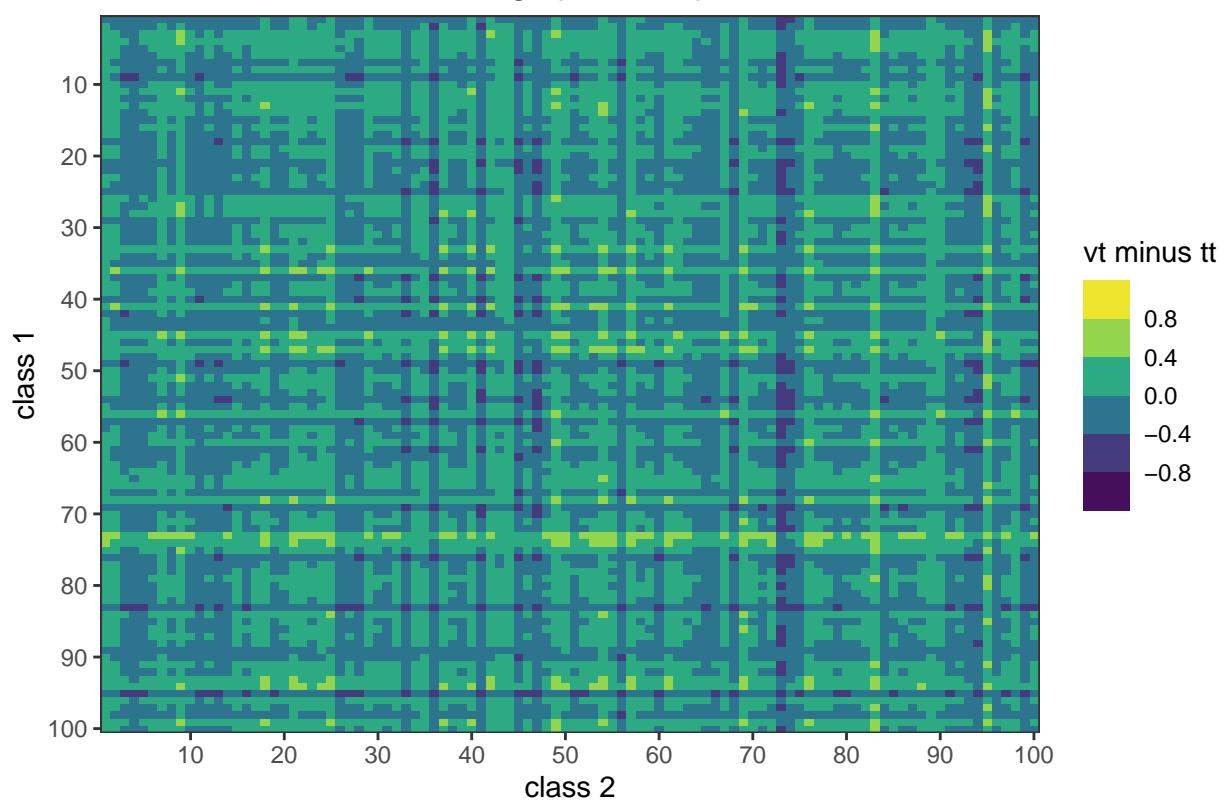
Differences between average pairwise probabilities – class 87



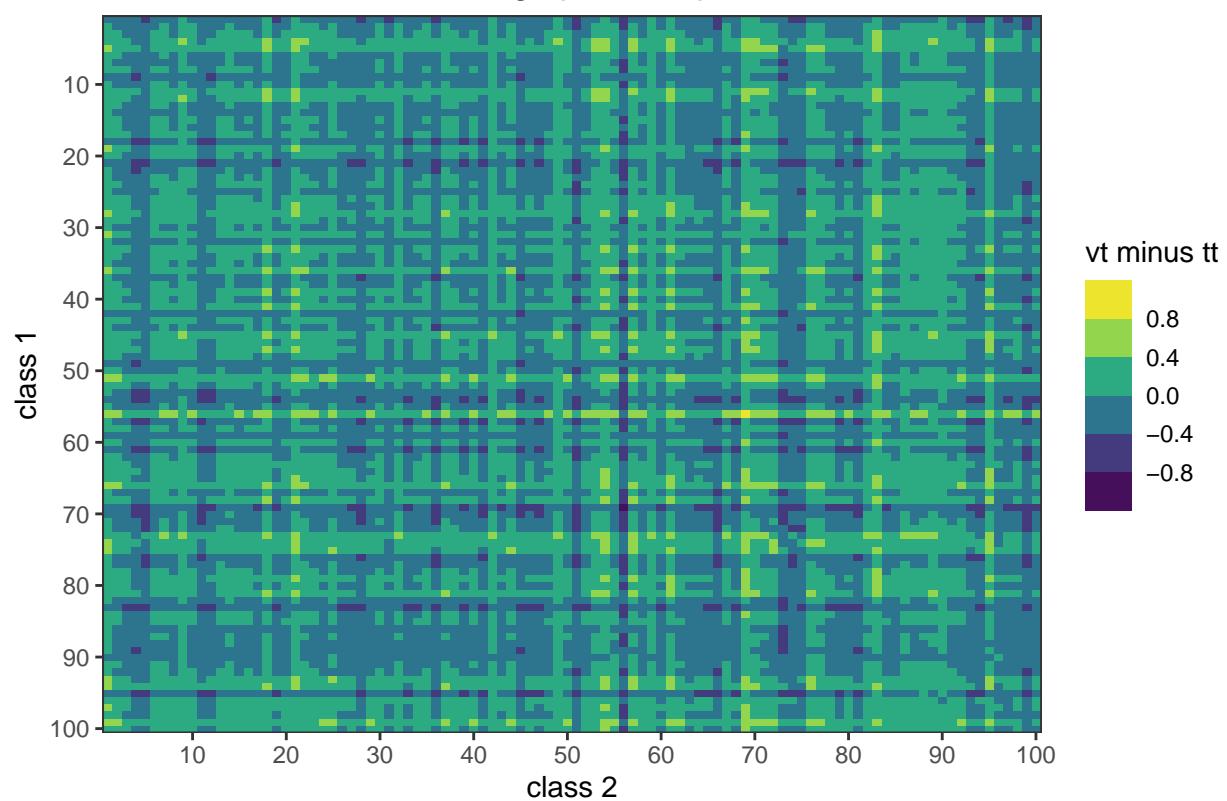
Differences between average pairwise probabilities – class 88



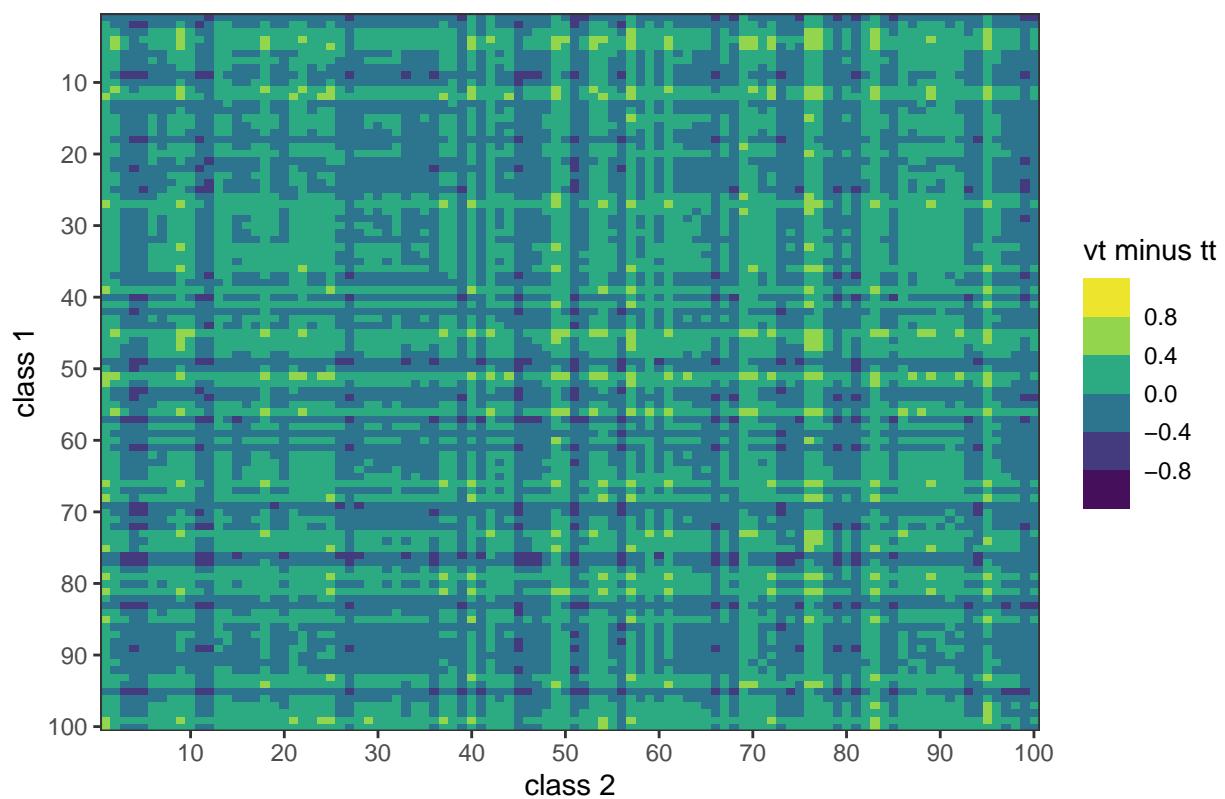
Differences between average pairwise probabilities – class 89



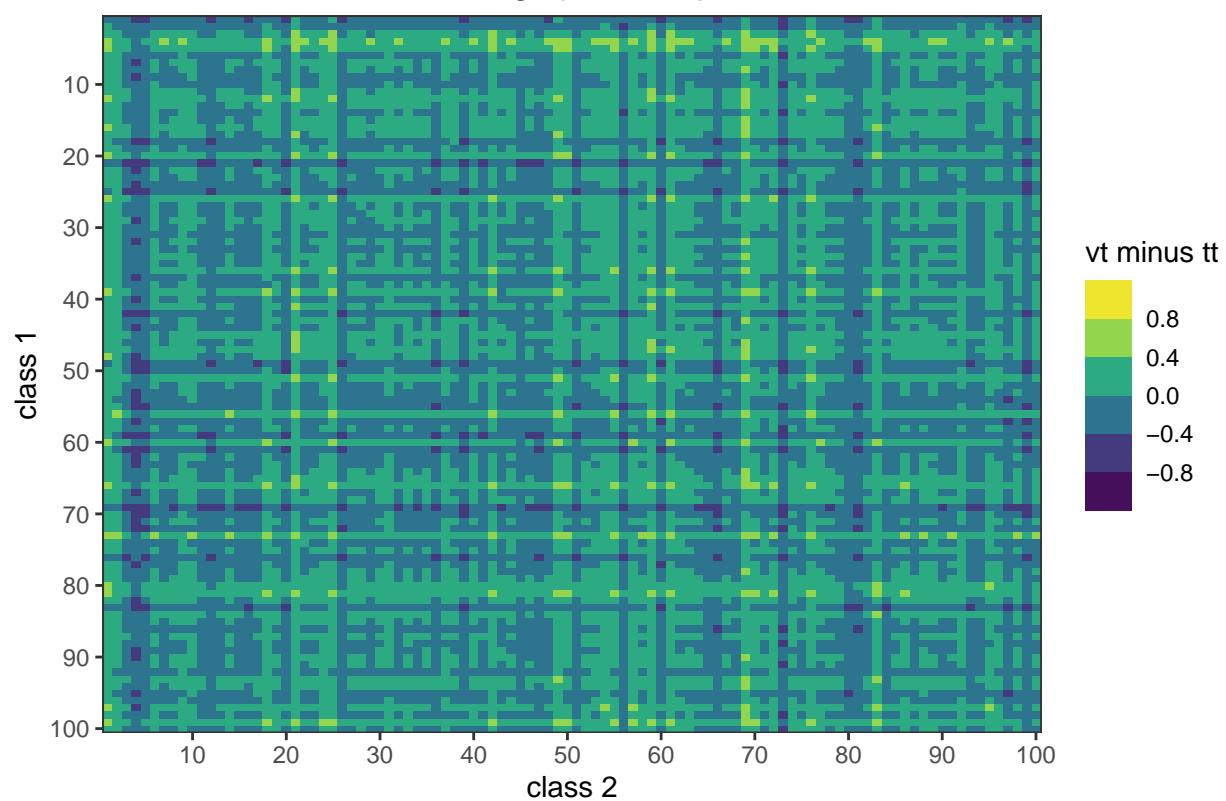
Differences between average pairwise probabilities – class 90



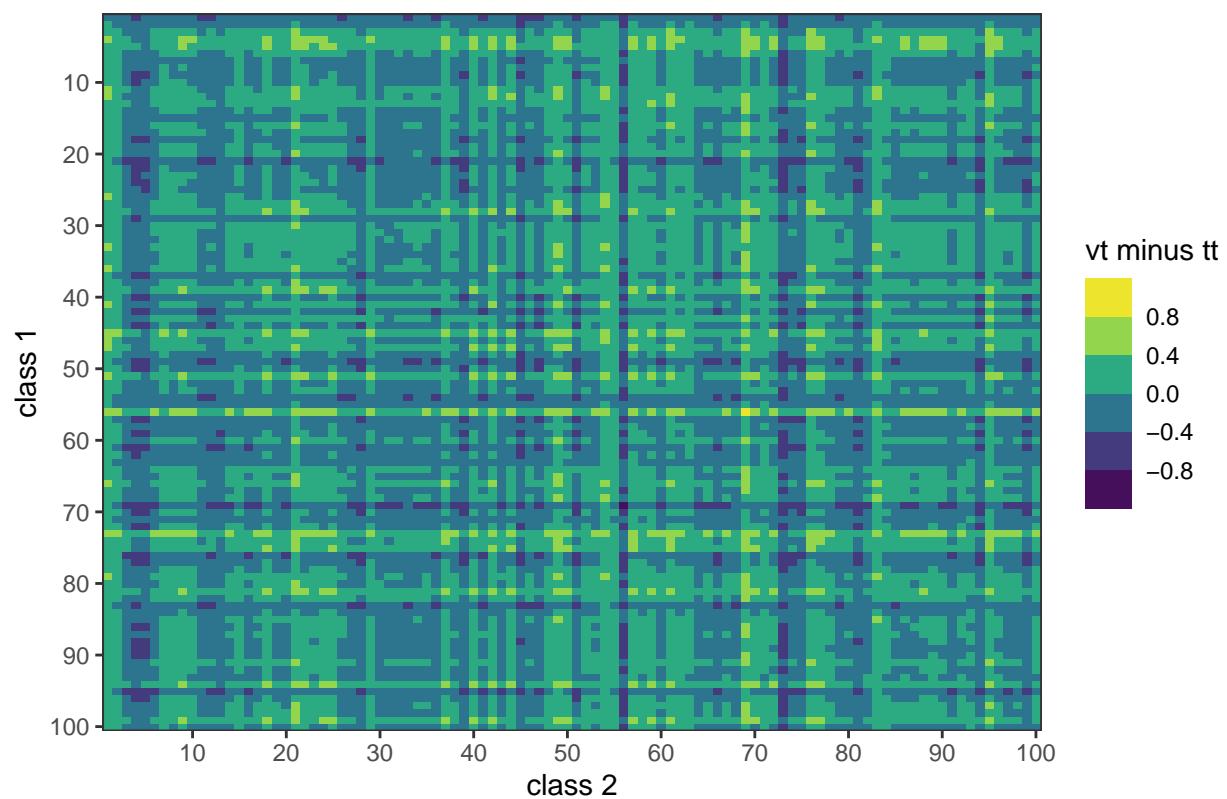
Differences between average pairwise probabilities – class 91



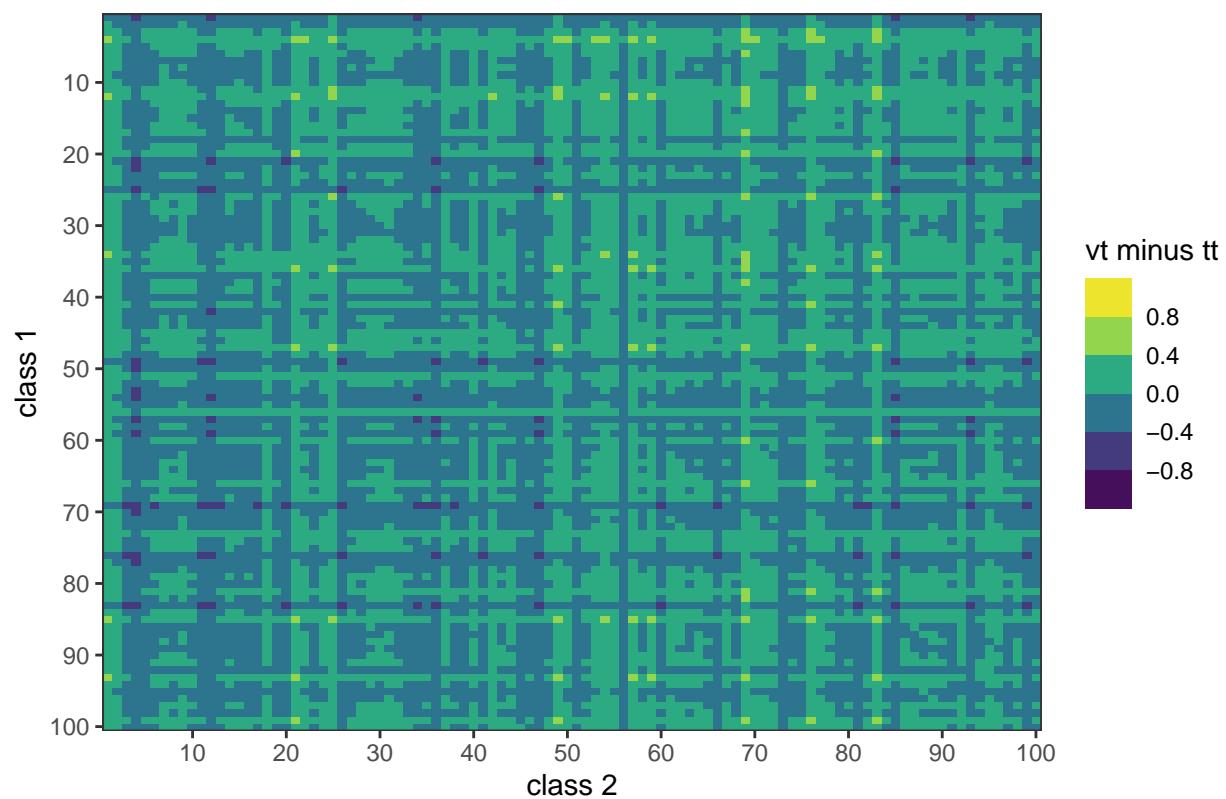
Differences between average pairwise probabilities – class 92



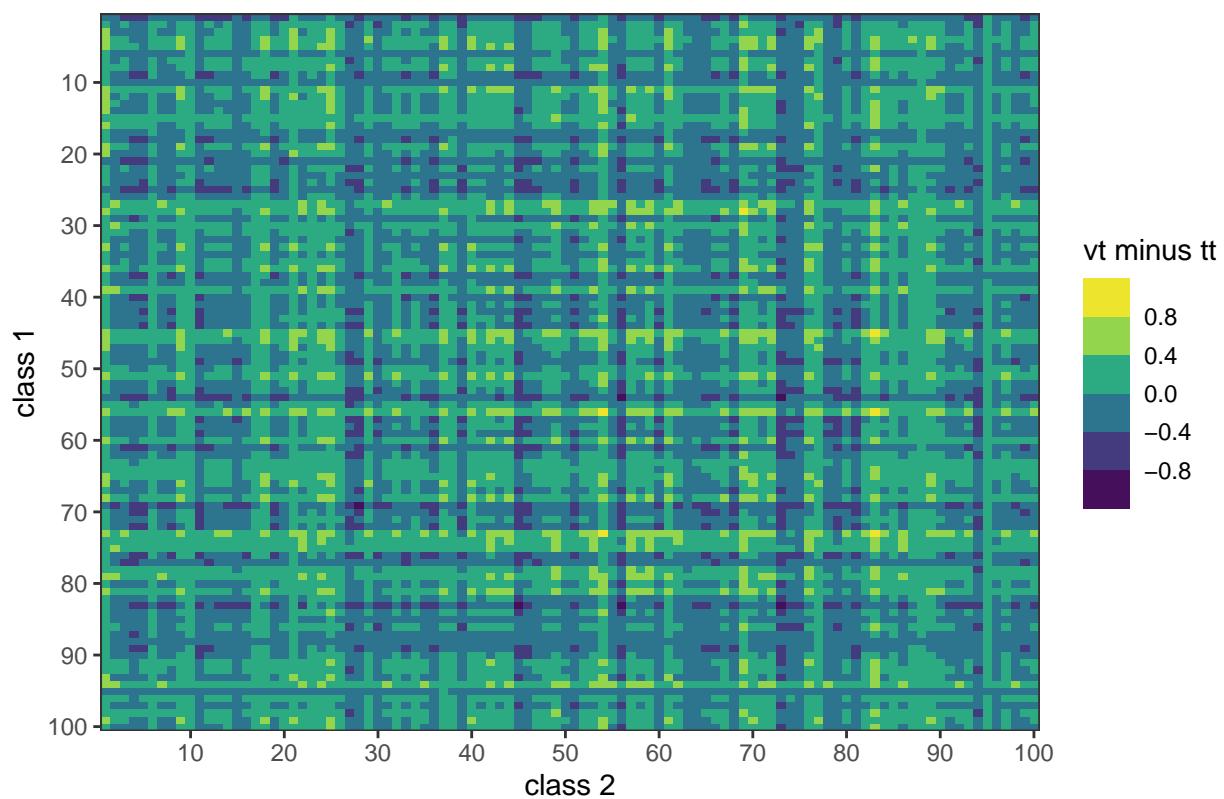
Differences between average pairwise probabilities – class 93



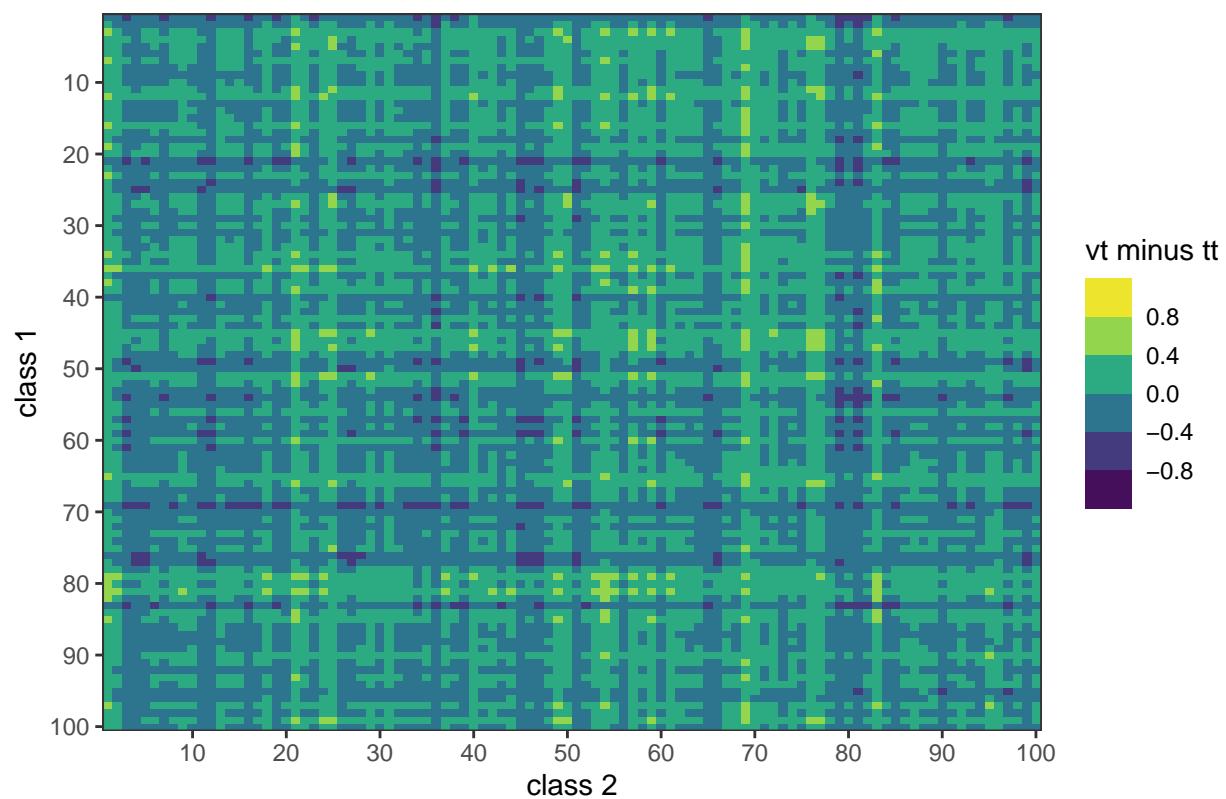
Differences between average pairwise probabilities – class 94



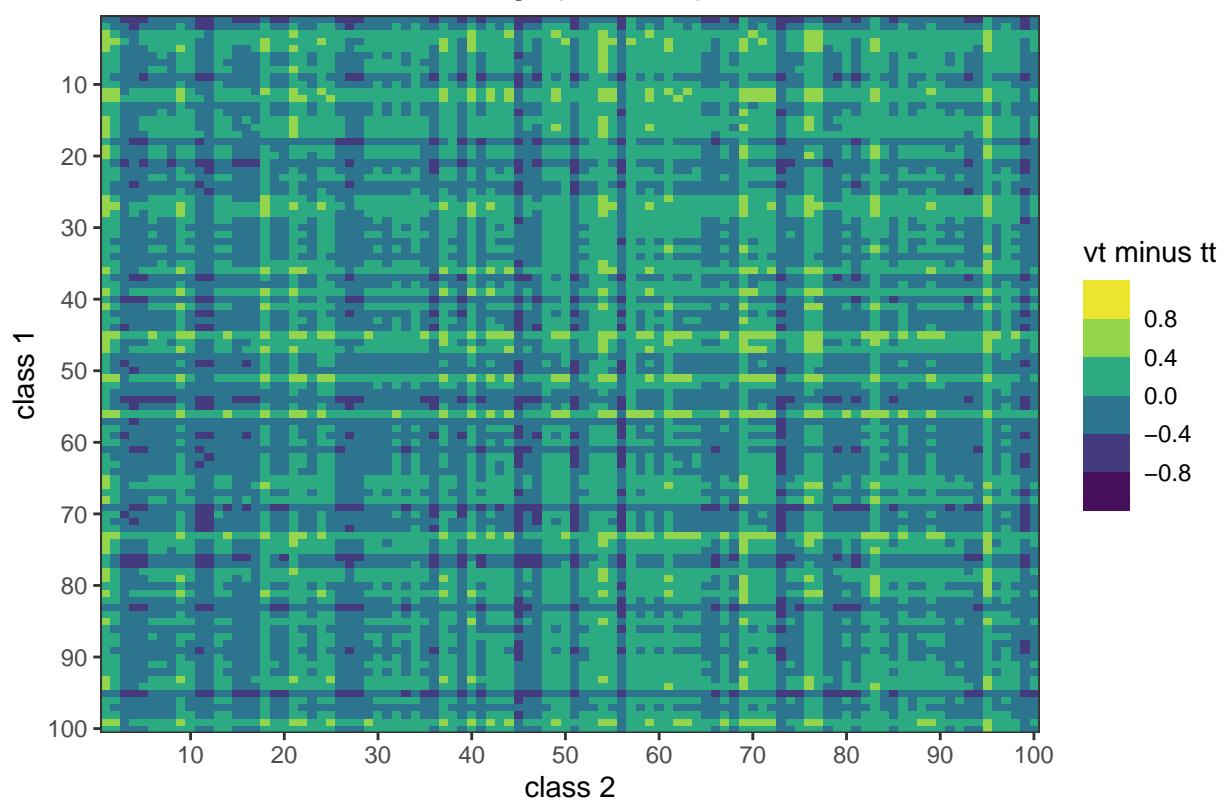
Differences between average pairwise probabilities – class 95



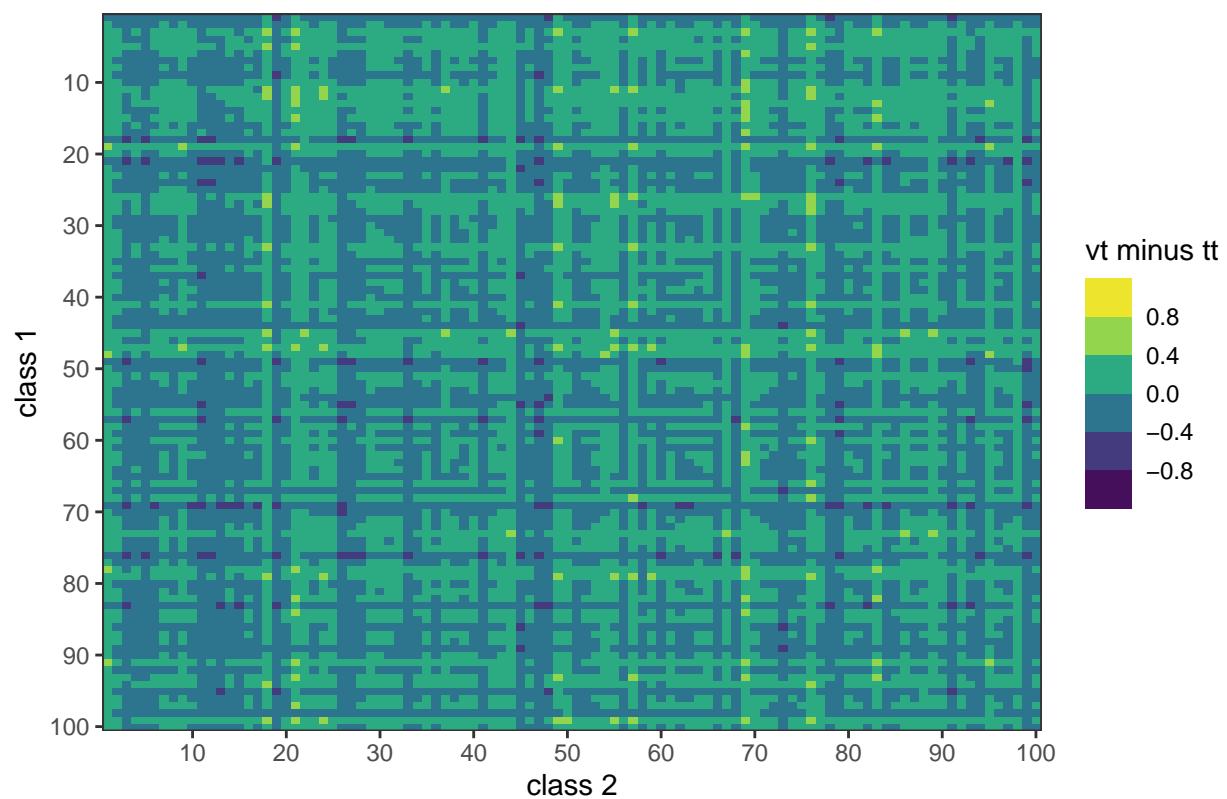
Differences between average pairwise probabilities – class 96



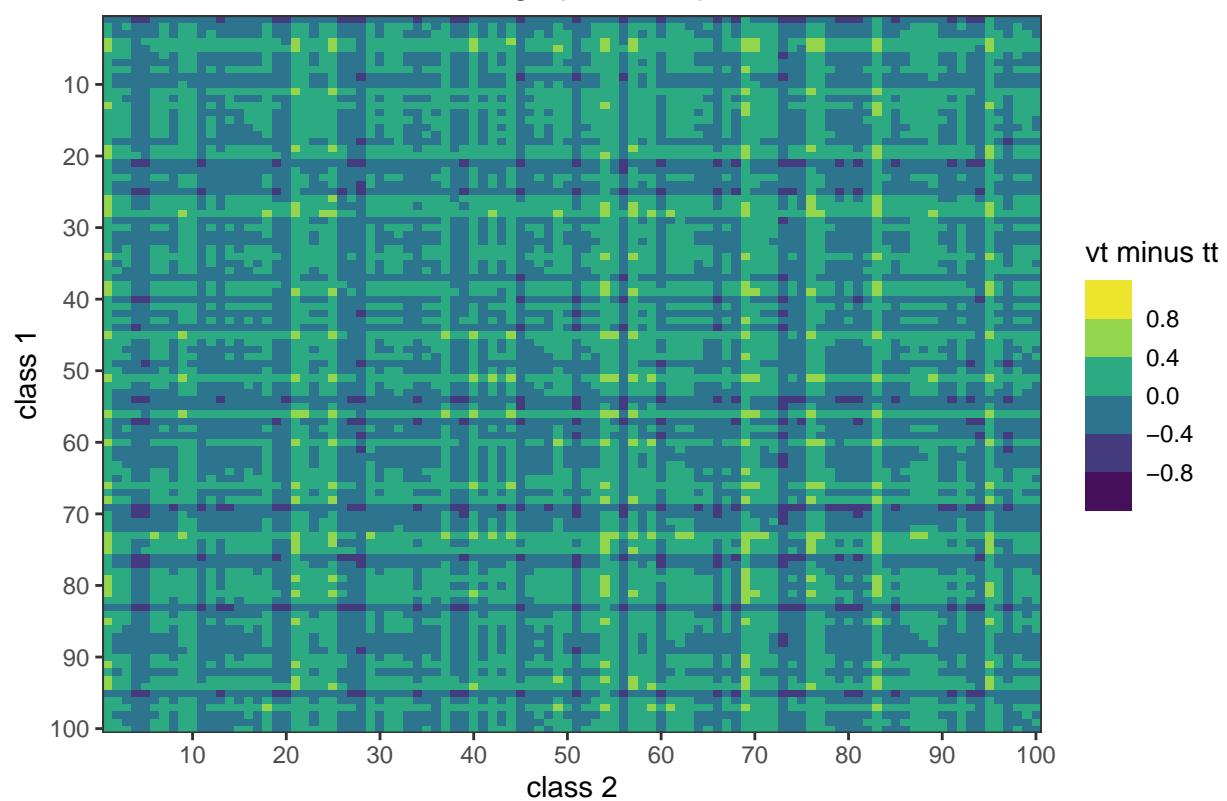
Differences between average pairwise probabilities – class 97



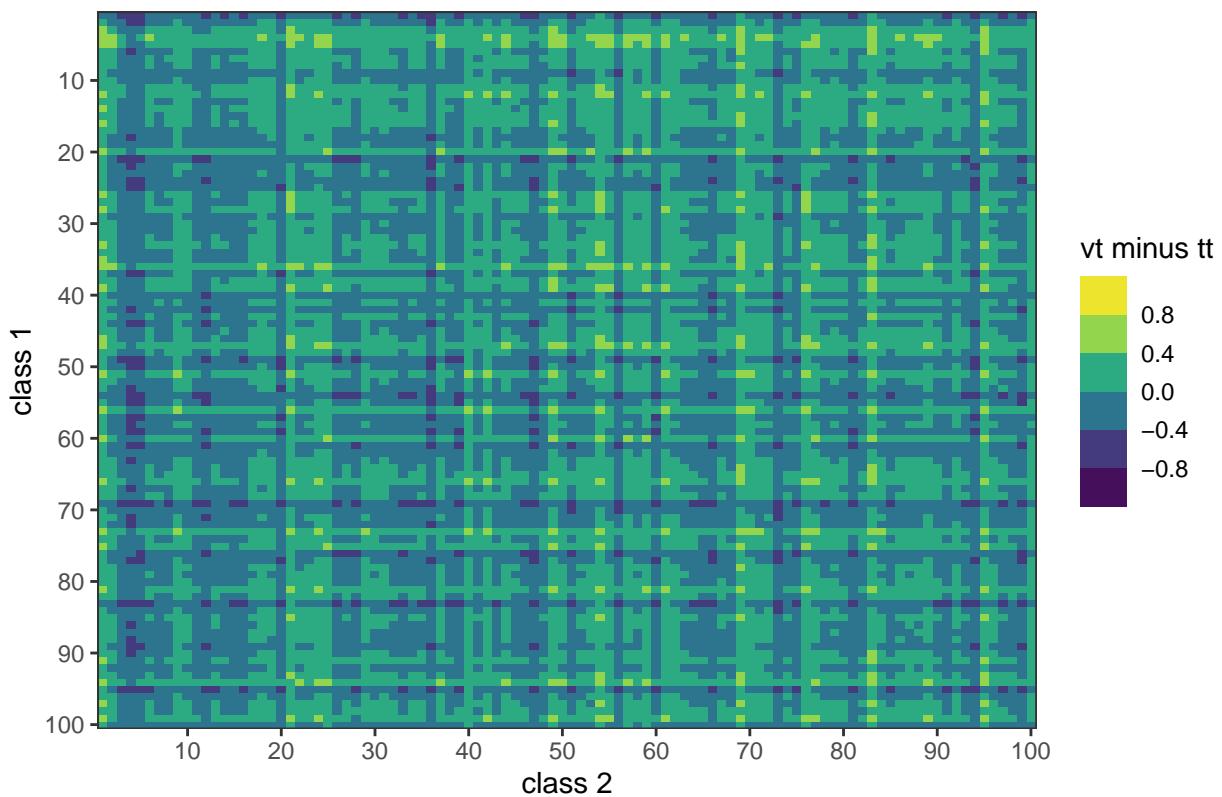
Differences between average pairwise probabilities – class 98



Differences between average pairwise probabilities – class 99



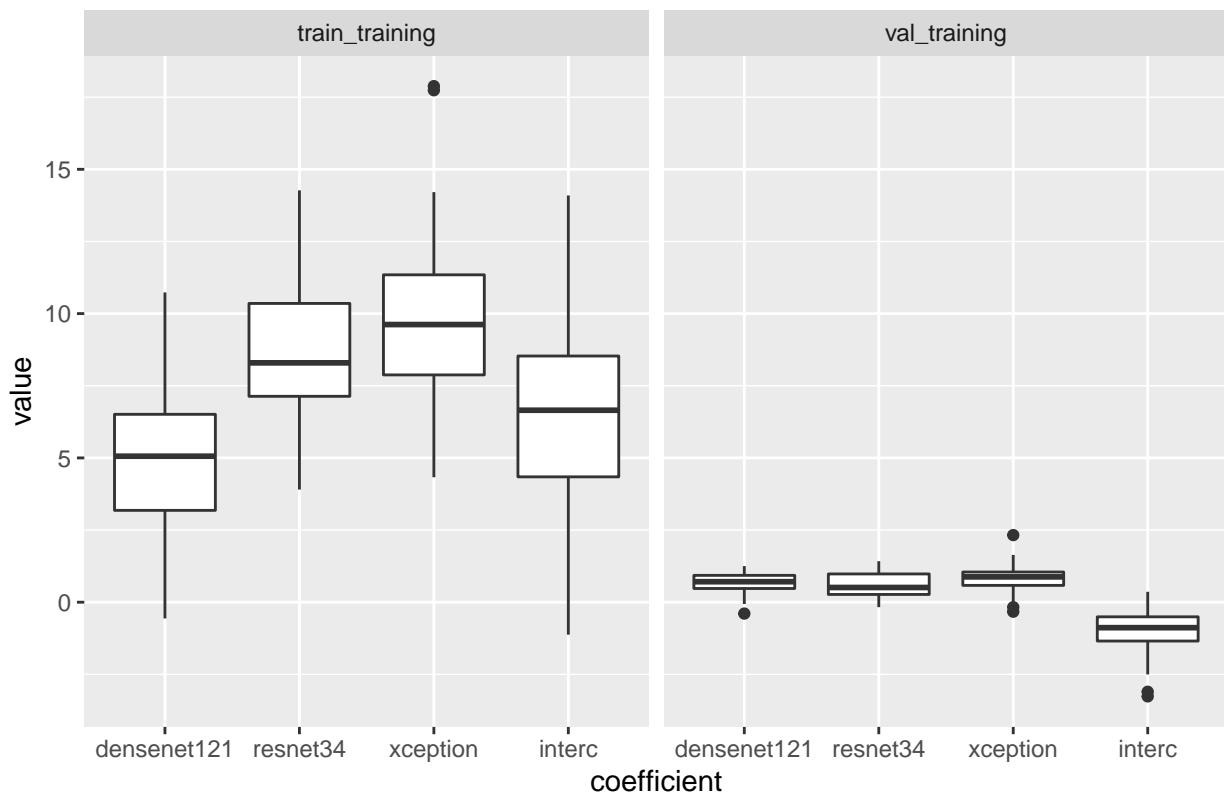
## Differences between average pairwise probabilities – class 100



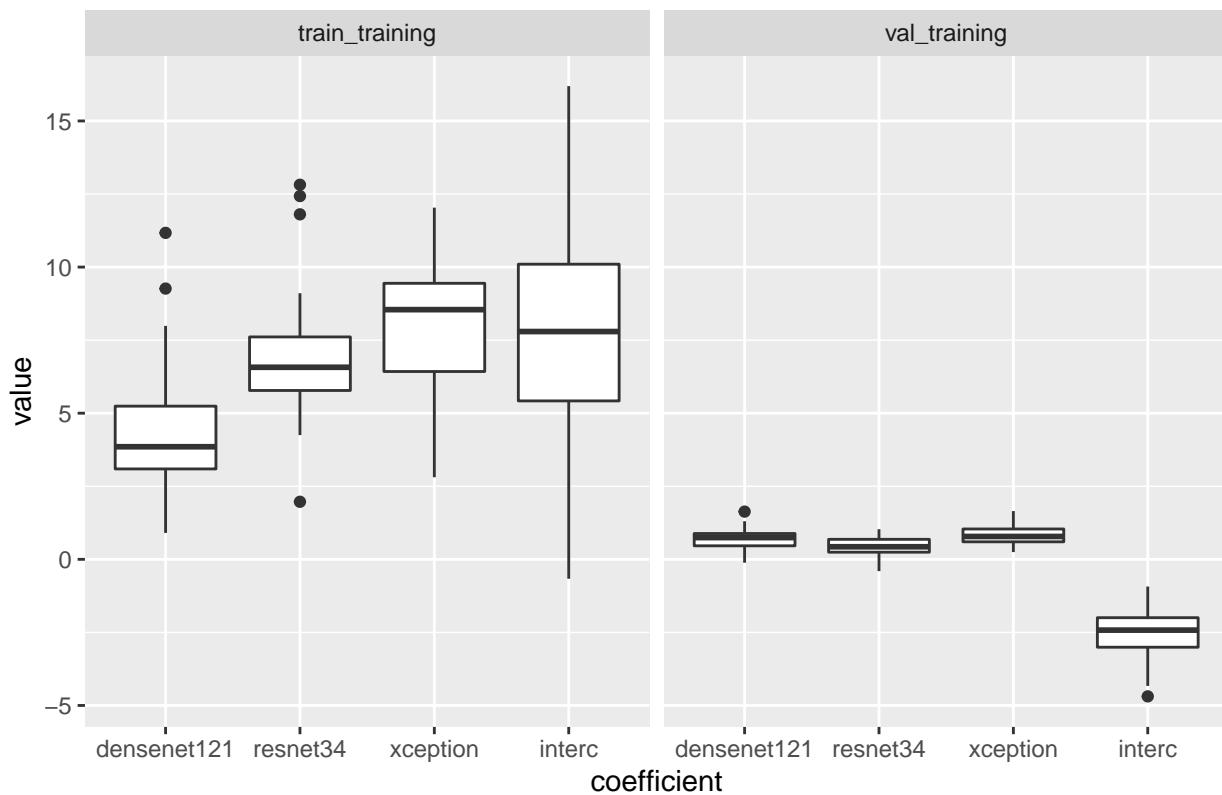
```
lda_coefs <- load_lda_coefs(base_dir, repls, folds)
```

```
for (cl1 in 1:19)
{
  for (cl2 in (cl1 + 1):20)
  {
    cur_plt <- lda_coefs %>% filter(class1 == cl1 & class2 == cl2) %>% ggplot() + geom_boxplot(aes(x=co
  }
}
```

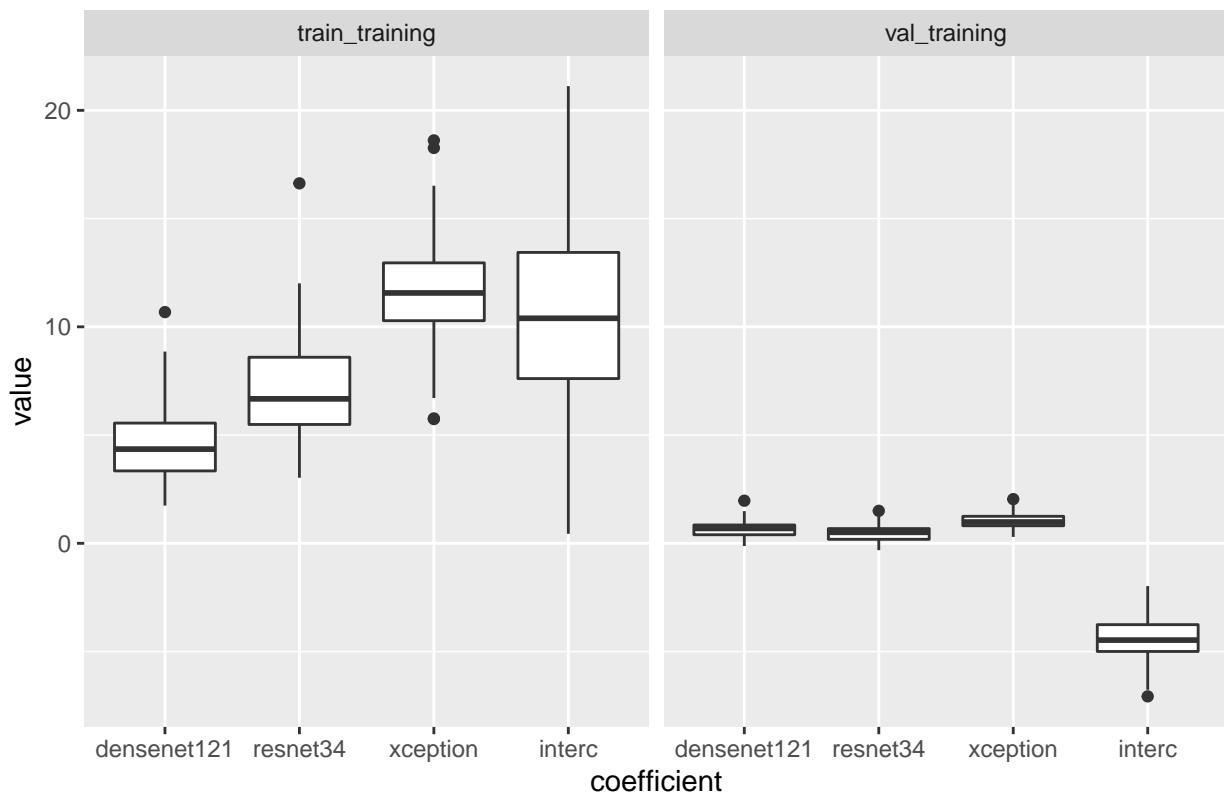
### Coefficients for class 1 vs 2



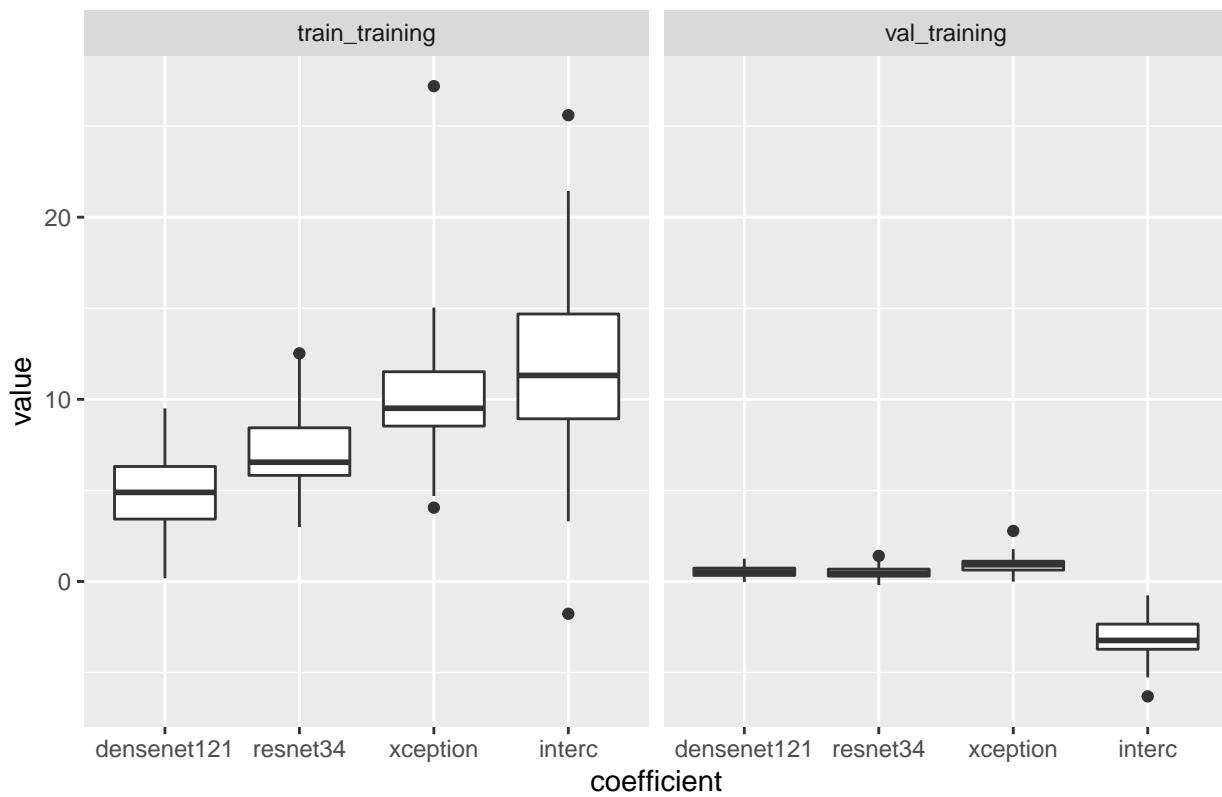
### Coefficients for class 1 vs 3



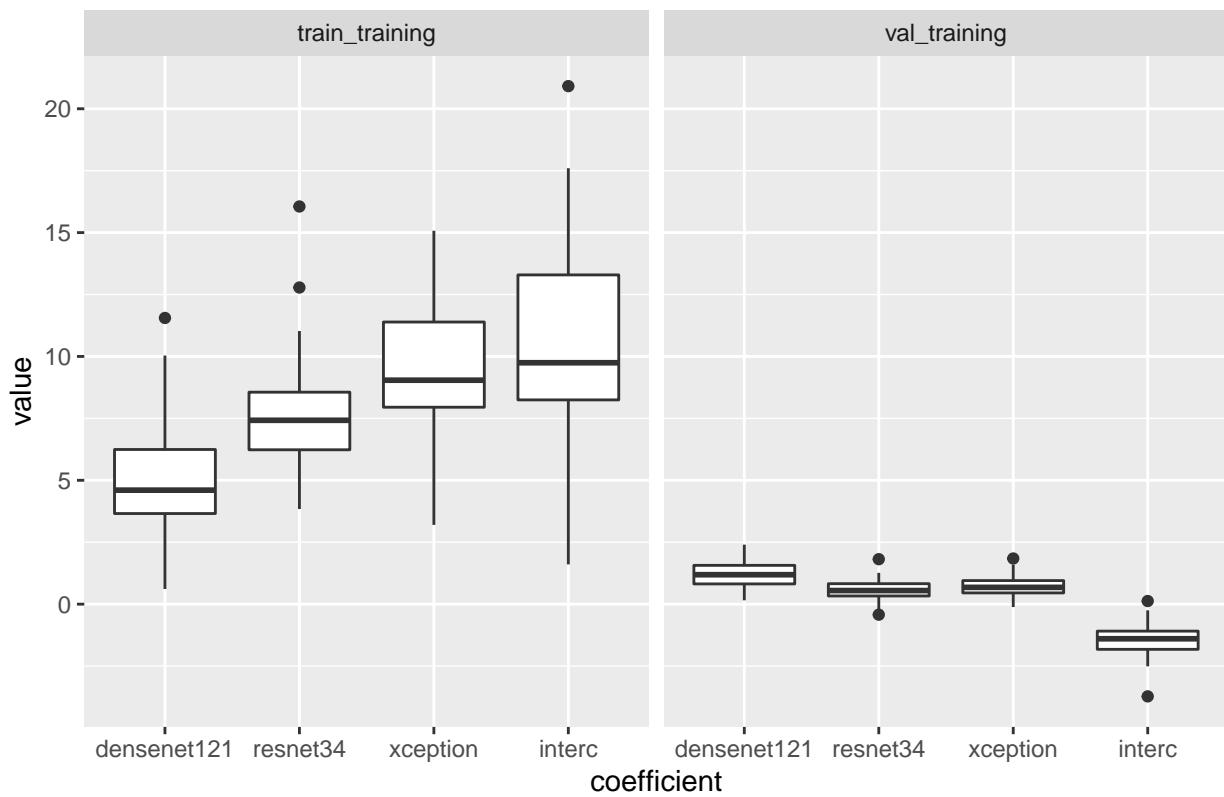
### Coefficients for class 1 vs 4



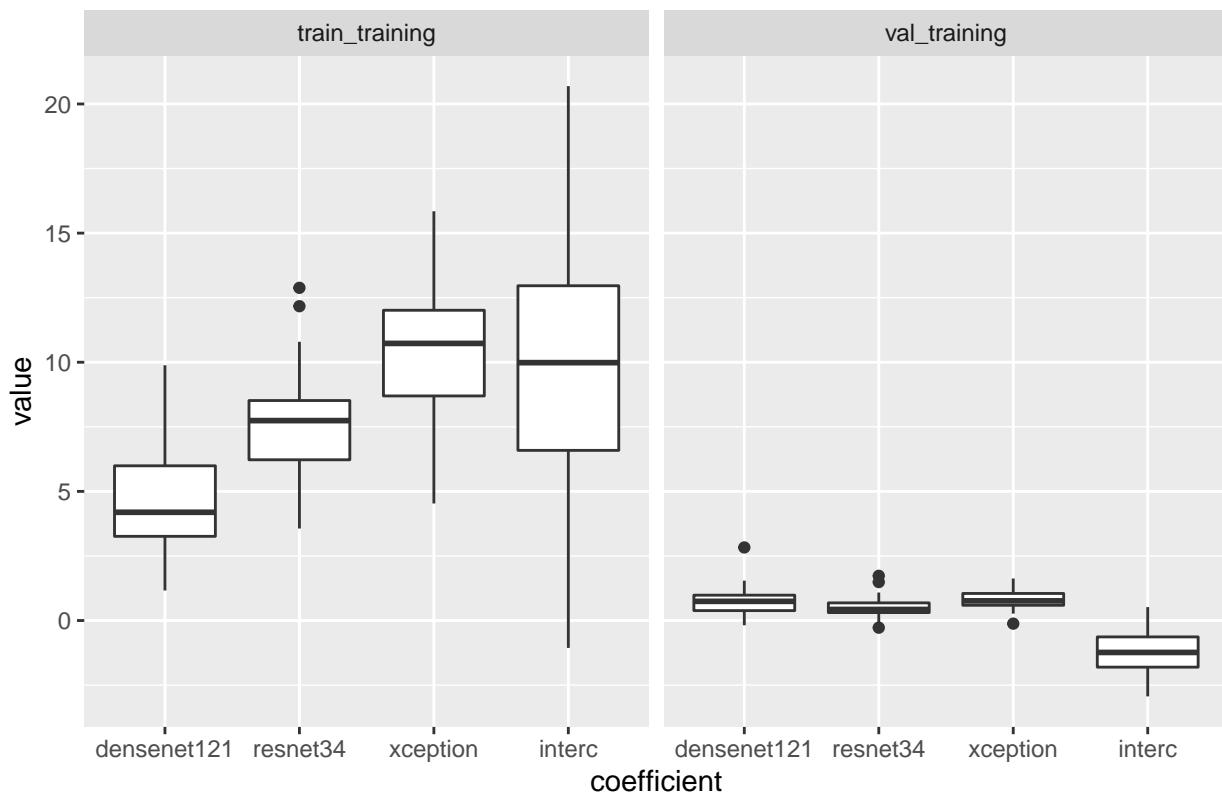
### Coefficients for class 1 vs 5



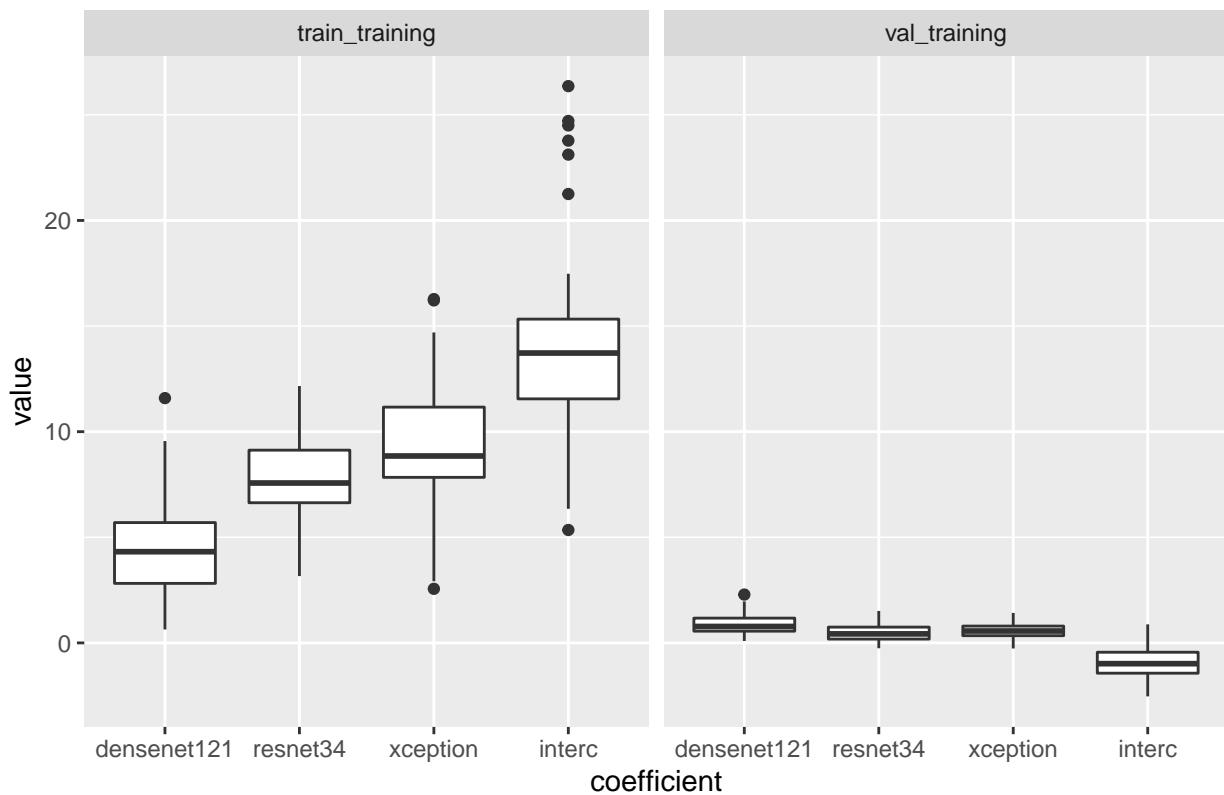
### Coefficients for class 1 vs 6



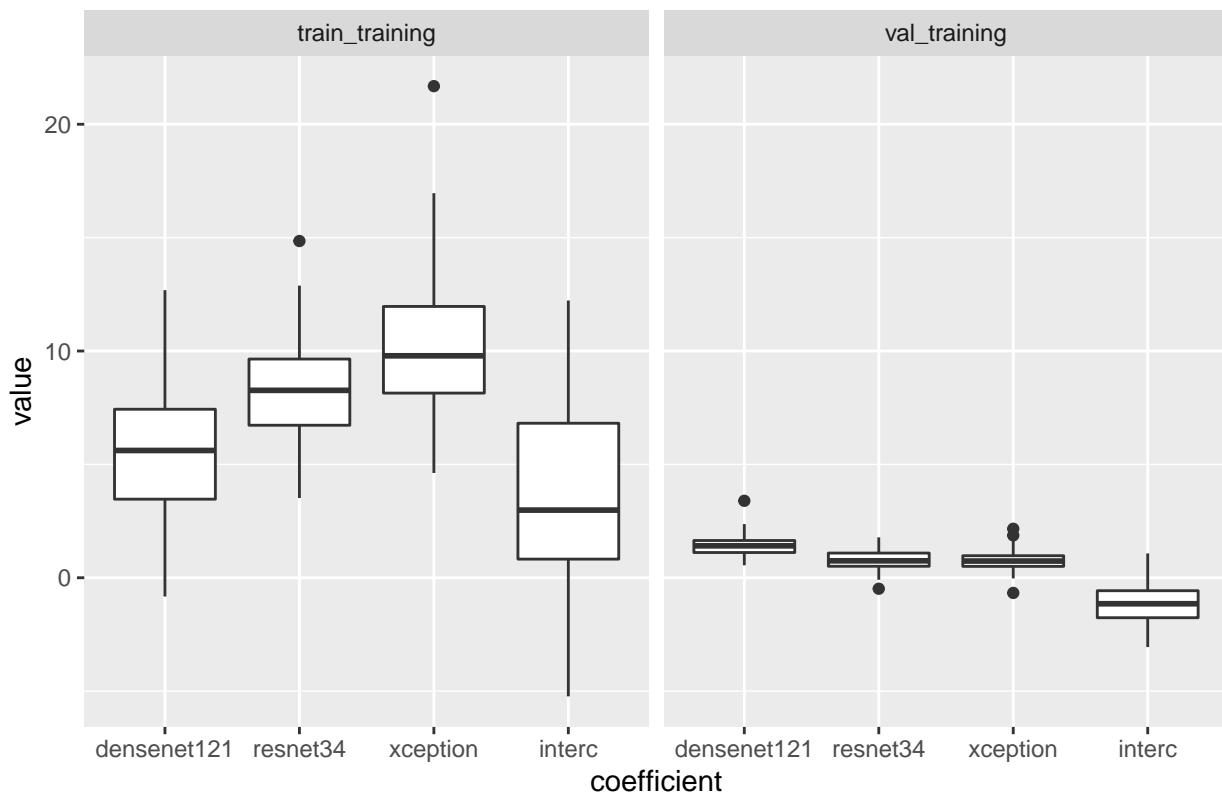
### Coefficients for class 1 vs 7



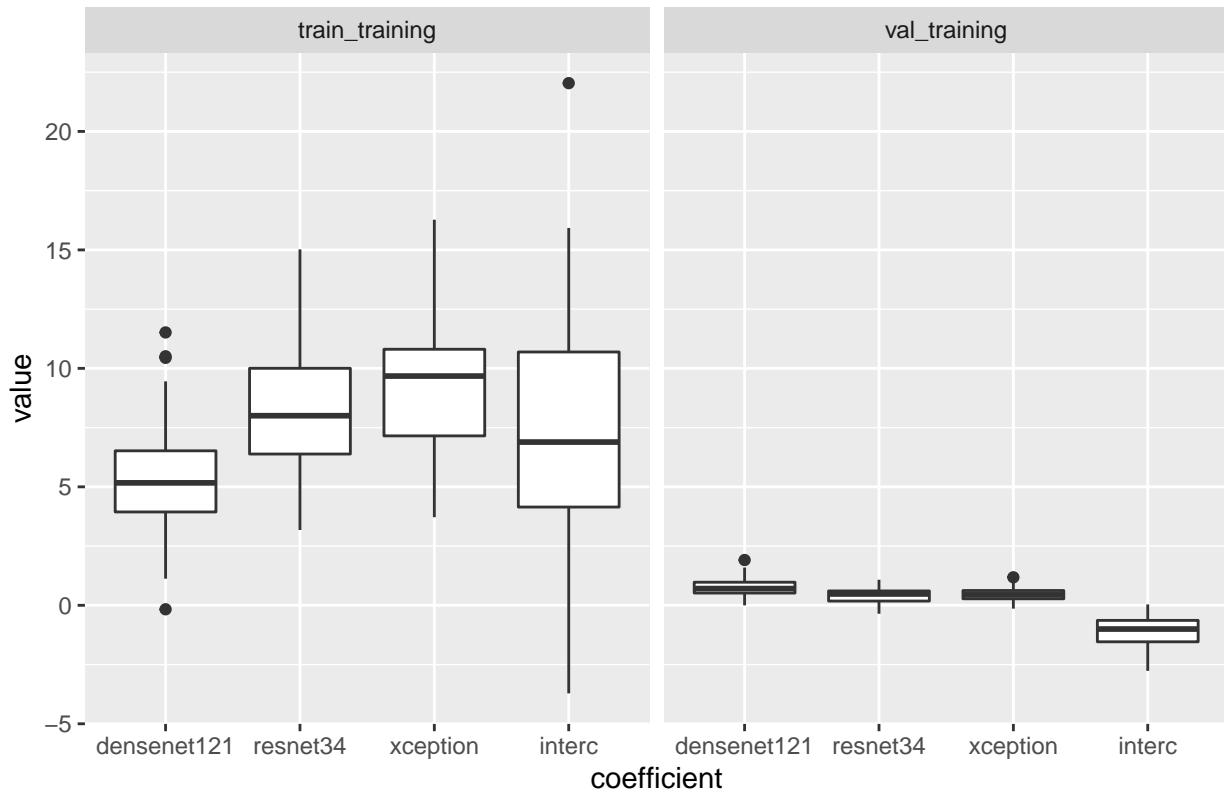
### Coefficients for class 1 vs 8



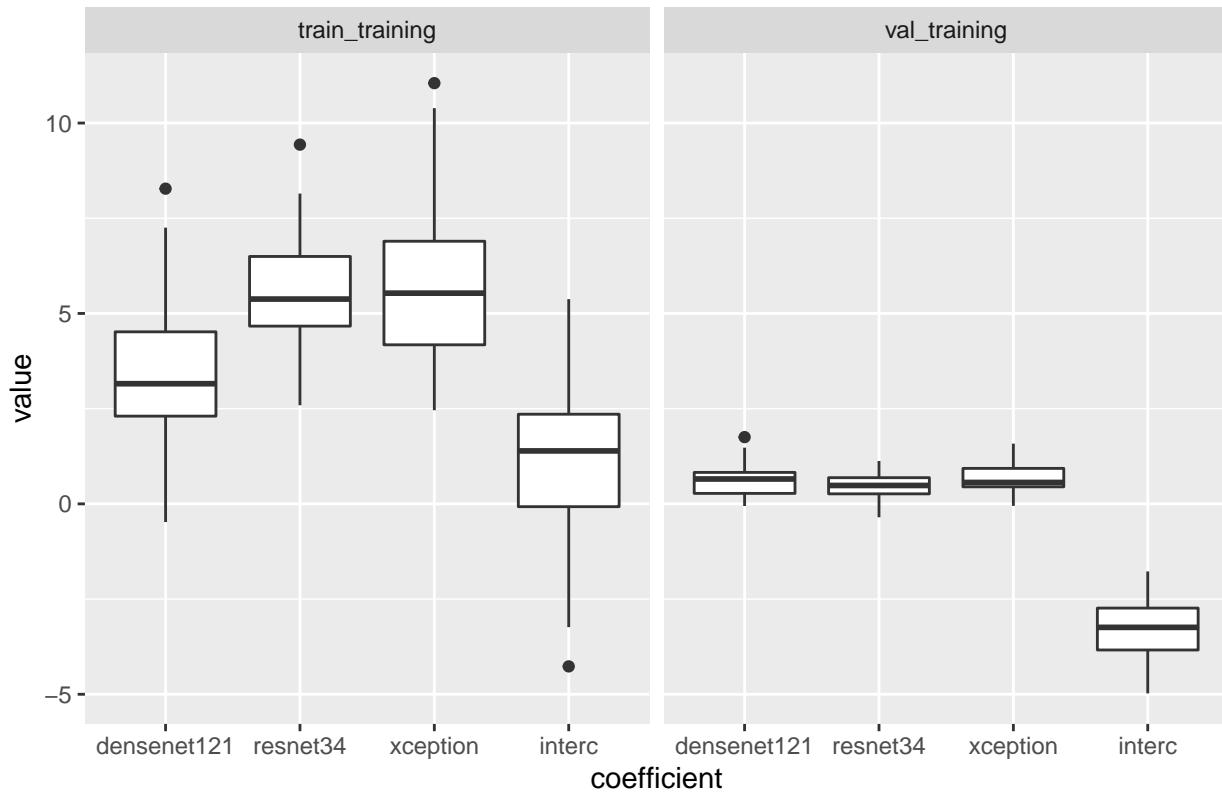
### Coefficients for class 1 vs 9



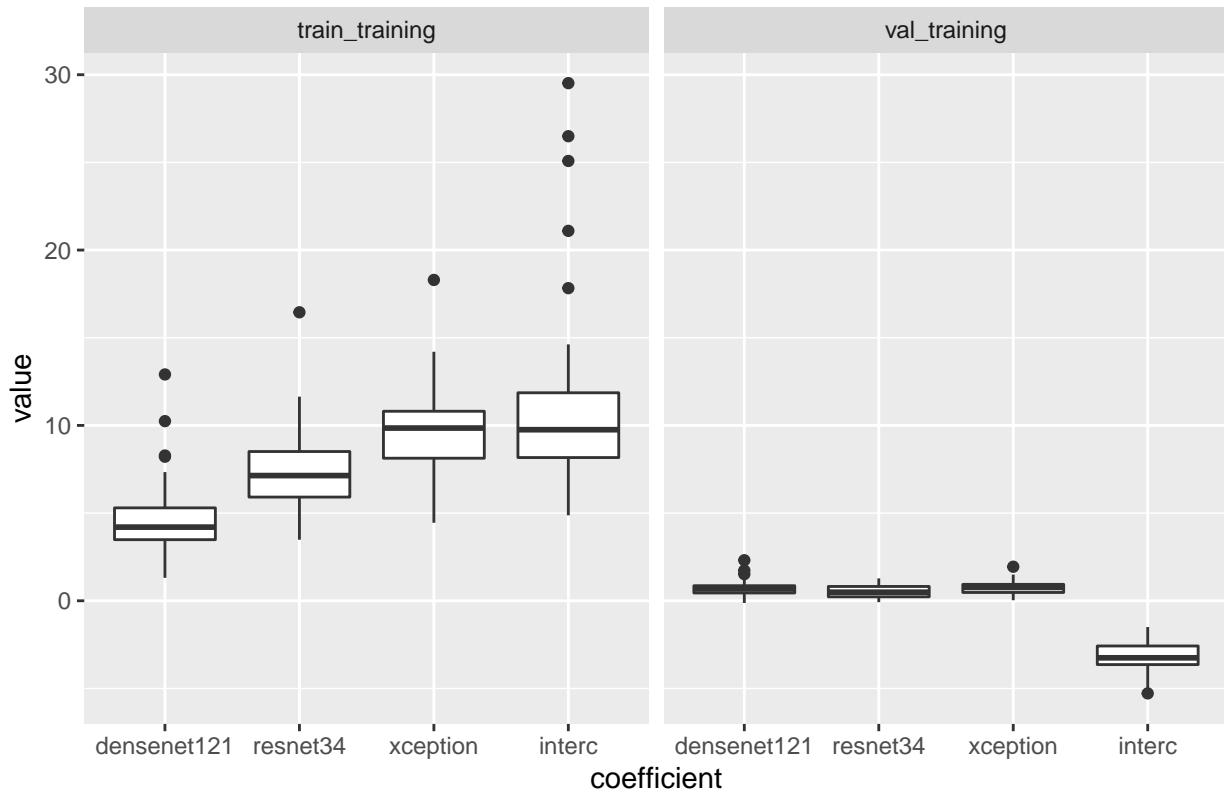
### Coefficients for class 1 vs 10



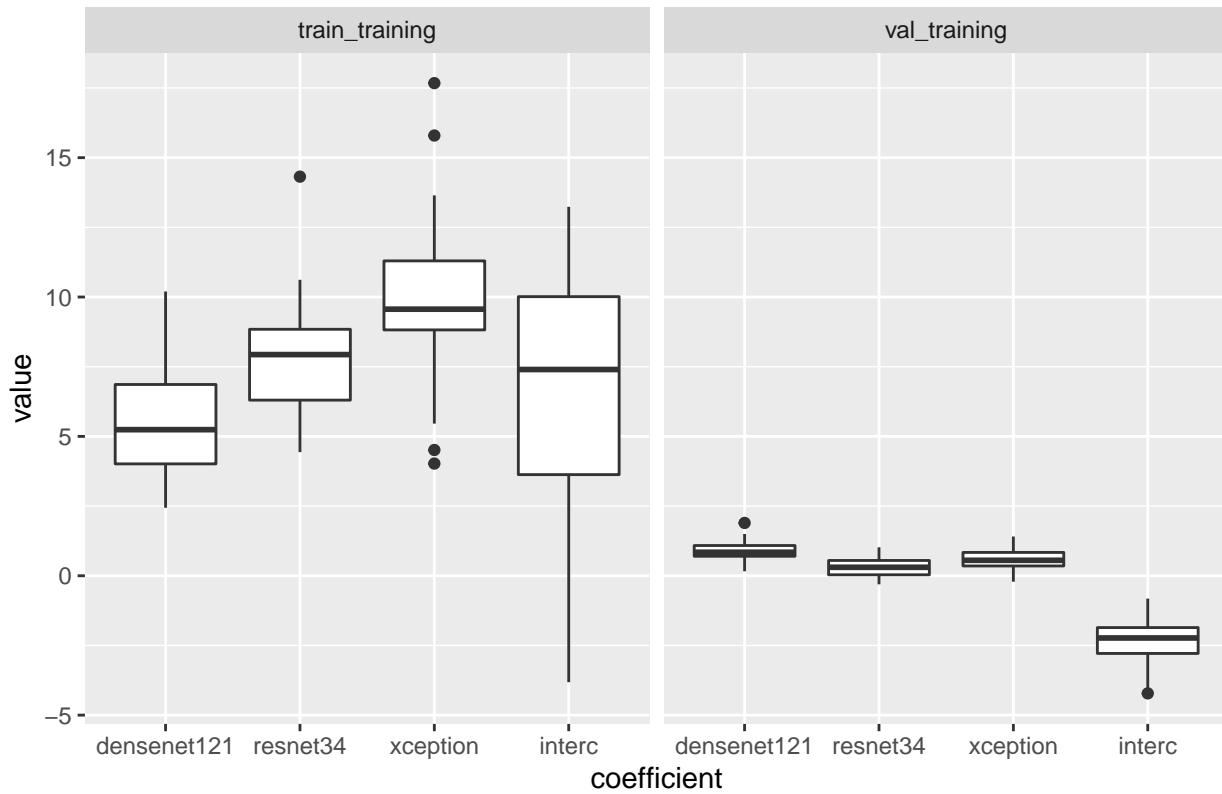
### Coefficients for class 1 vs 11



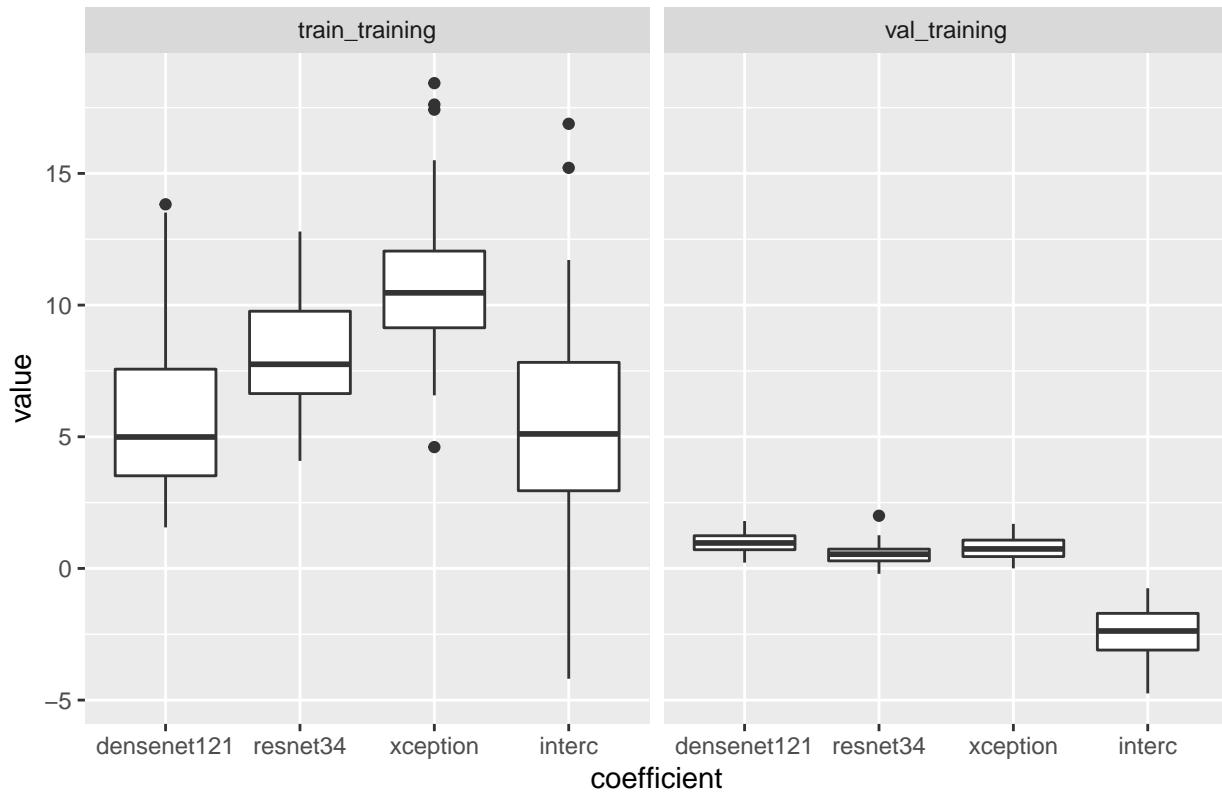
### Coefficients for class 1 vs 12



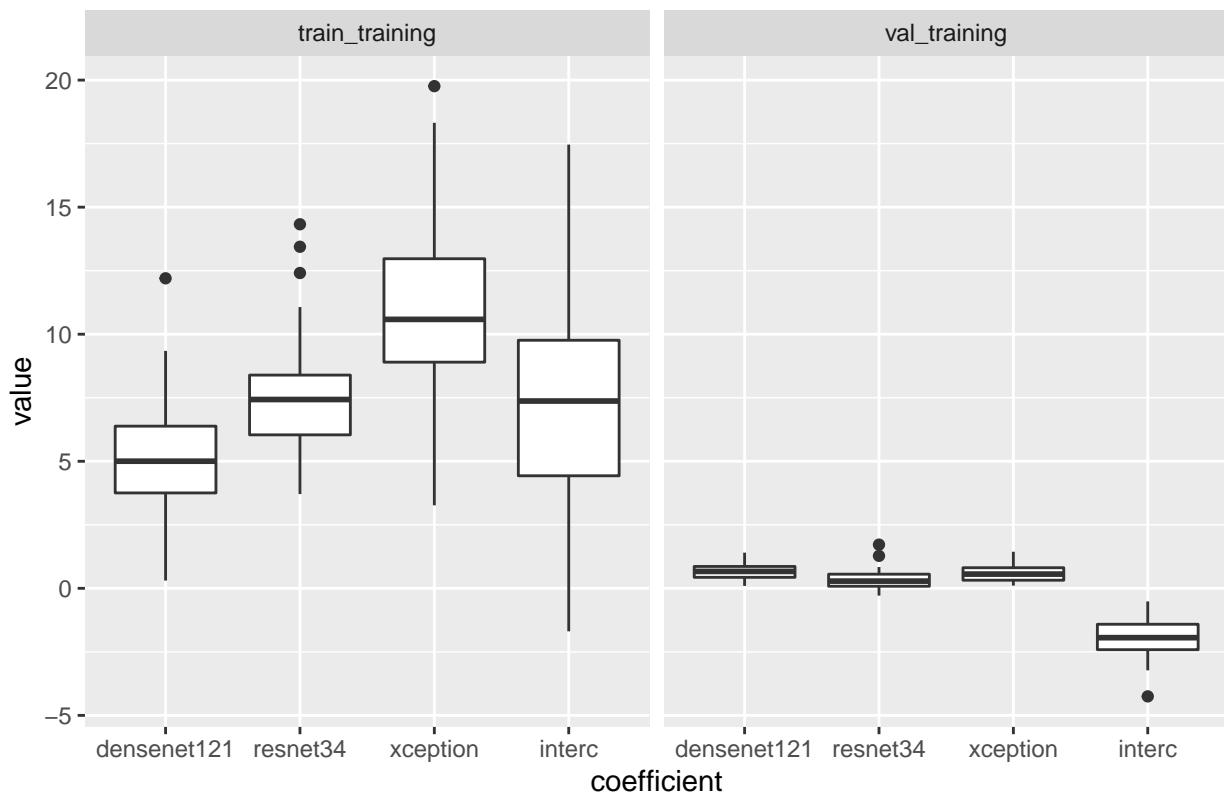
### Coefficients for class 1 vs 13



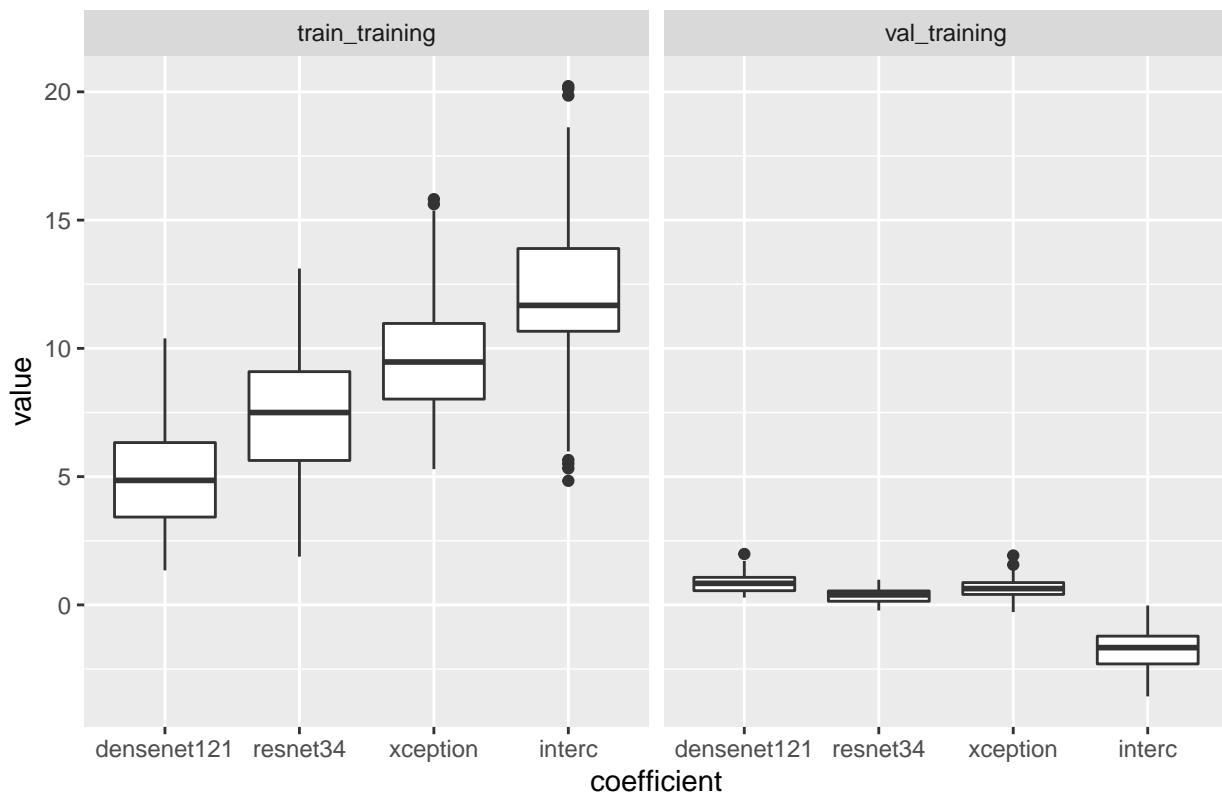
### Coefficients for class 1 vs 14



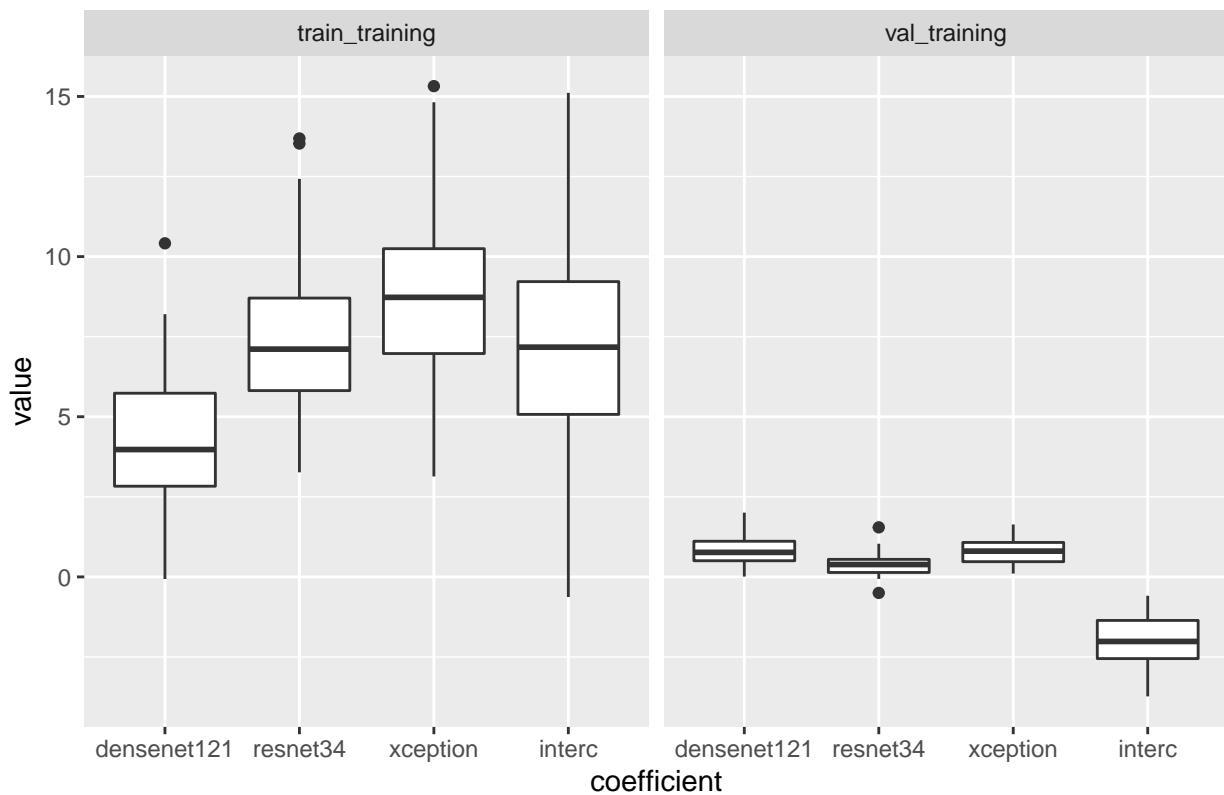
### Coefficients for class 1 vs 15



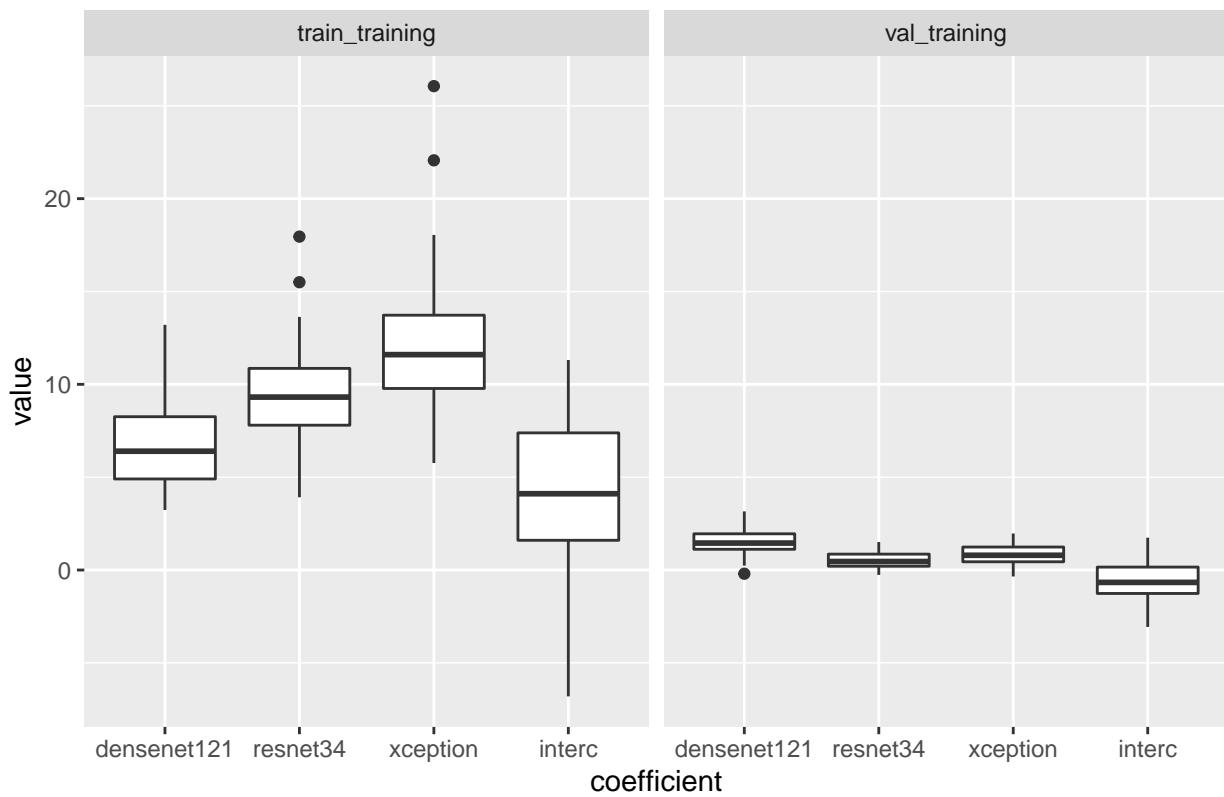
### Coefficients for class 1 vs 16



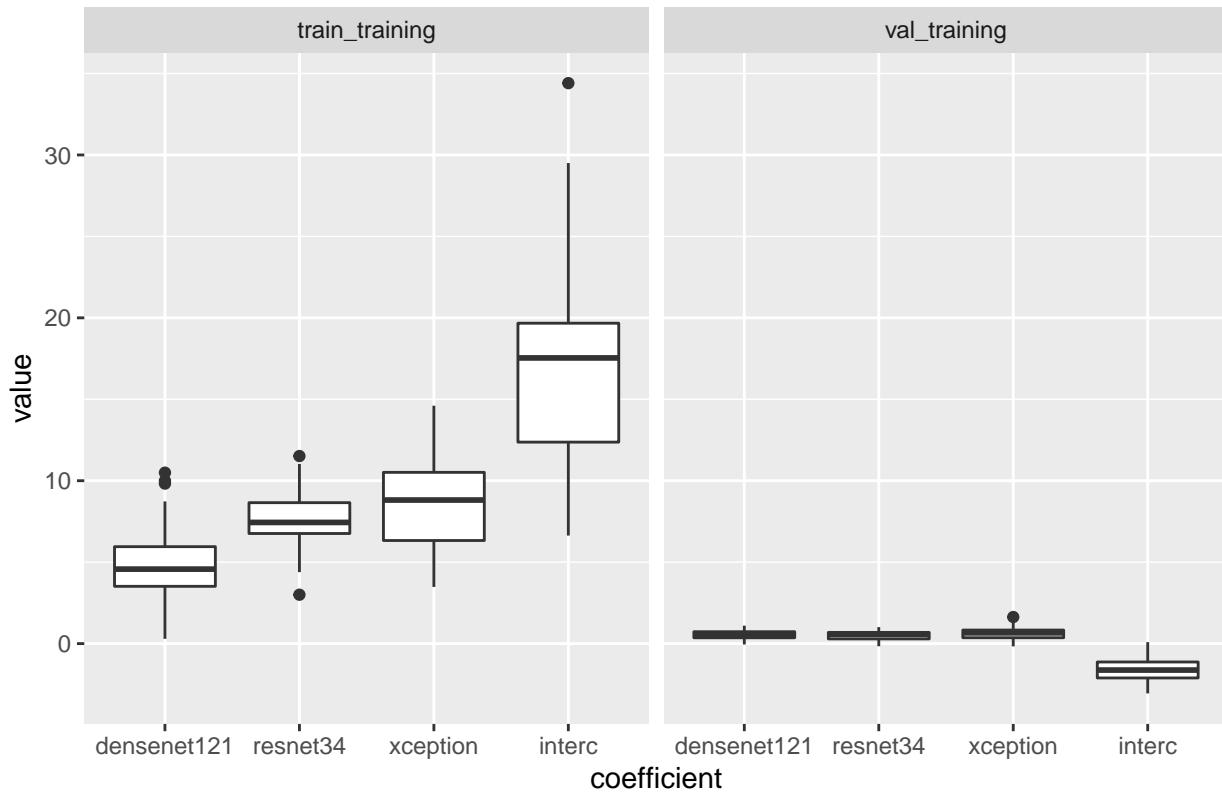
## Coefficients for class 1 vs 17



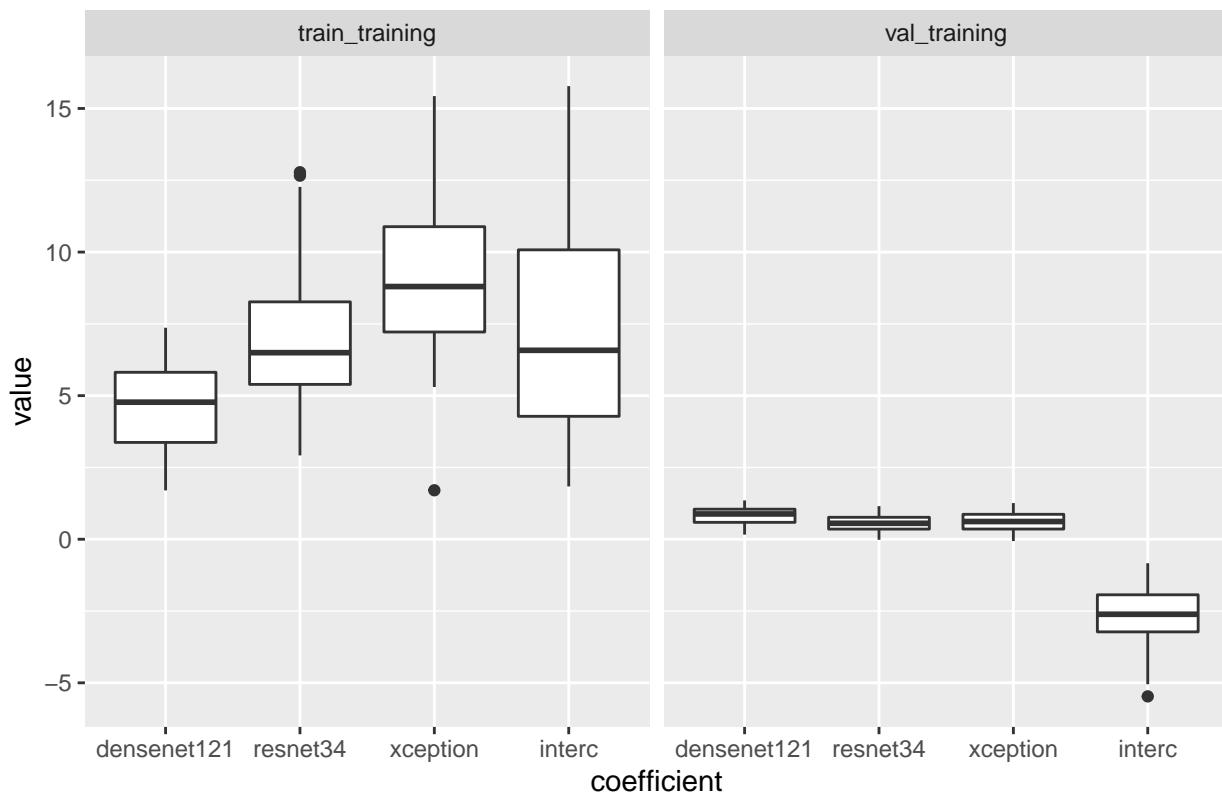
### Coefficients for class 1 vs 18



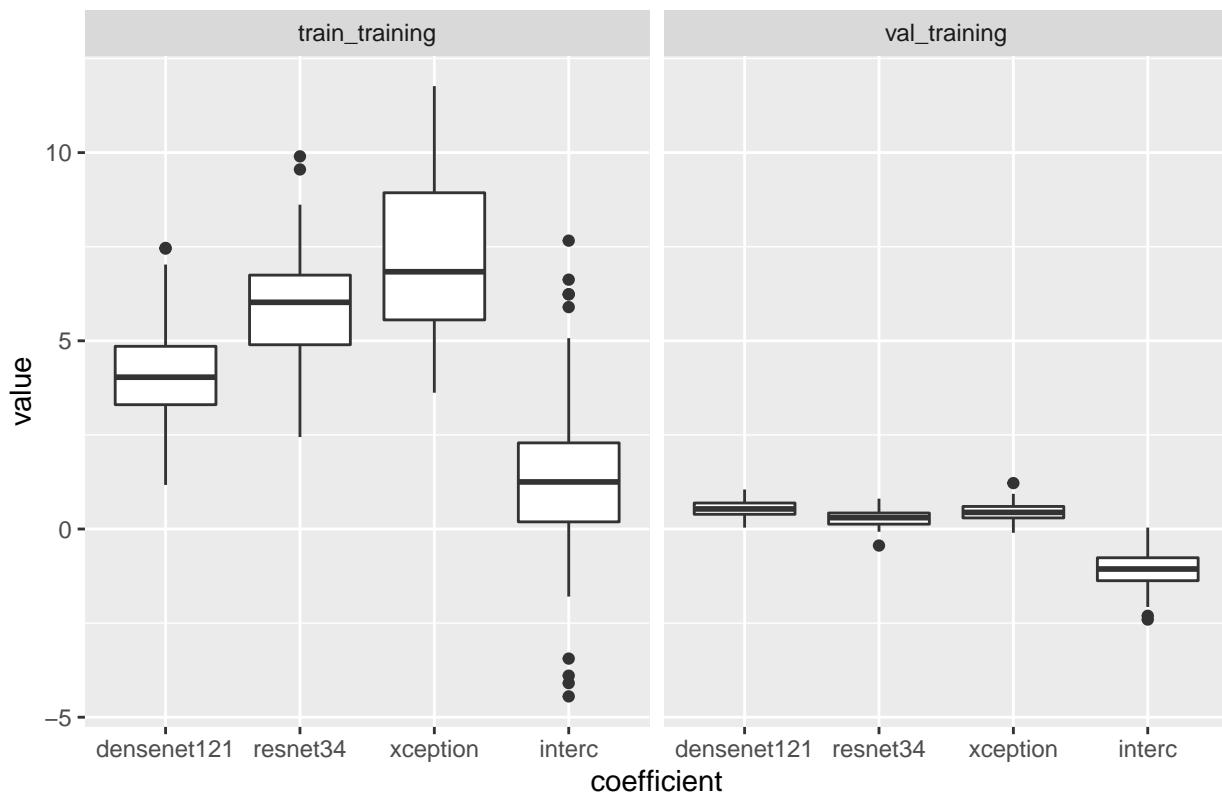
### Coefficients for class 1 vs 19



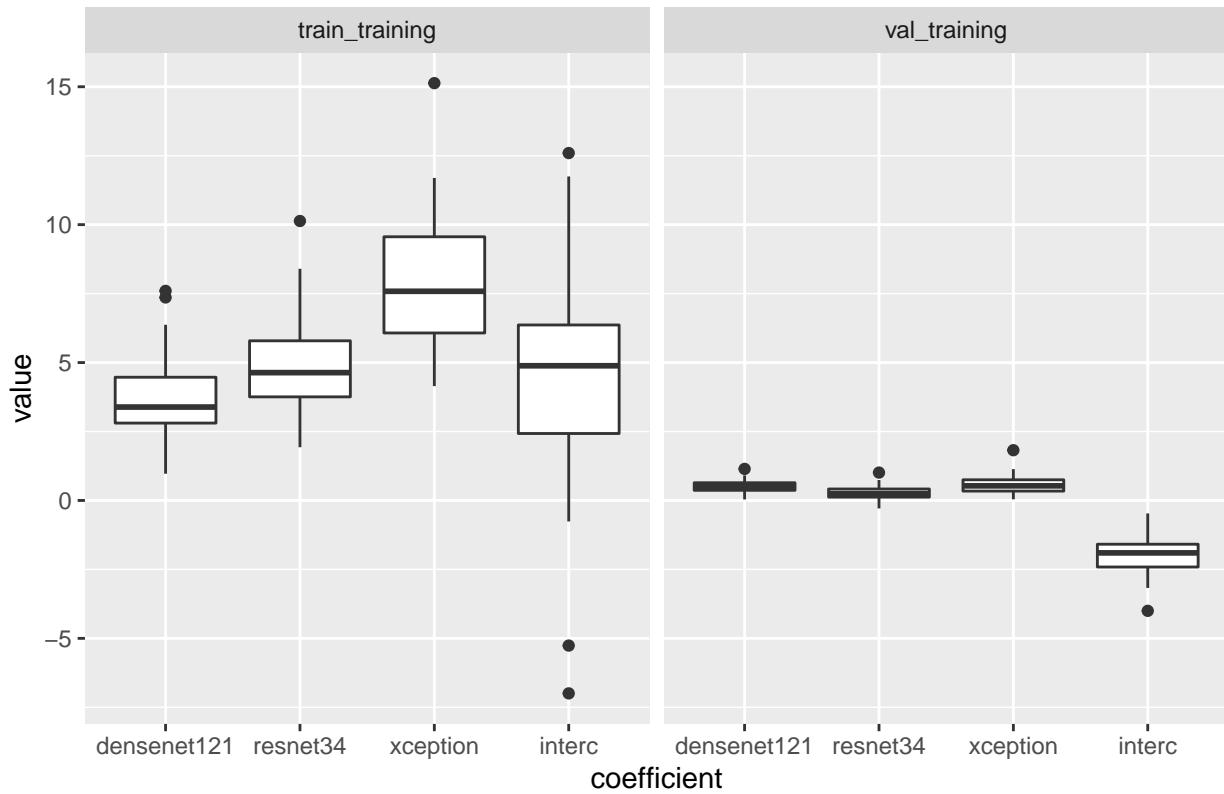
### Coefficients for class 1 vs 20



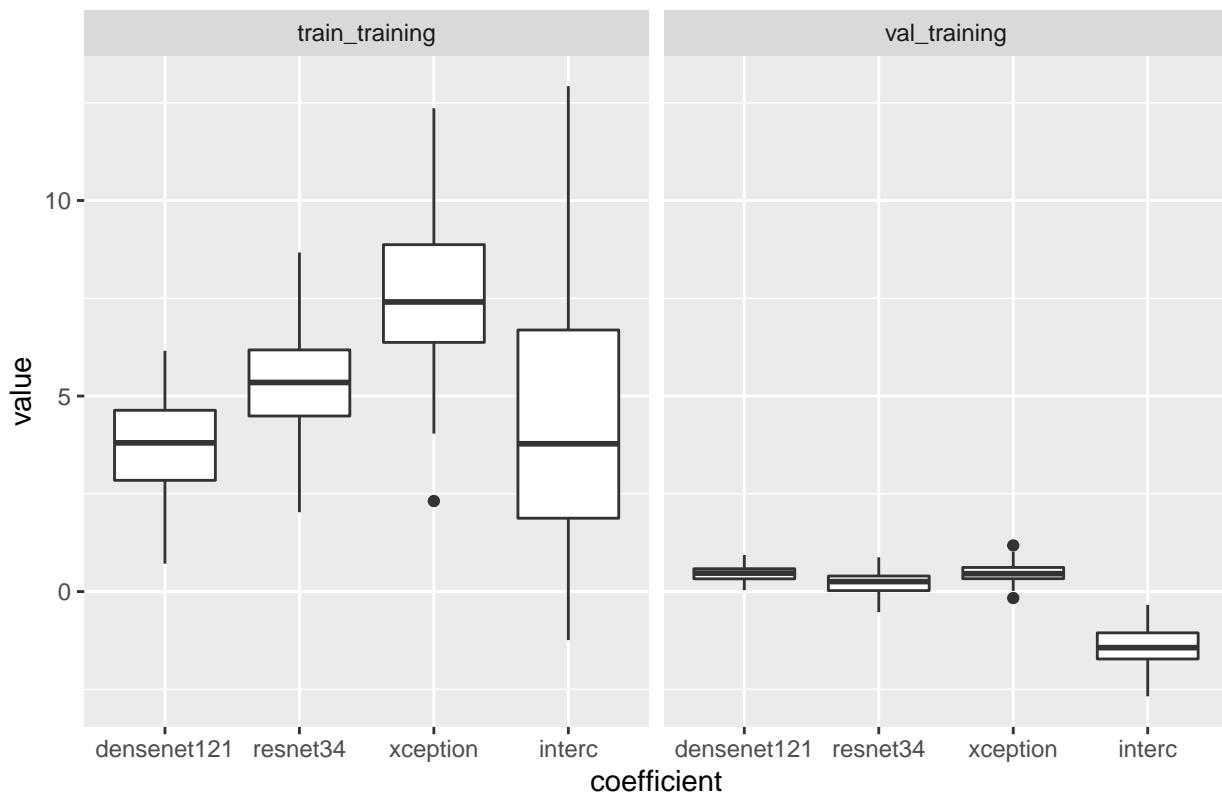
### Coefficients for class 2 vs 3



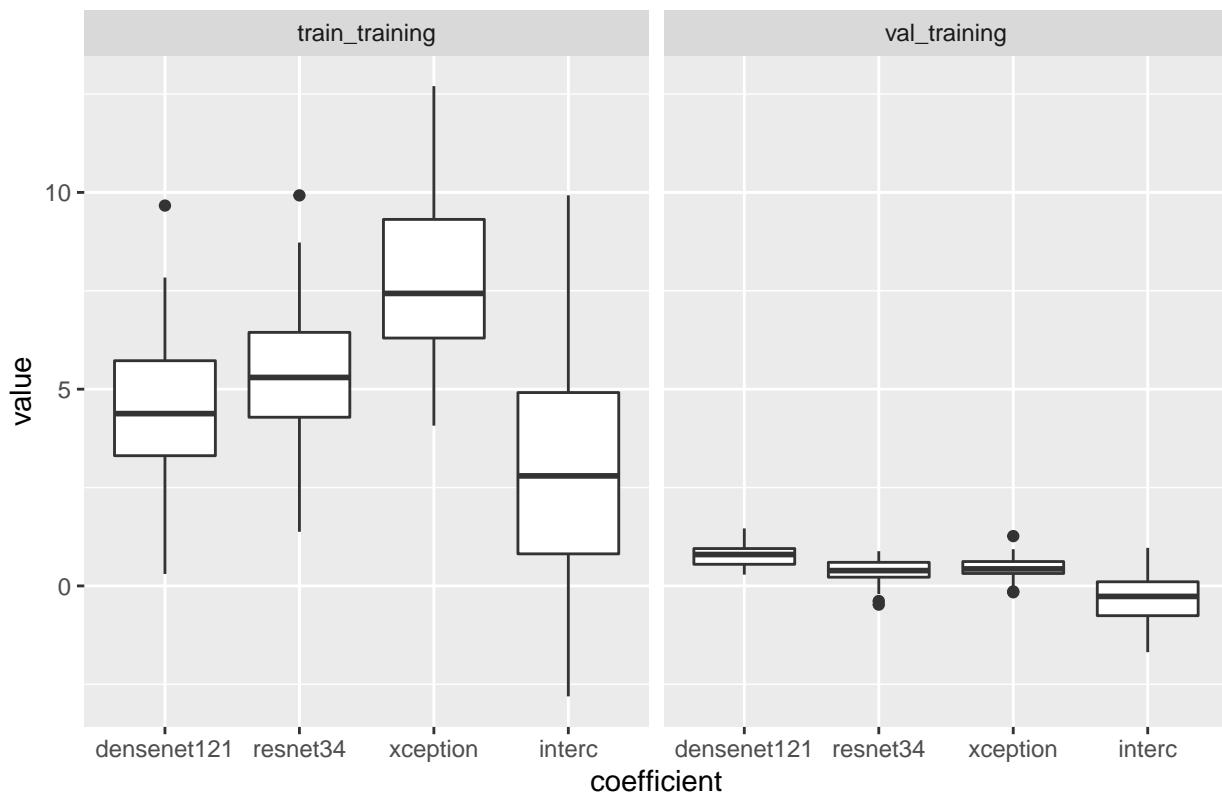
### Coefficients for class 2 vs 4



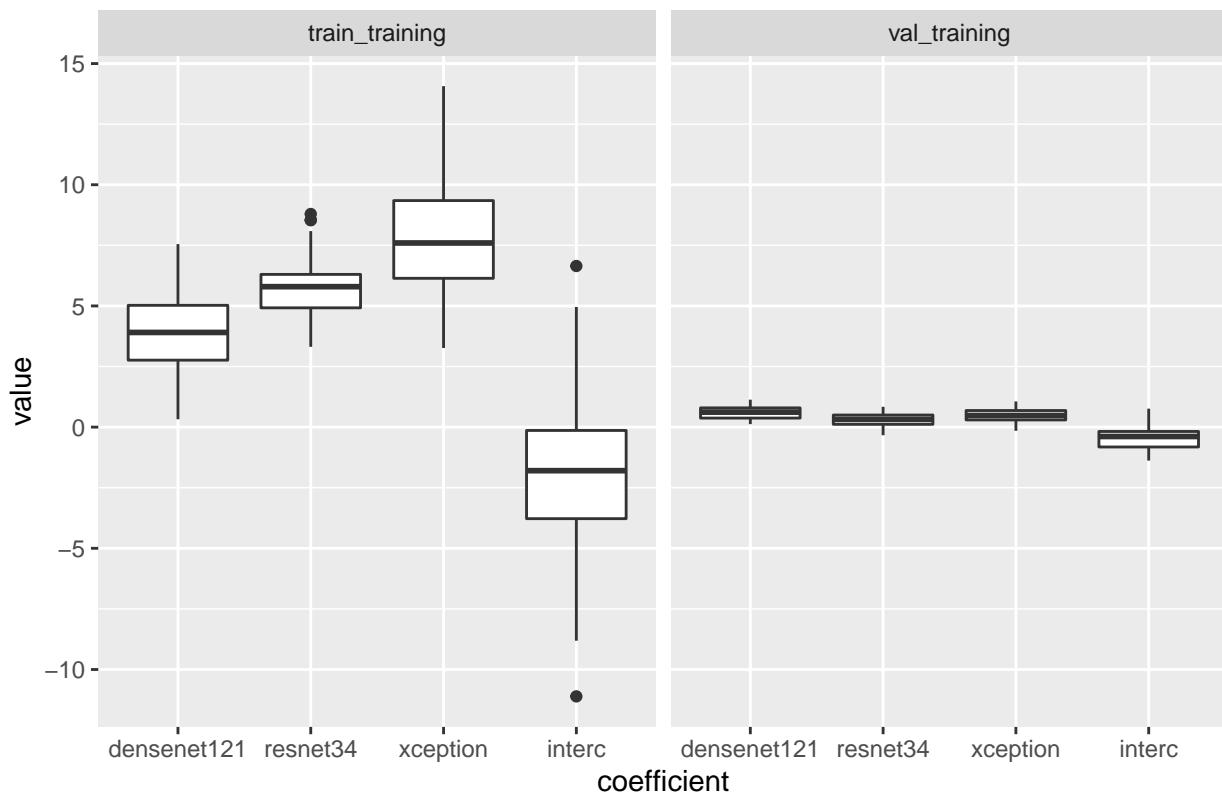
### Coefficients for class 2 vs 5



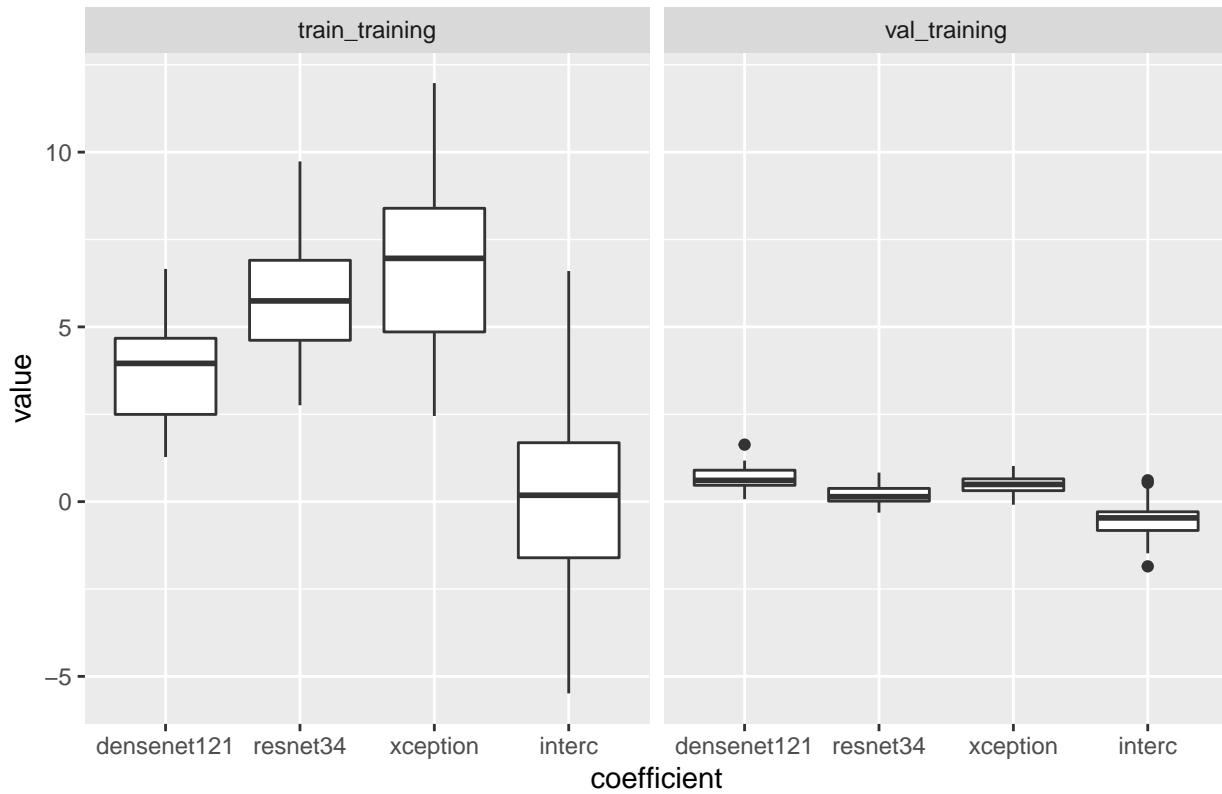
## Coefficients for class 2 vs 6



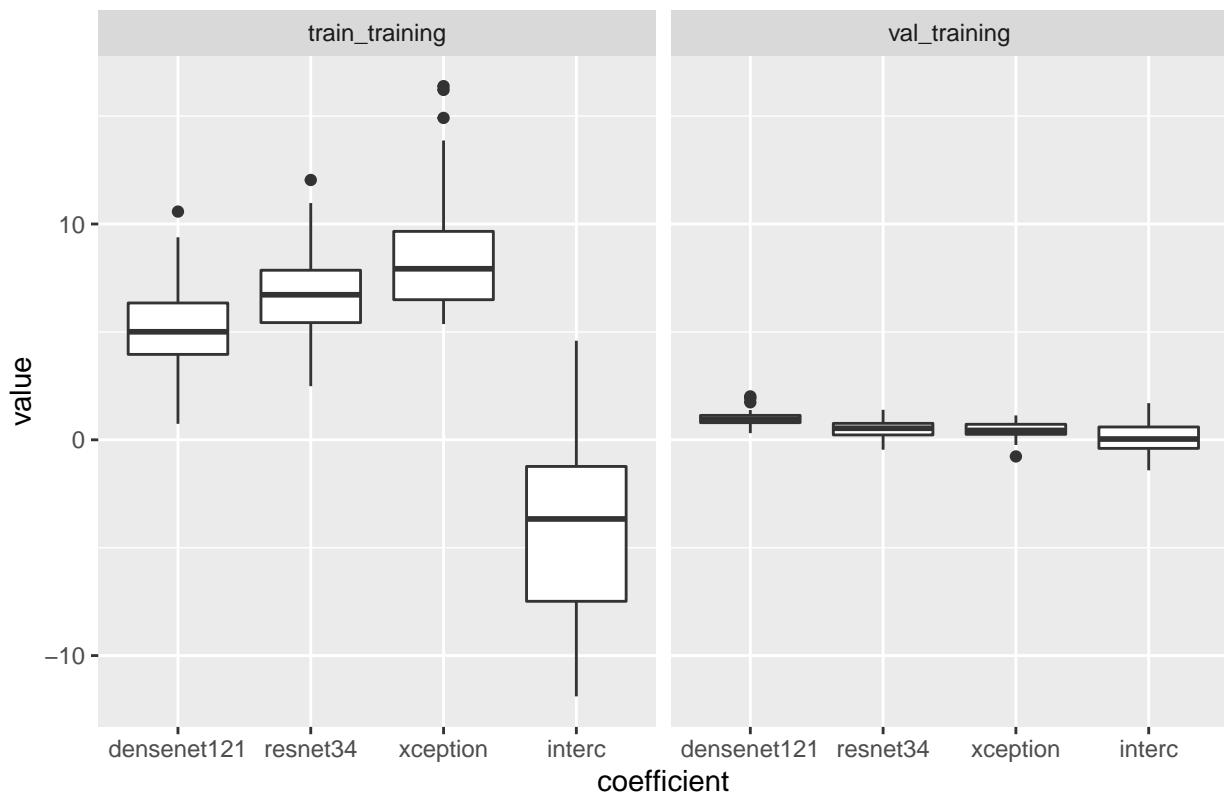
## Coefficients for class 2 vs 7



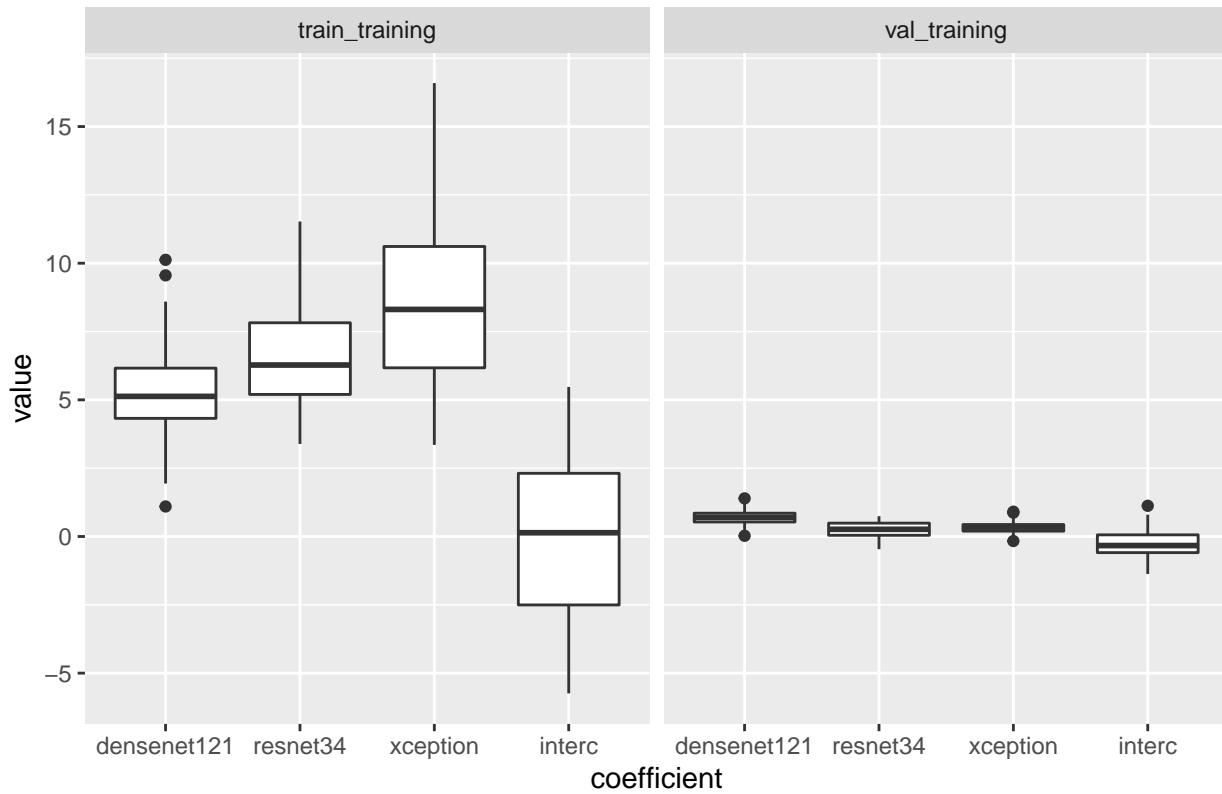
## Coefficients for class 2 vs 8



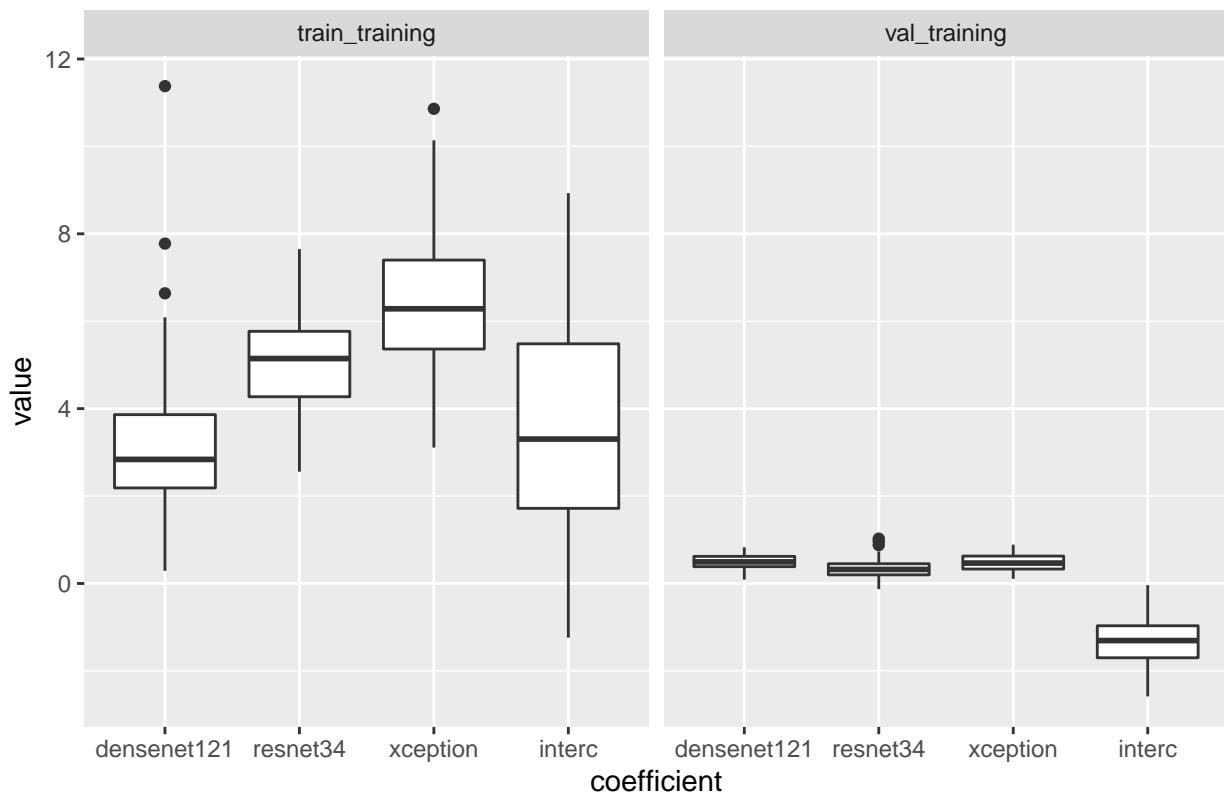
## Coefficients for class 2 vs 9



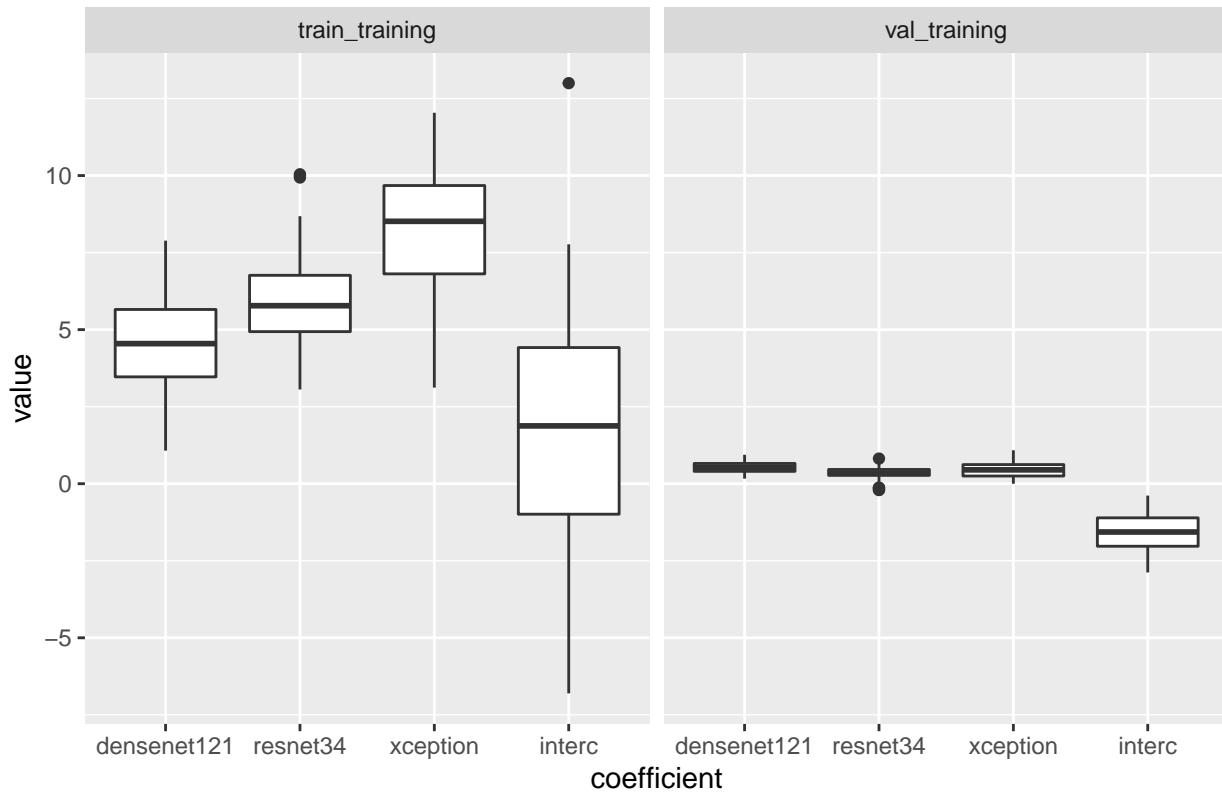
### Coefficients for class 2 vs 10



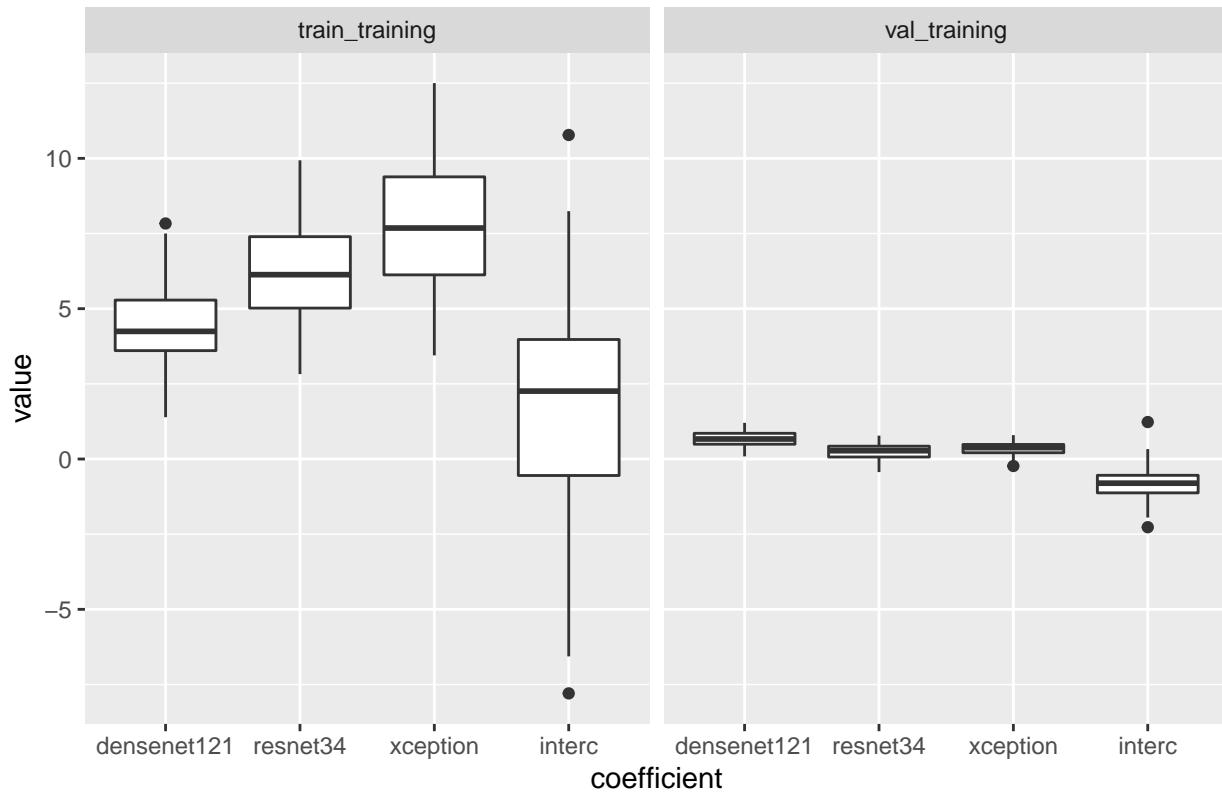
### Coefficients for class 2 vs 11



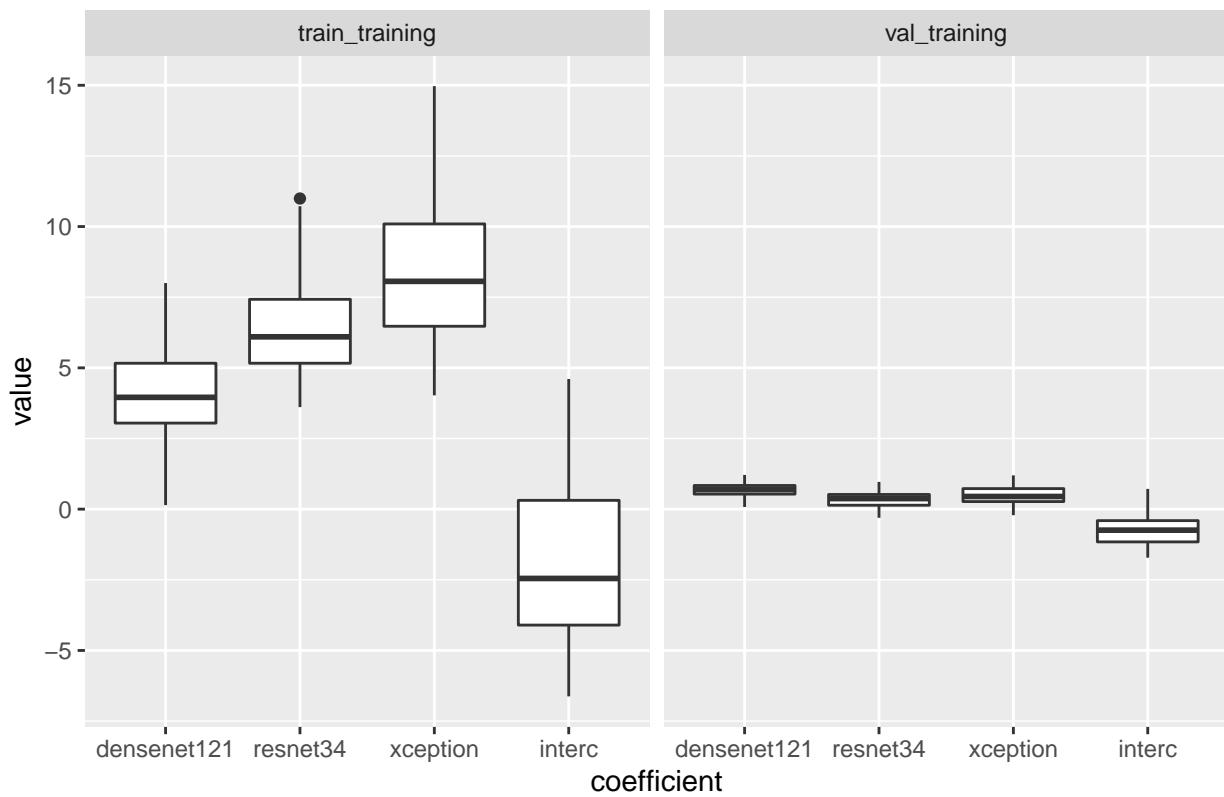
## Coefficients for class 2 vs 12



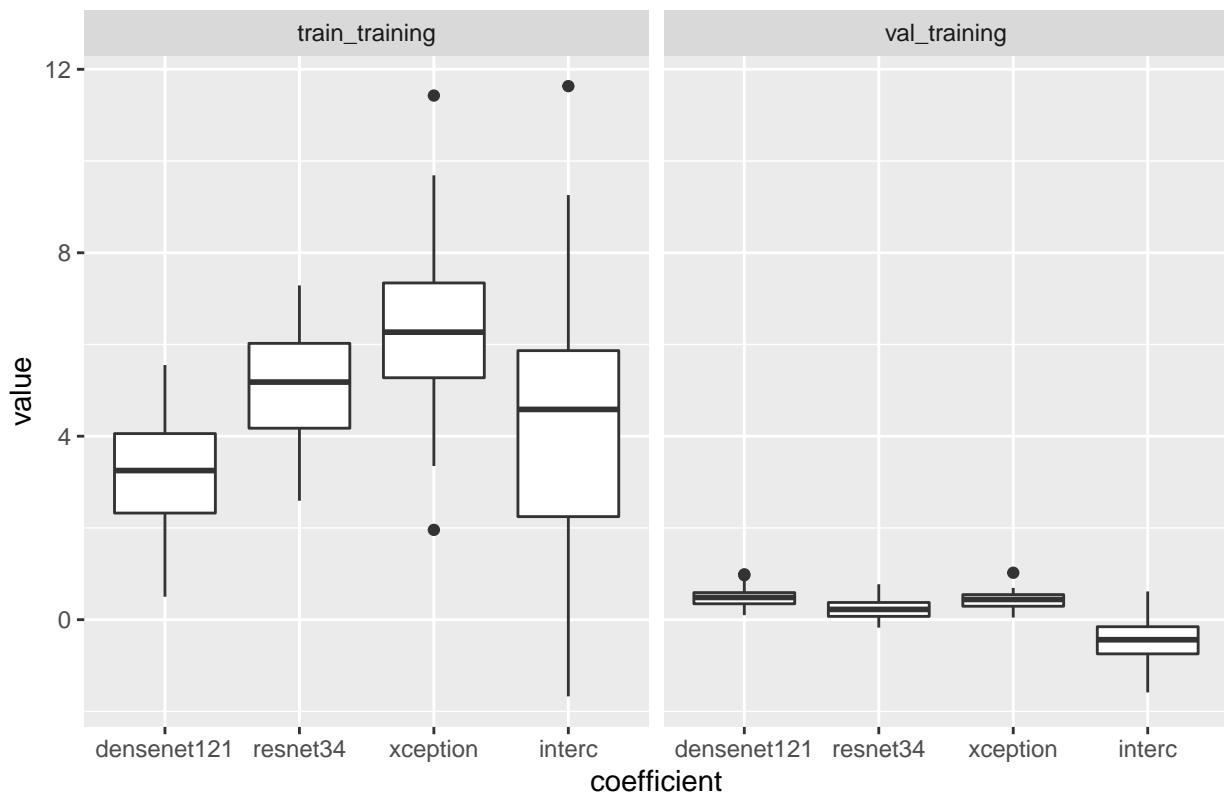
### Coefficients for class 2 vs 13



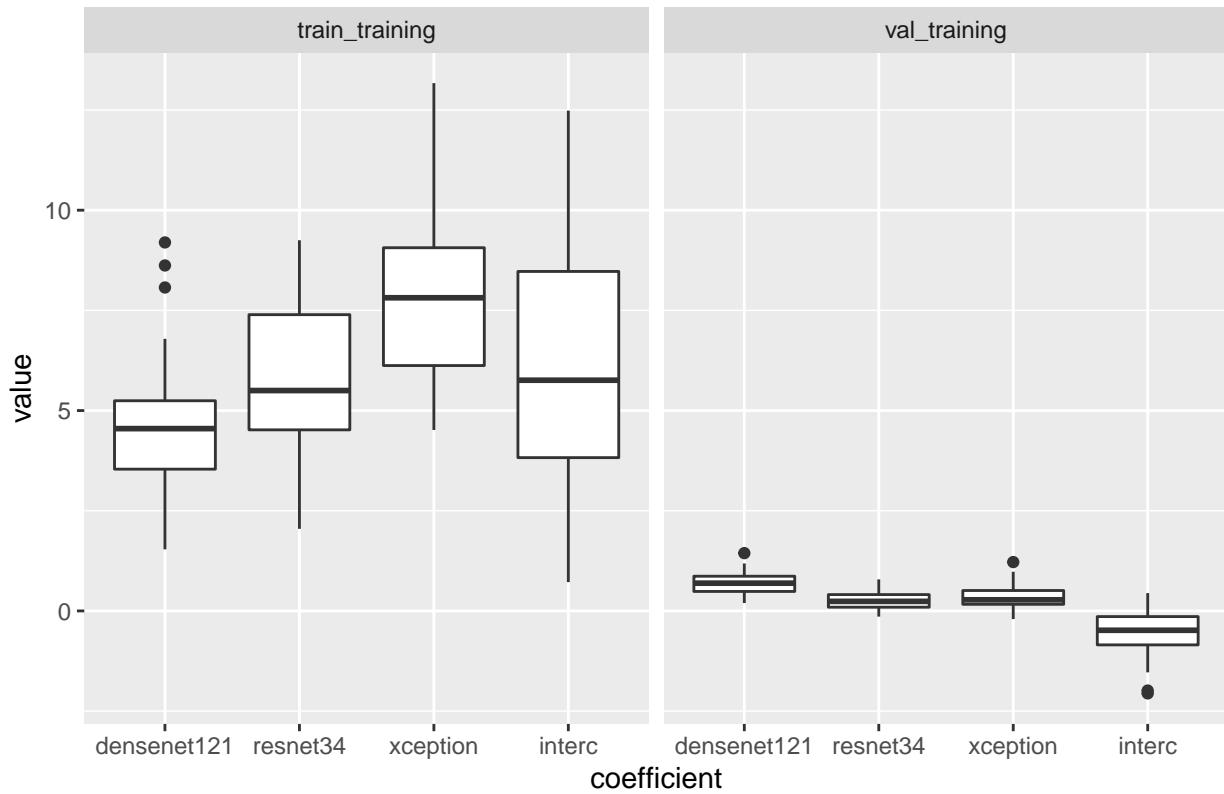
### Coefficients for class 2 vs 14



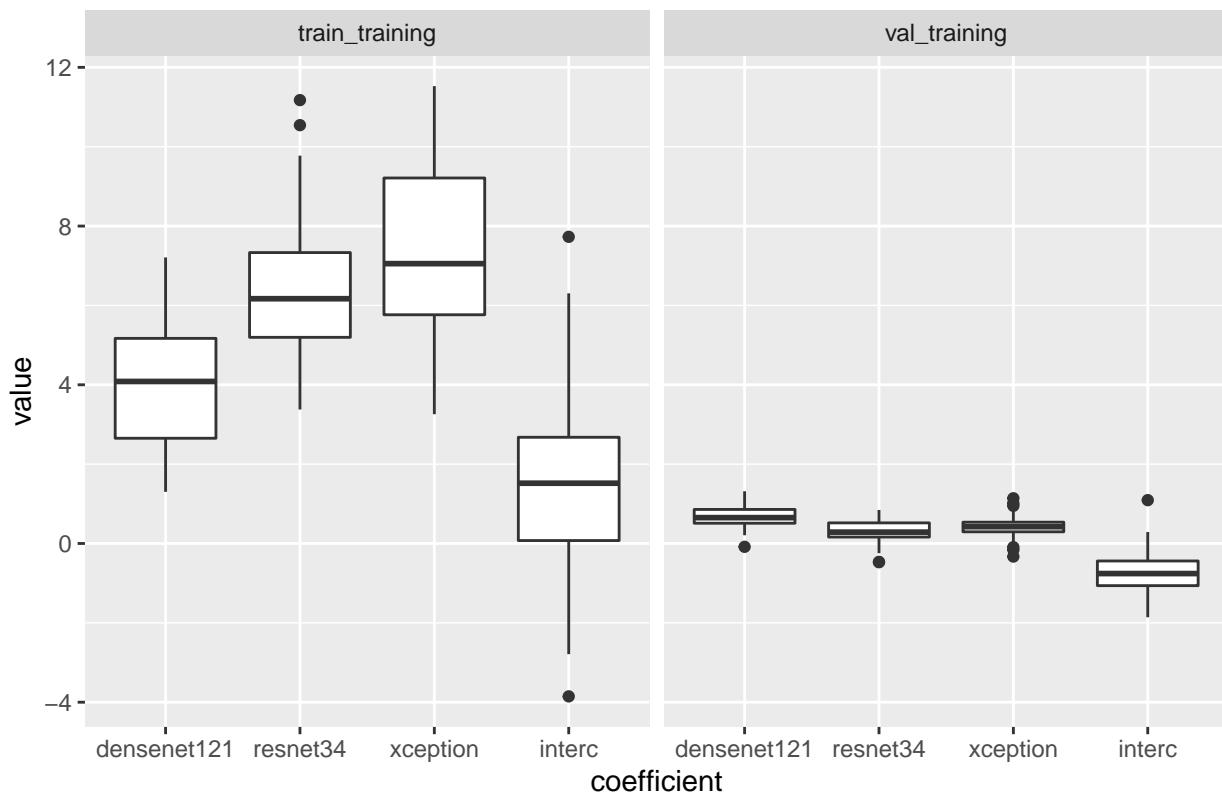
### Coefficients for class 2 vs 15



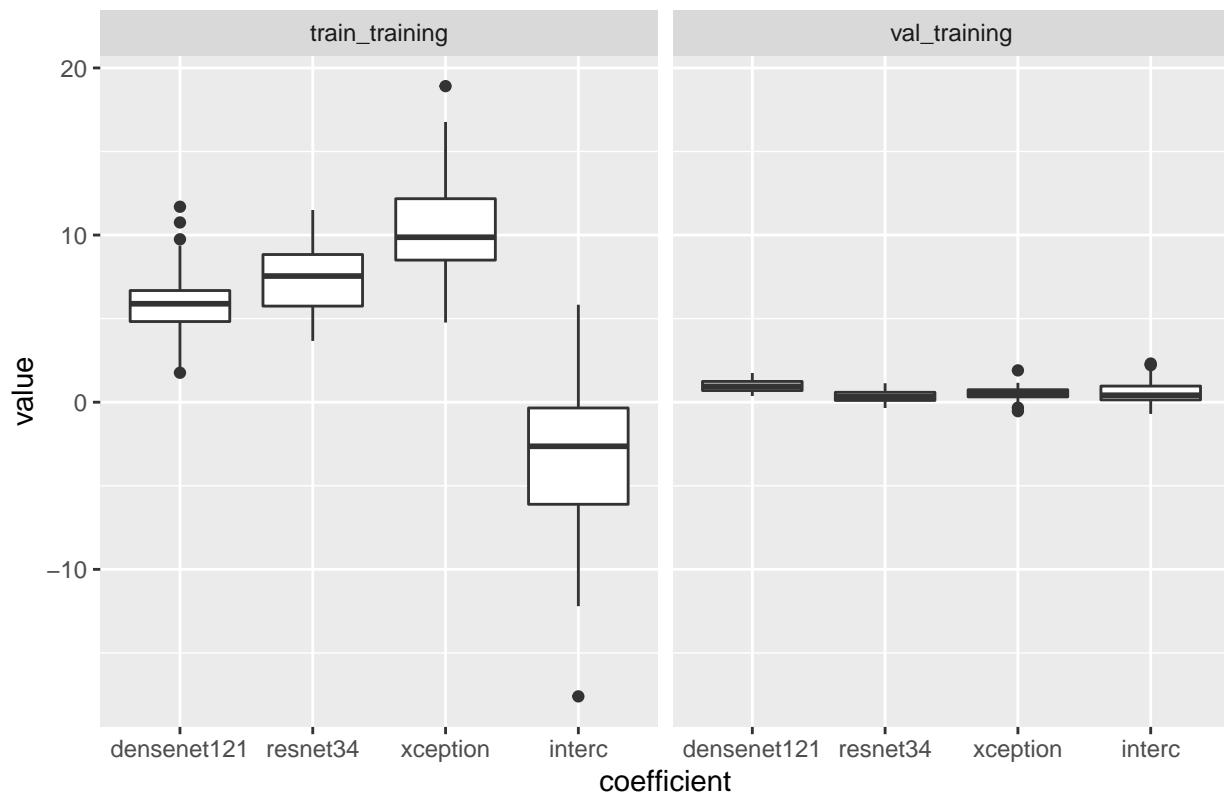
## Coefficients for class 2 vs 16



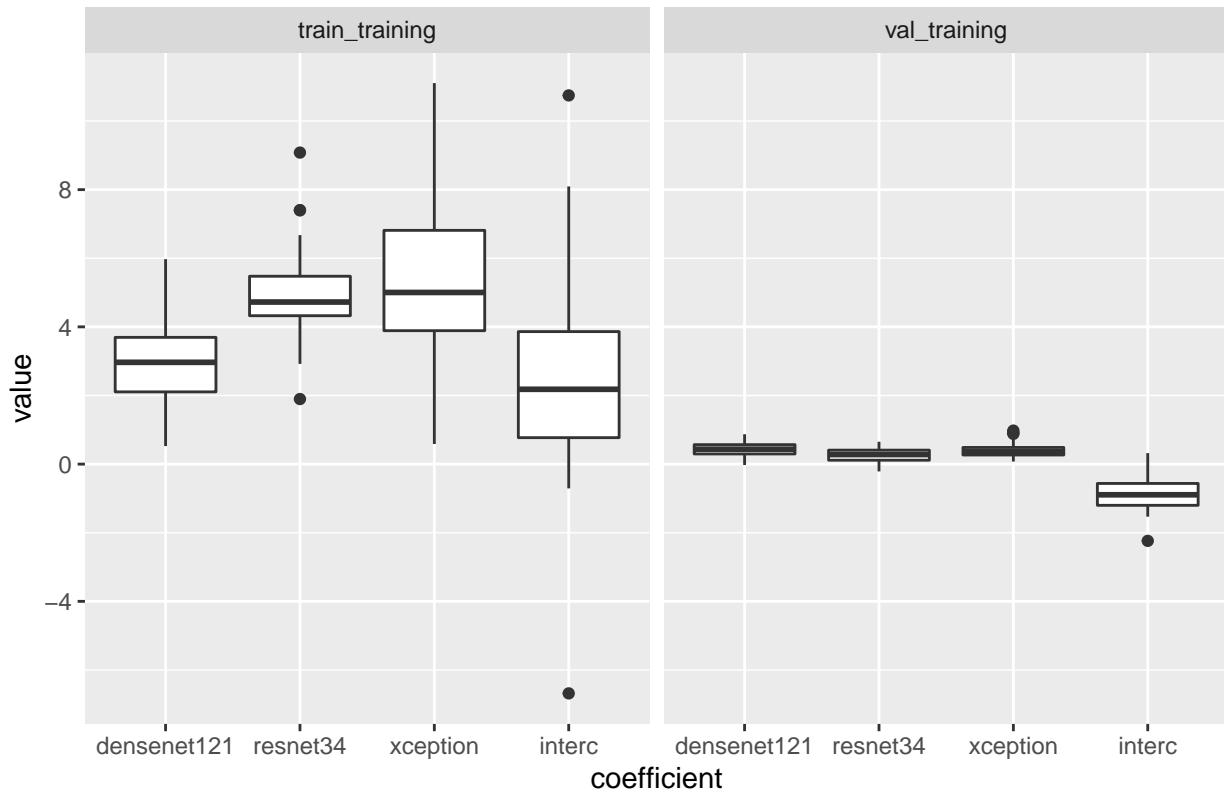
### Coefficients for class 2 vs 17



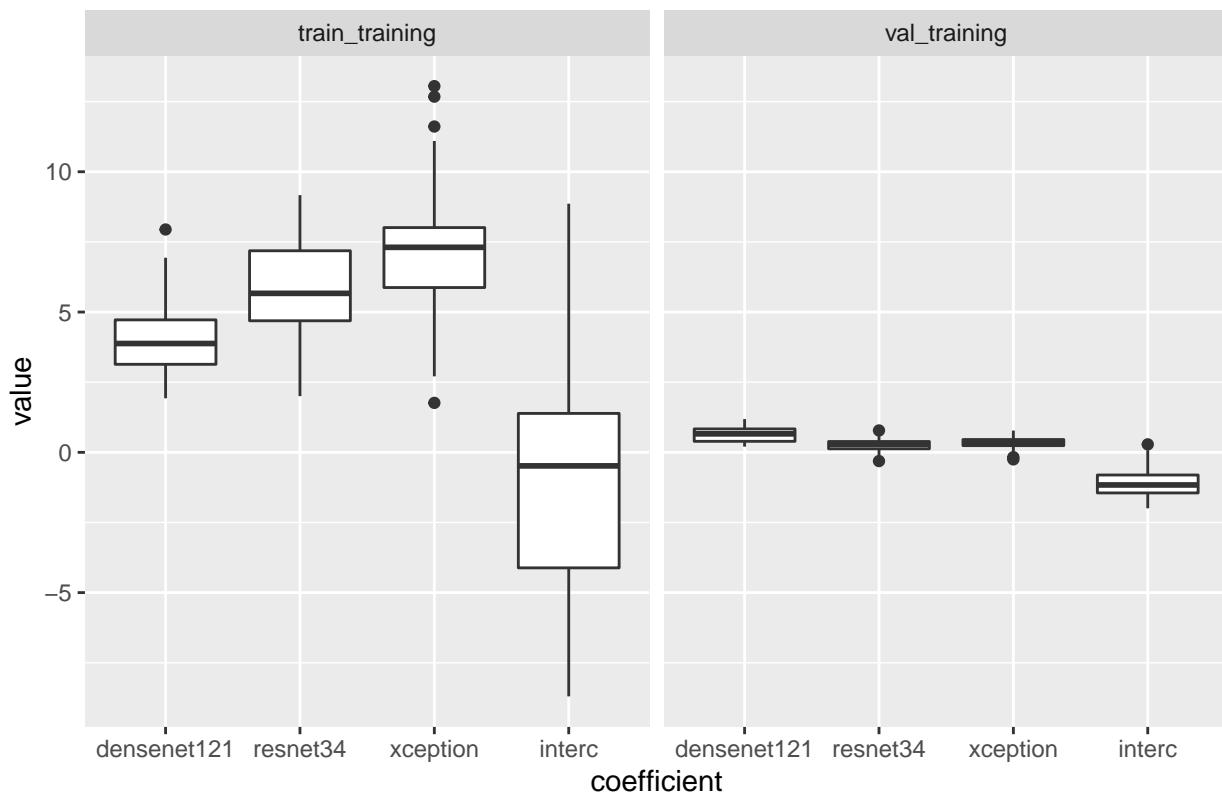
## Coefficients for class 2 vs 18



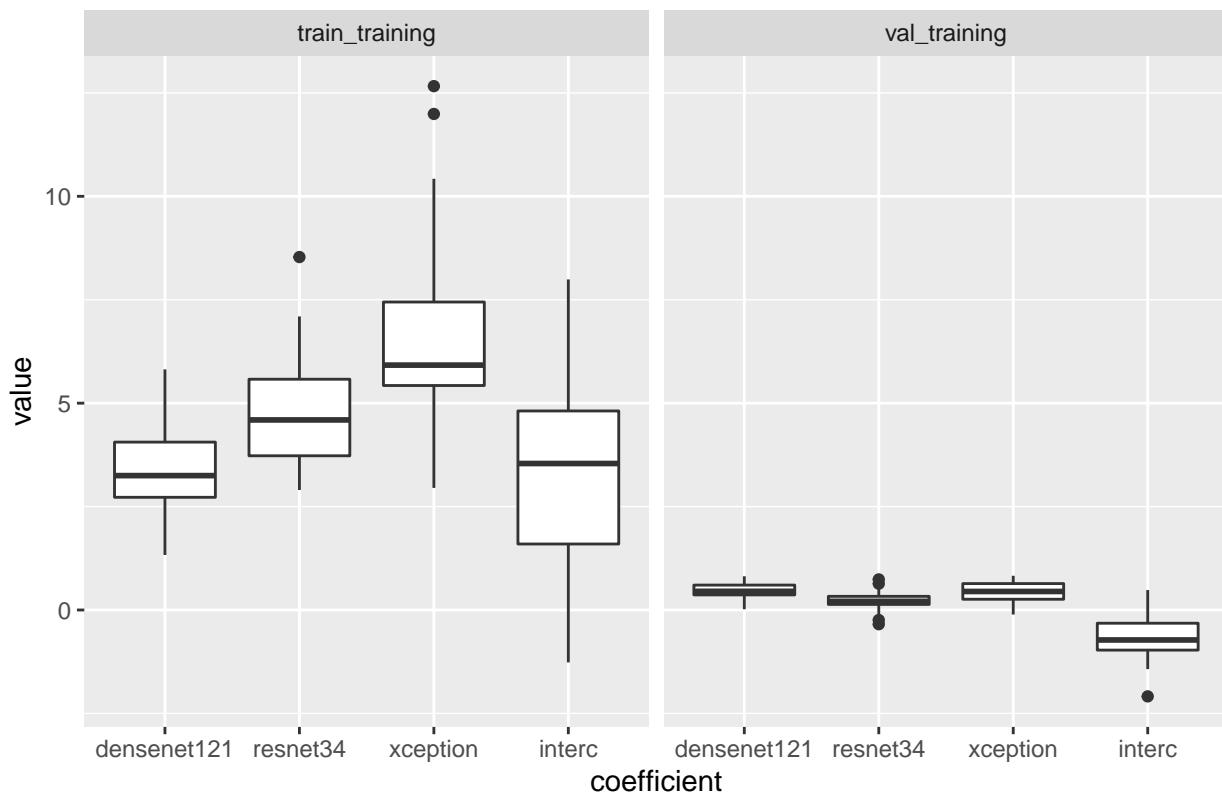
### Coefficients for class 2 vs 19



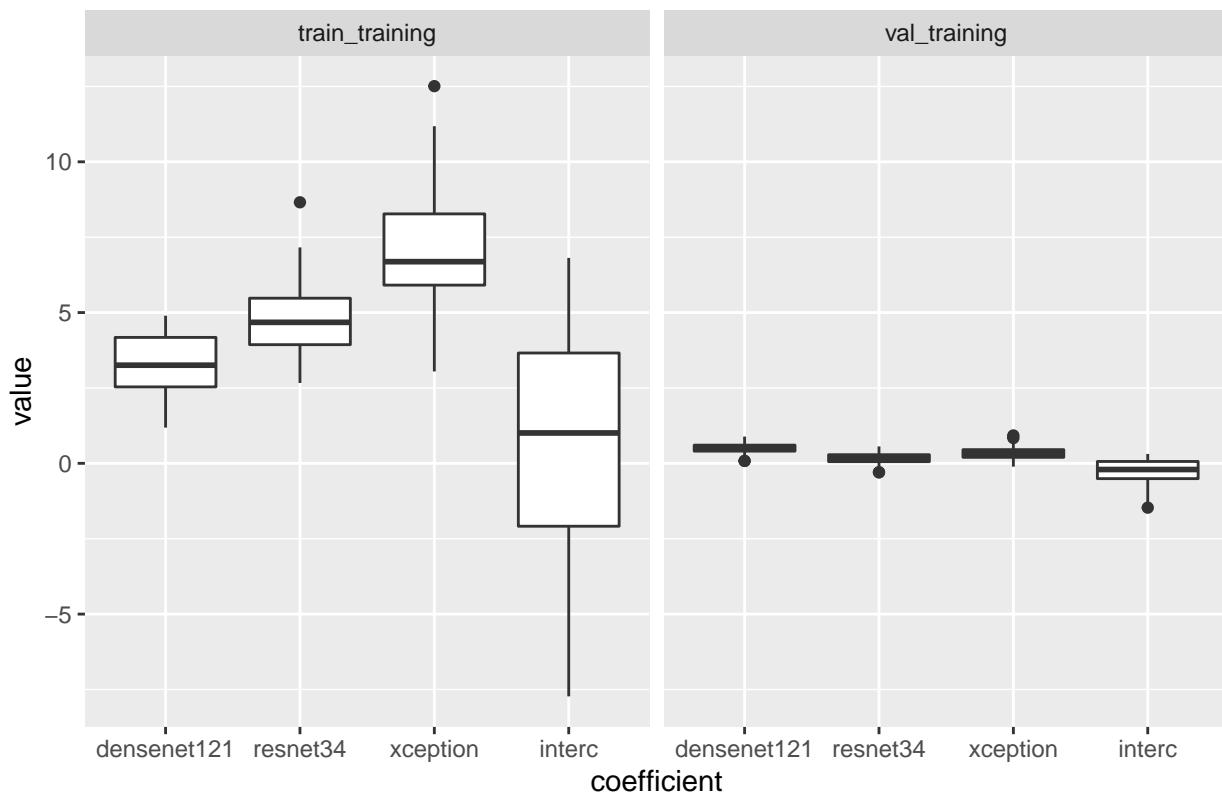
### Coefficients for class 2 vs 20



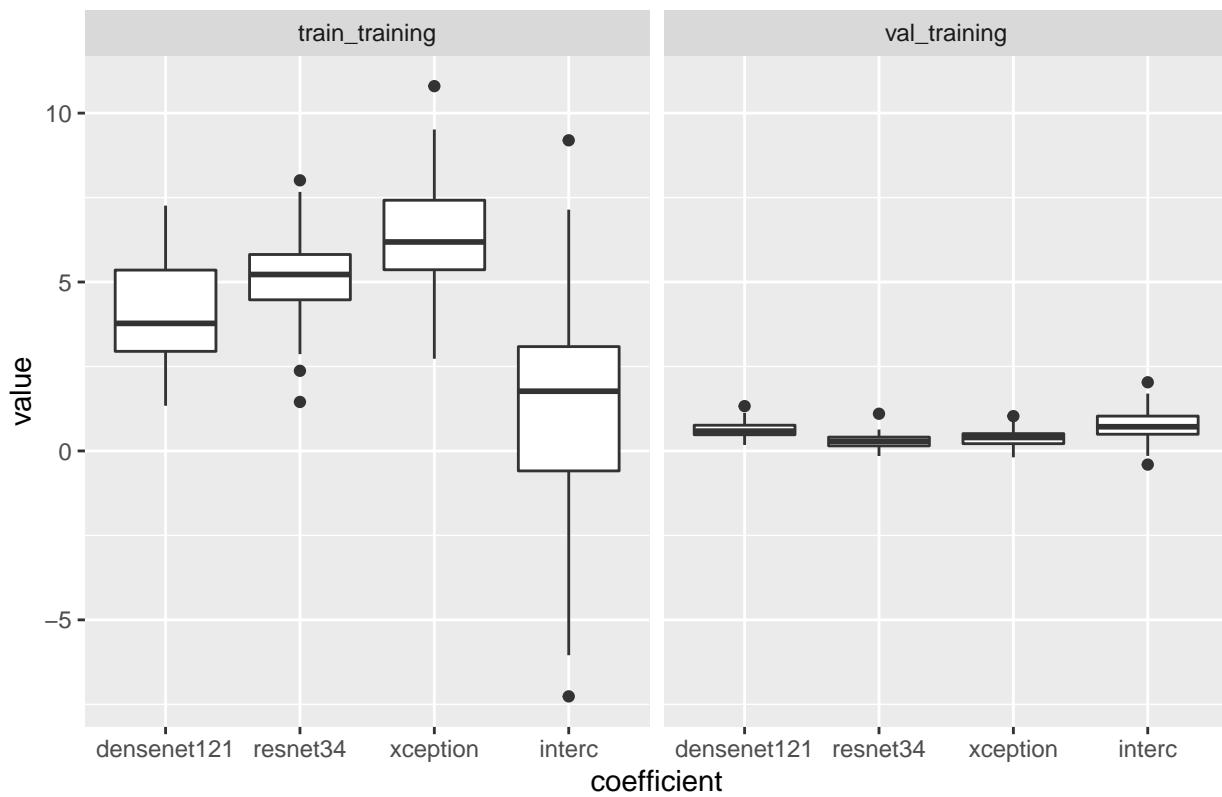
### Coefficients for class 3 vs 4



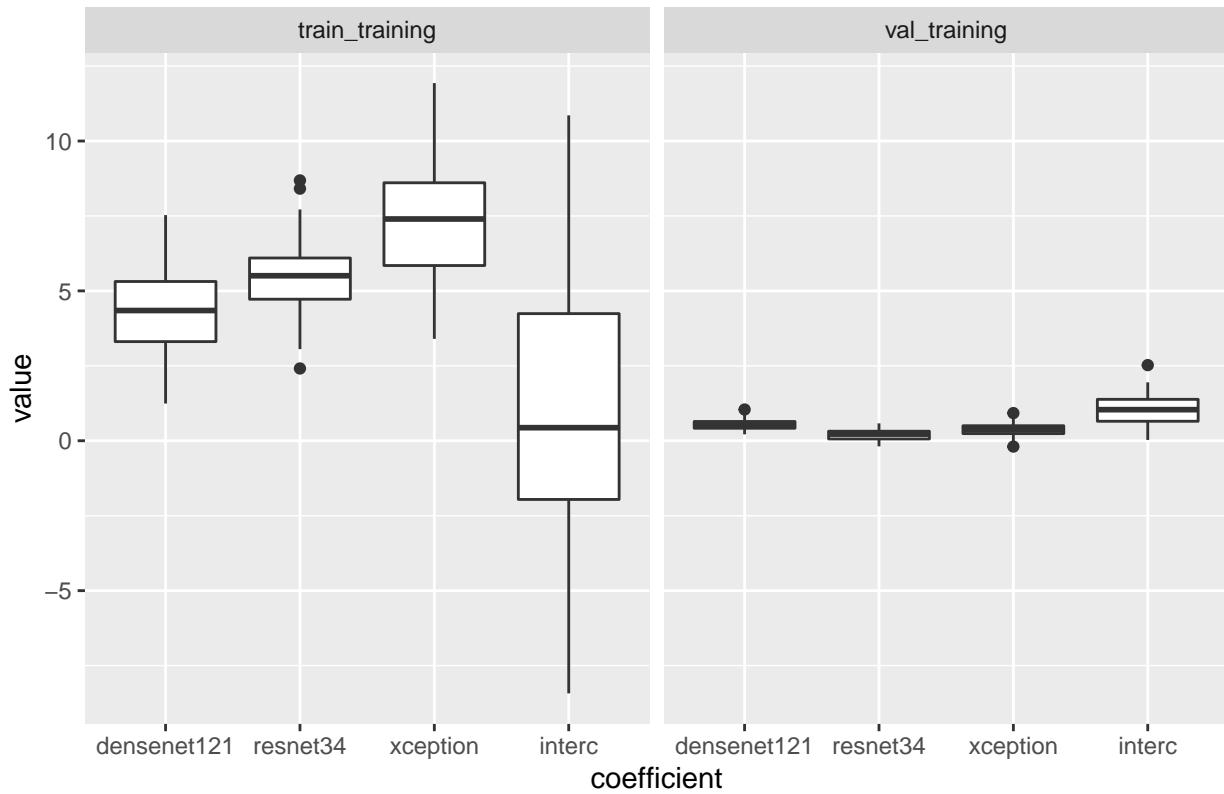
### Coefficients for class 3 vs 5



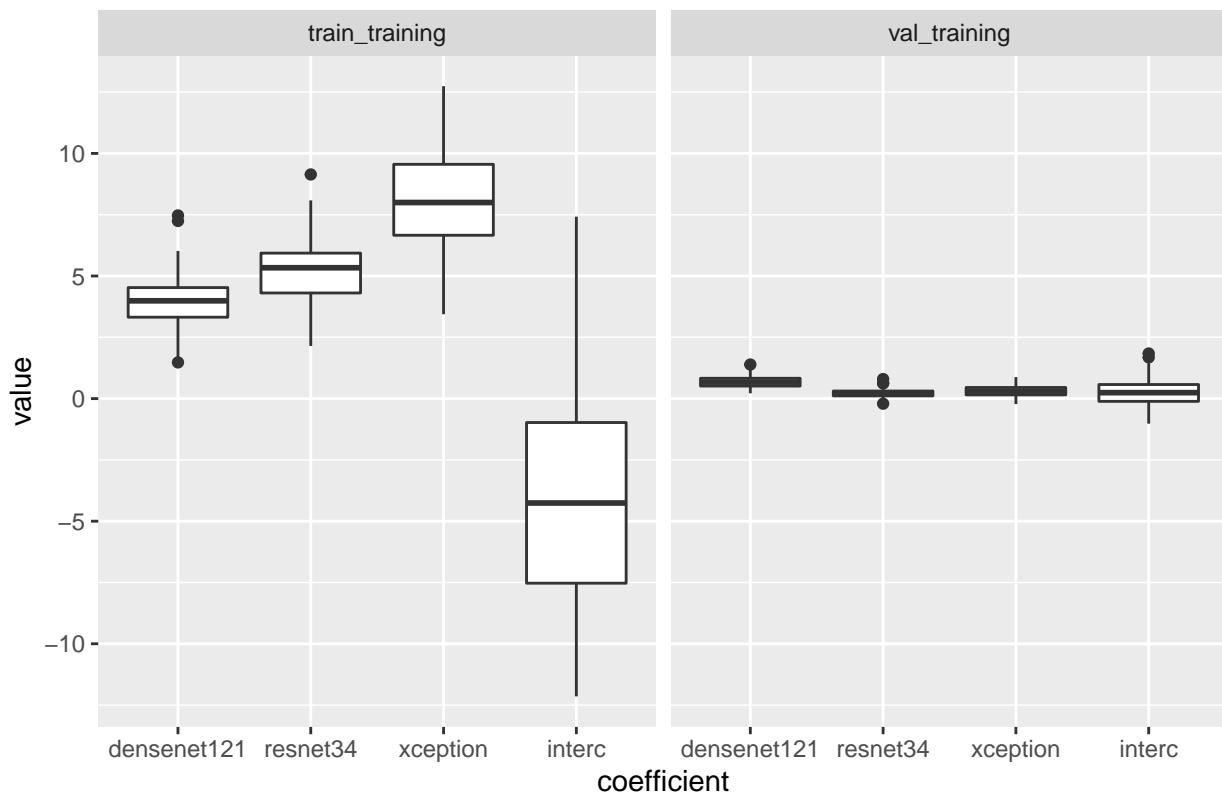
### Coefficients for class 3 vs 6



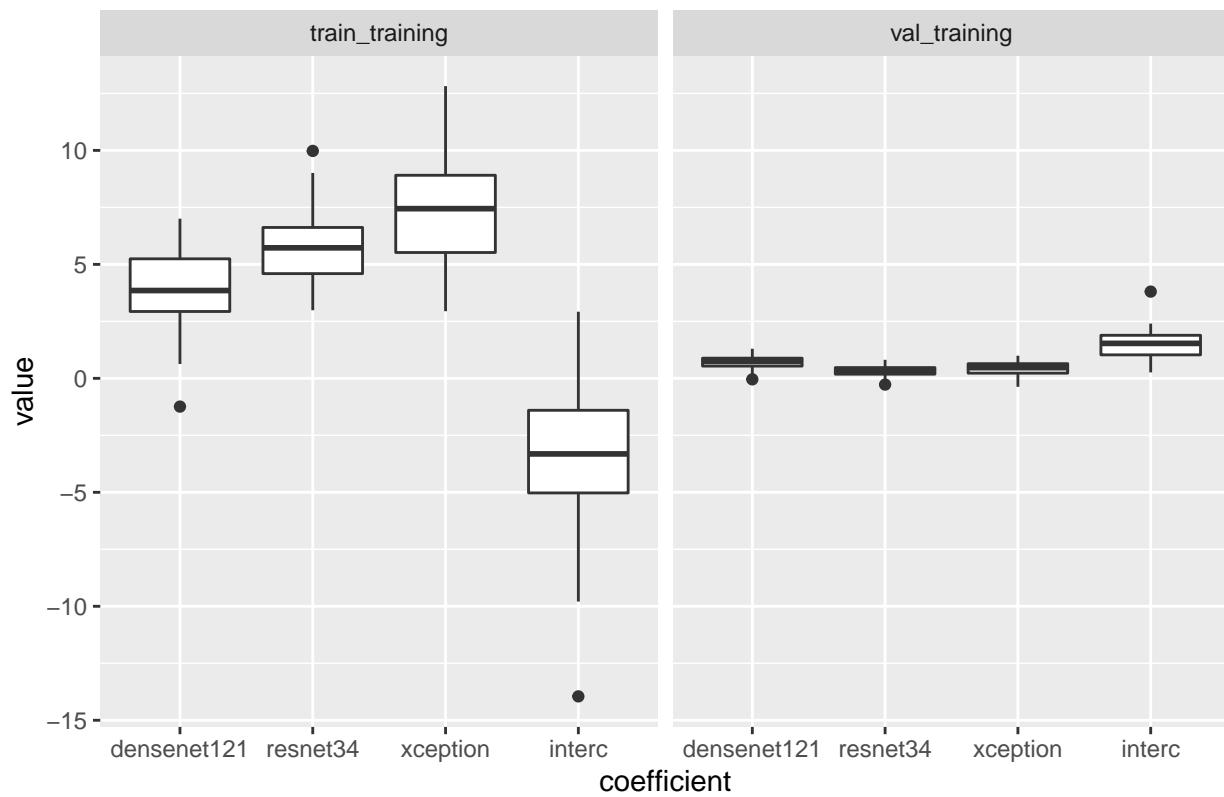
### Coefficients for class 3 vs 7



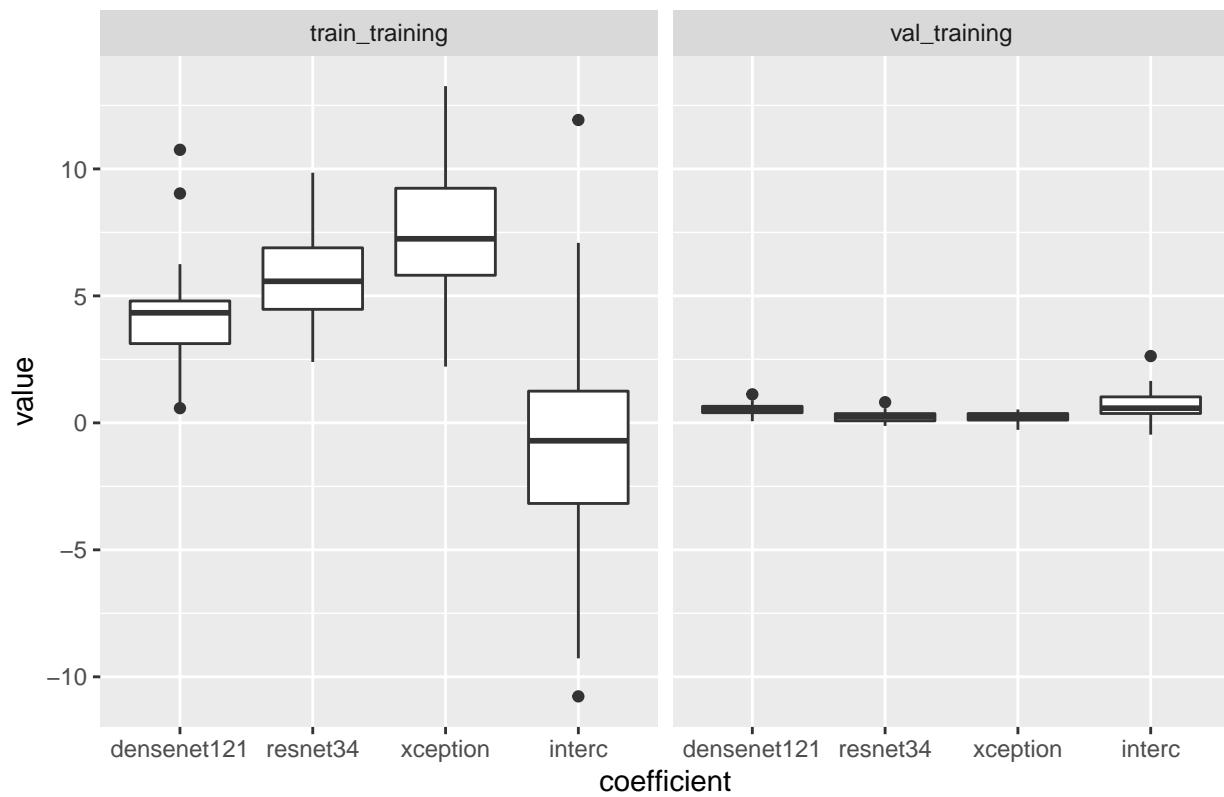
### Coefficients for class 3 vs 8



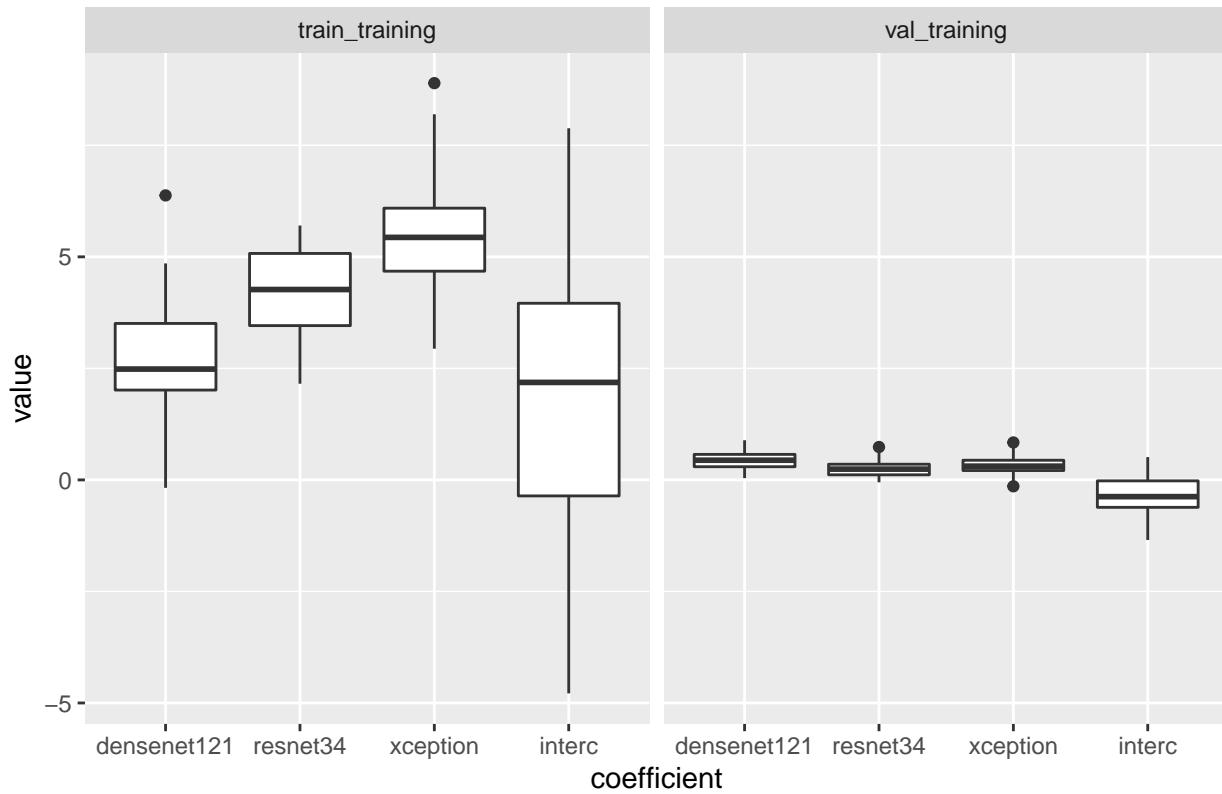
### Coefficients for class 3 vs 9



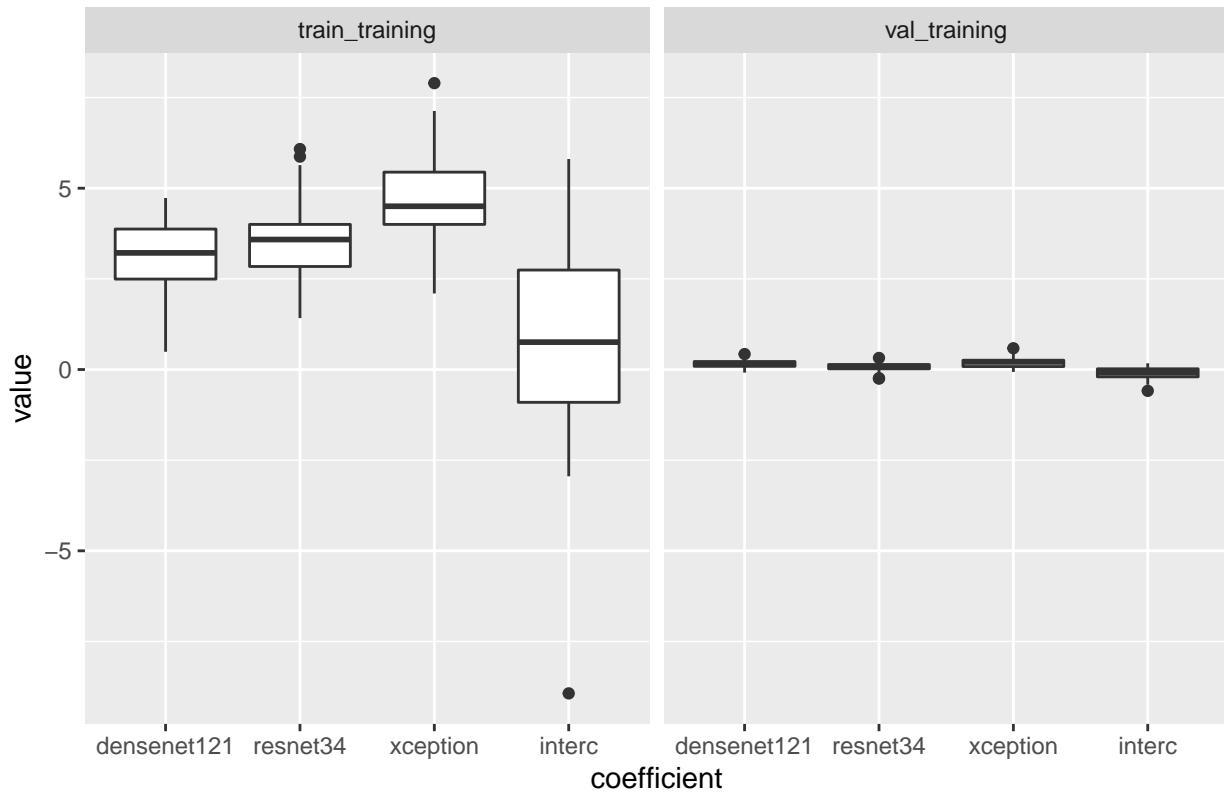
### Coefficients for class 3 vs 10



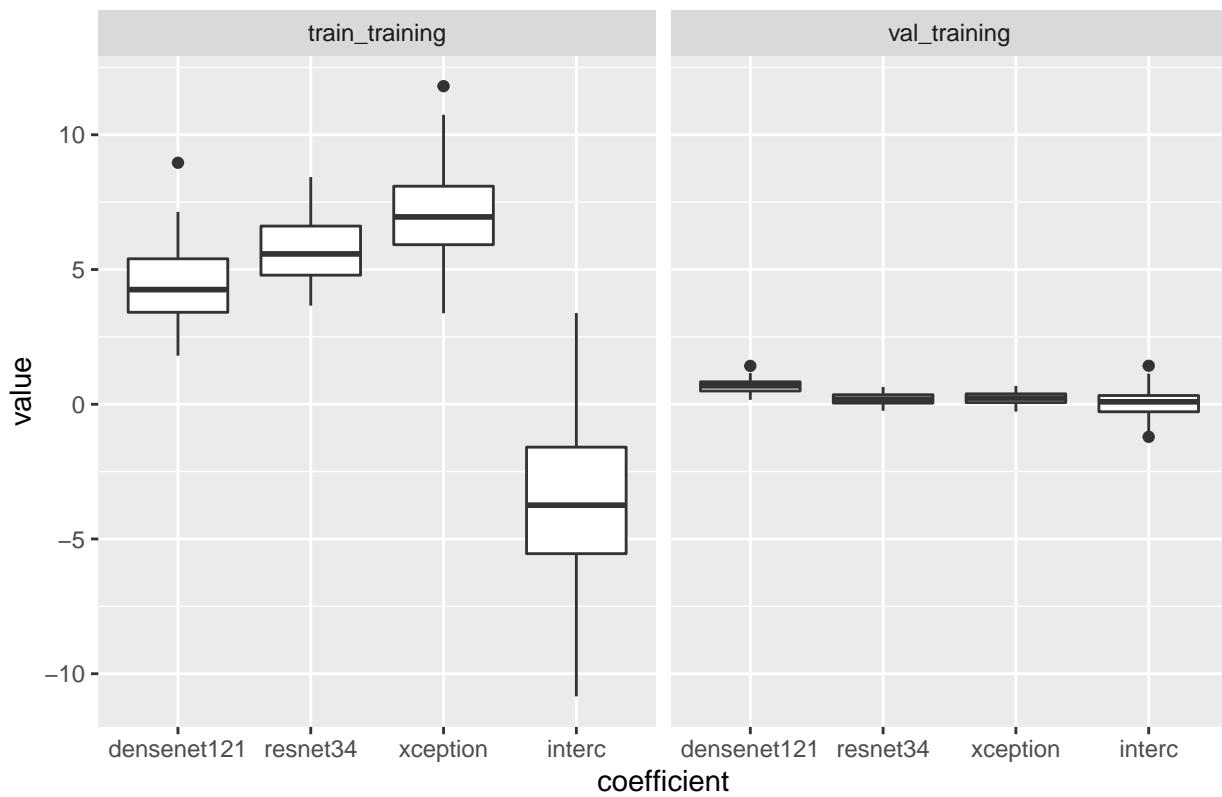
### Coefficients for class 3 vs 11



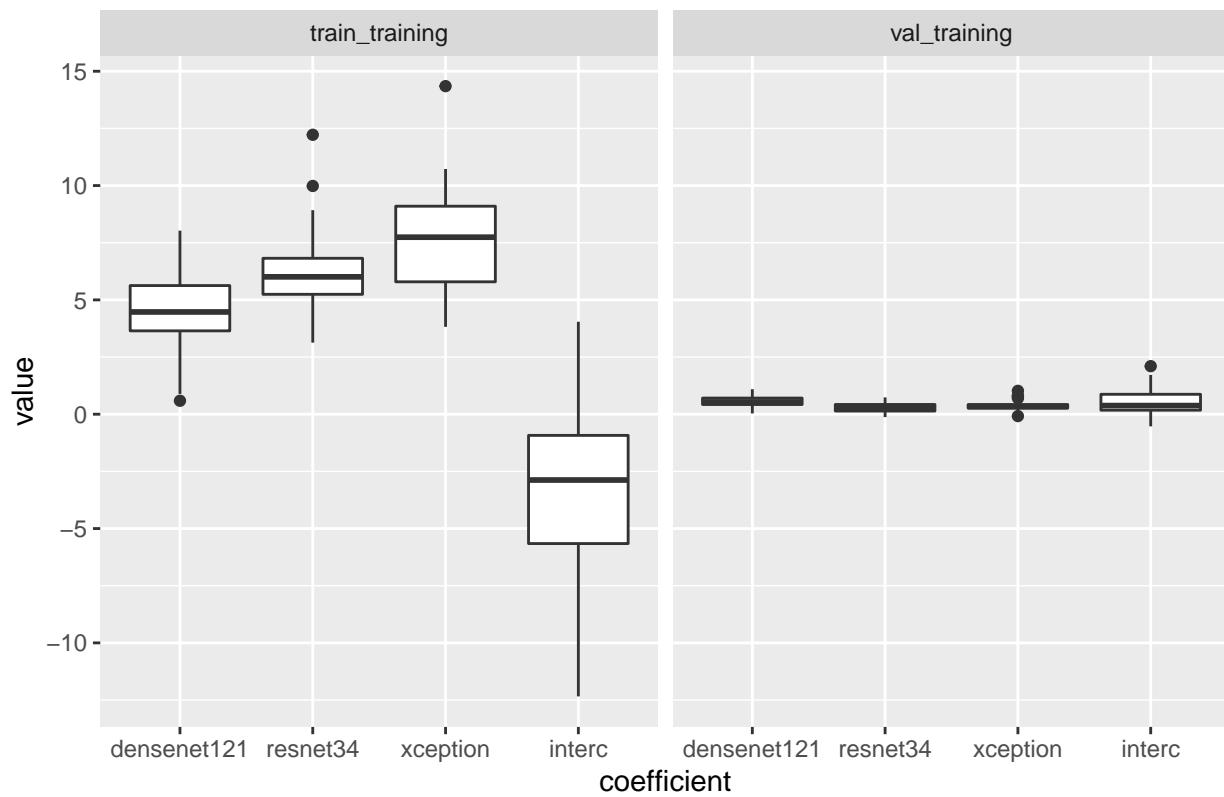
### Coefficients for class 3 vs 12



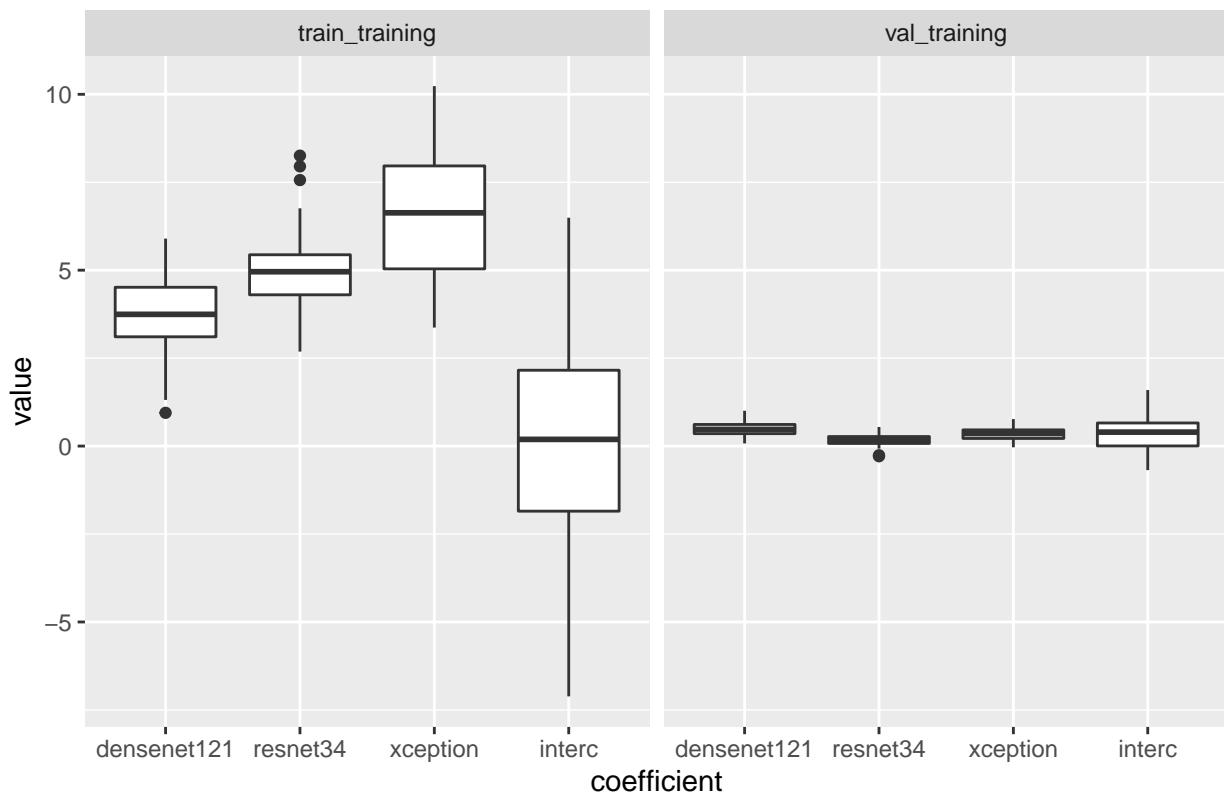
### Coefficients for class 3 vs 13



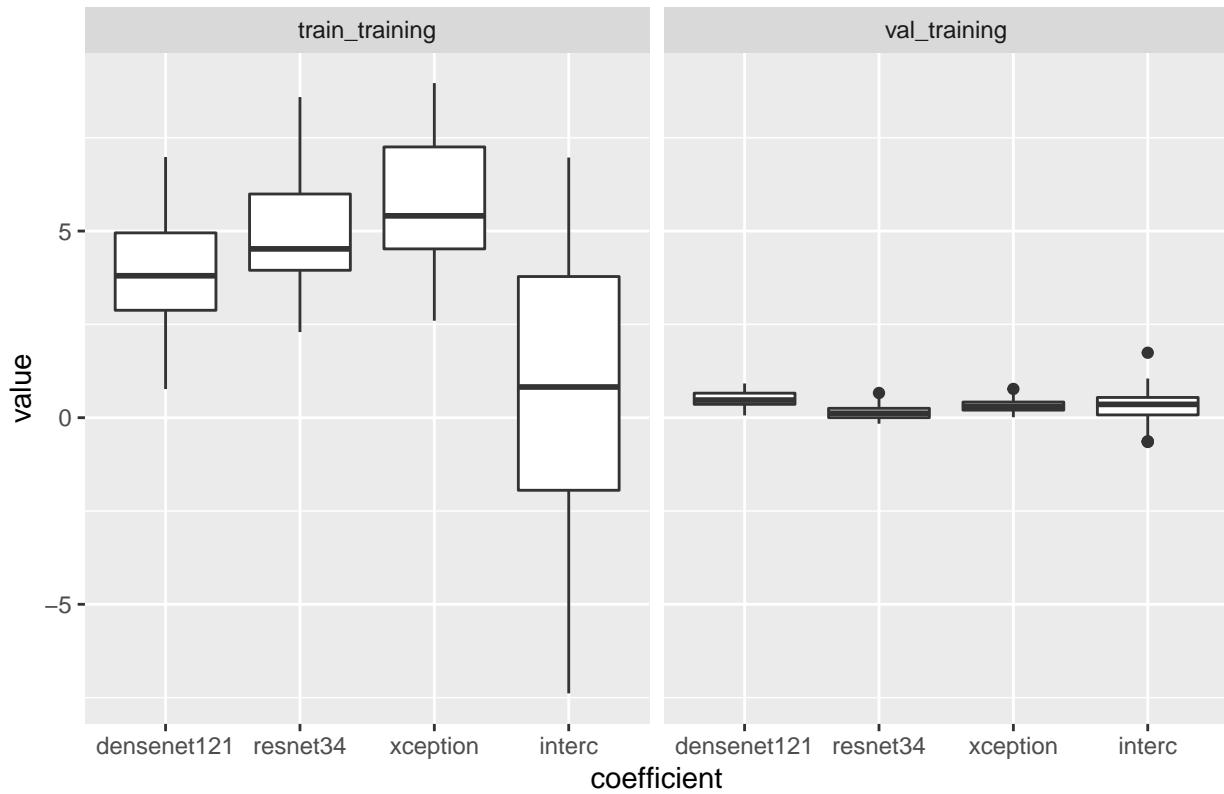
### Coefficients for class 3 vs 14



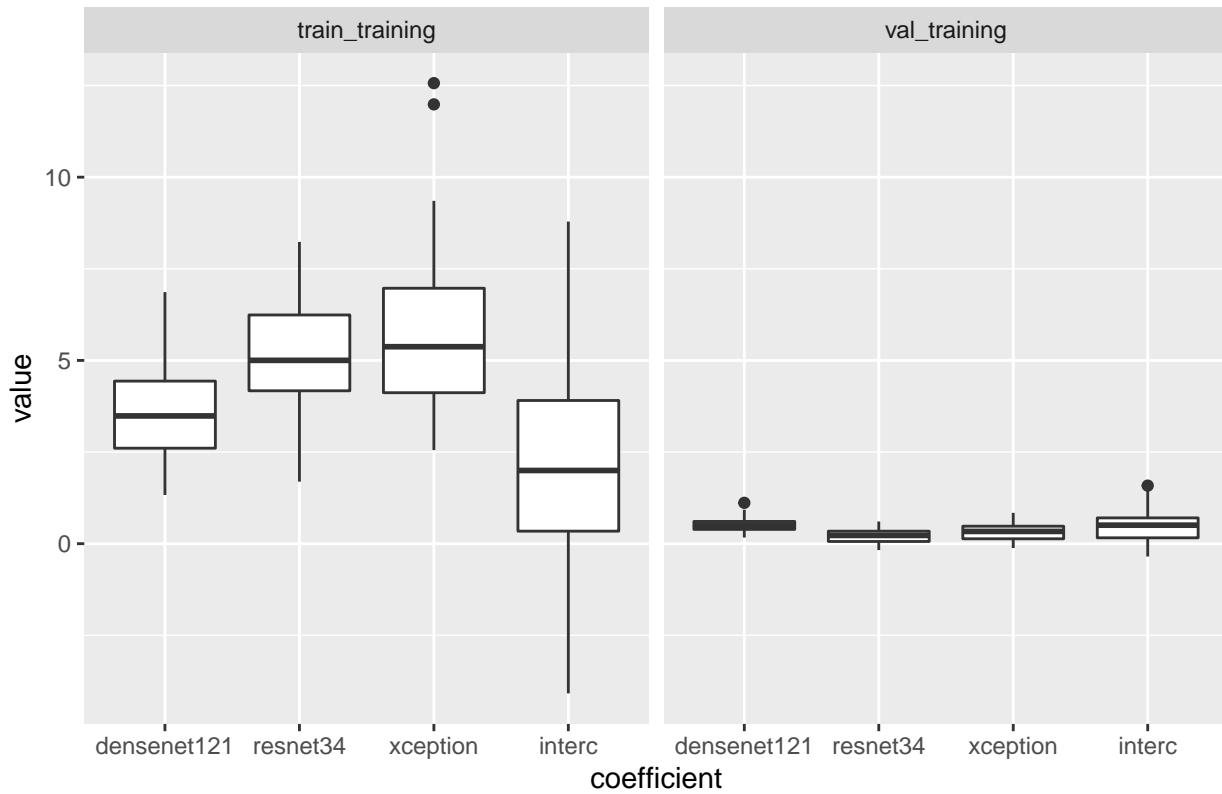
### Coefficients for class 3 vs 15



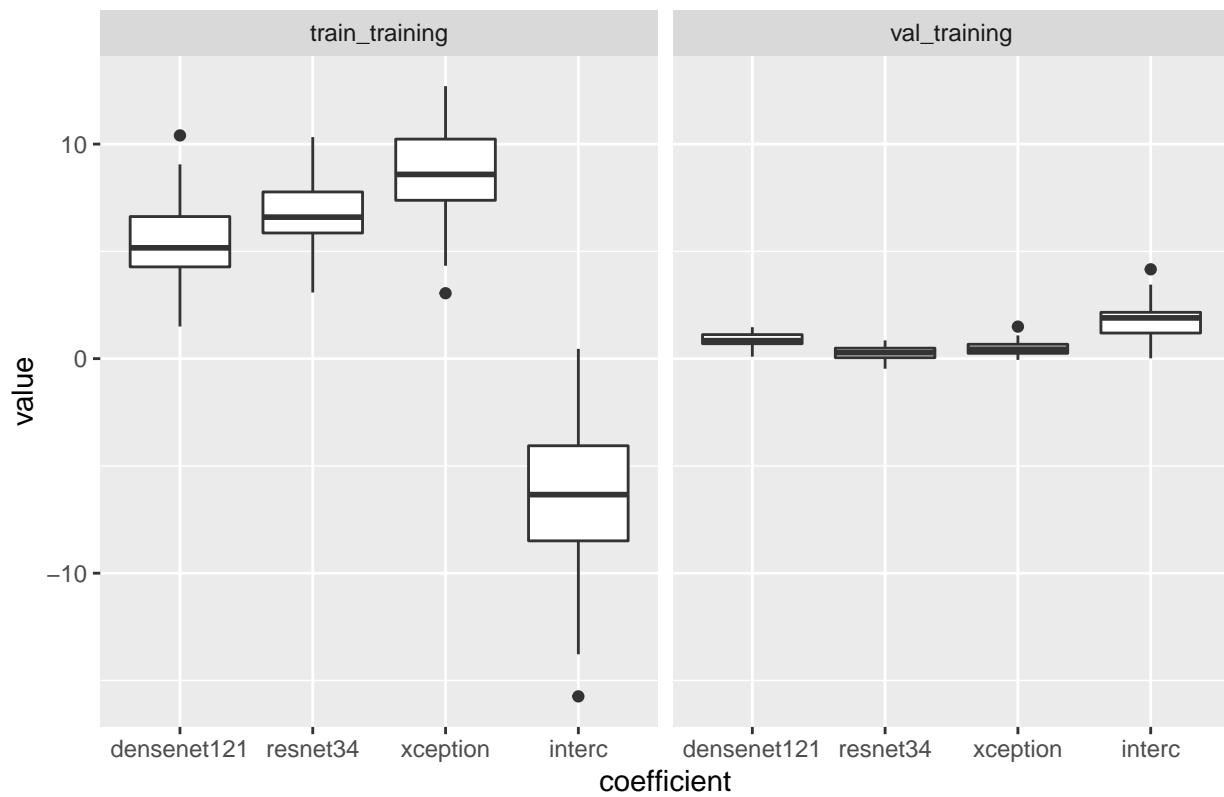
### Coefficients for class 3 vs 16



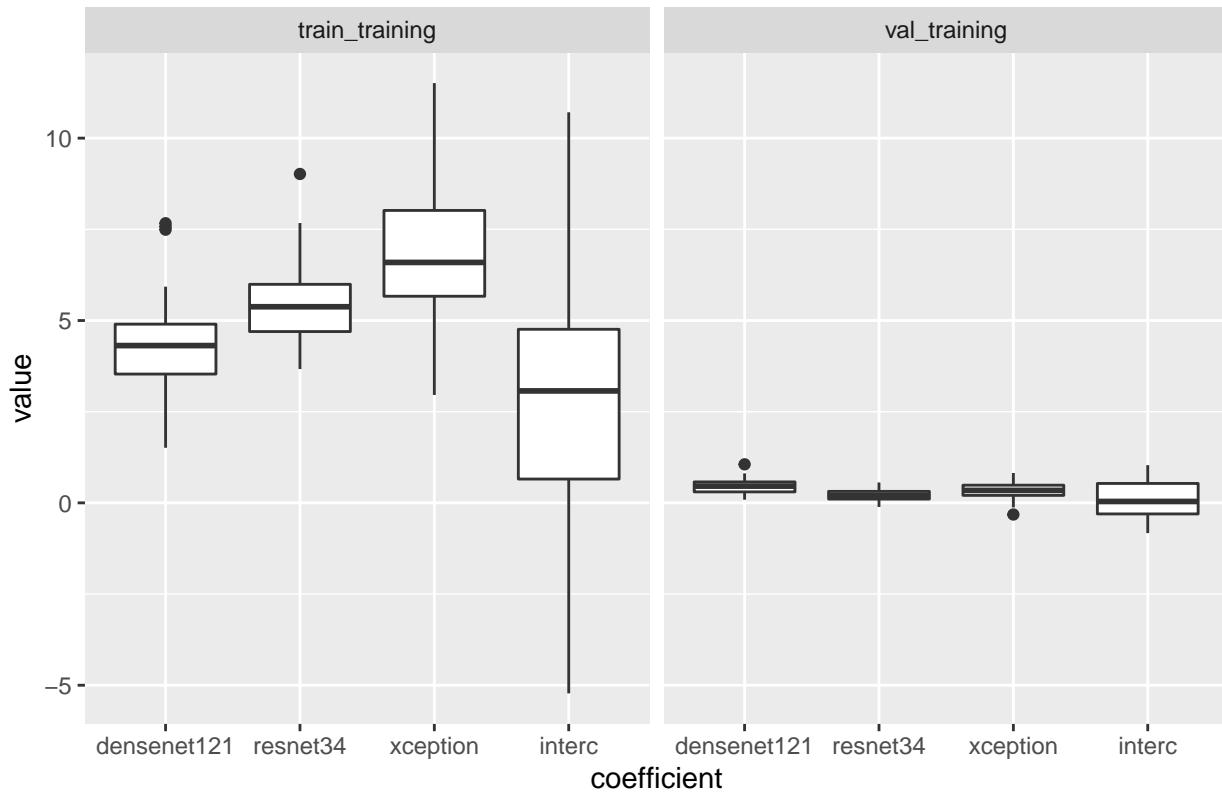
### Coefficients for class 3 vs 17



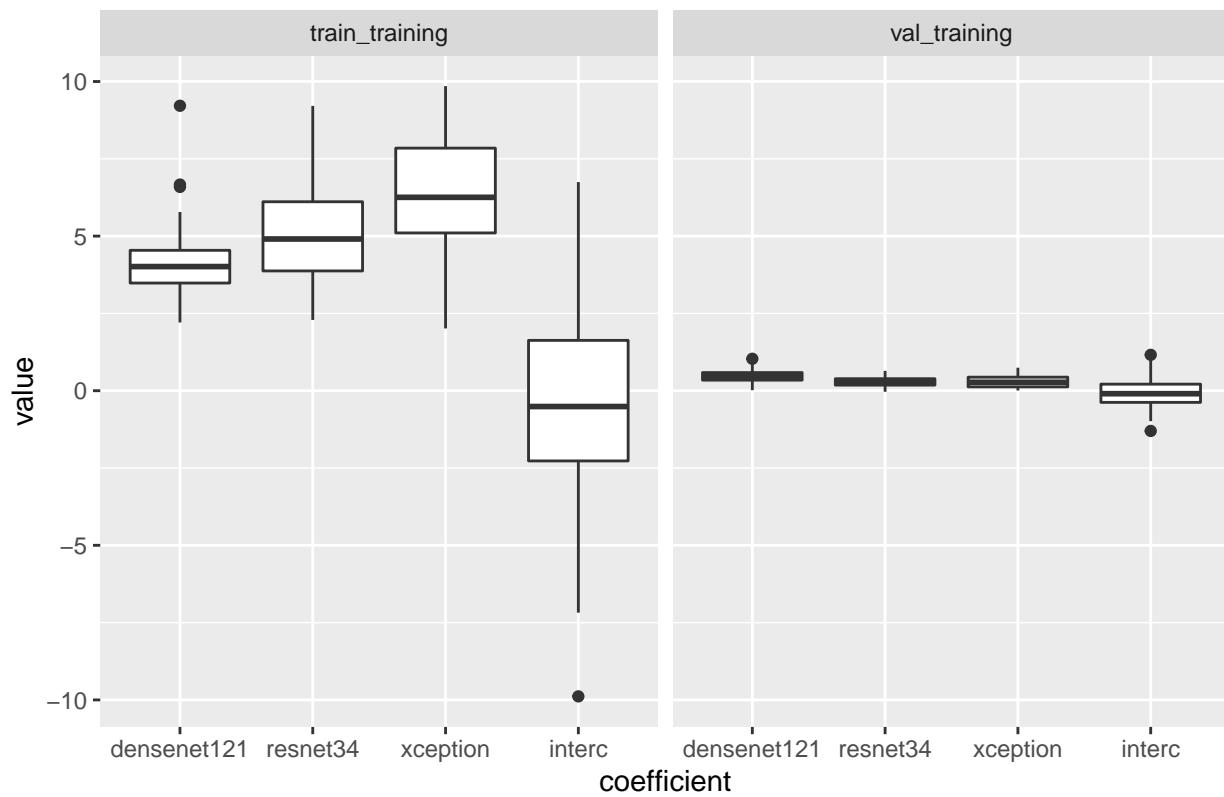
### Coefficients for class 3 vs 18



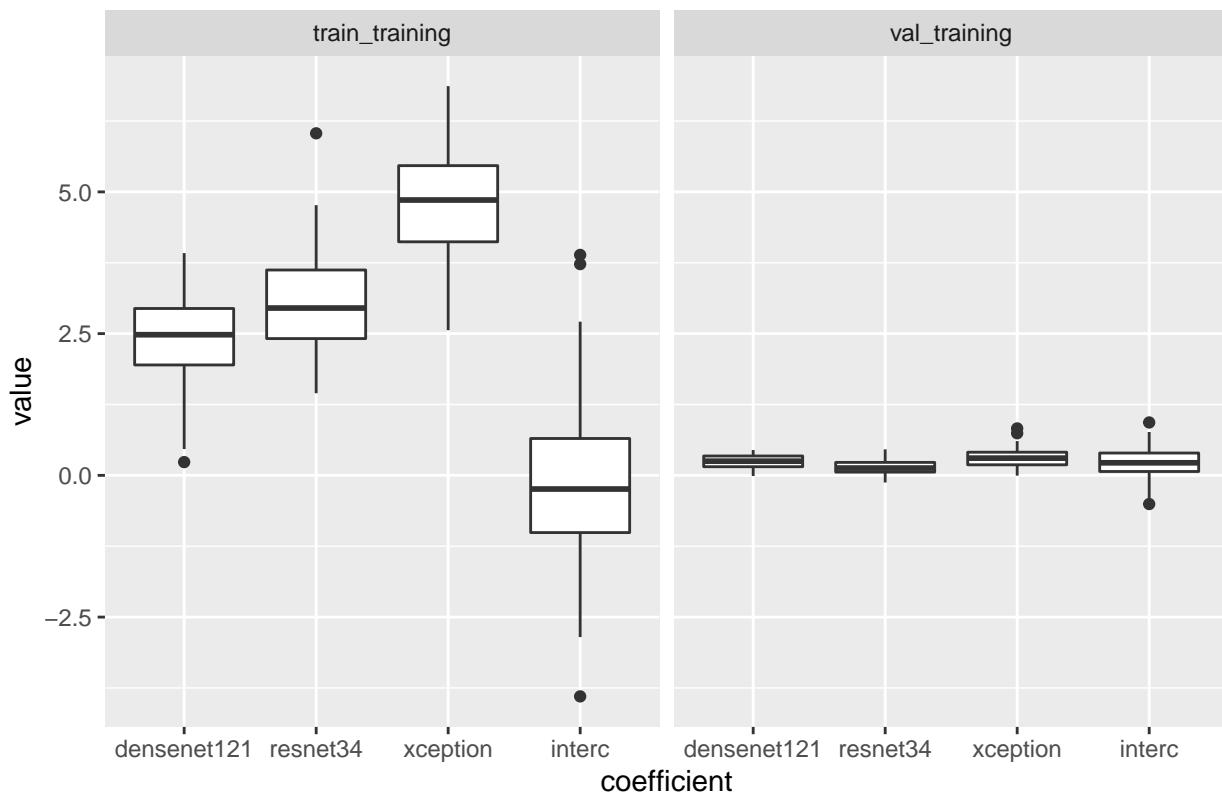
### Coefficients for class 3 vs 19



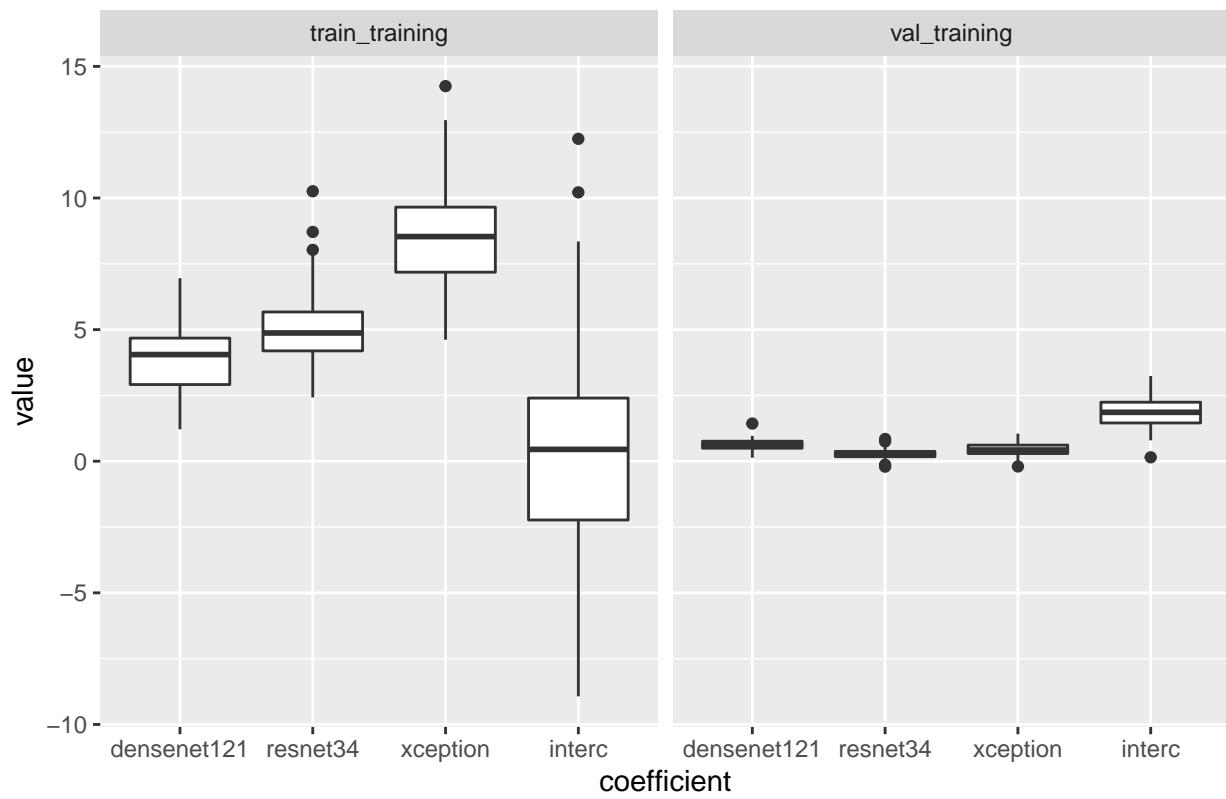
### Coefficients for class 3 vs 20



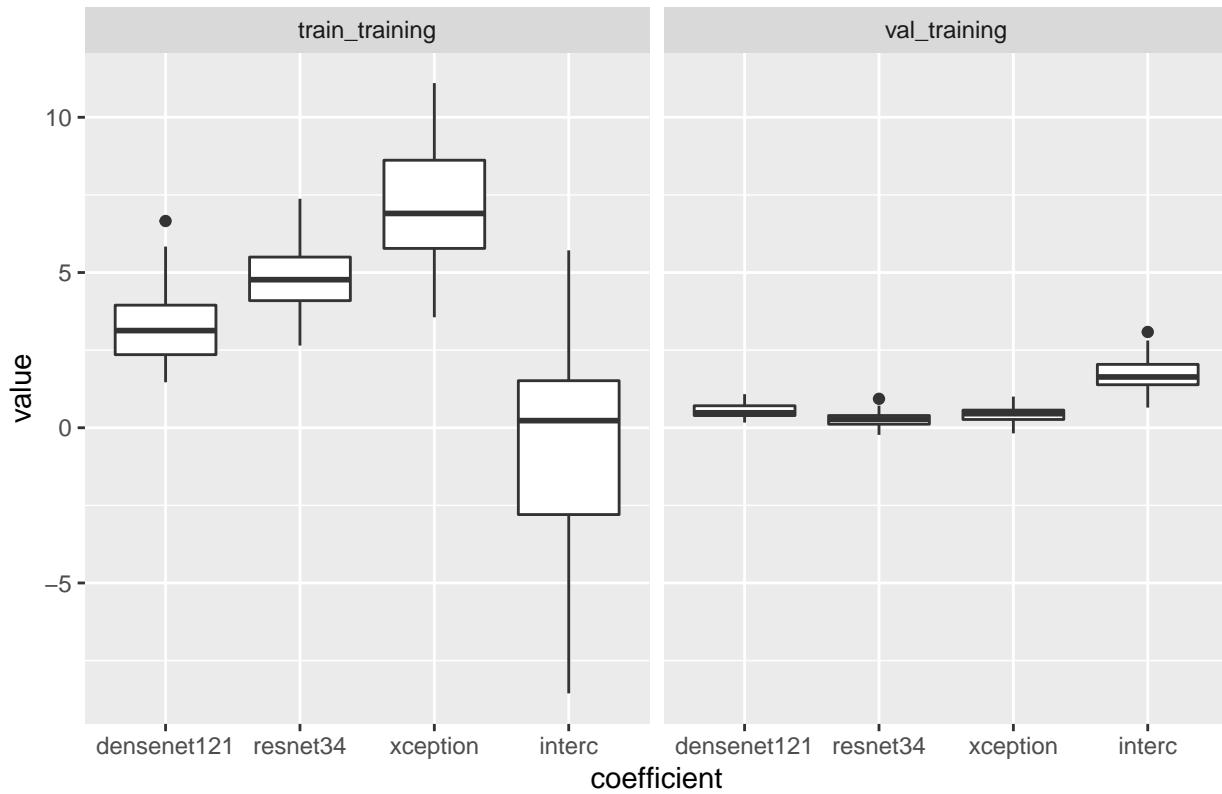
### Coefficients for class 4 vs 5



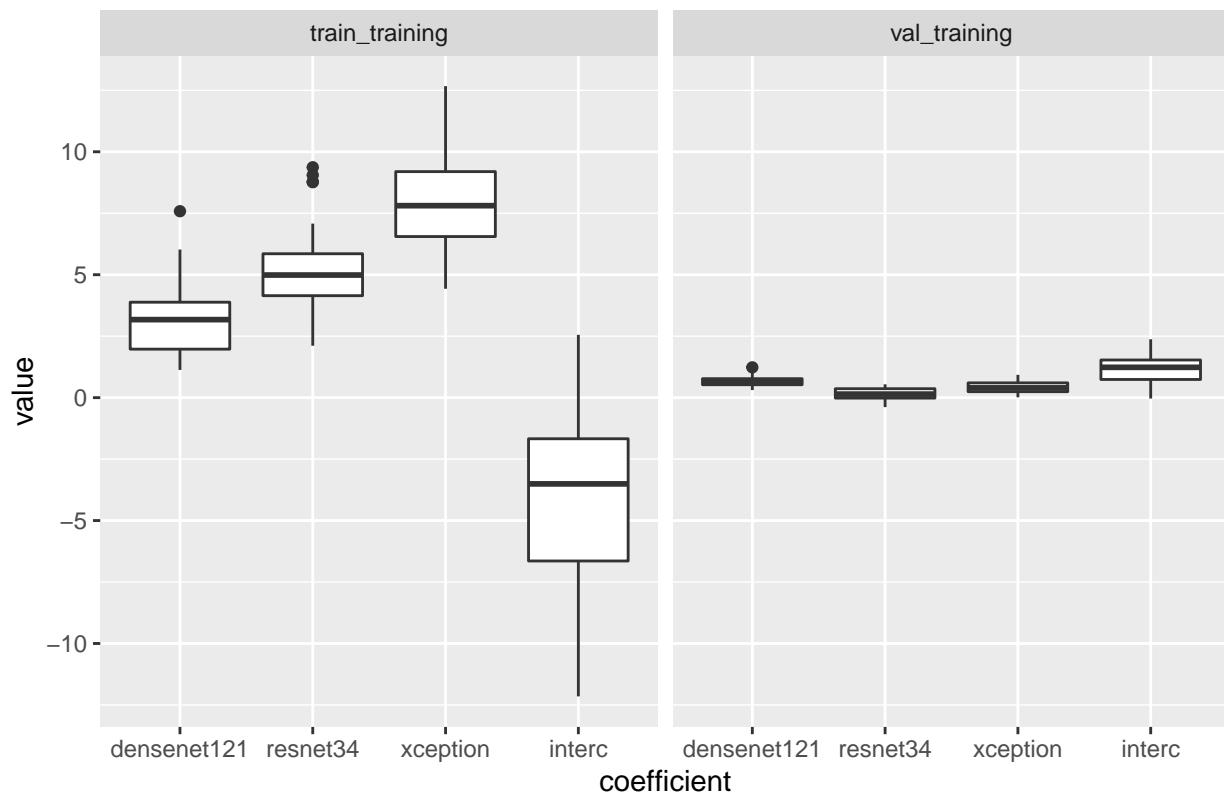
### Coefficients for class 4 vs 6



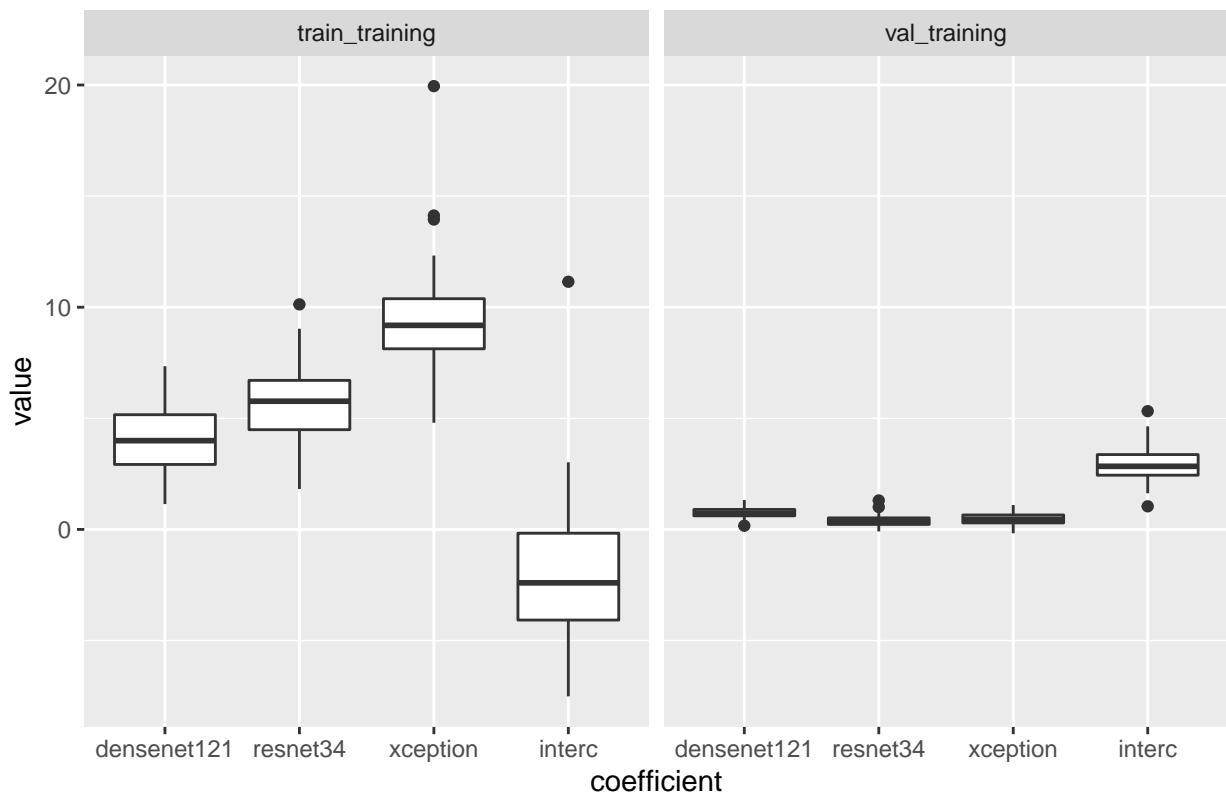
### Coefficients for class 4 vs 7



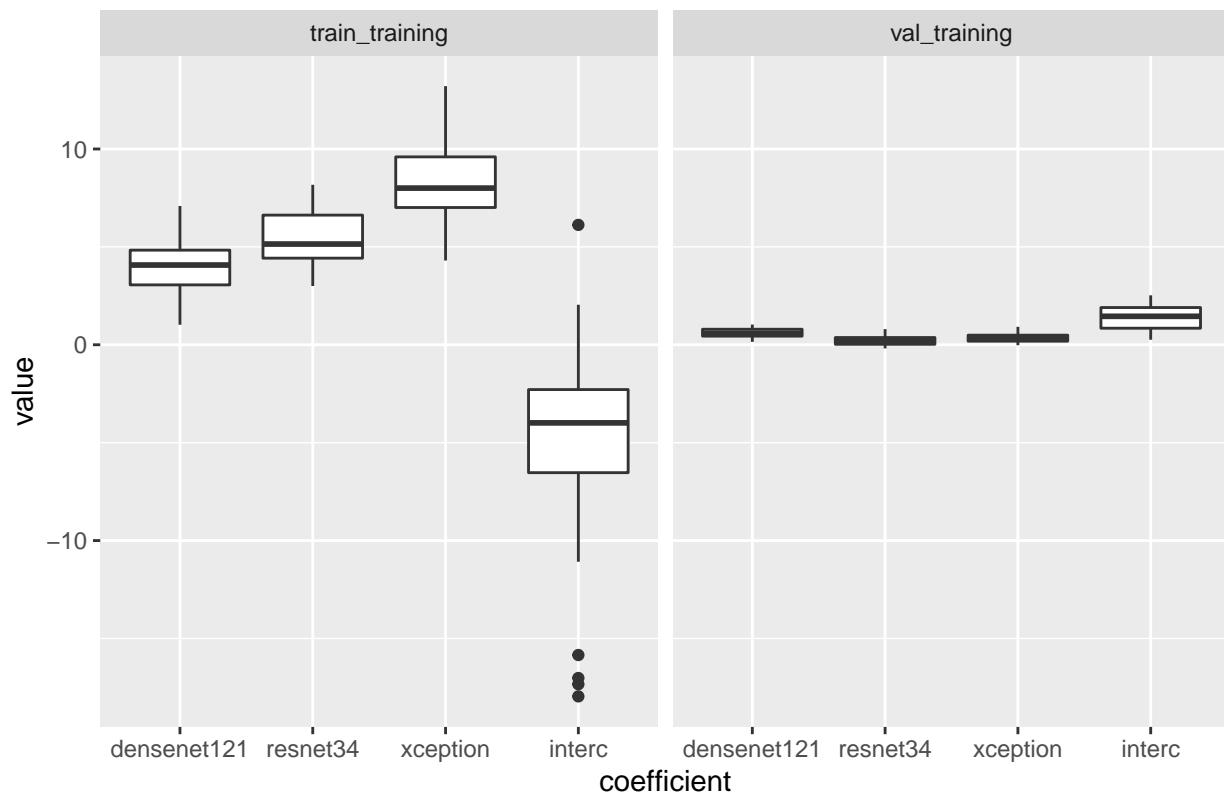
## Coefficients for class 4 vs 8



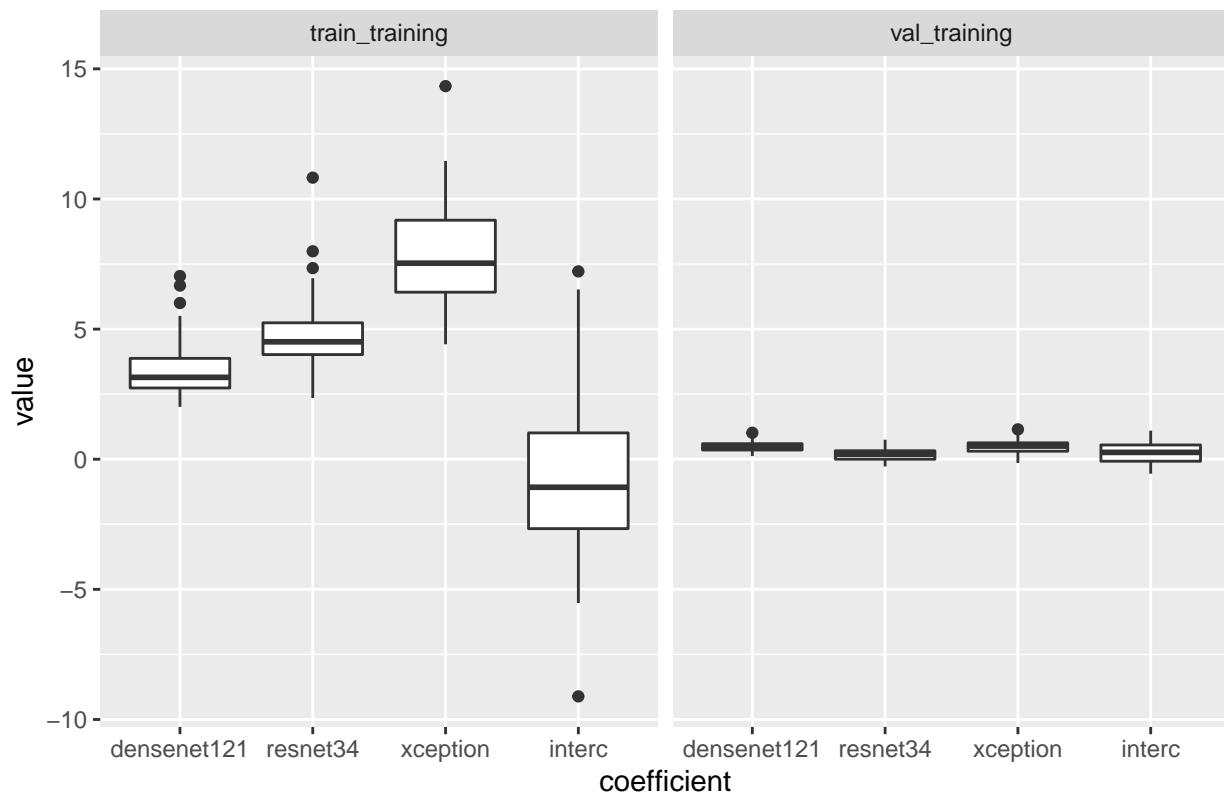
### Coefficients for class 4 vs 9



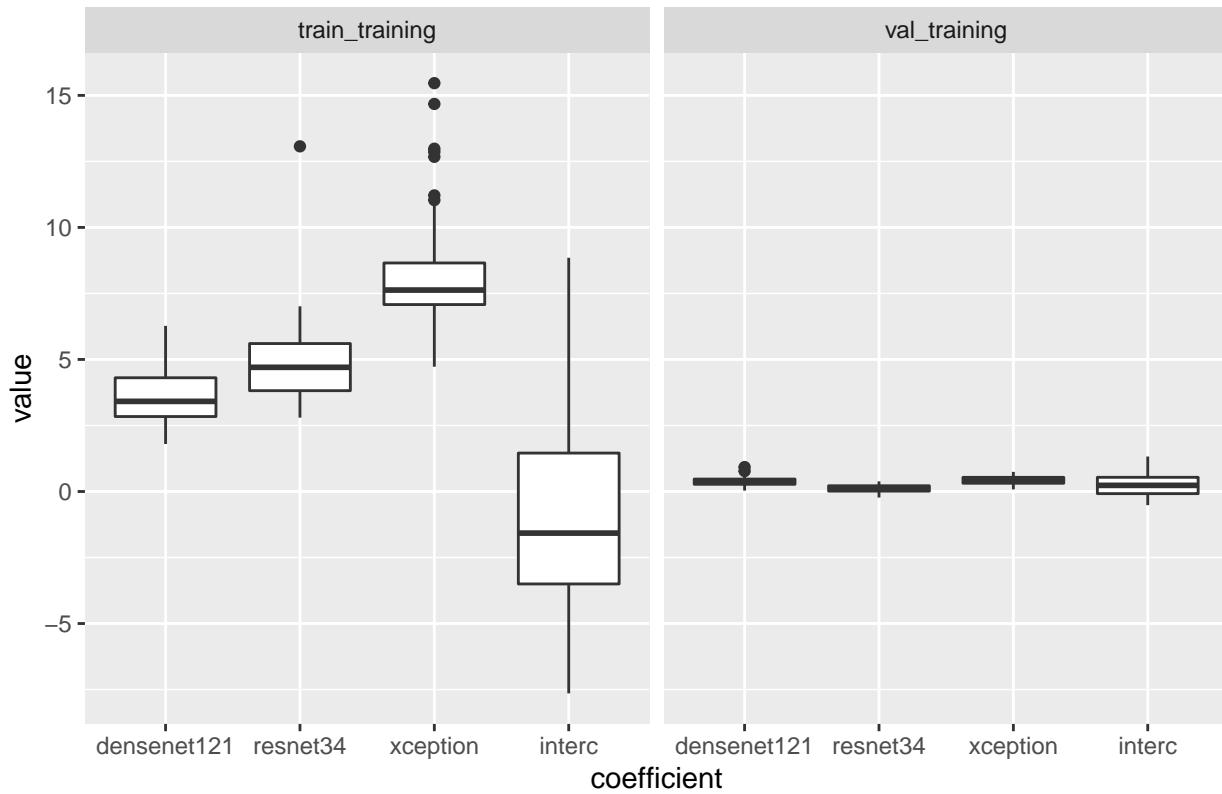
## Coefficients for class 4 vs 10



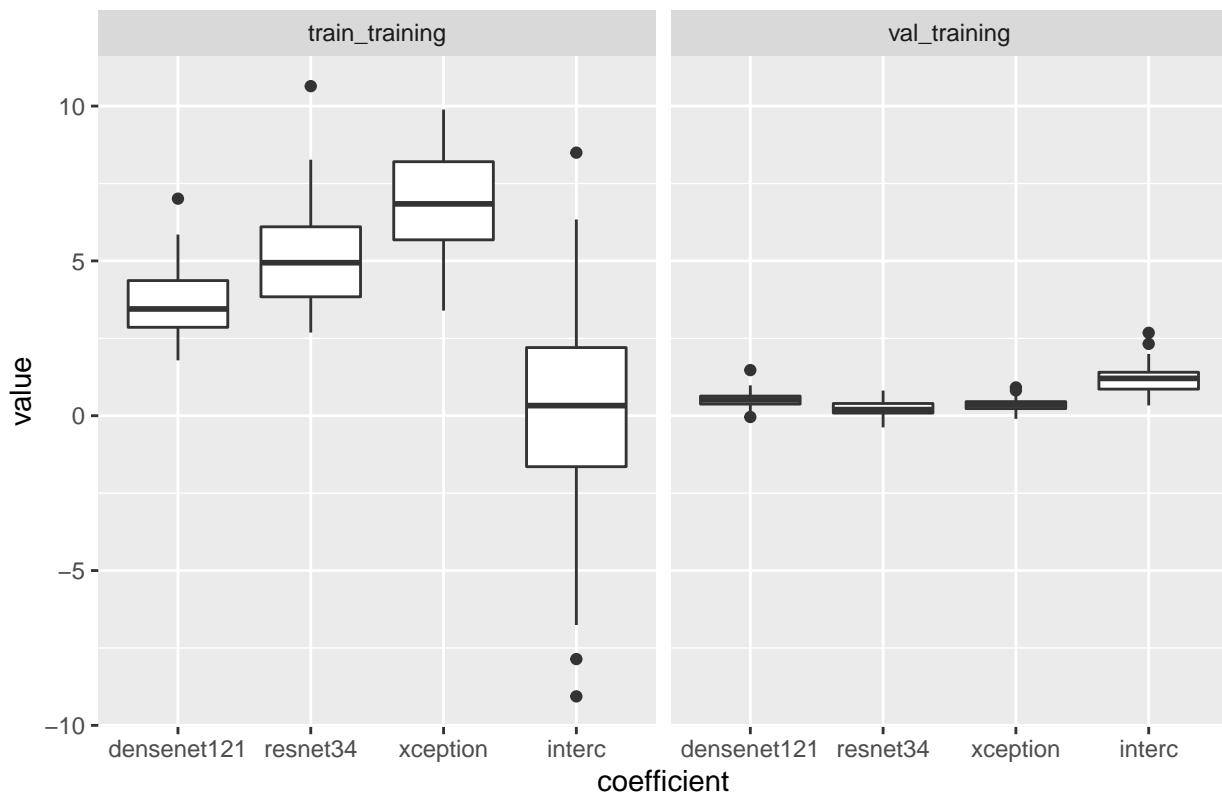
### Coefficients for class 4 vs 11



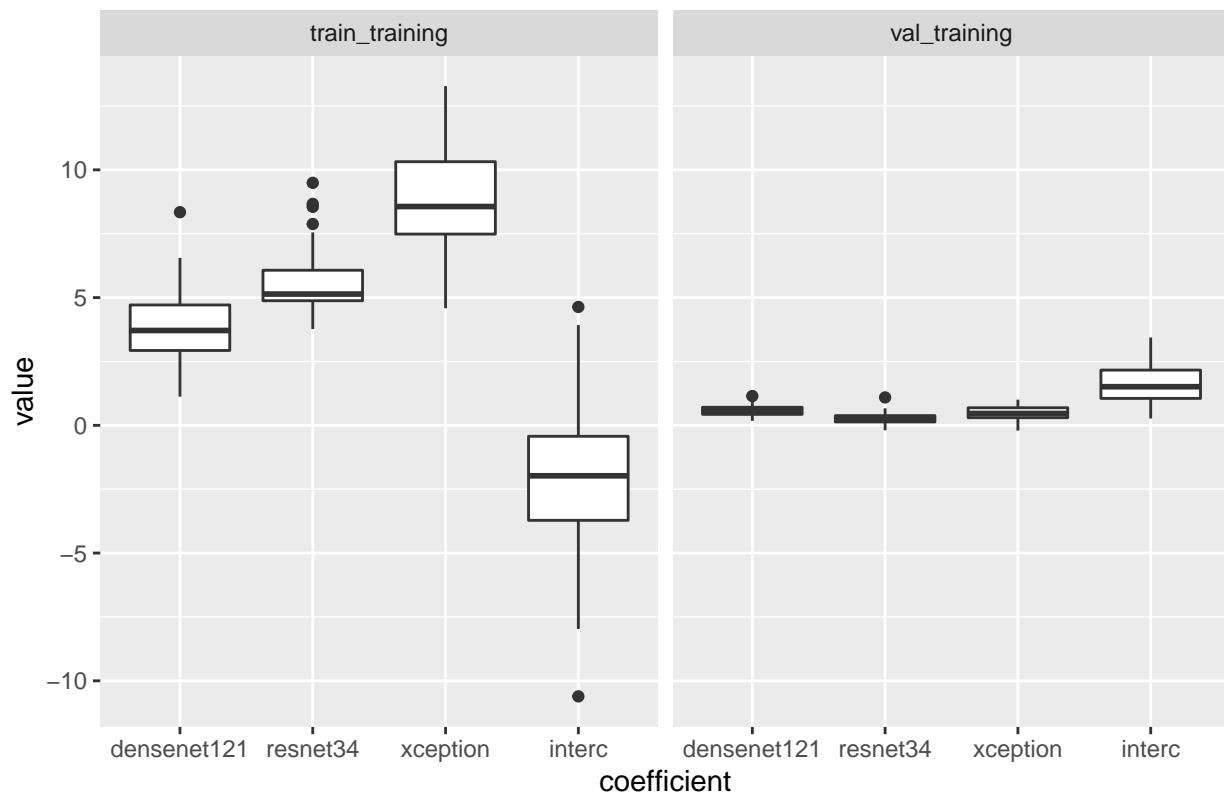
## Coefficients for class 4 vs 12



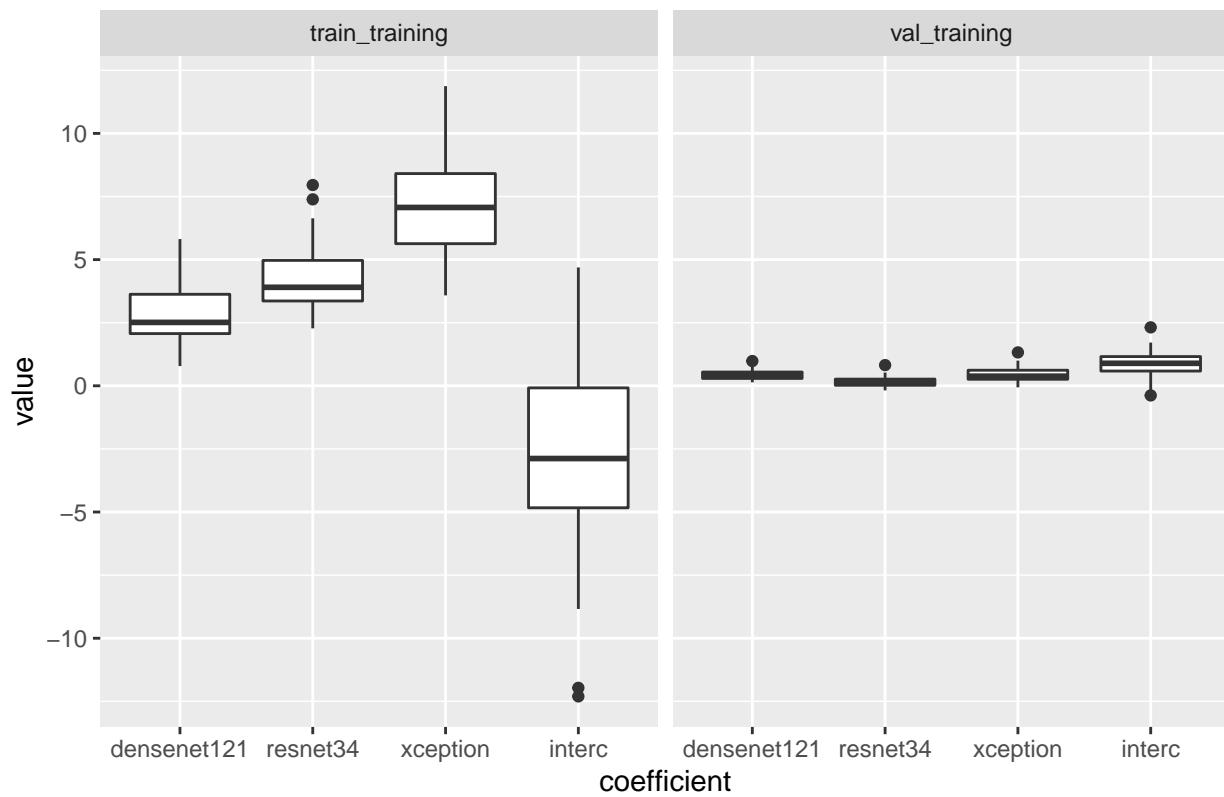
### Coefficients for class 4 vs 13



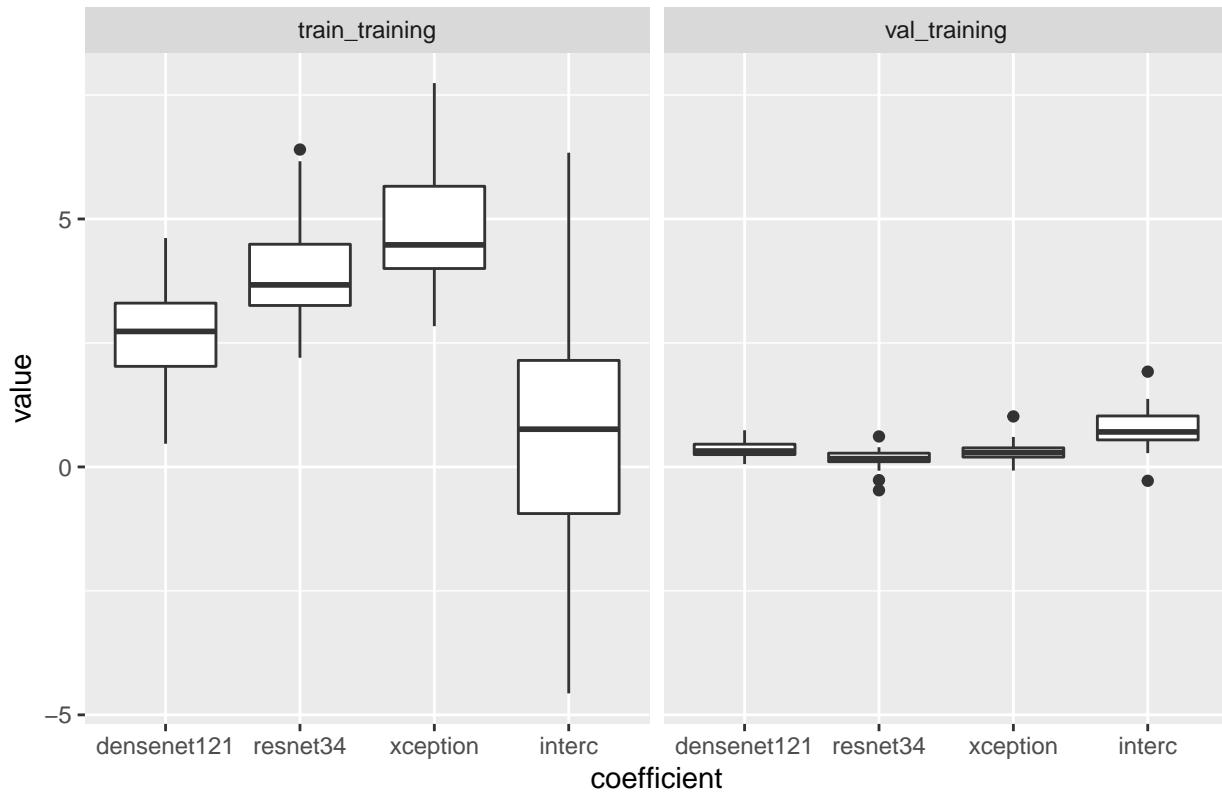
### Coefficients for class 4 vs 14



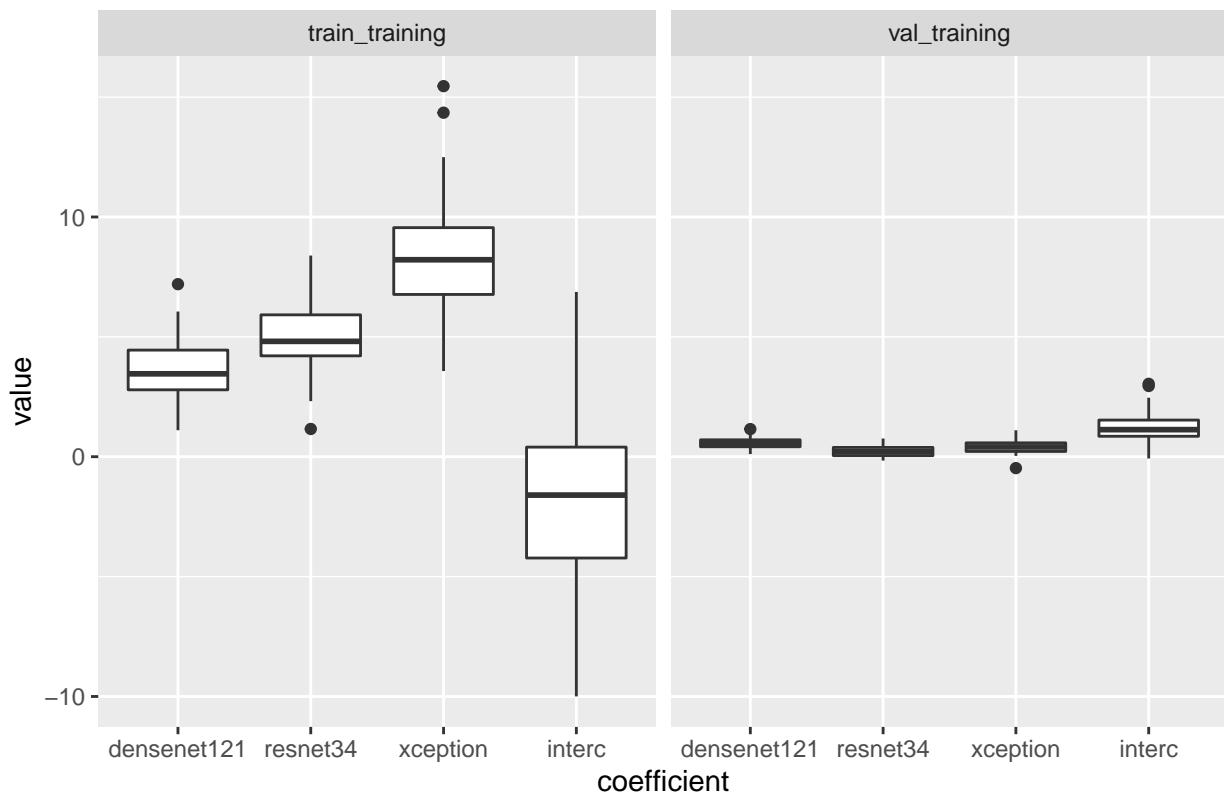
## Coefficients for class 4 vs 15



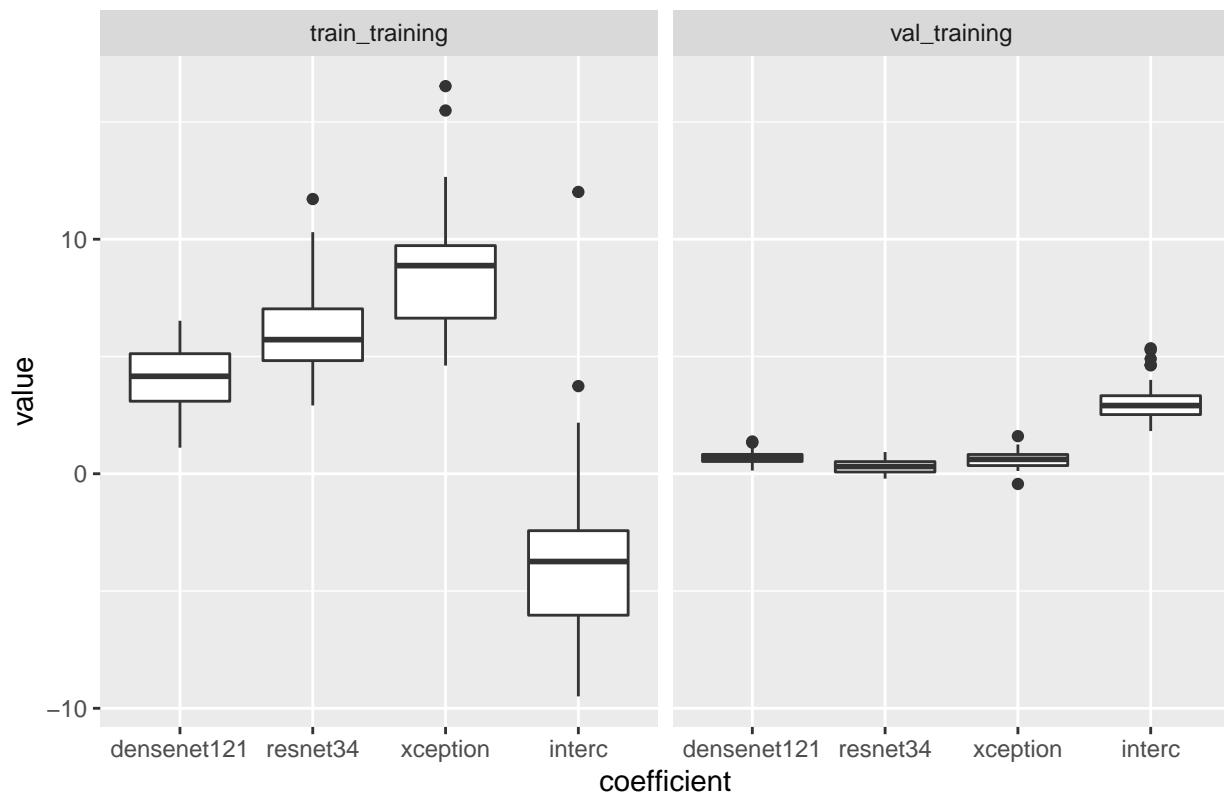
### Coefficients for class 4 vs 16



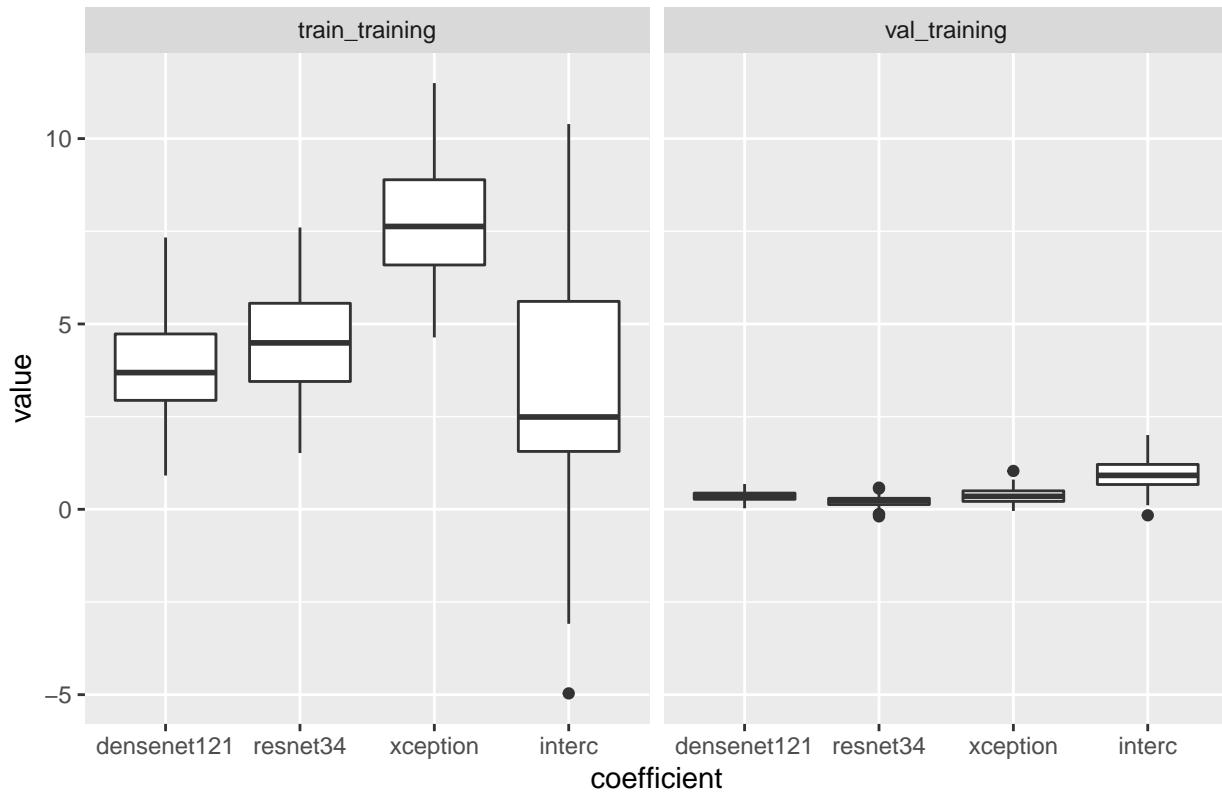
## Coefficients for class 4 vs 17



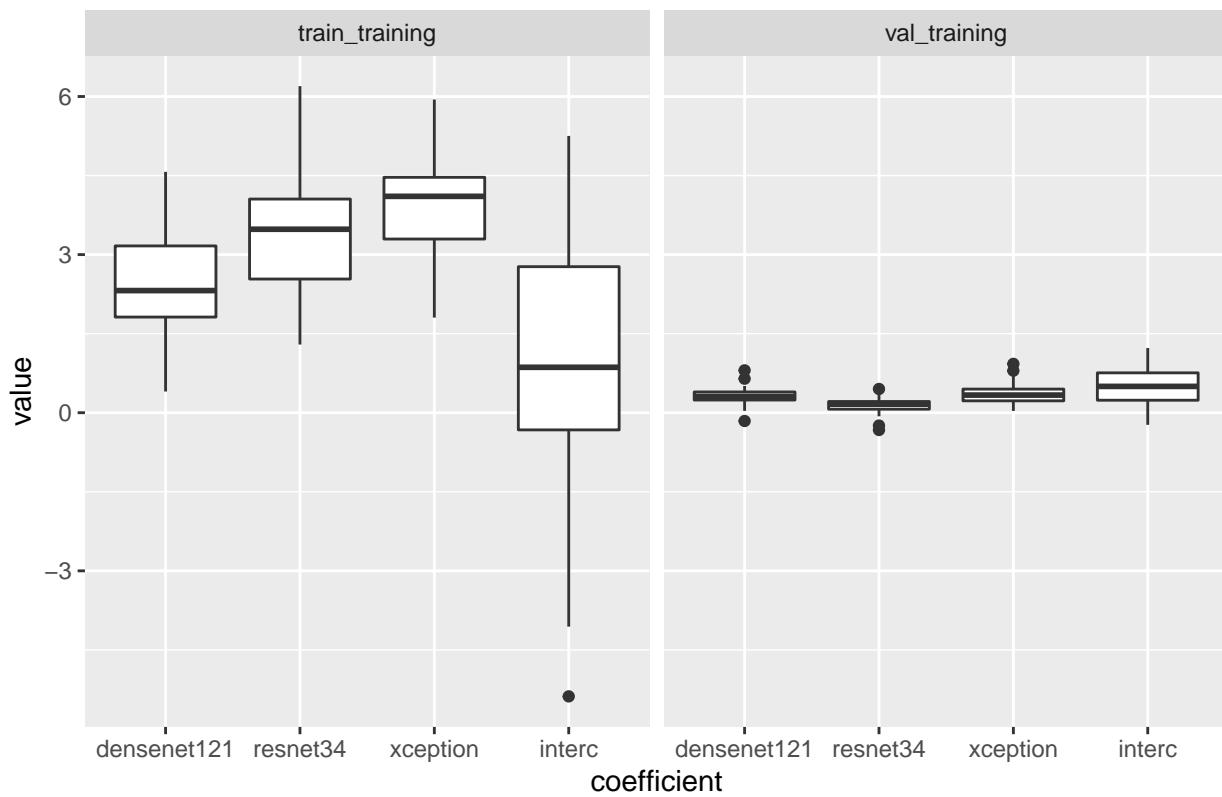
### Coefficients for class 4 vs 18



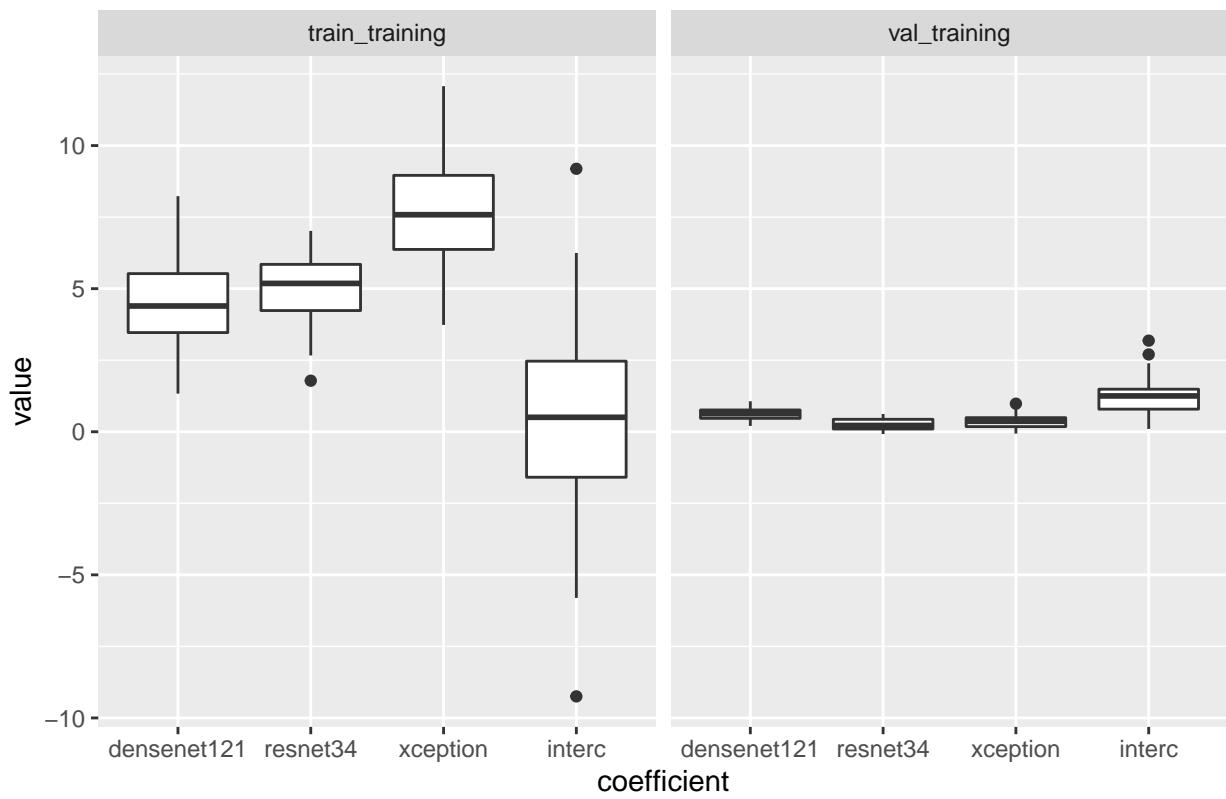
### Coefficients for class 4 vs 19



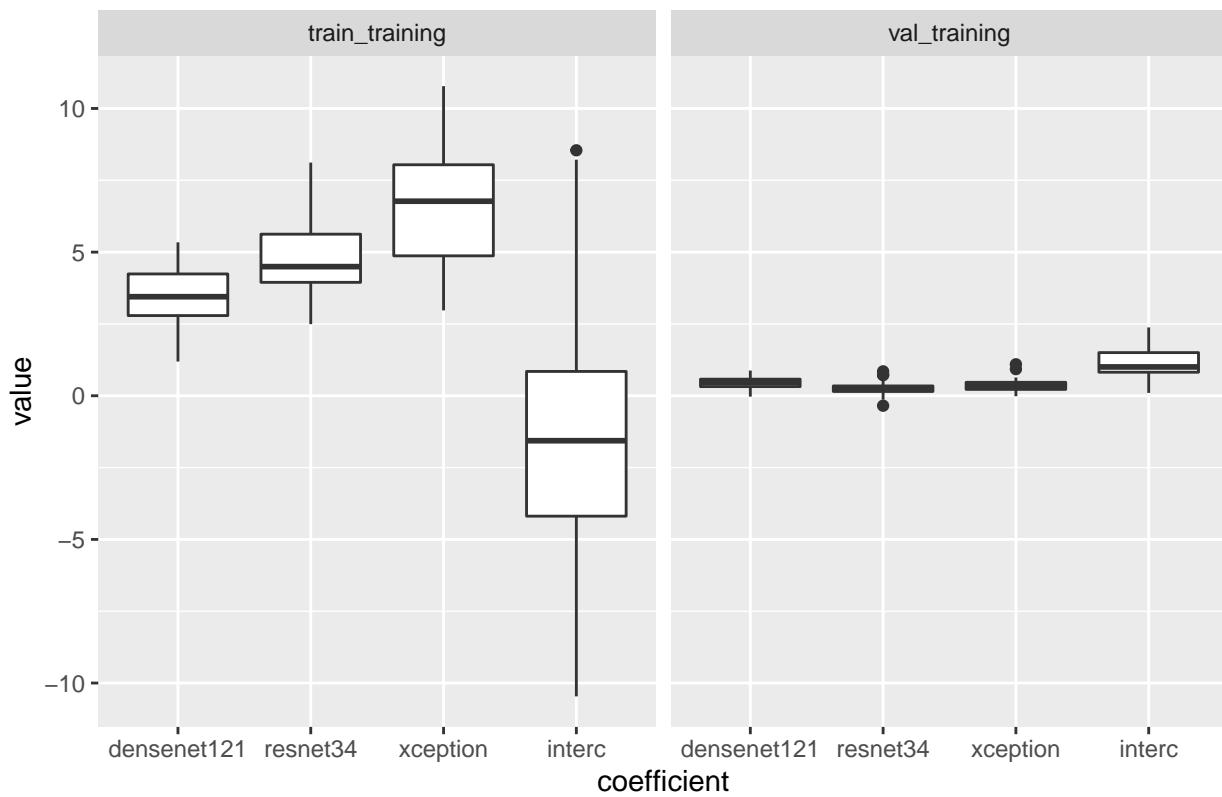
### Coefficients for class 4 vs 20



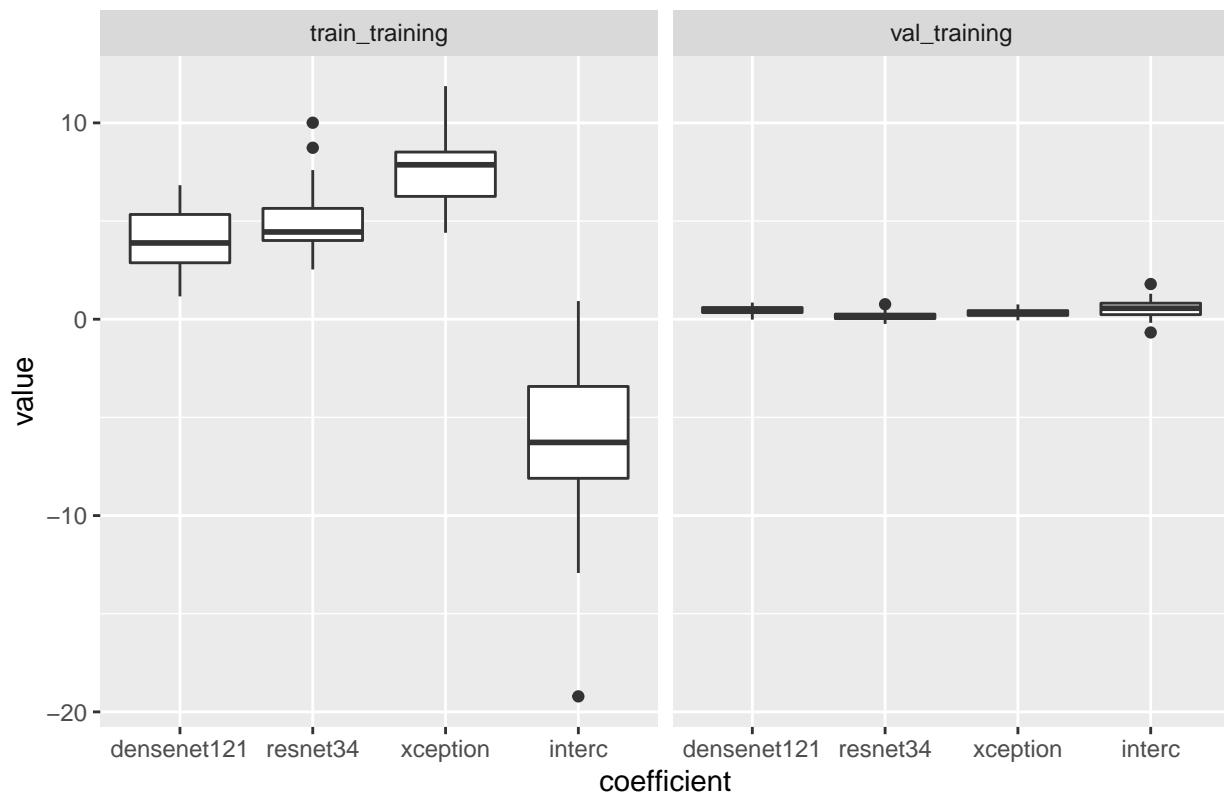
### Coefficients for class 5 vs 6



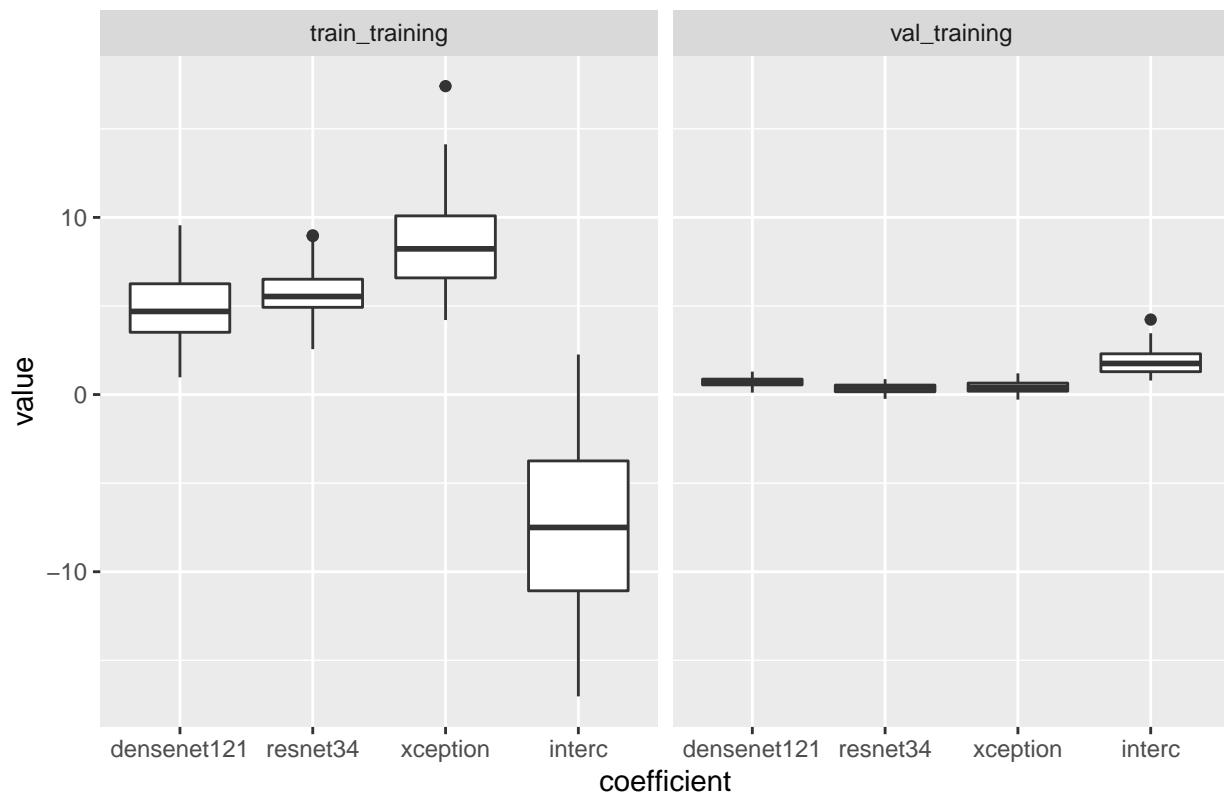
## Coefficients for class 5 vs 7



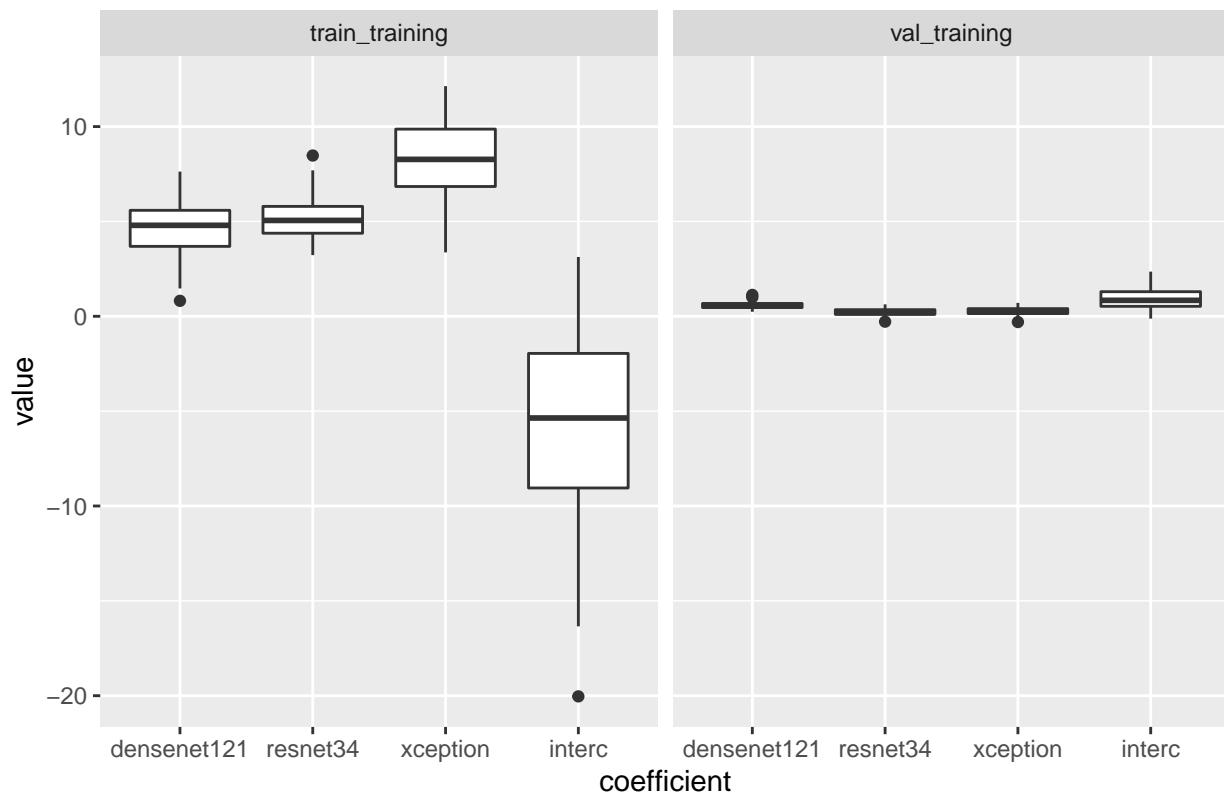
### Coefficients for class 5 vs 8



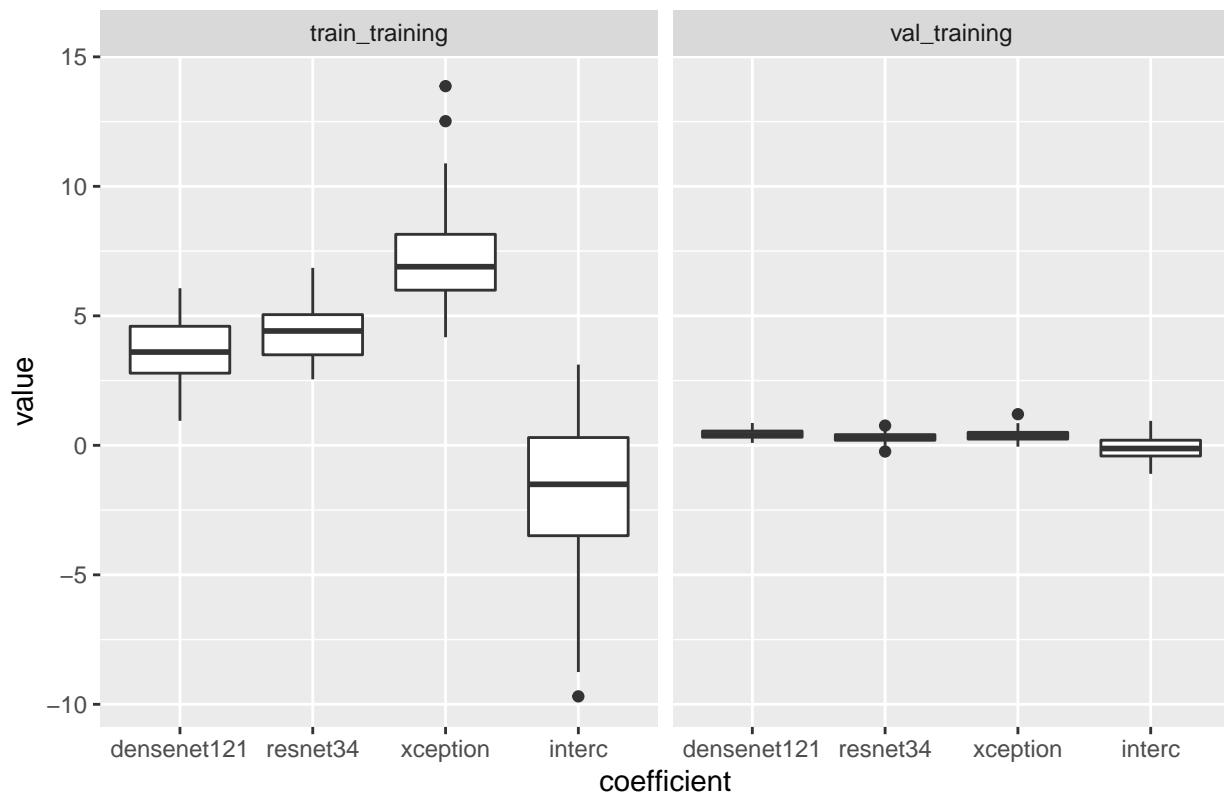
## Coefficients for class 5 vs 9



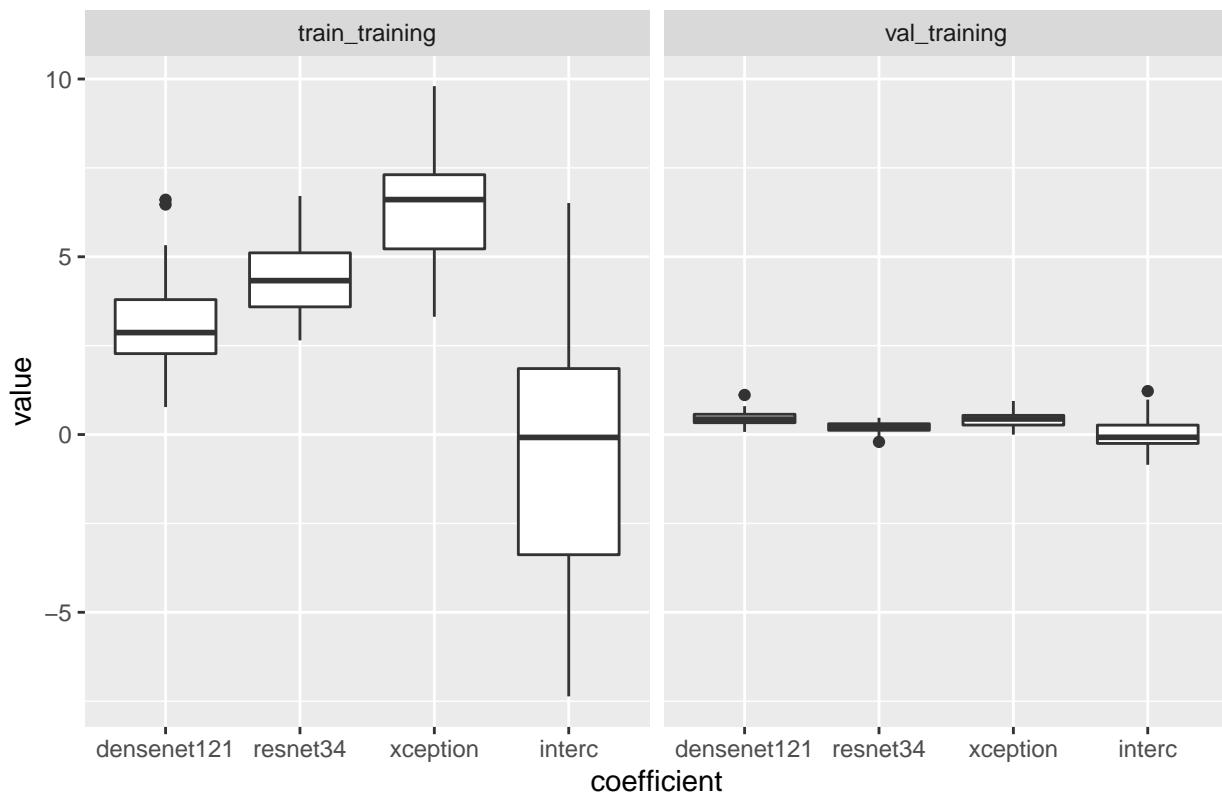
## Coefficients for class 5 vs 10



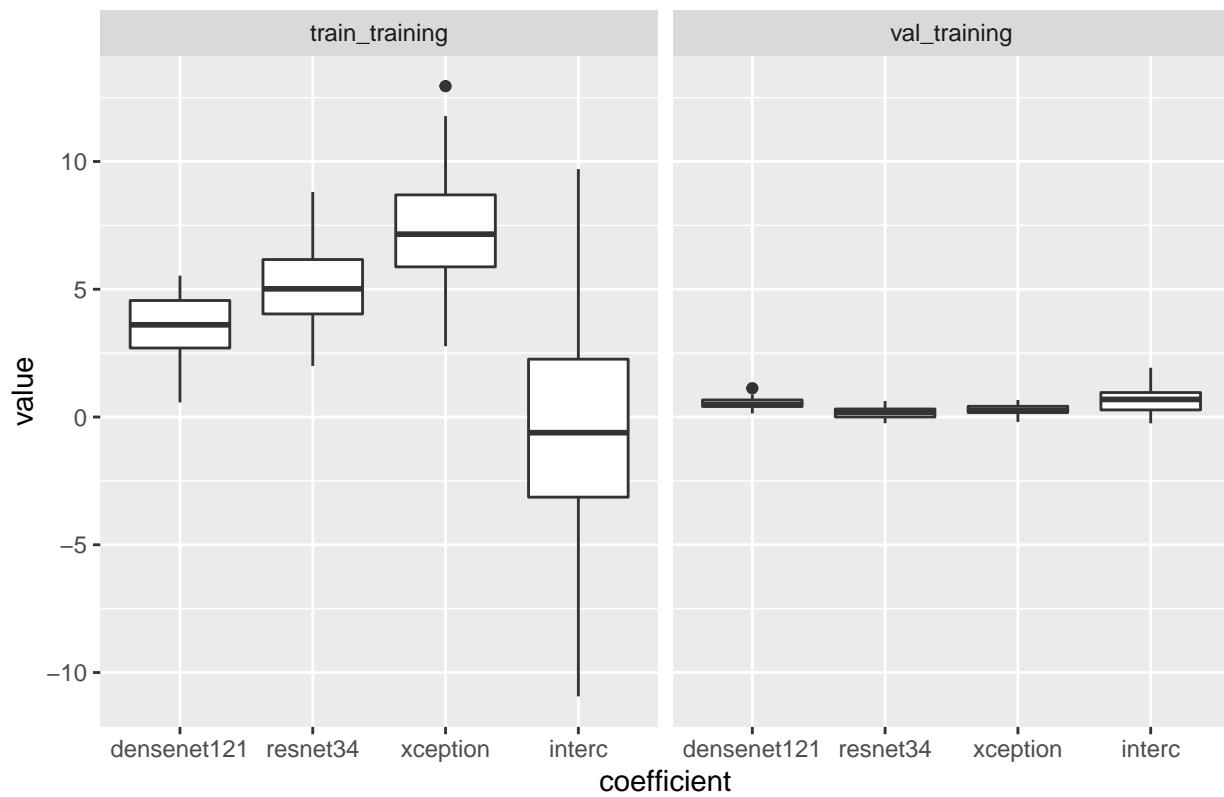
### Coefficients for class 5 vs 11



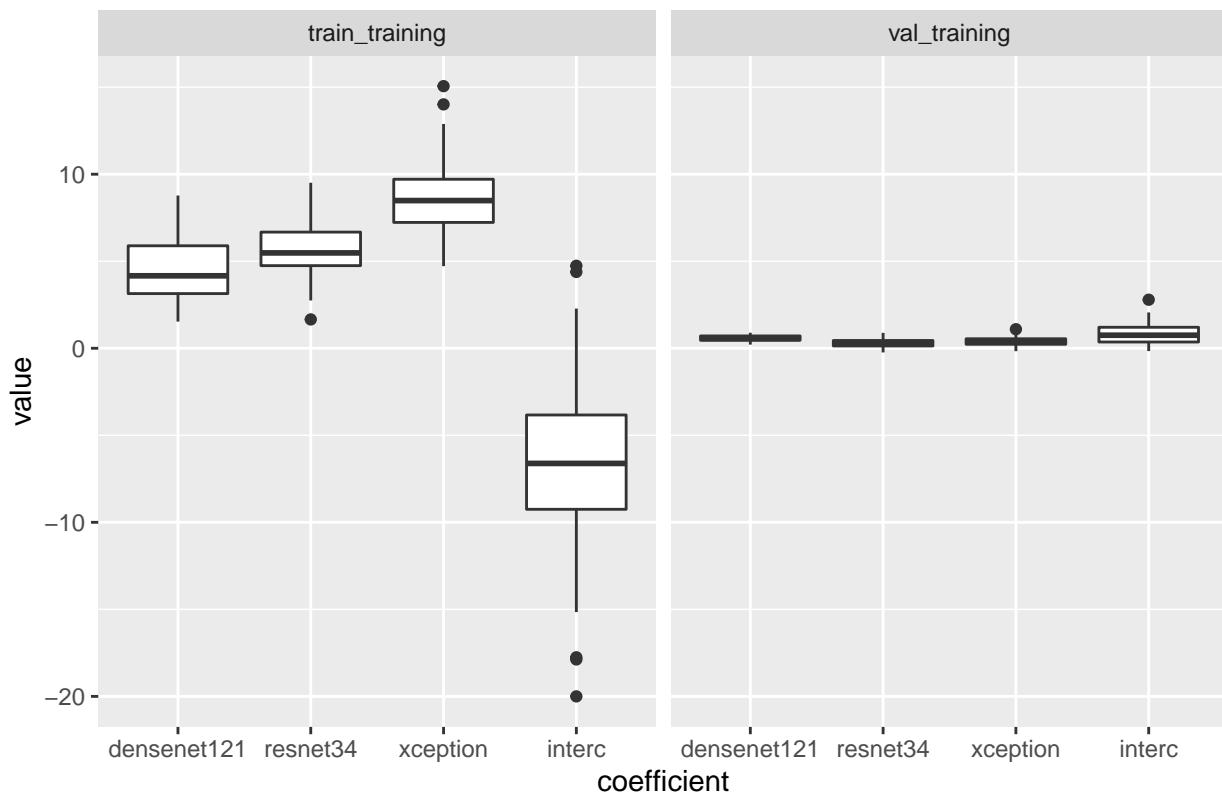
### Coefficients for class 5 vs 12



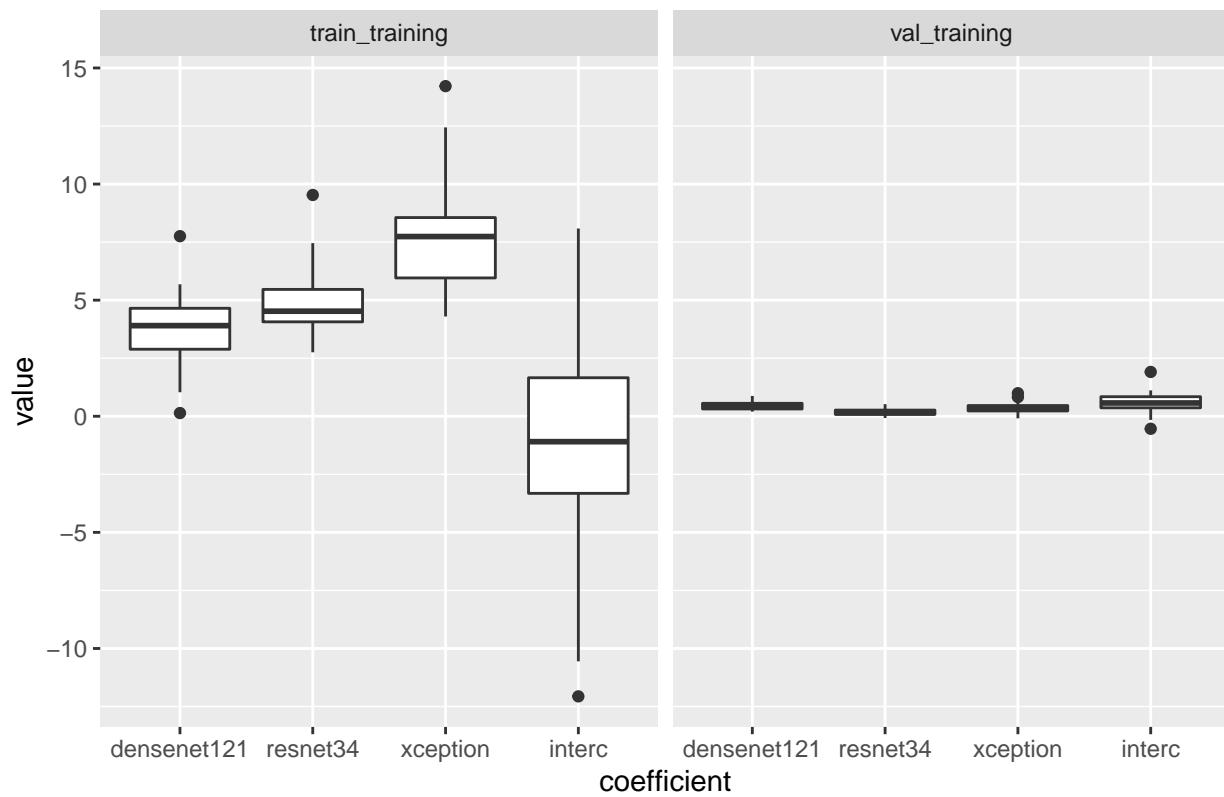
### Coefficients for class 5 vs 13



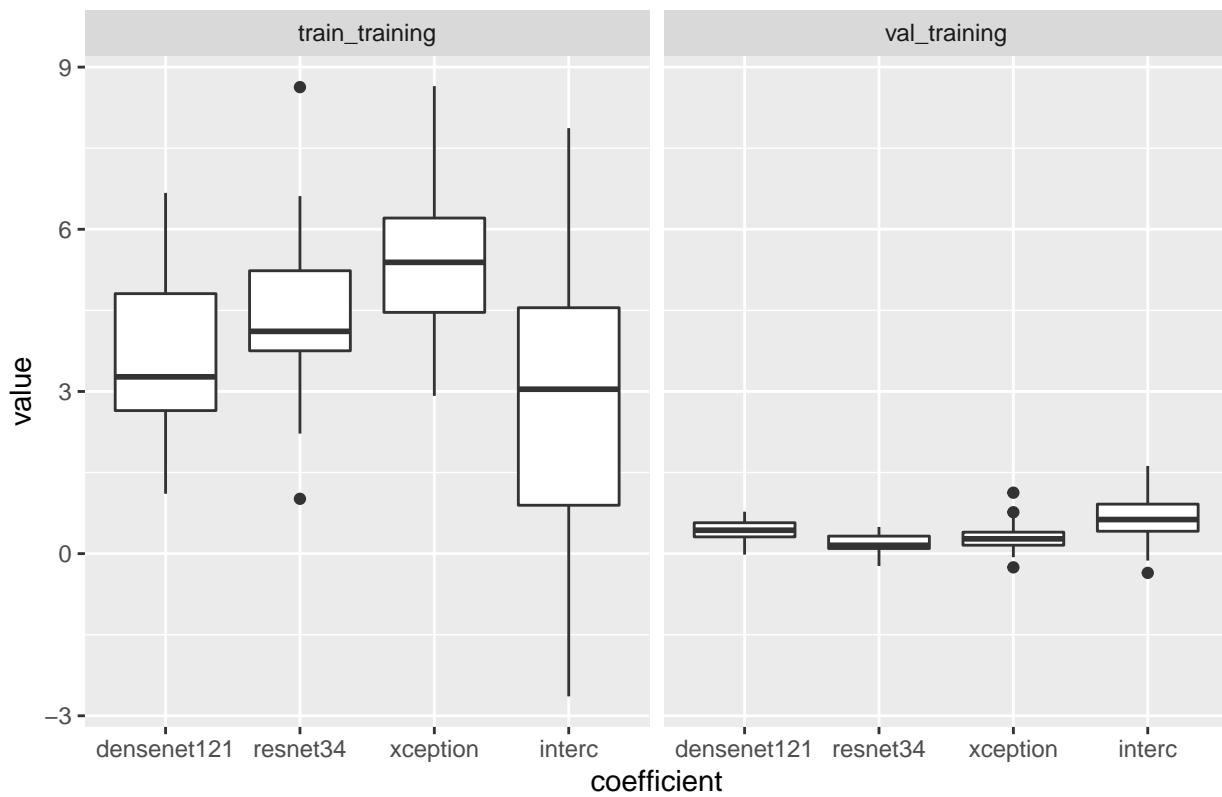
### Coefficients for class 5 vs 14



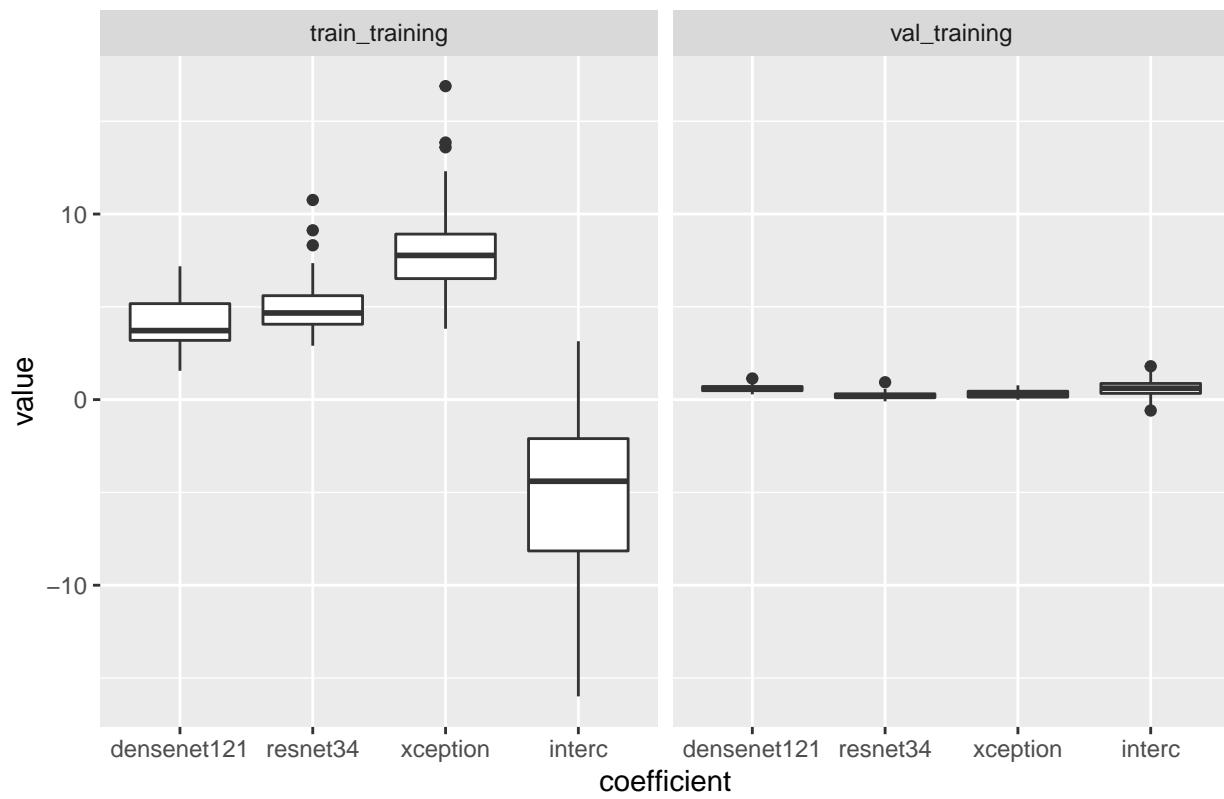
### Coefficients for class 5 vs 15



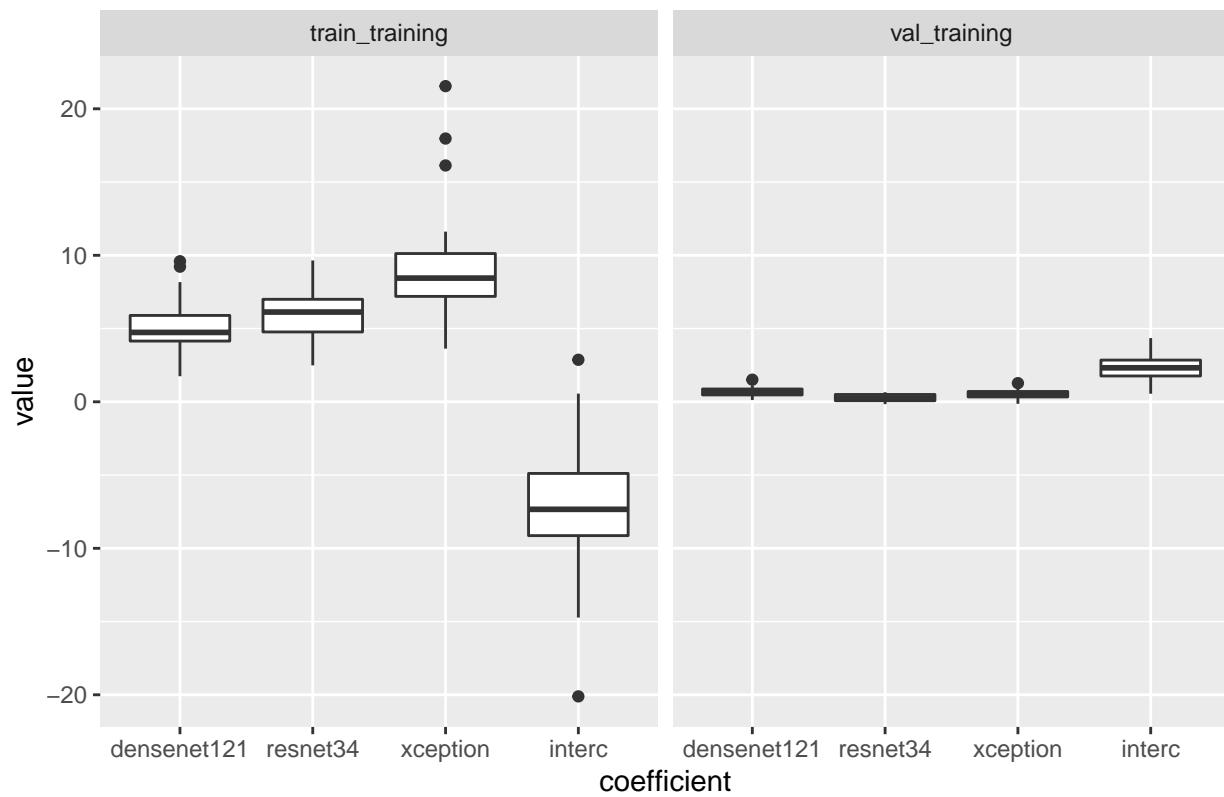
### Coefficients for class 5 vs 16



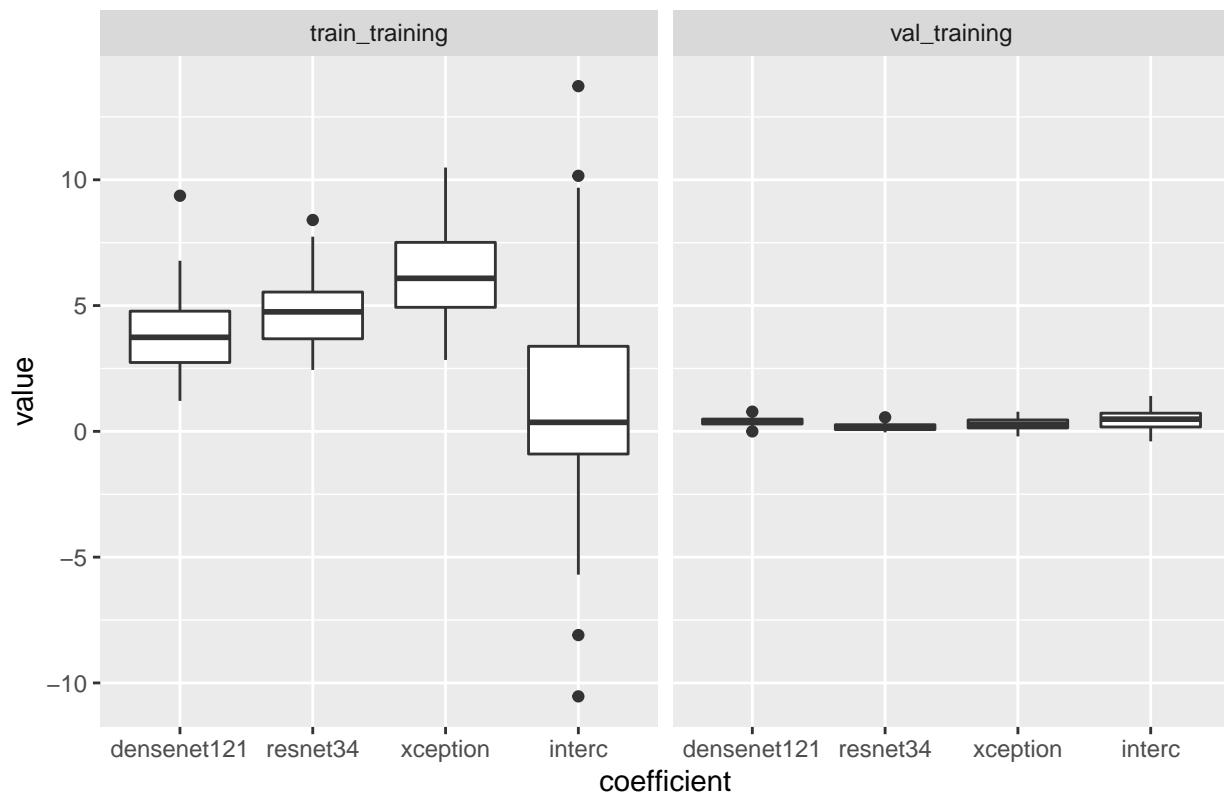
## Coefficients for class 5 vs 17



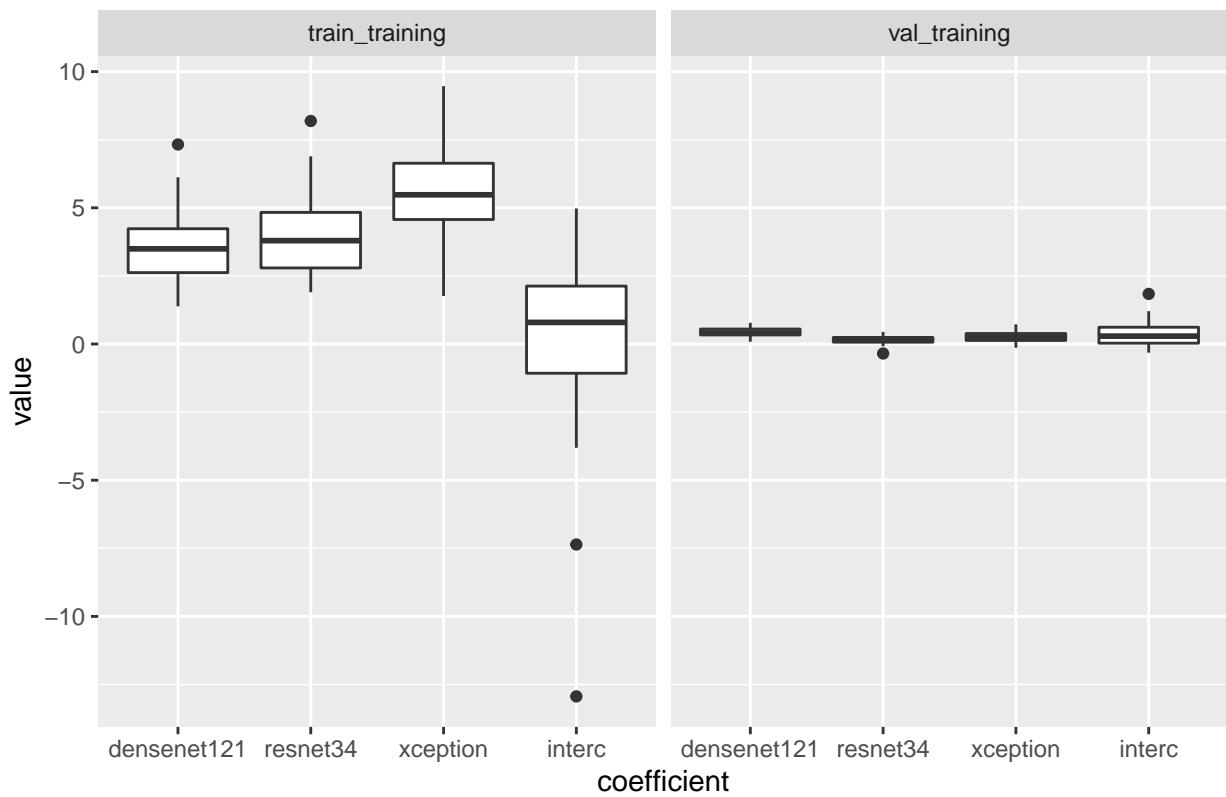
### Coefficients for class 5 vs 18



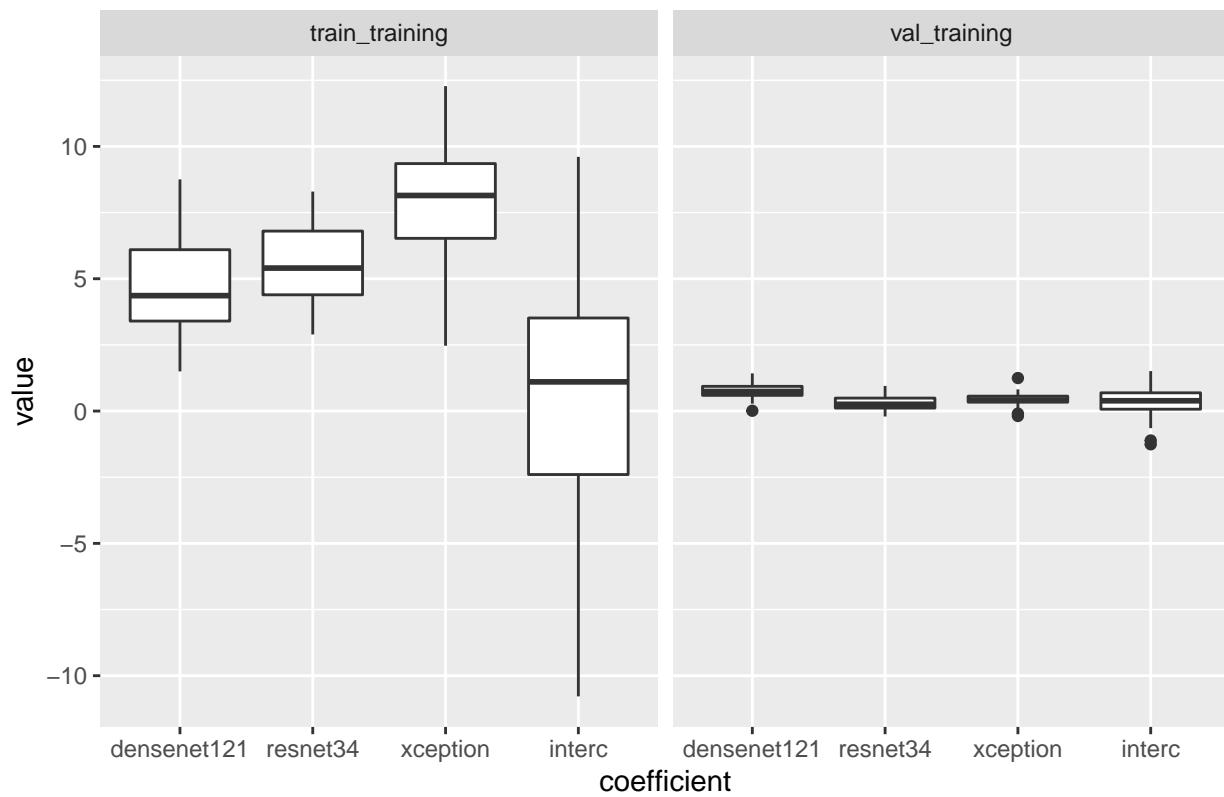
### Coefficients for class 5 vs 19



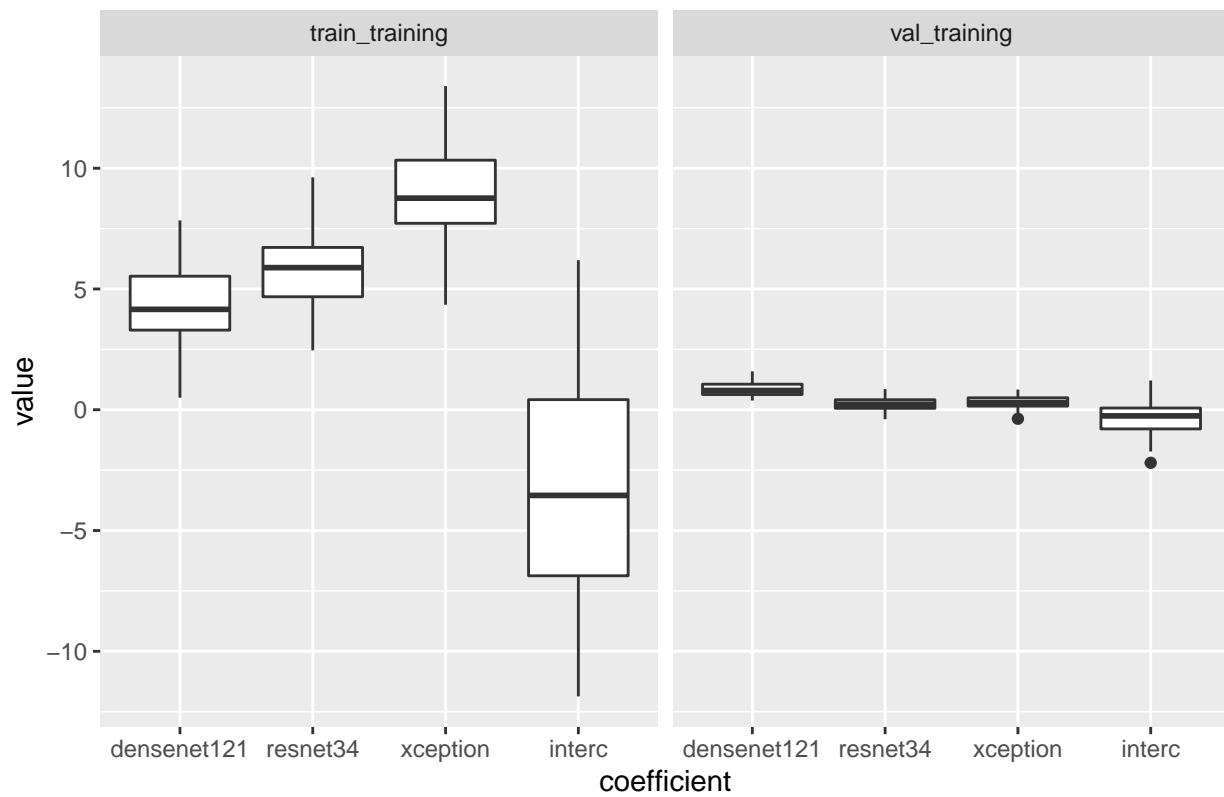
### Coefficients for class 5 vs 20



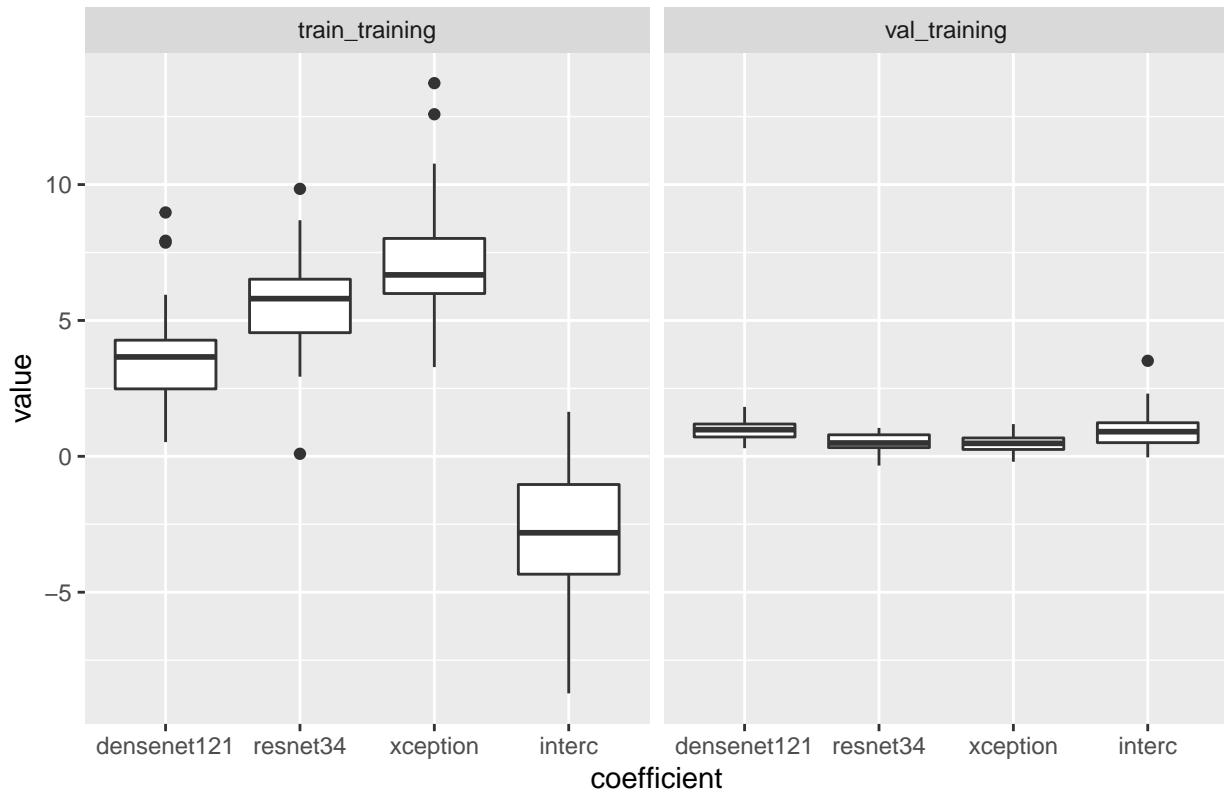
## Coefficients for class 6 vs 7



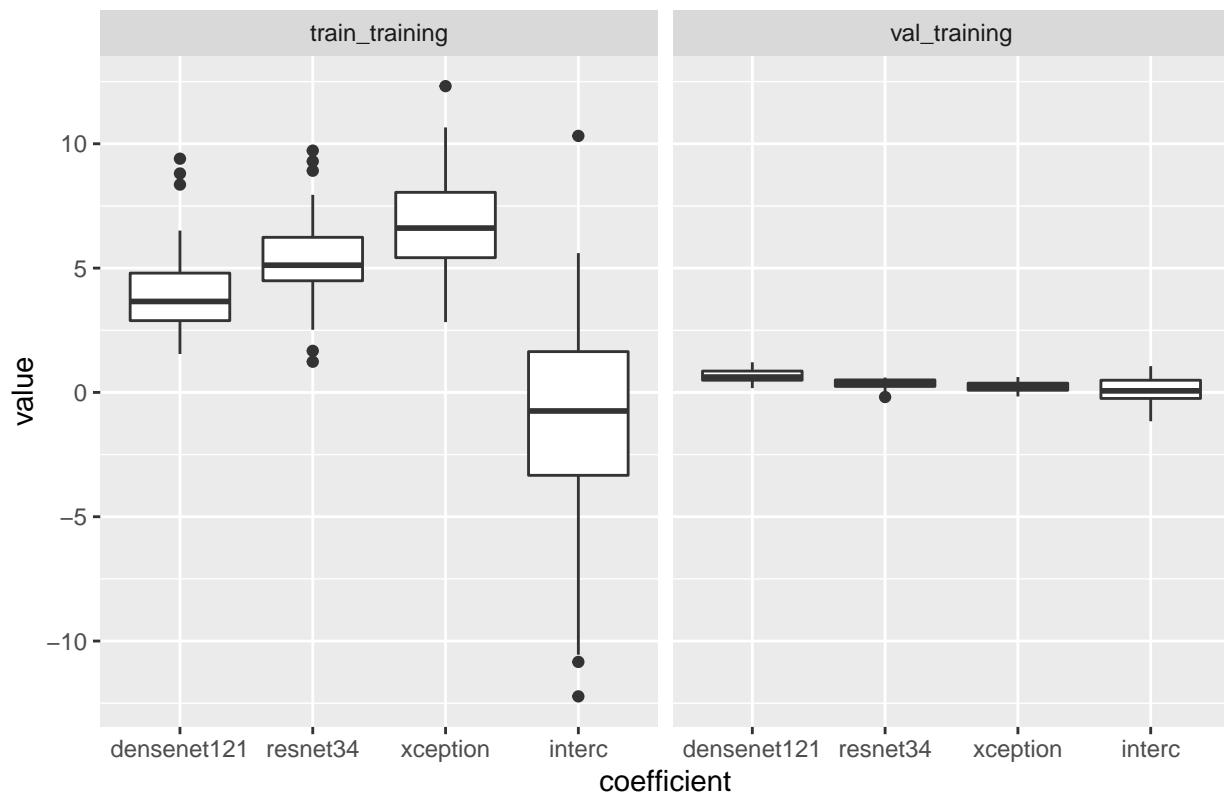
## Coefficients for class 6 vs 8



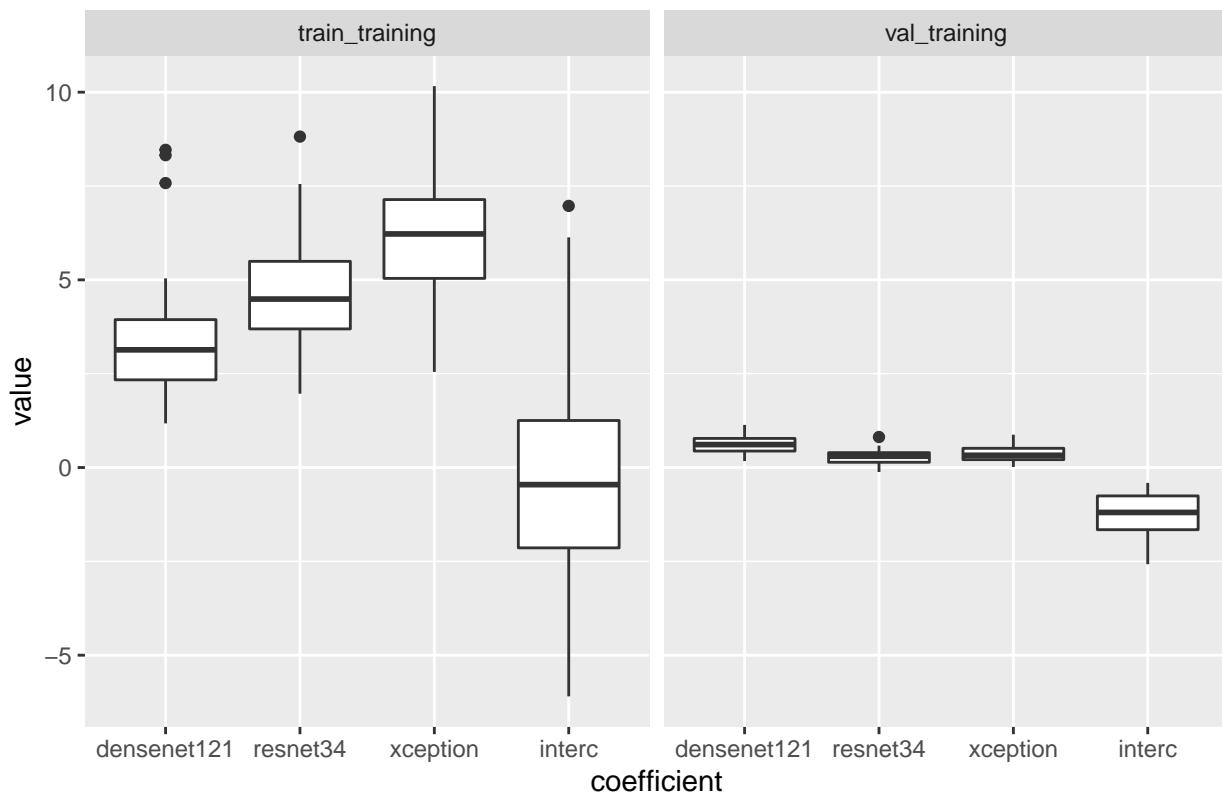
### Coefficients for class 6 vs 9



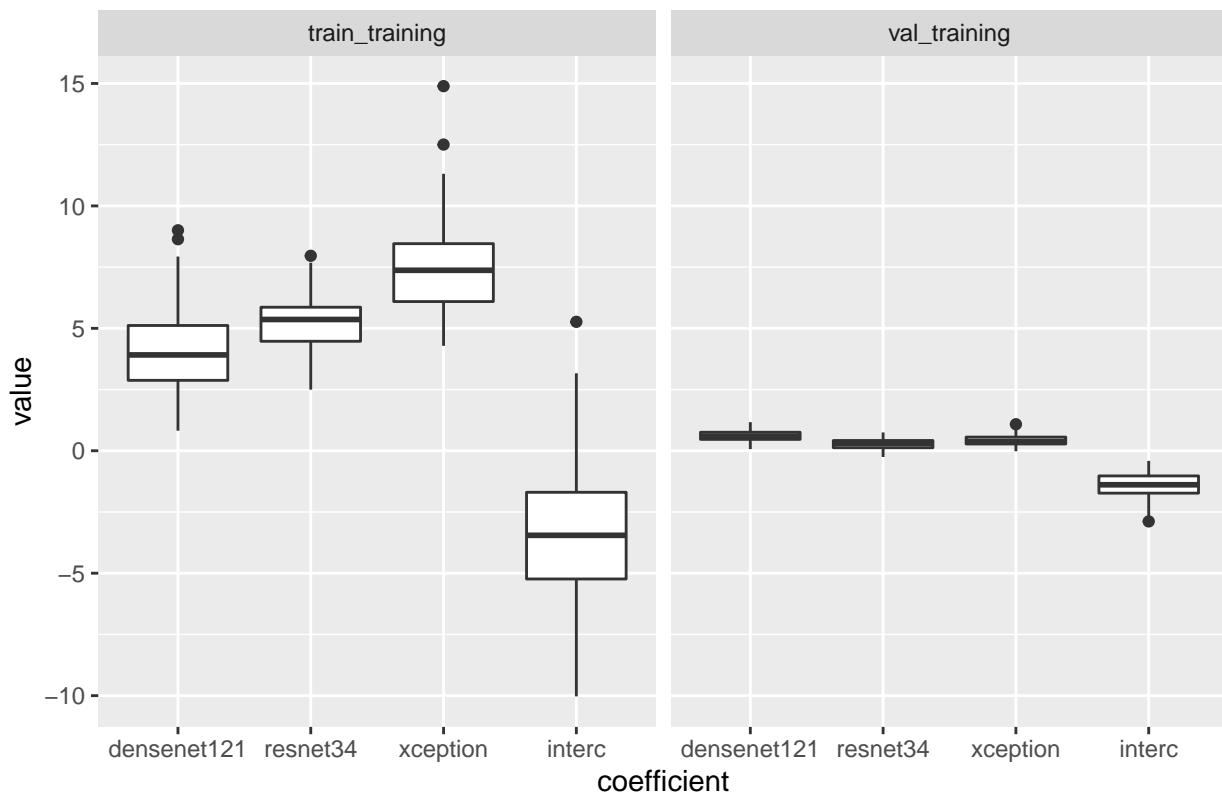
## Coefficients for class 6 vs 10



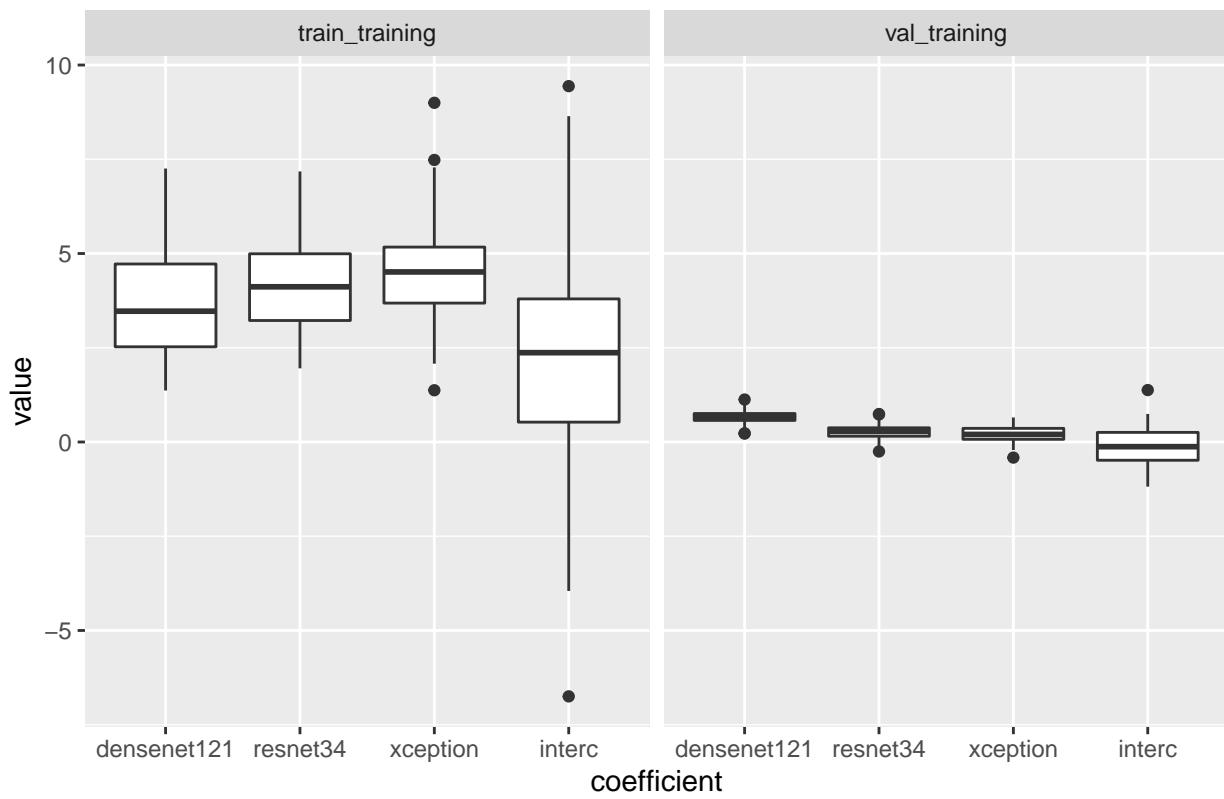
### Coefficients for class 6 vs 11



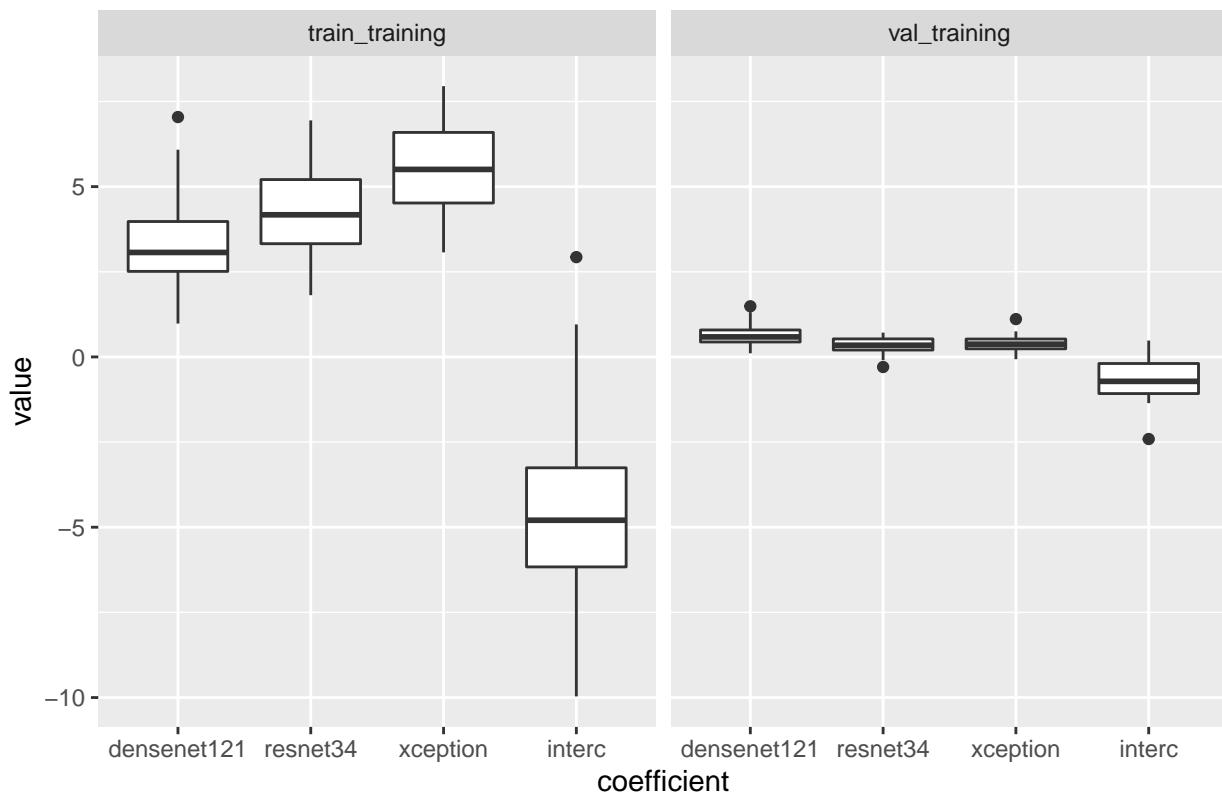
## Coefficients for class 6 vs 12



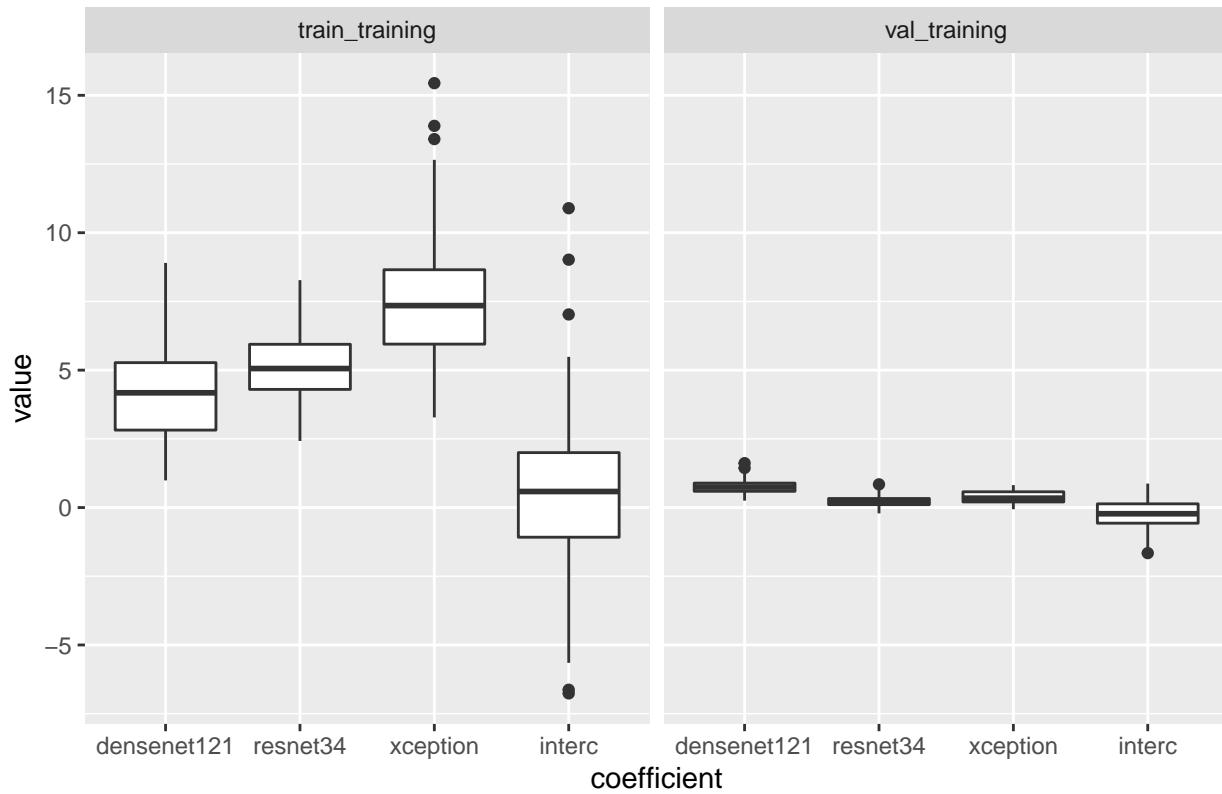
### Coefficients for class 6 vs 13



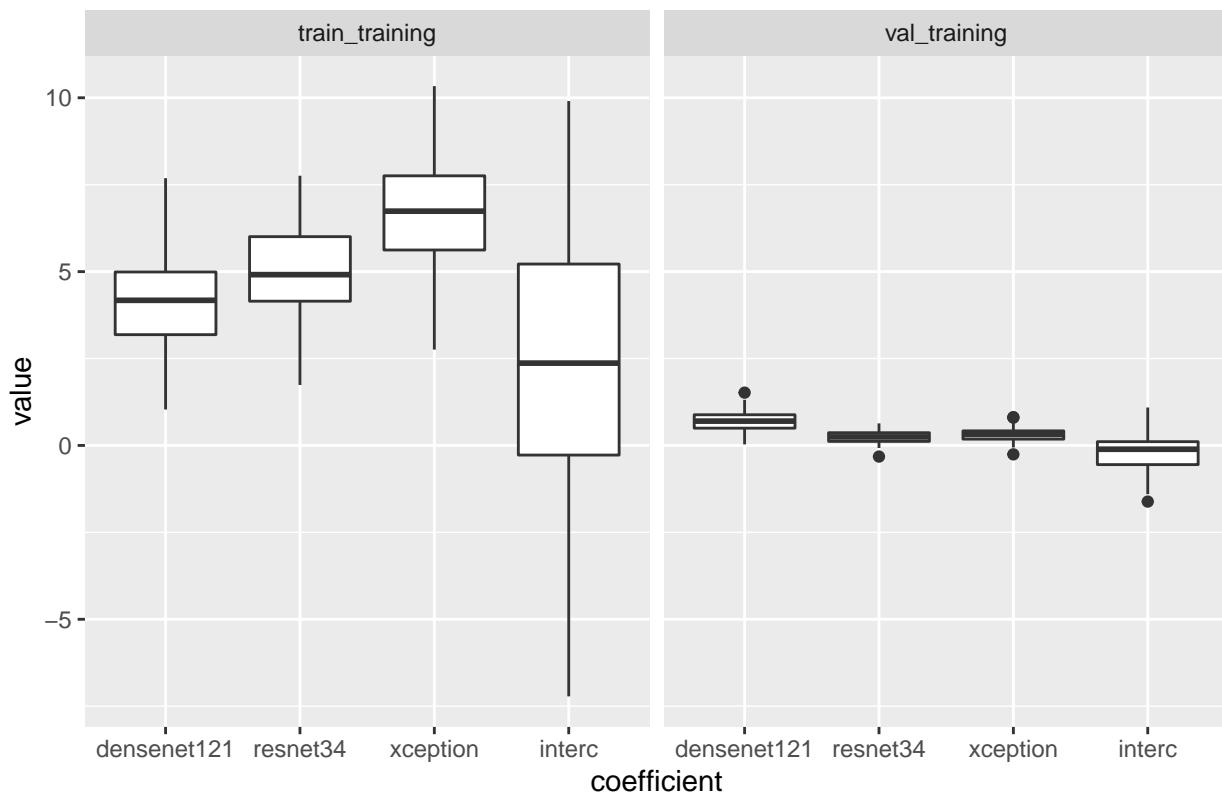
### Coefficients for class 6 vs 14



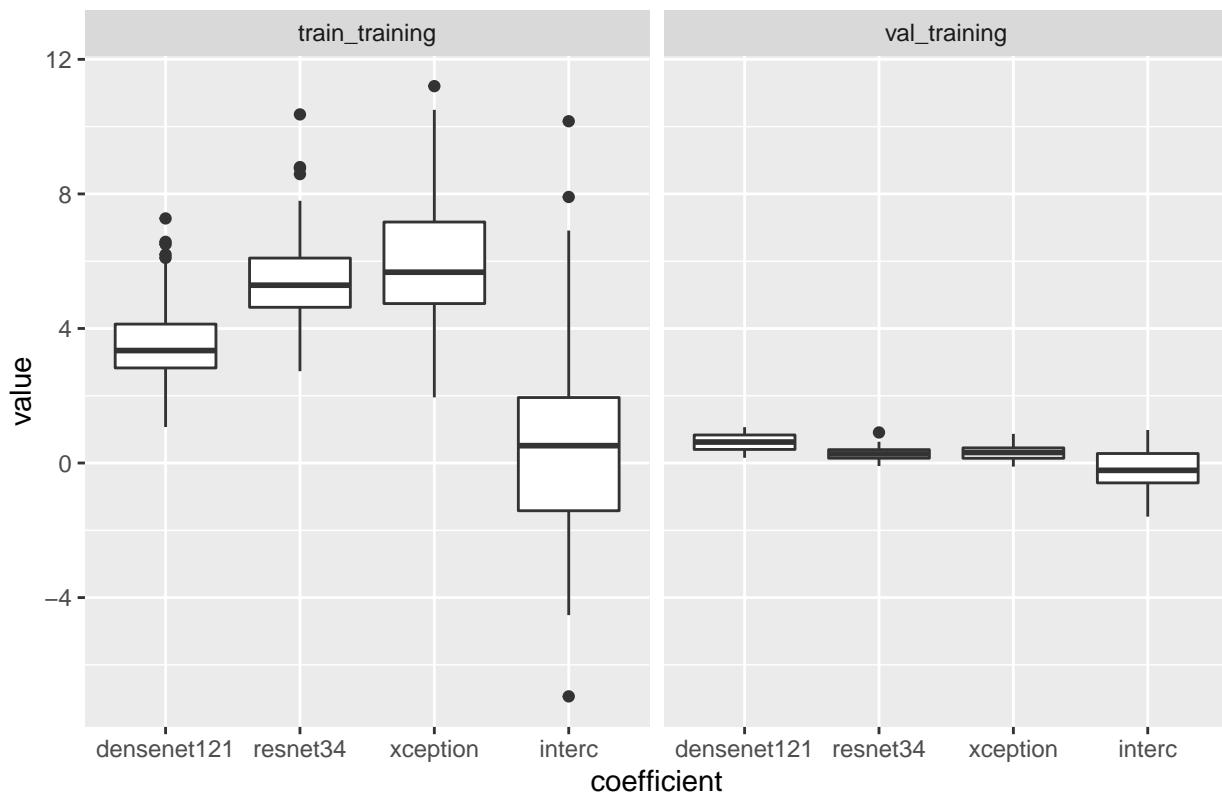
### Coefficients for class 6 vs 15



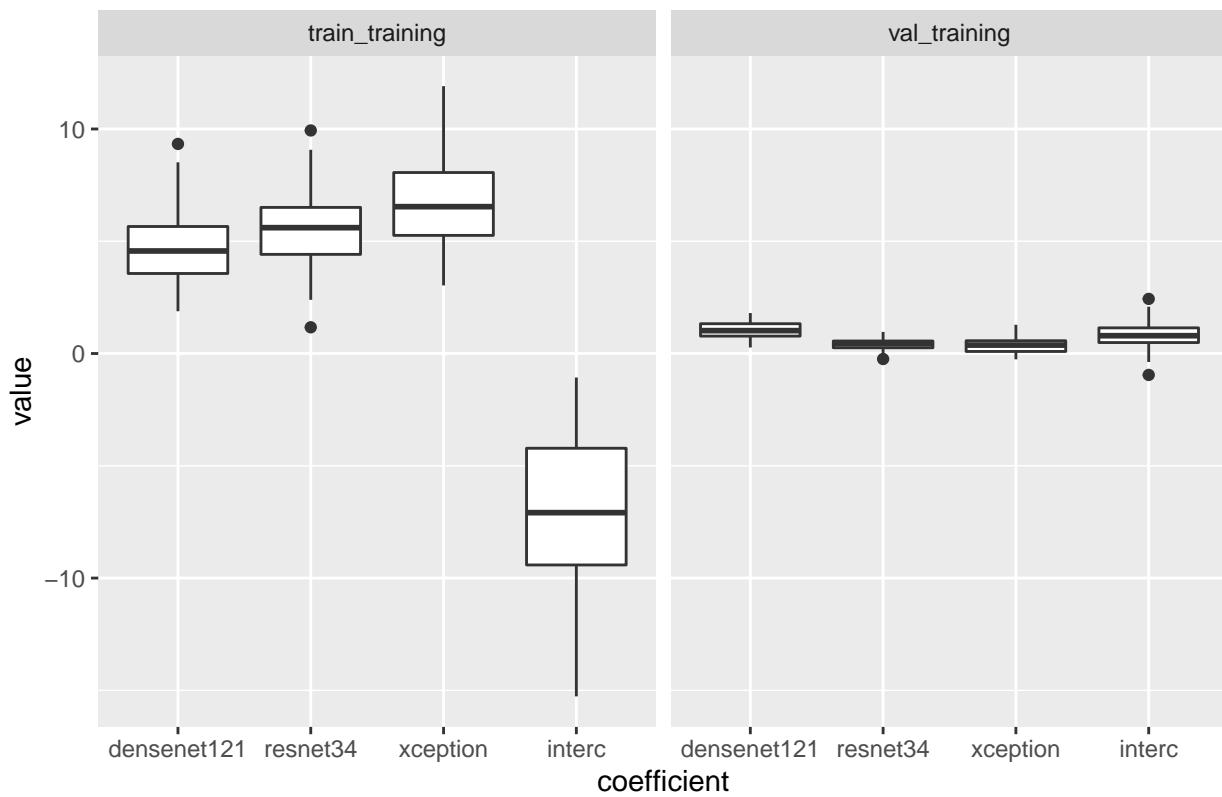
### Coefficients for class 6 vs 16



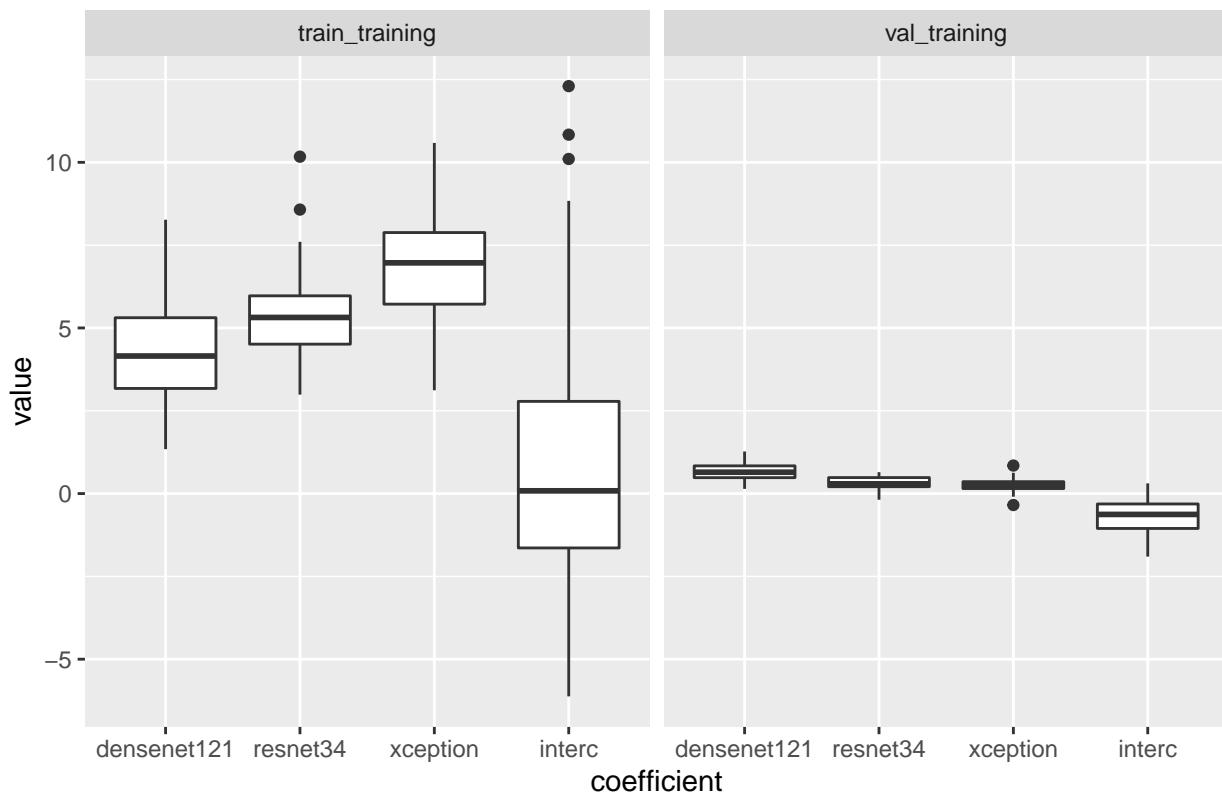
### Coefficients for class 6 vs 17



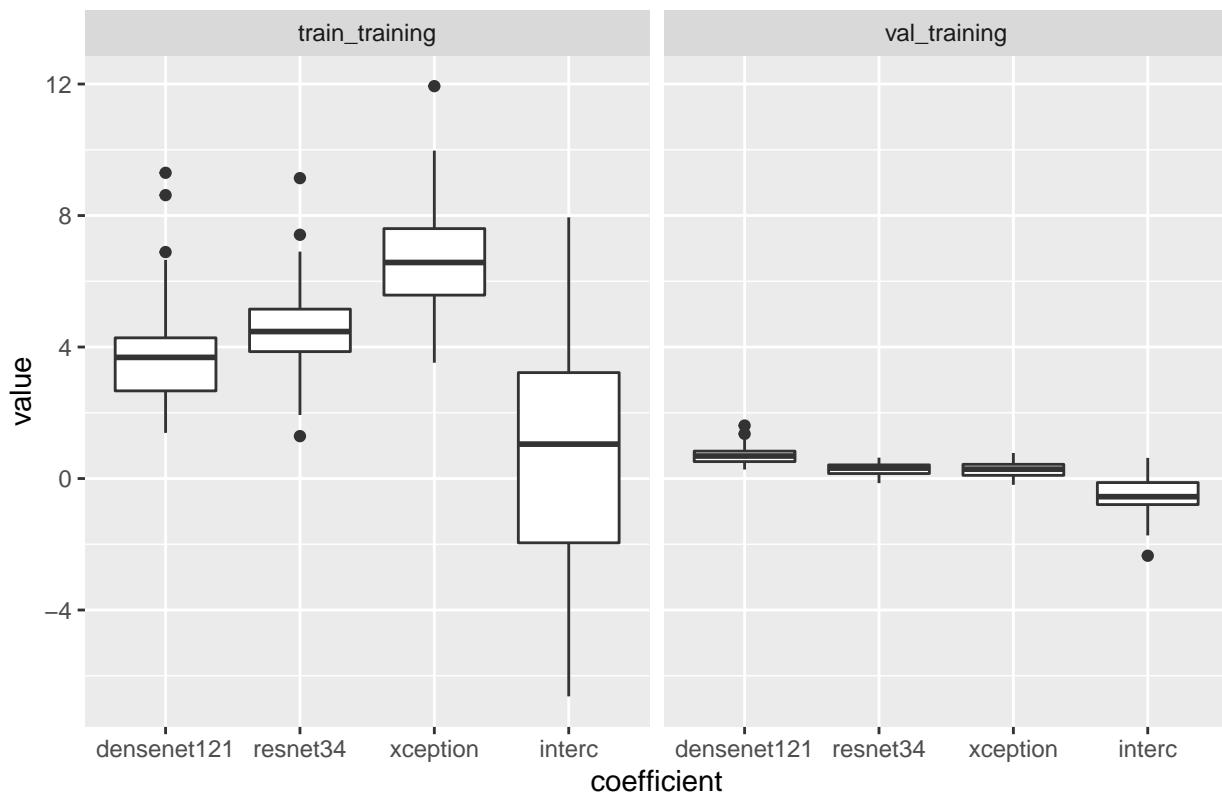
### Coefficients for class 6 vs 18



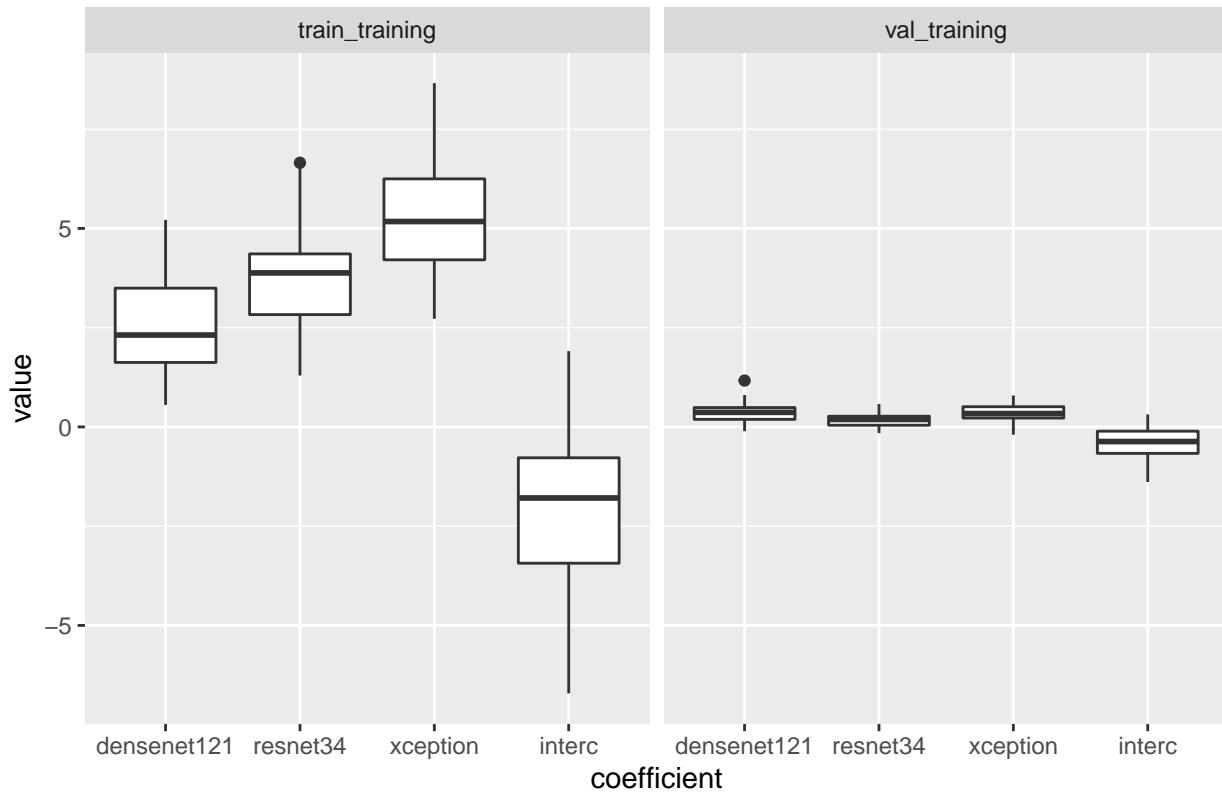
### Coefficients for class 6 vs 19



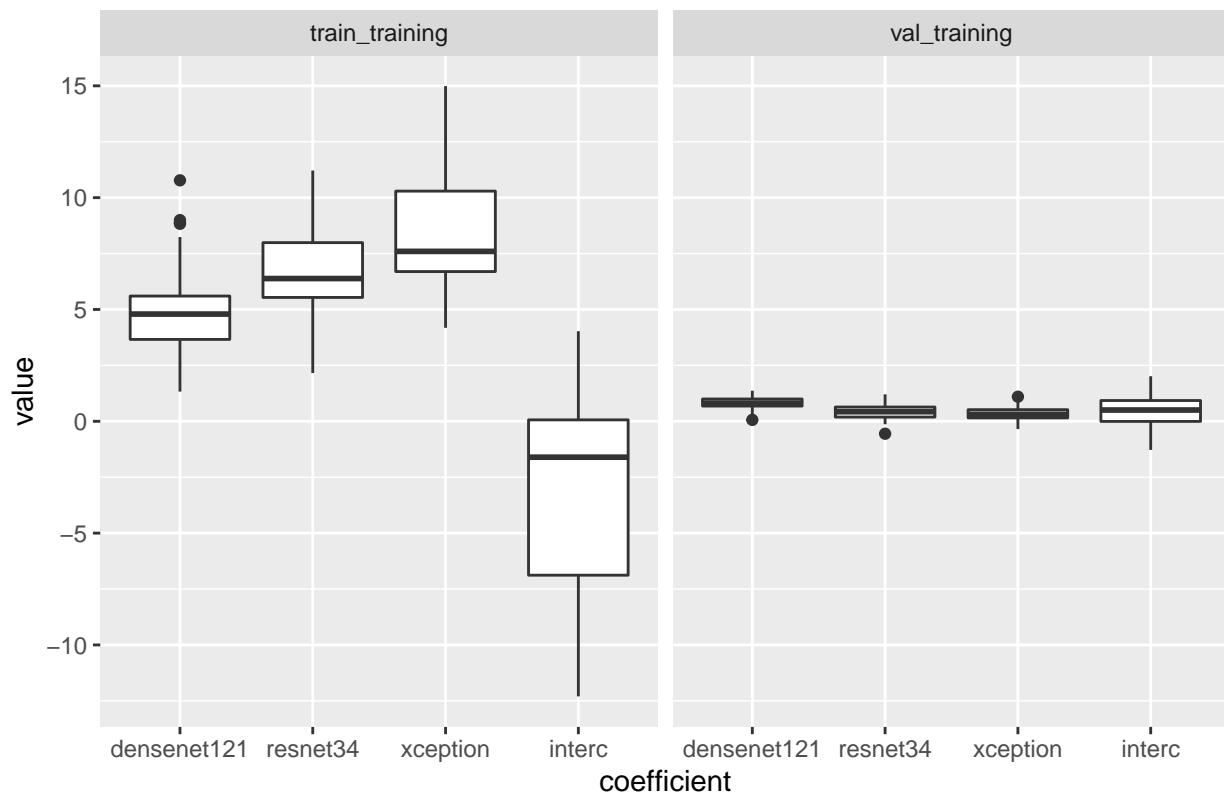
### Coefficients for class 6 vs 20



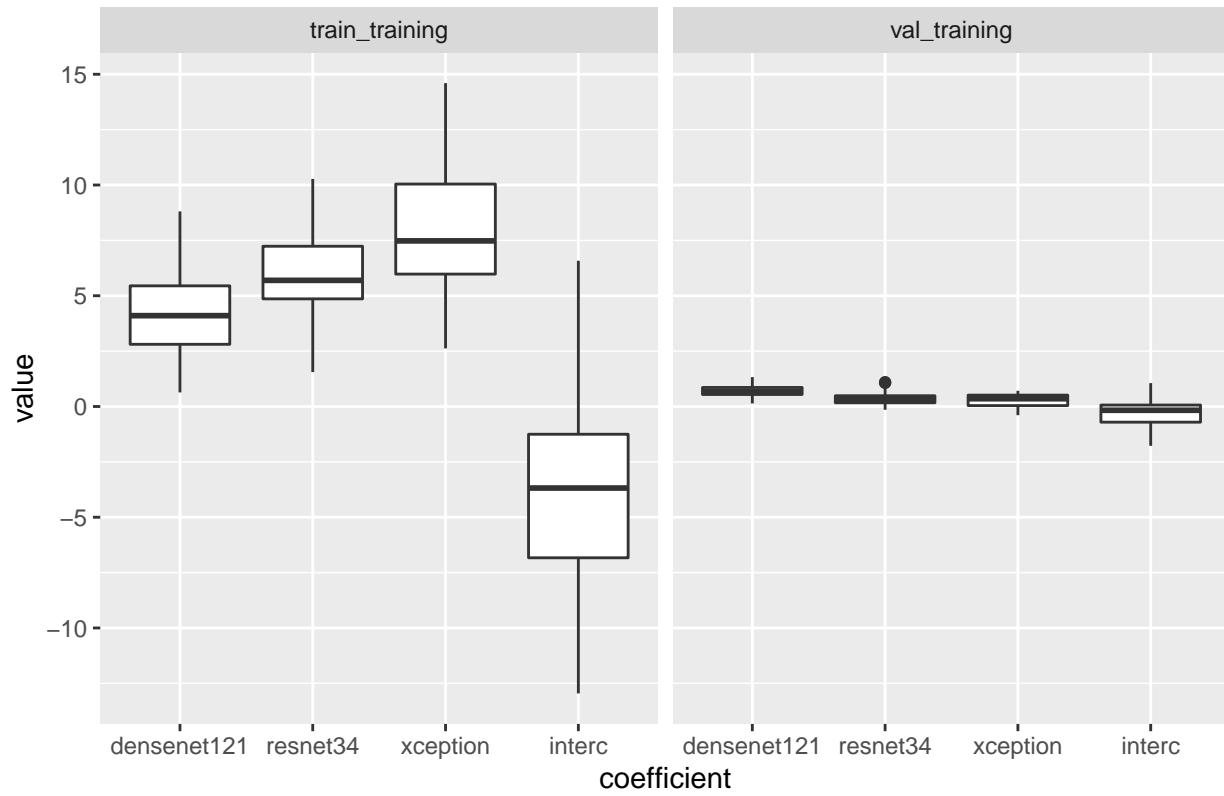
### Coefficients for class 7 vs 8



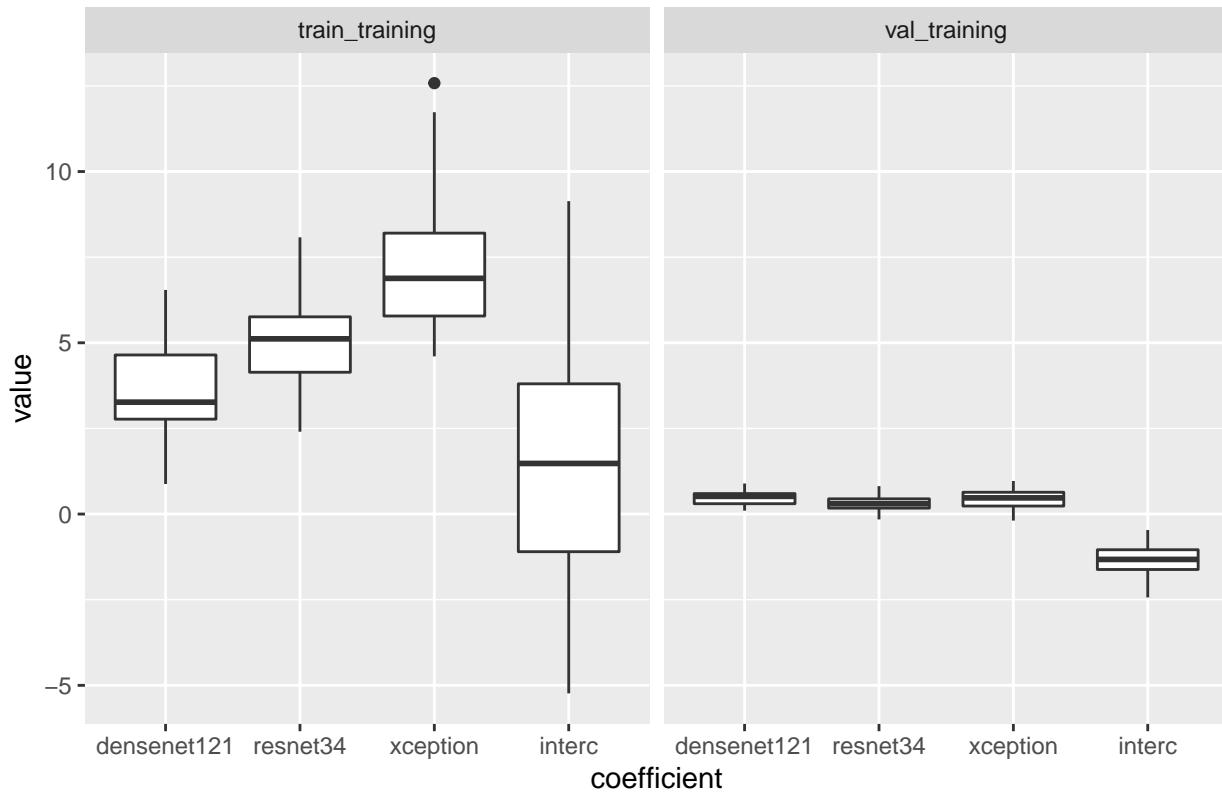
### Coefficients for class 7 vs 9



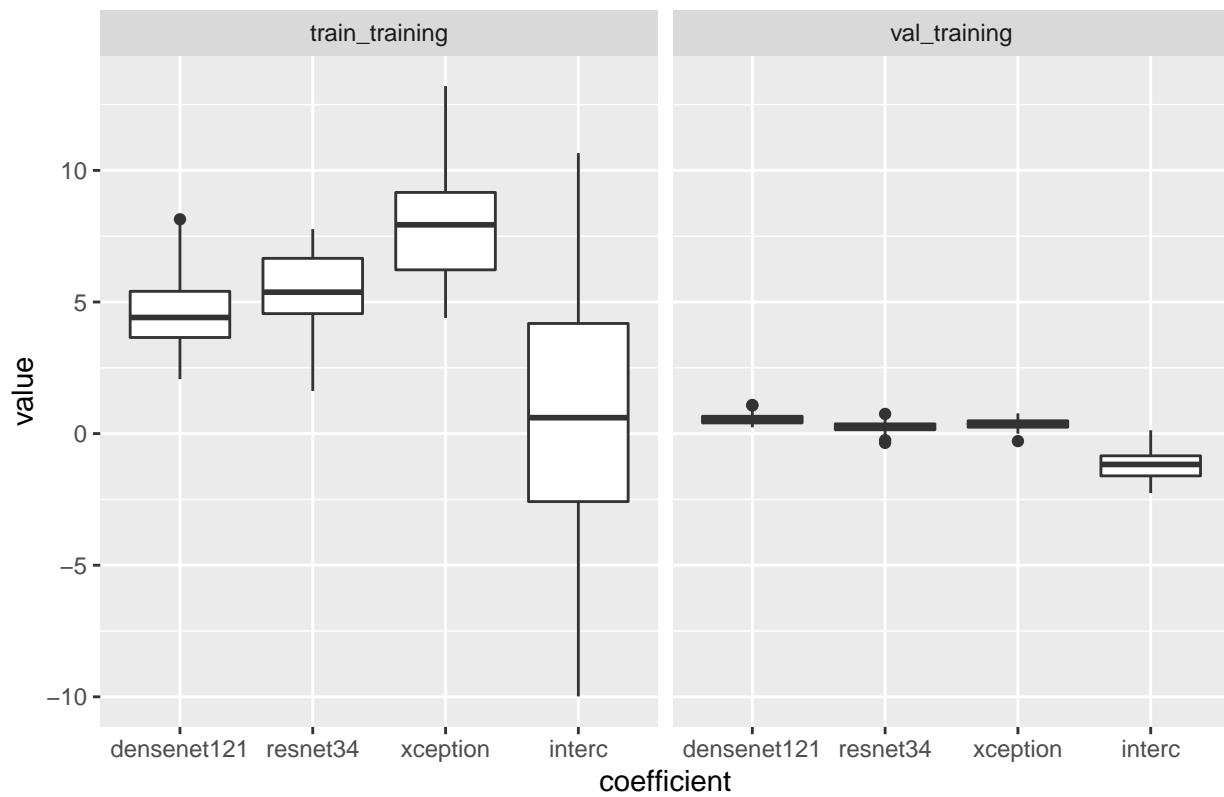
## Coefficients for class 7 vs 10



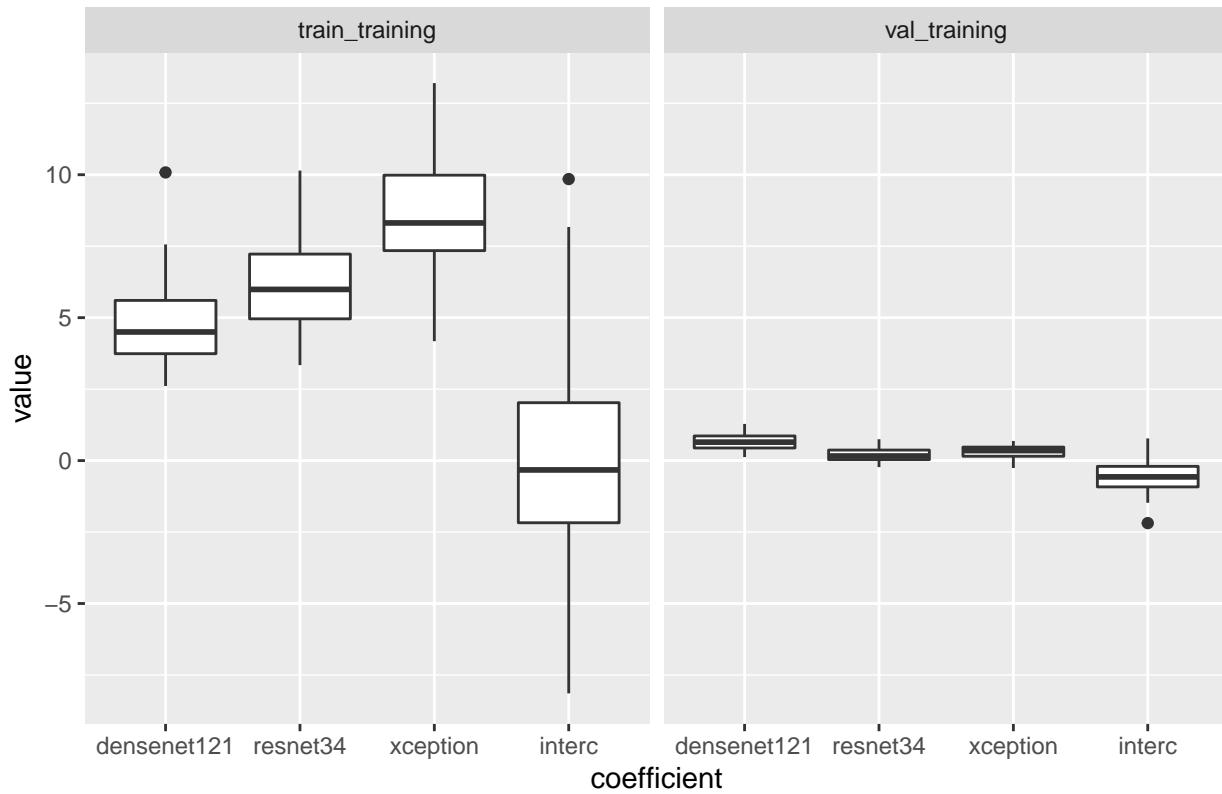
### Coefficients for class 7 vs 11



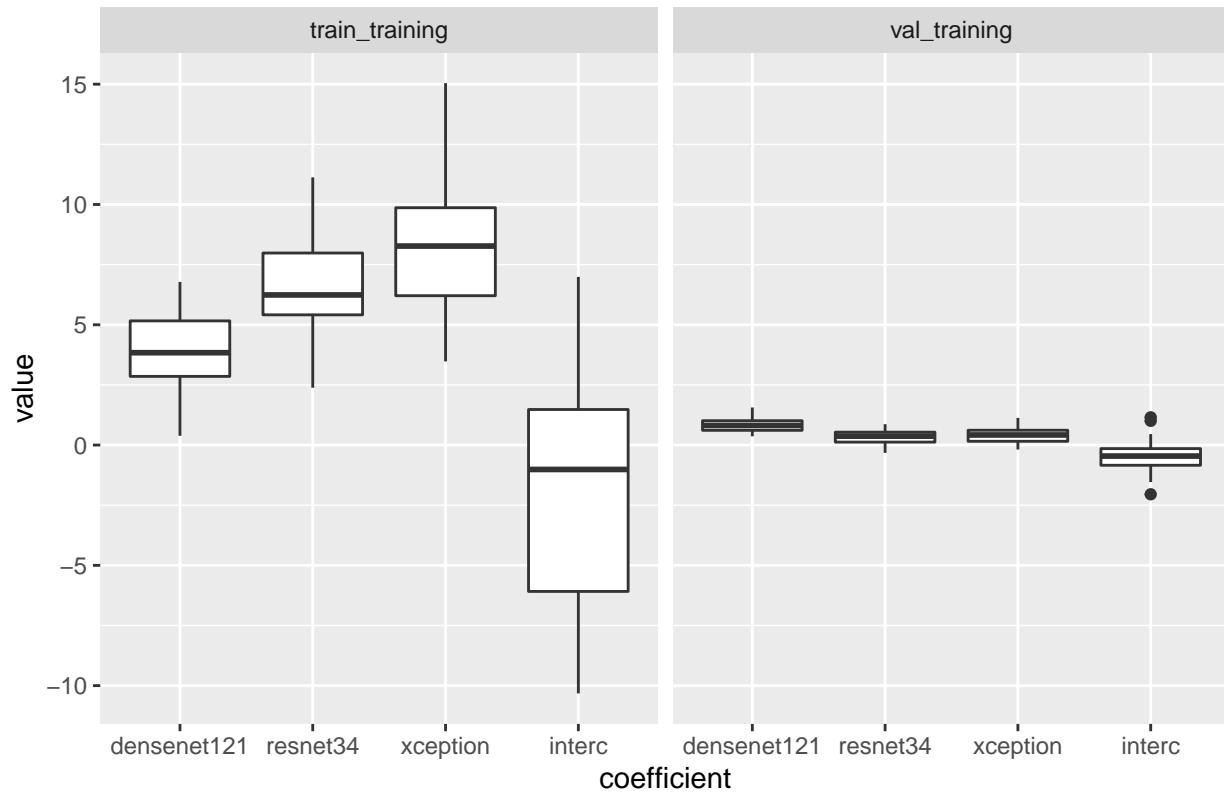
### Coefficients for class 7 vs 12



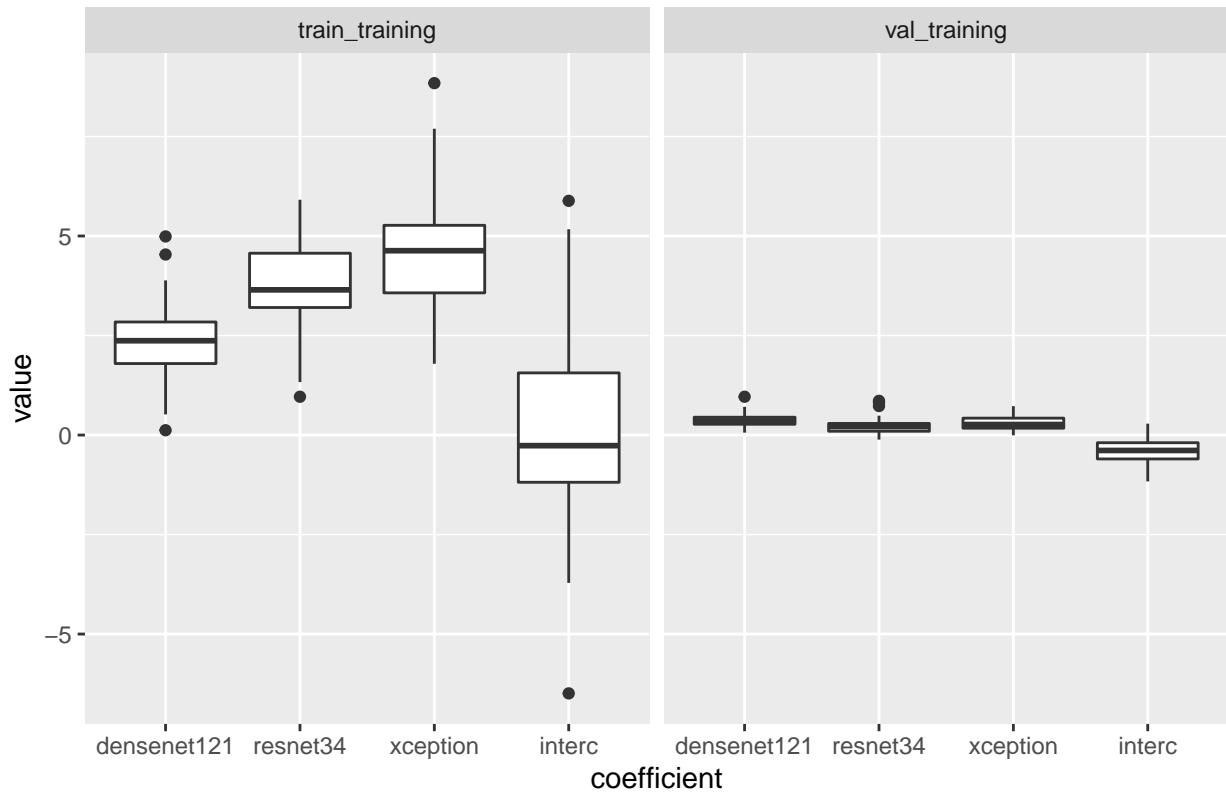
### Coefficients for class 7 vs 13



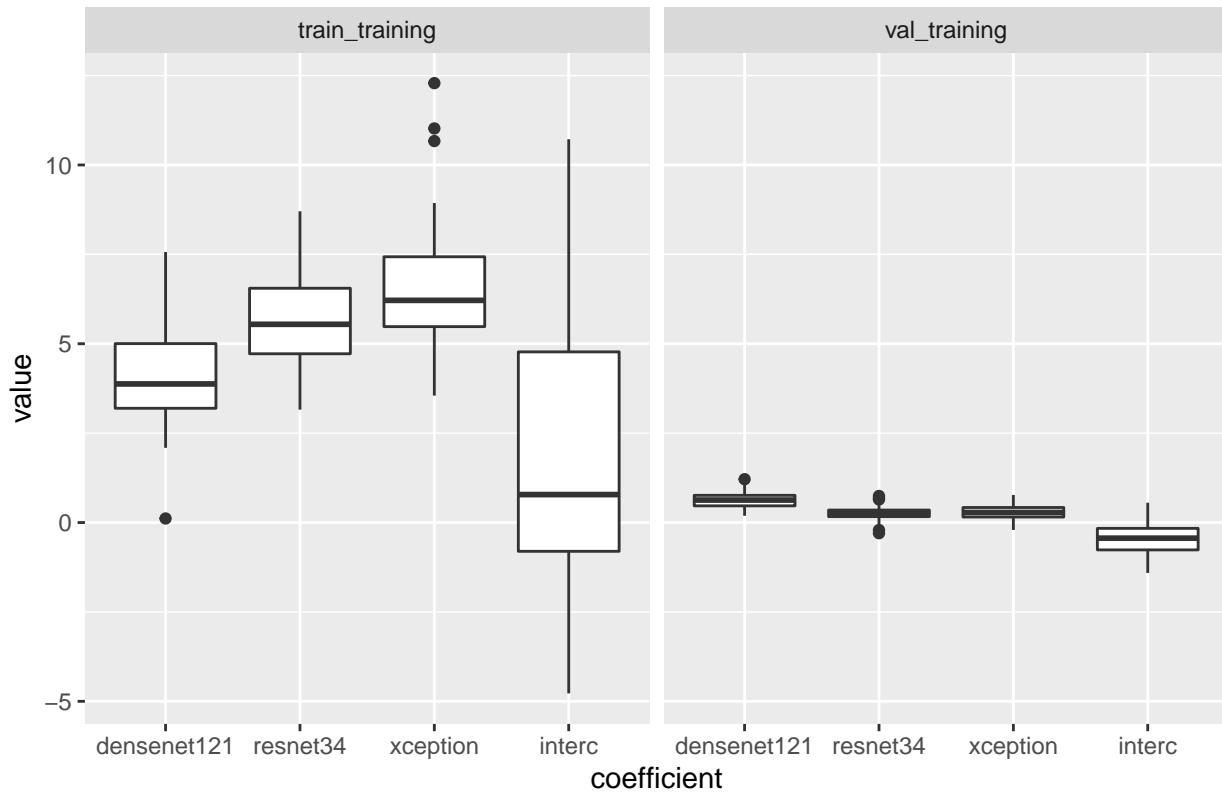
### Coefficients for class 7 vs 14



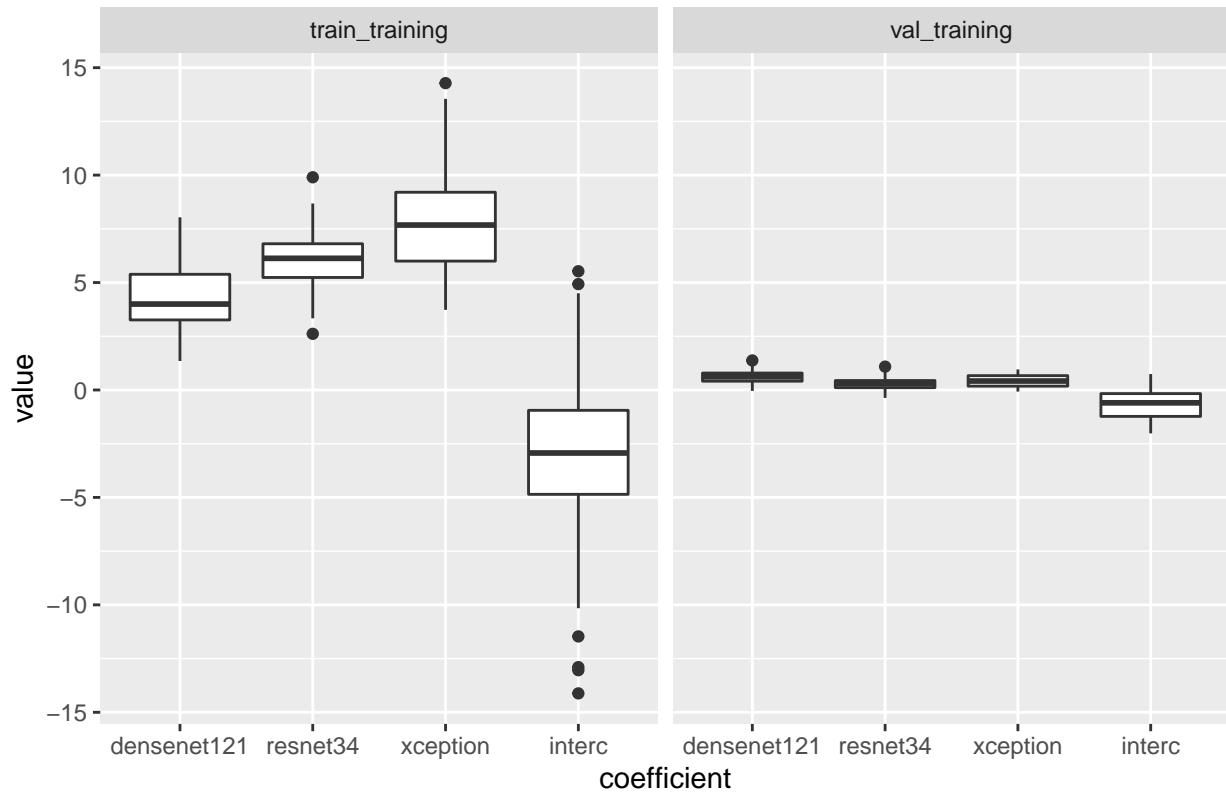
### Coefficients for class 7 vs 15



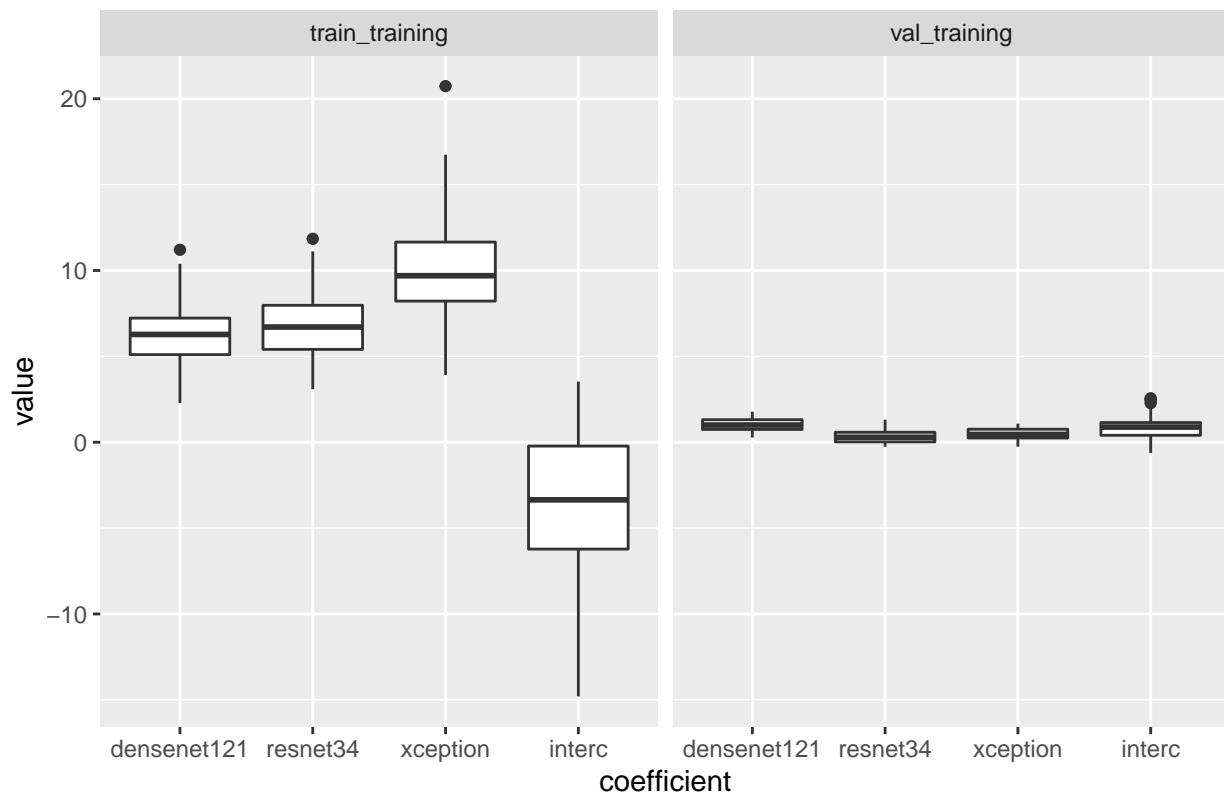
## Coefficients for class 7 vs 16



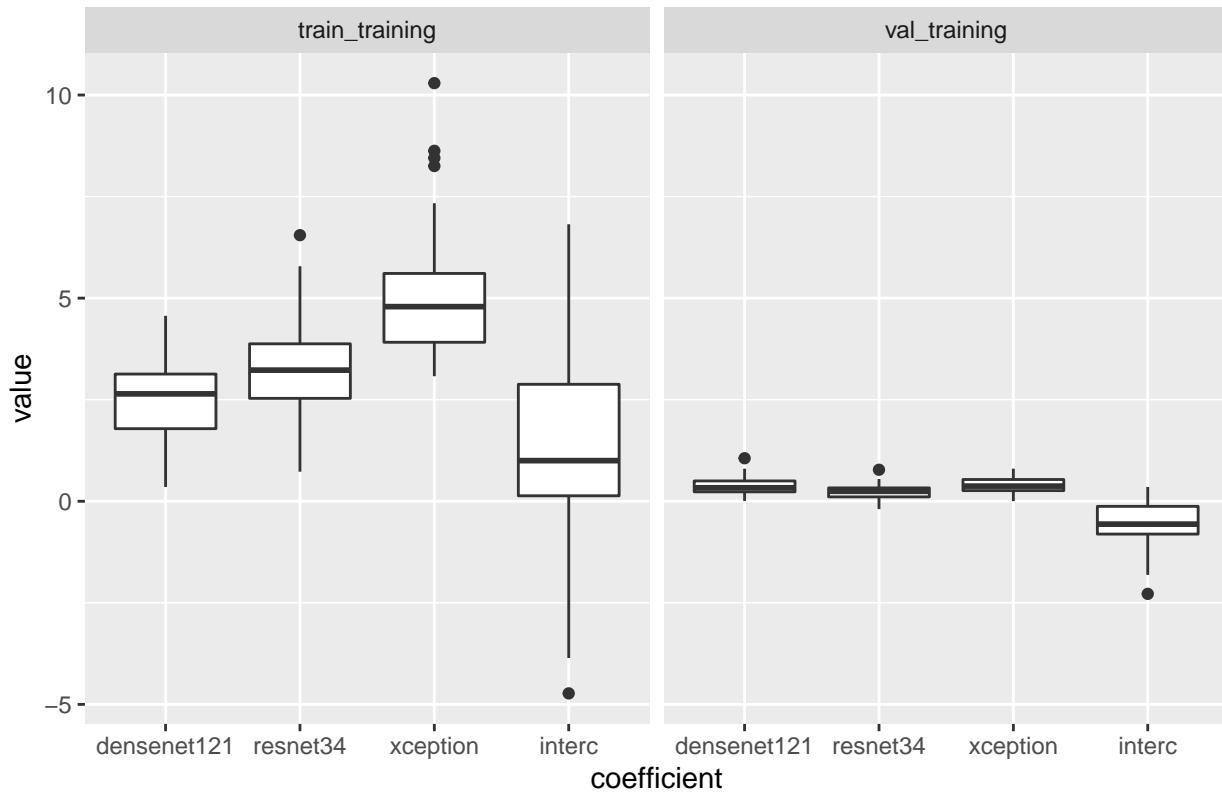
### Coefficients for class 7 vs 17



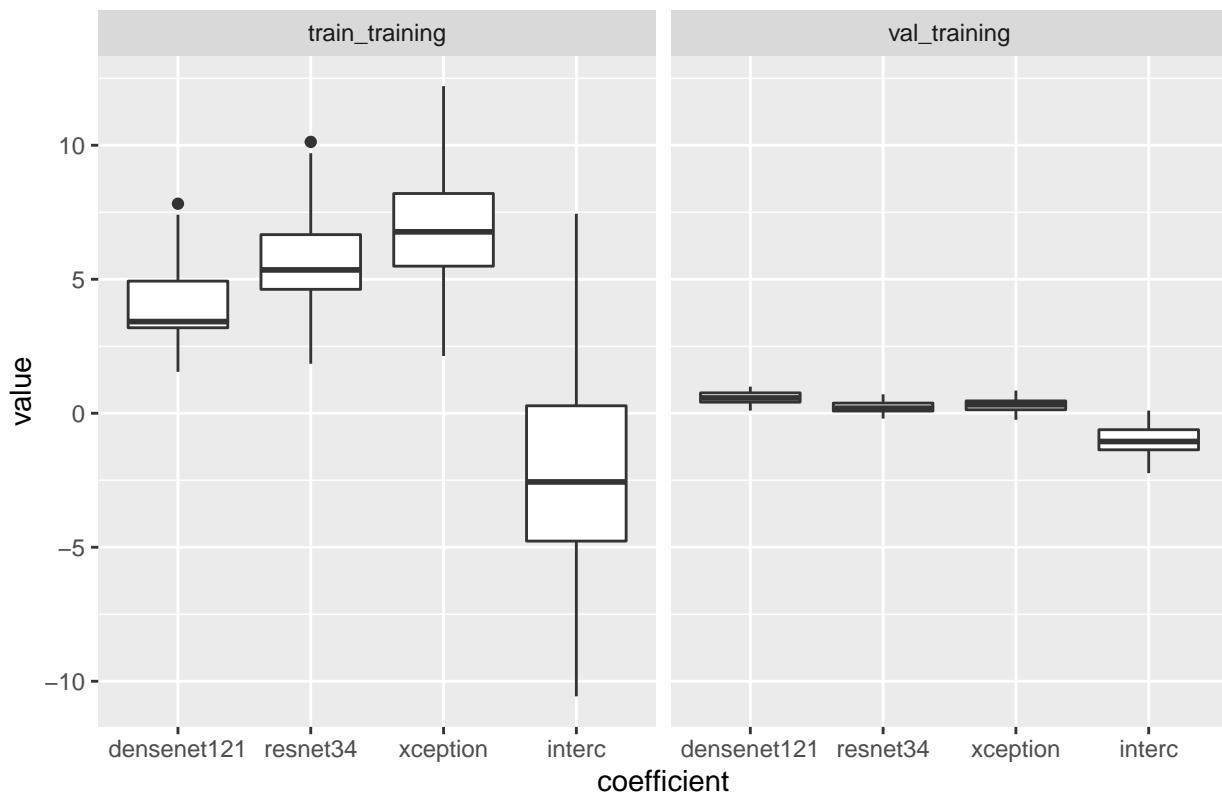
### Coefficients for class 7 vs 18



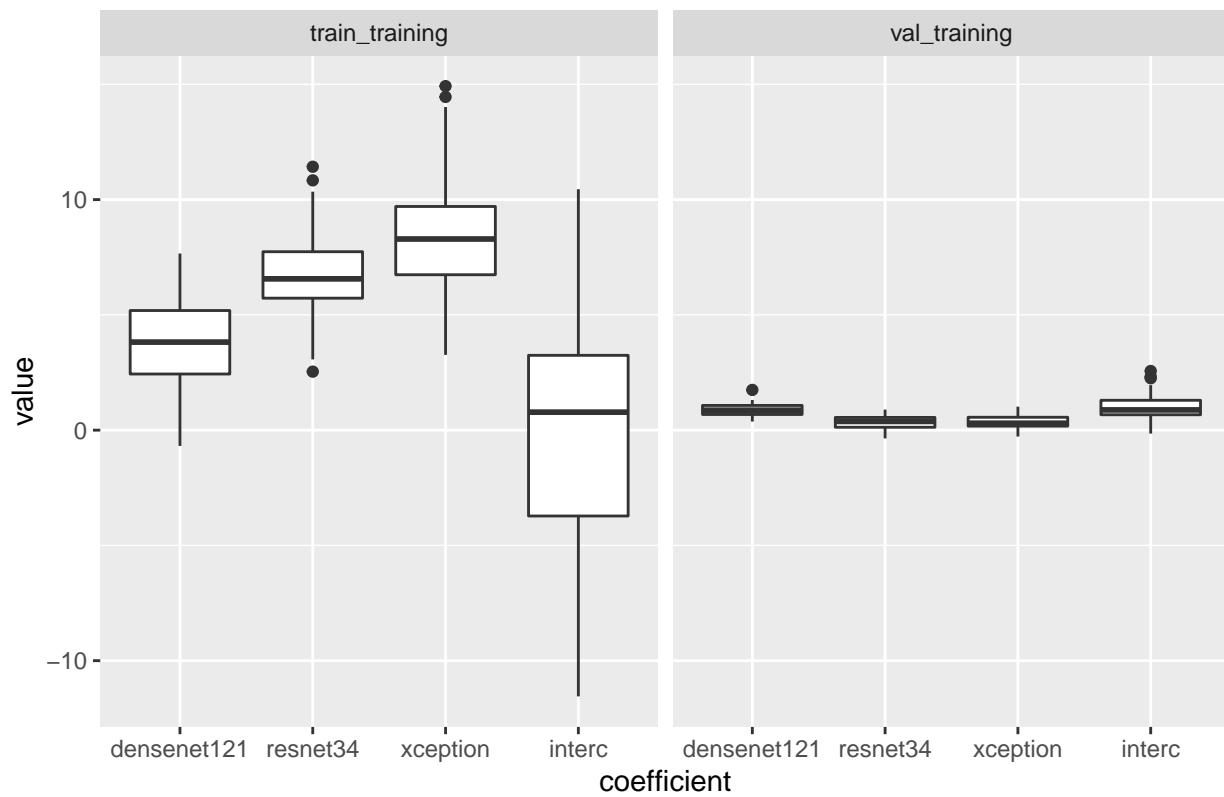
### Coefficients for class 7 vs 19



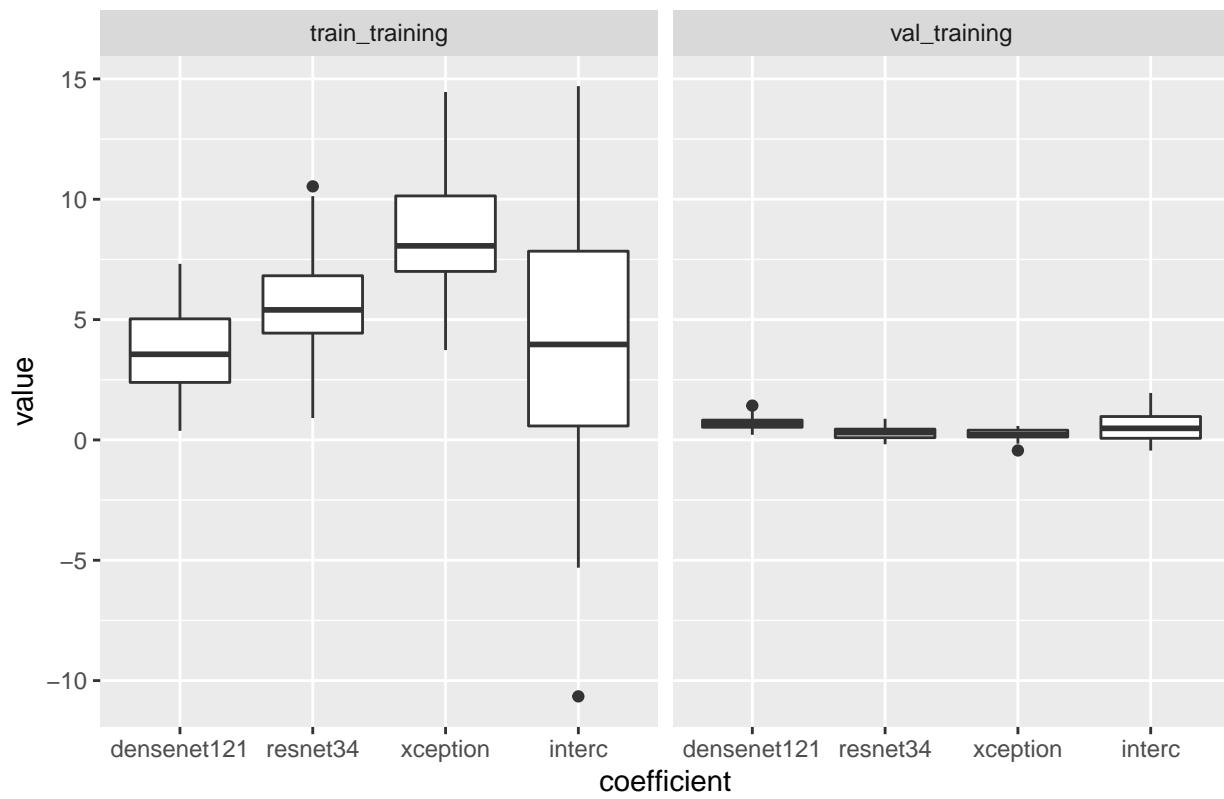
### Coefficients for class 7 vs 20



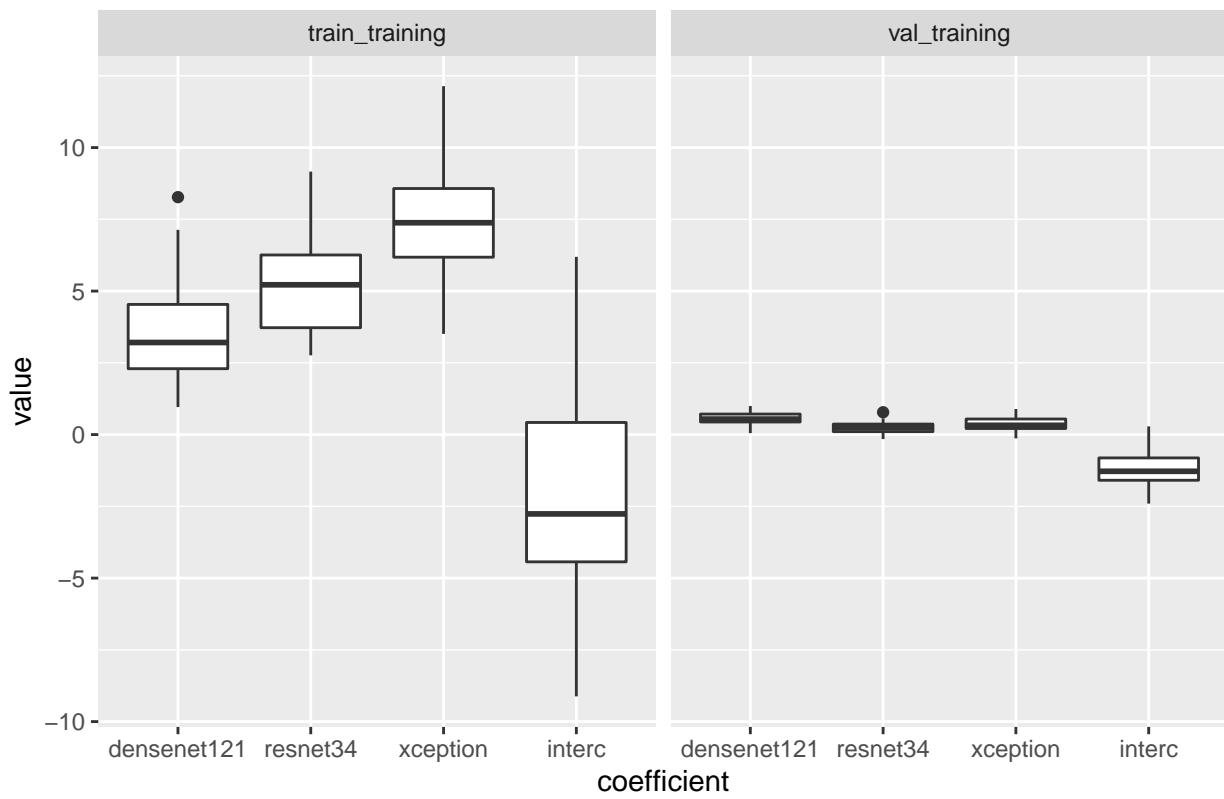
## Coefficients for class 8 vs 9



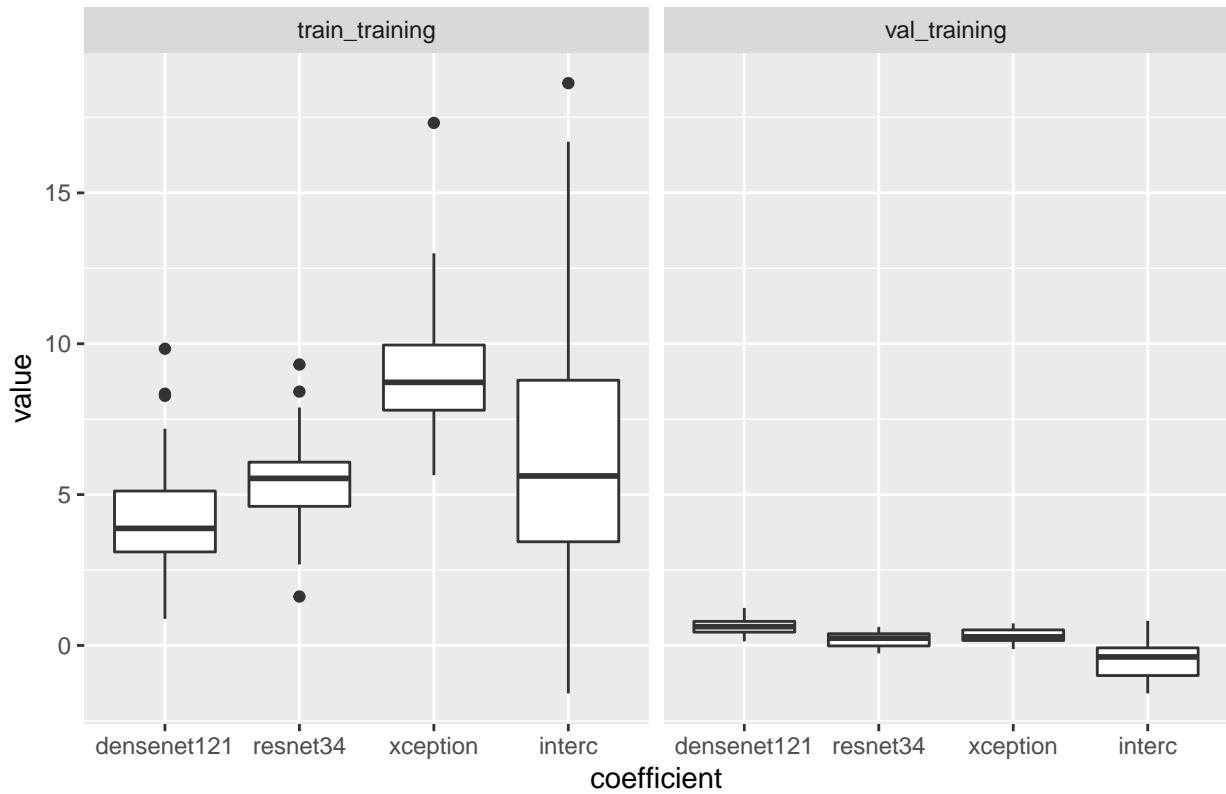
## Coefficients for class 8 vs 10



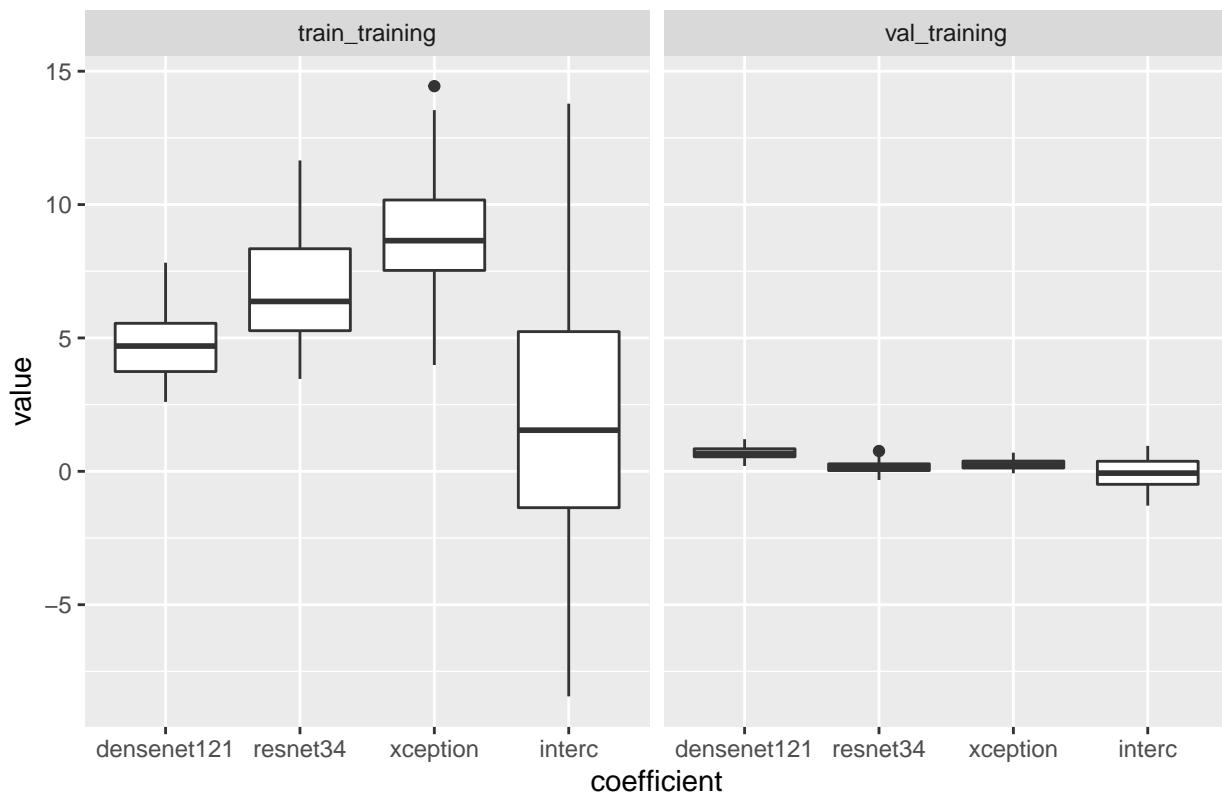
## Coefficients for class 8 vs 11



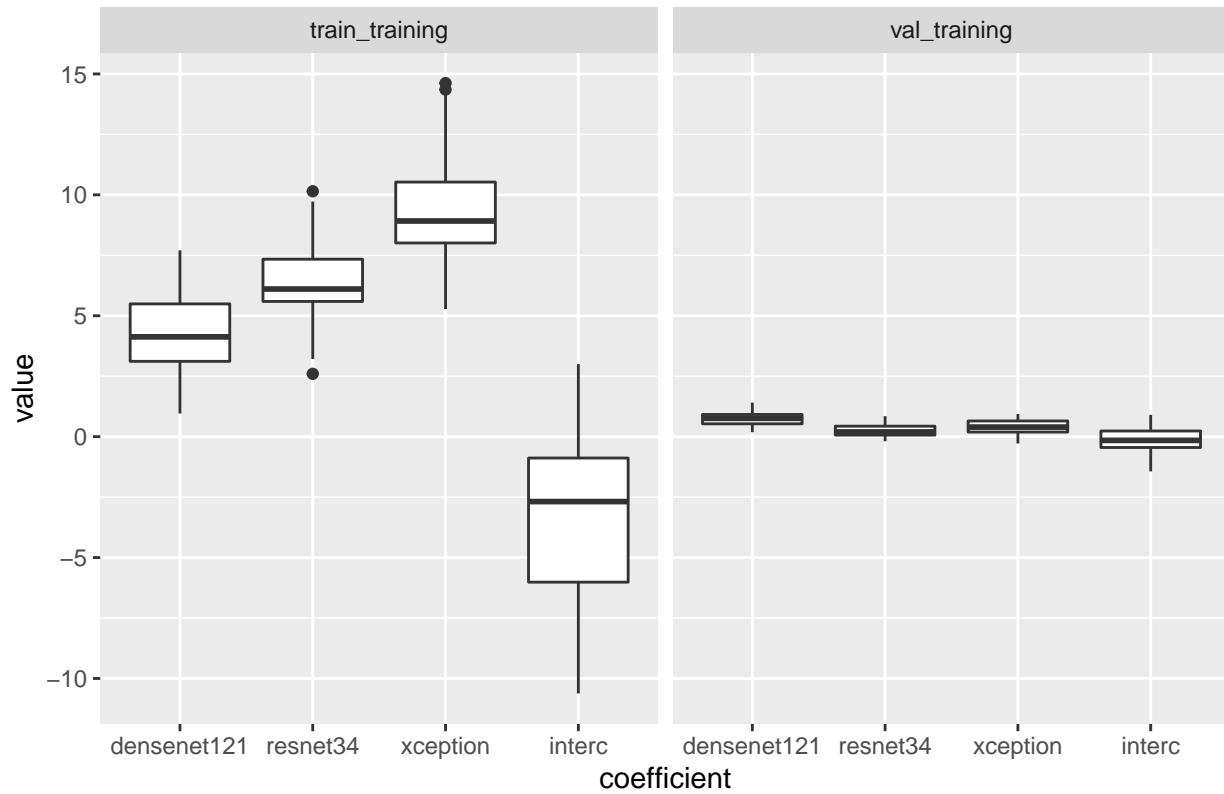
### Coefficients for class 8 vs 12



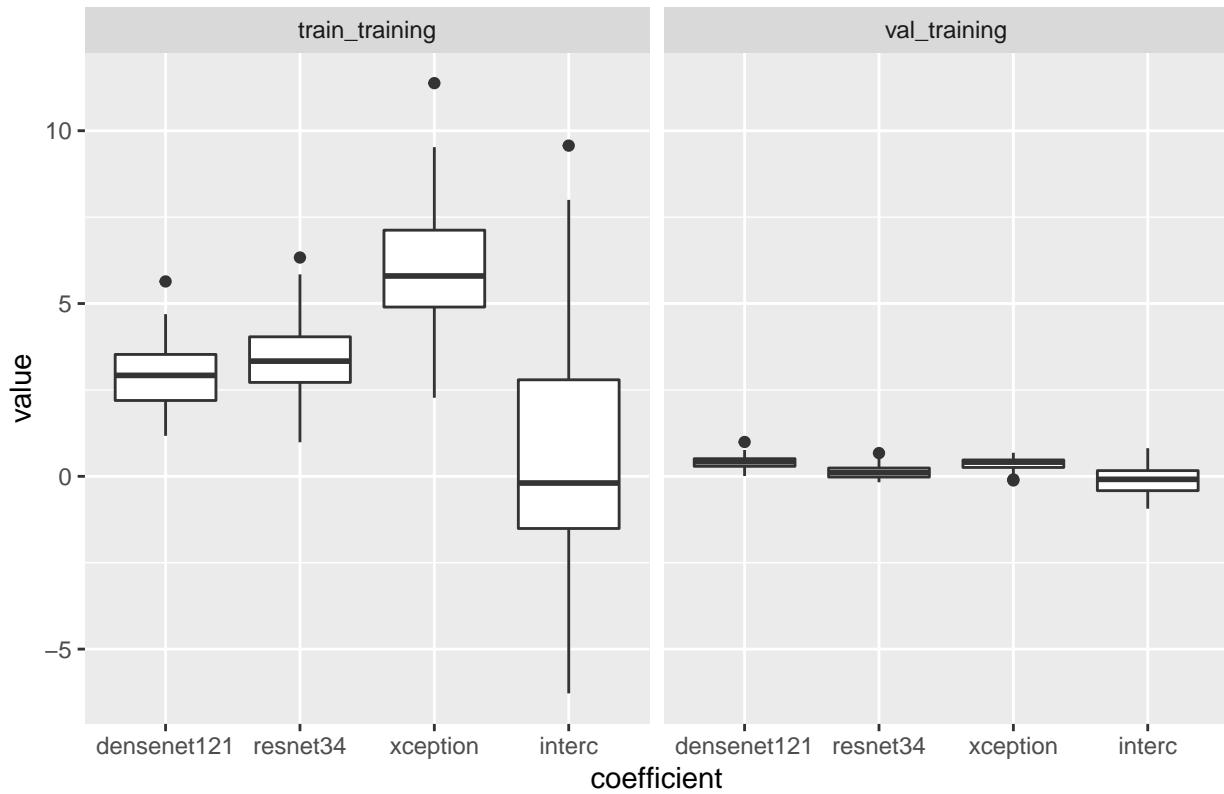
### Coefficients for class 8 vs 13



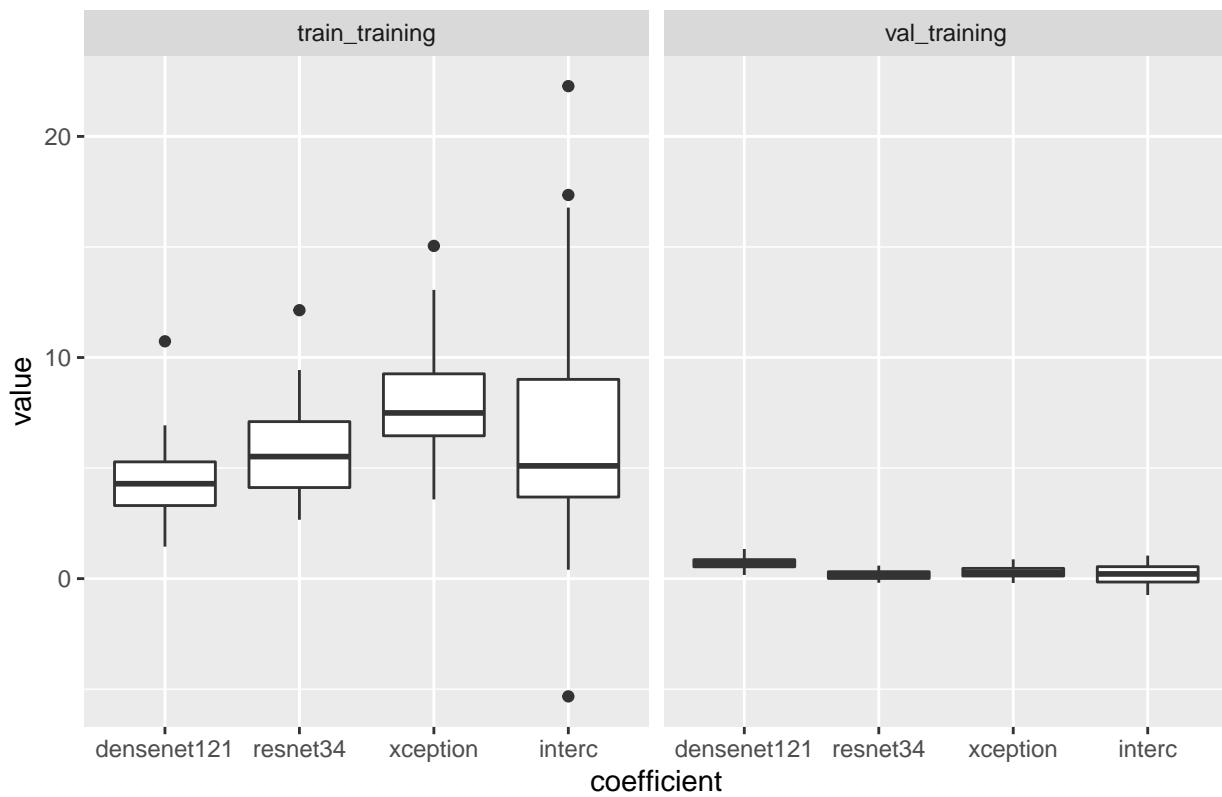
## Coefficients for class 8 vs 14



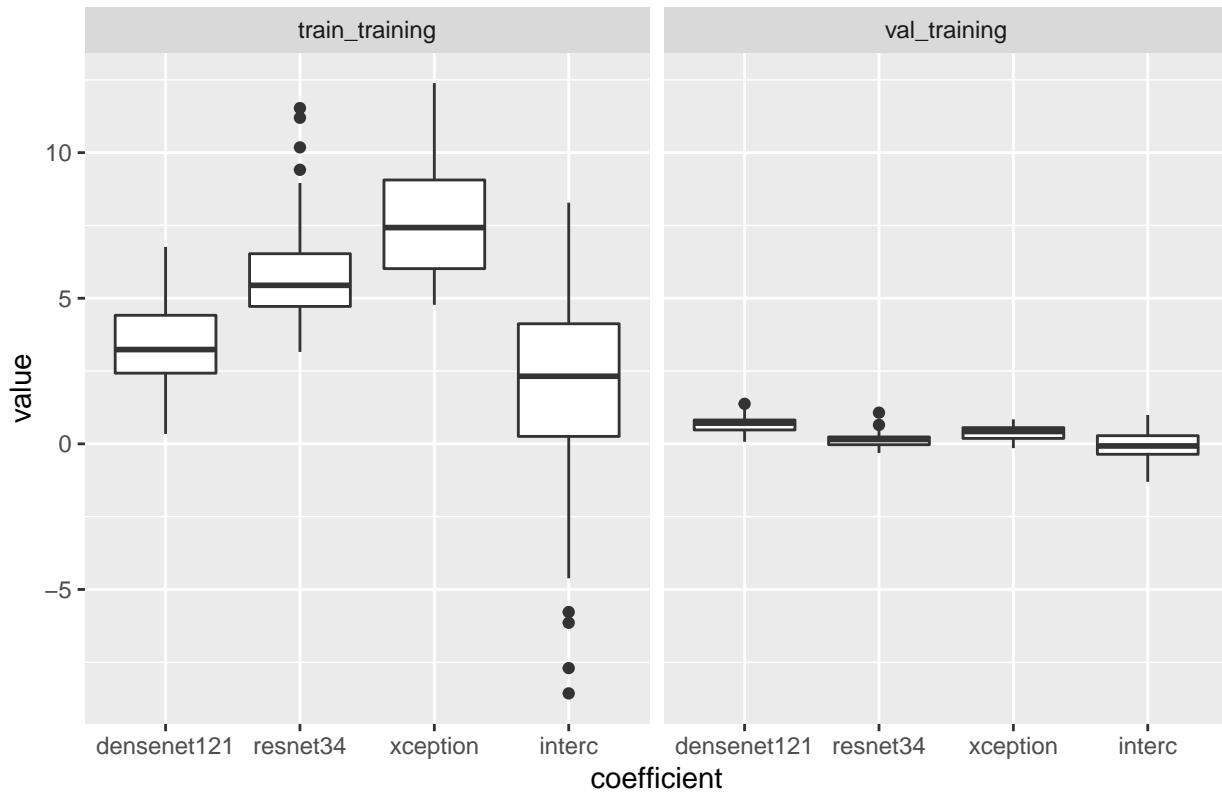
## Coefficients for class 8 vs 15



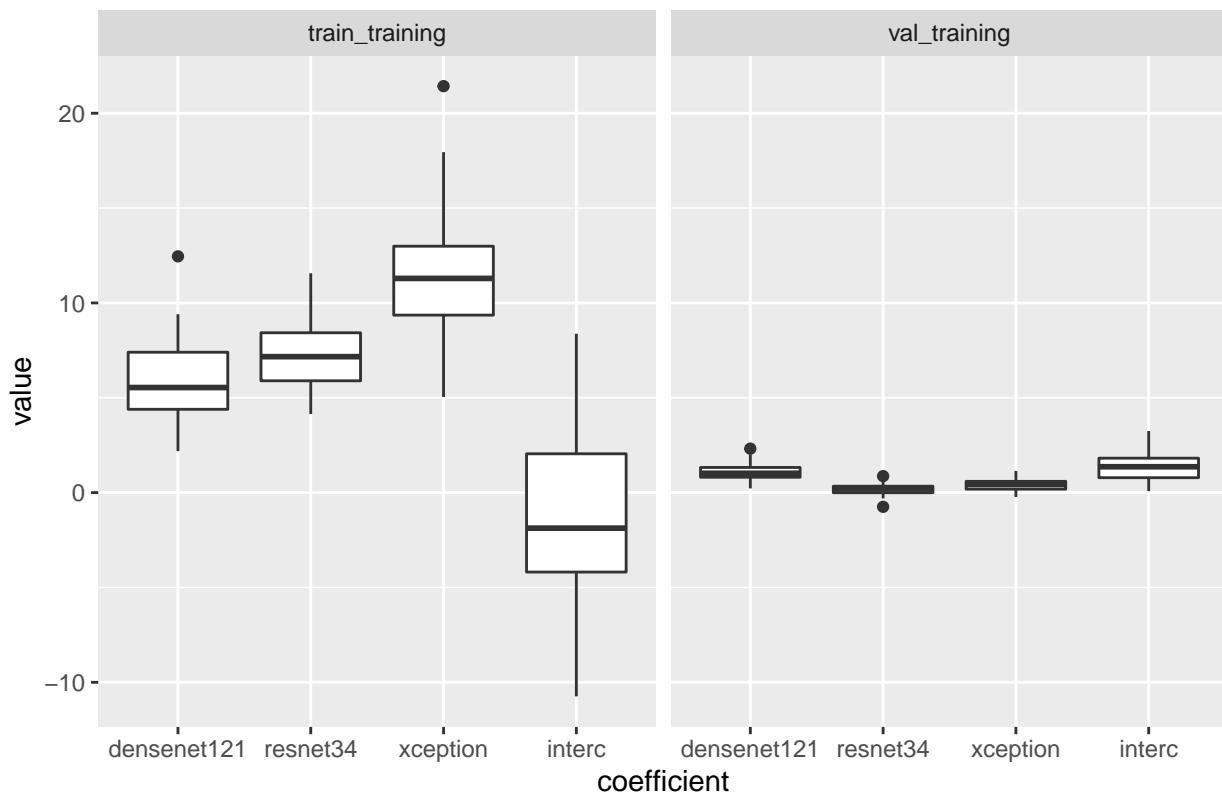
### Coefficients for class 8 vs 16



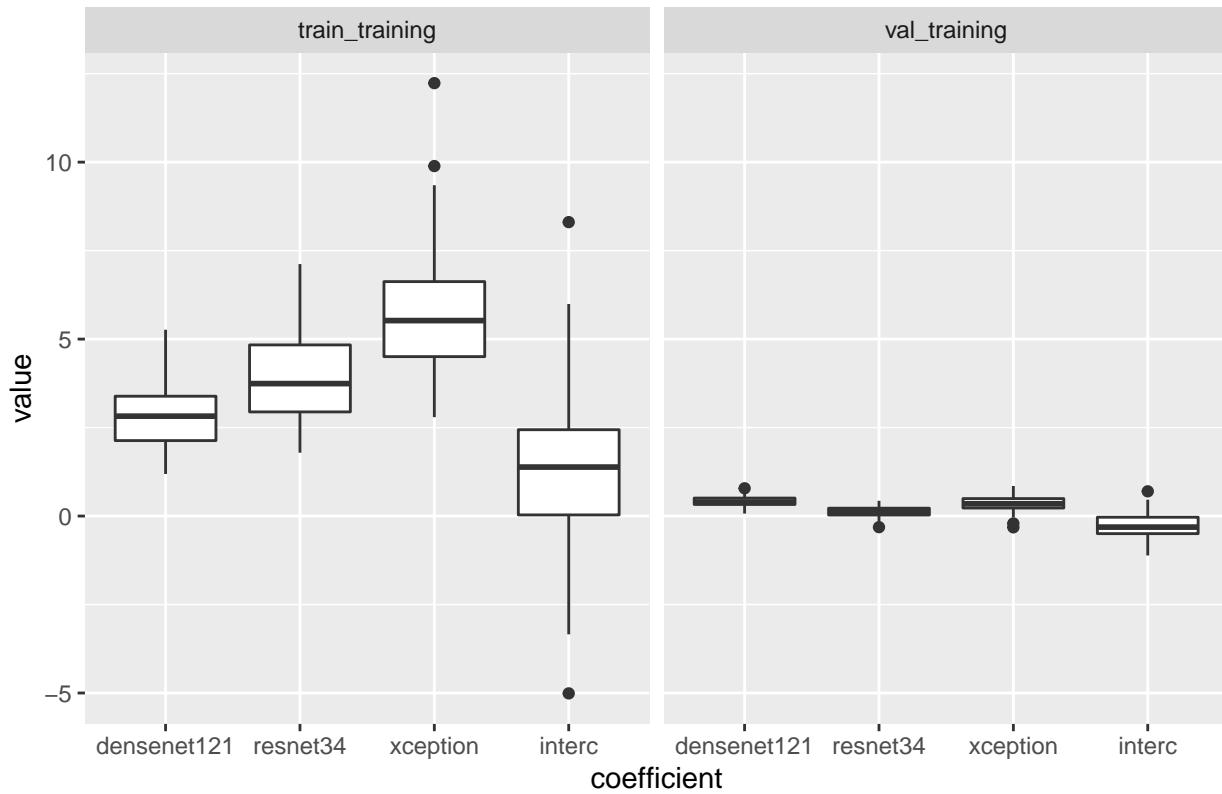
## Coefficients for class 8 vs 17



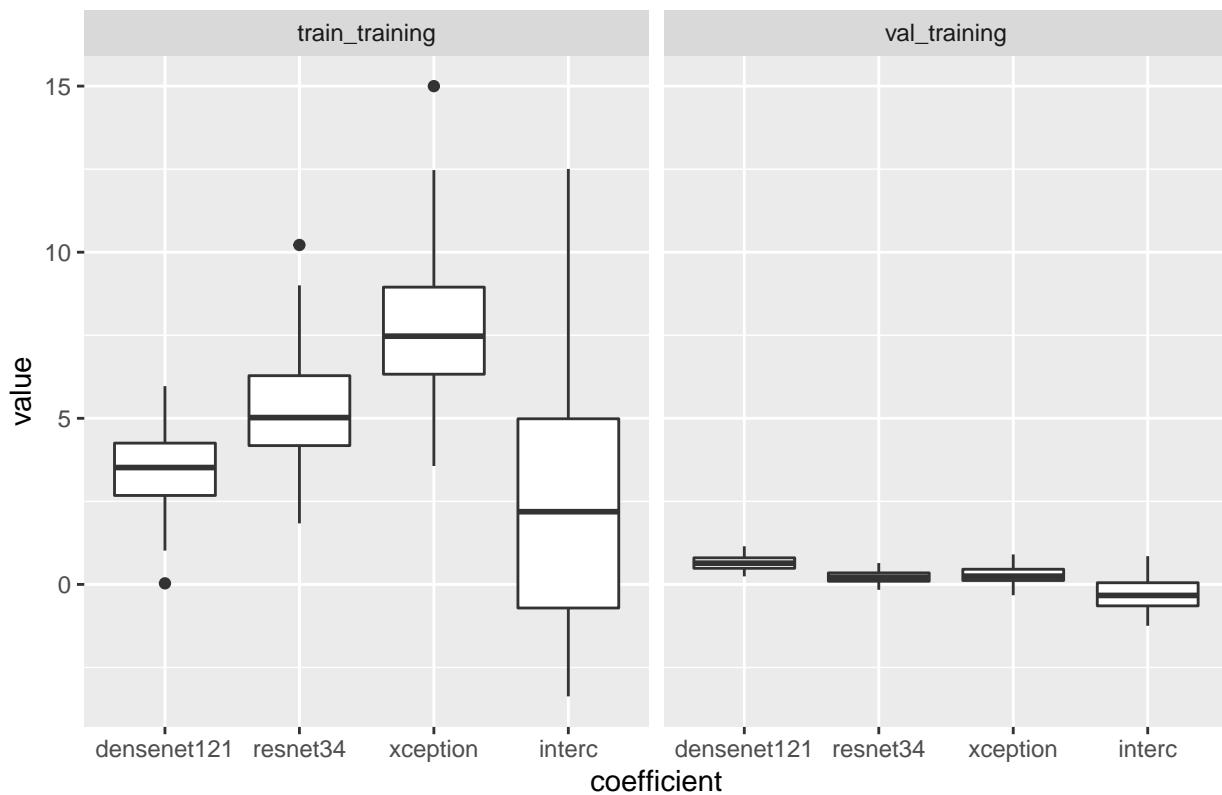
## Coefficients for class 8 vs 18



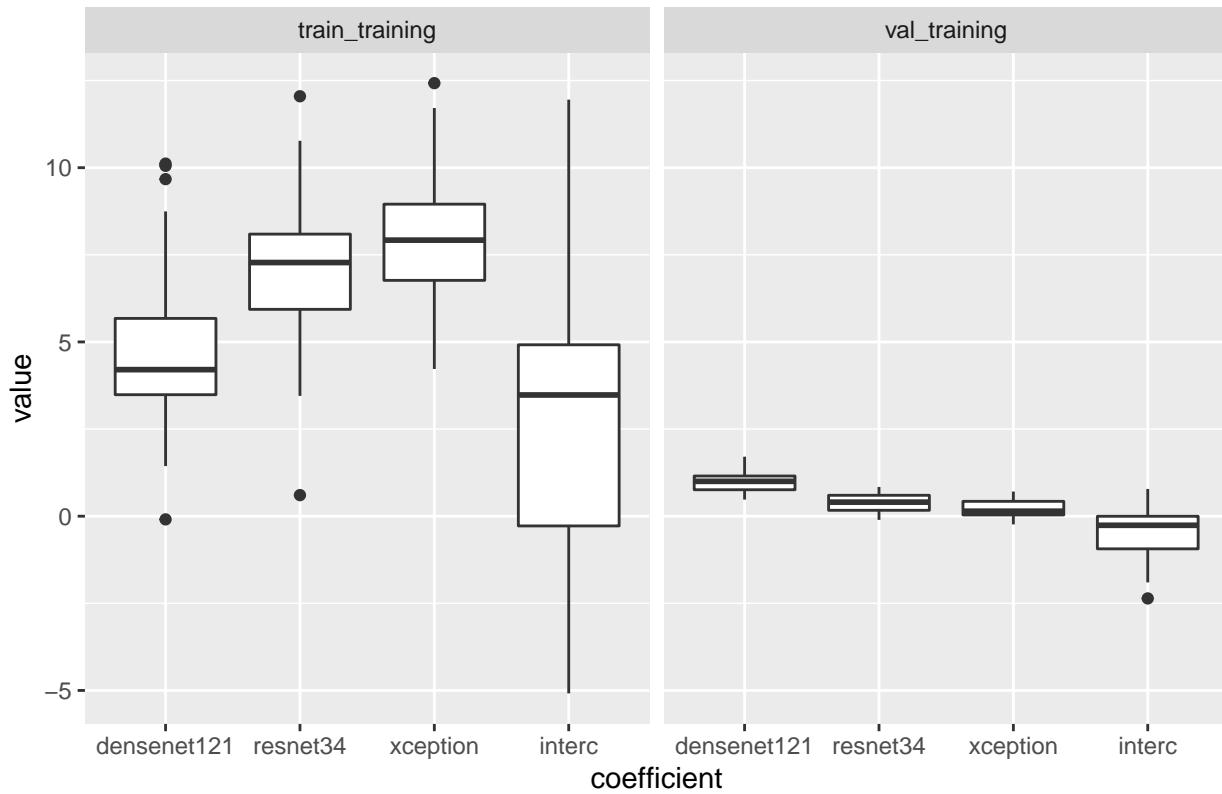
### Coefficients for class 8 vs 19



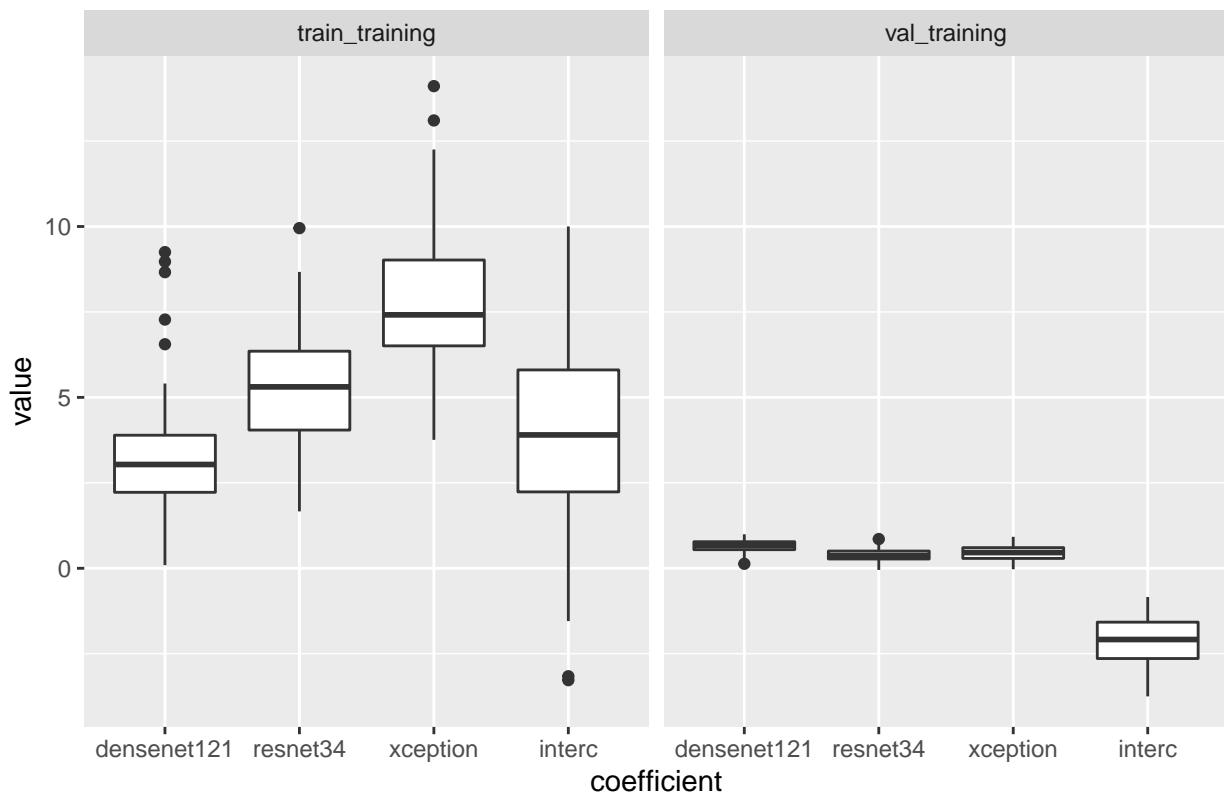
### Coefficients for class 8 vs 20



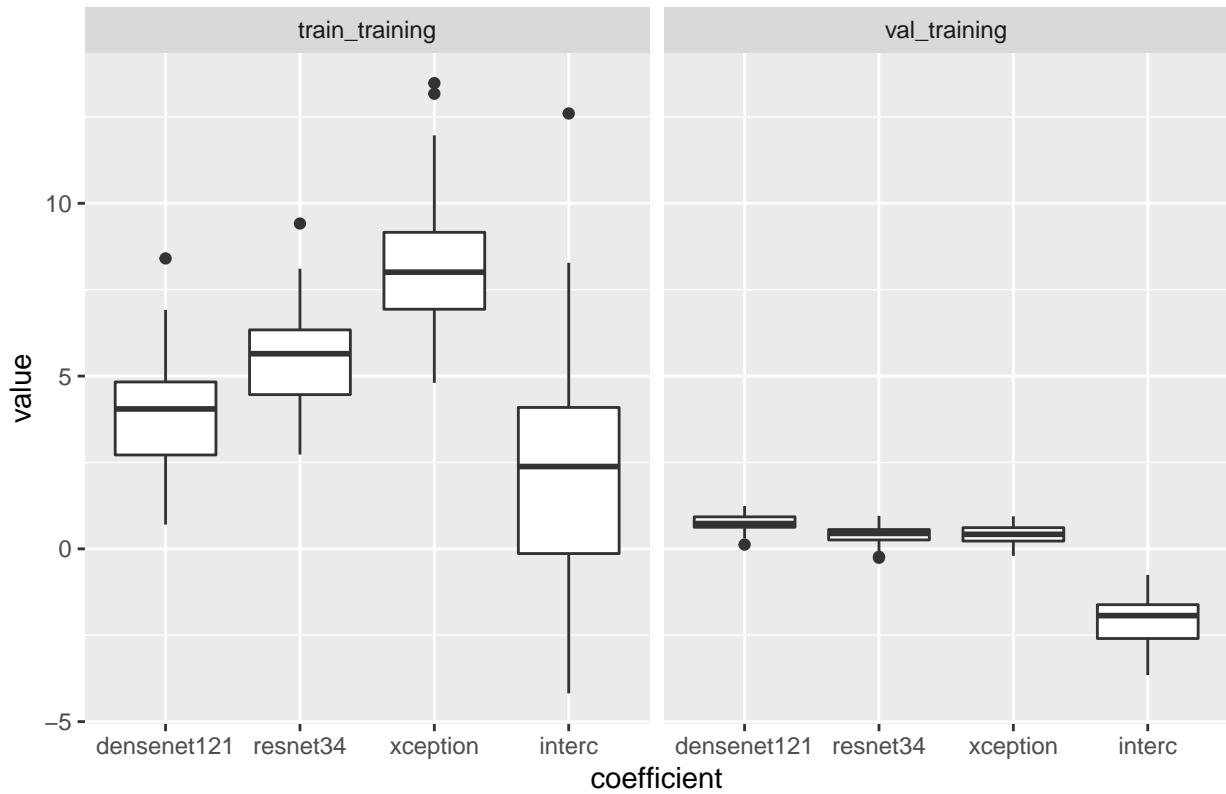
## Coefficients for class 9 vs 10



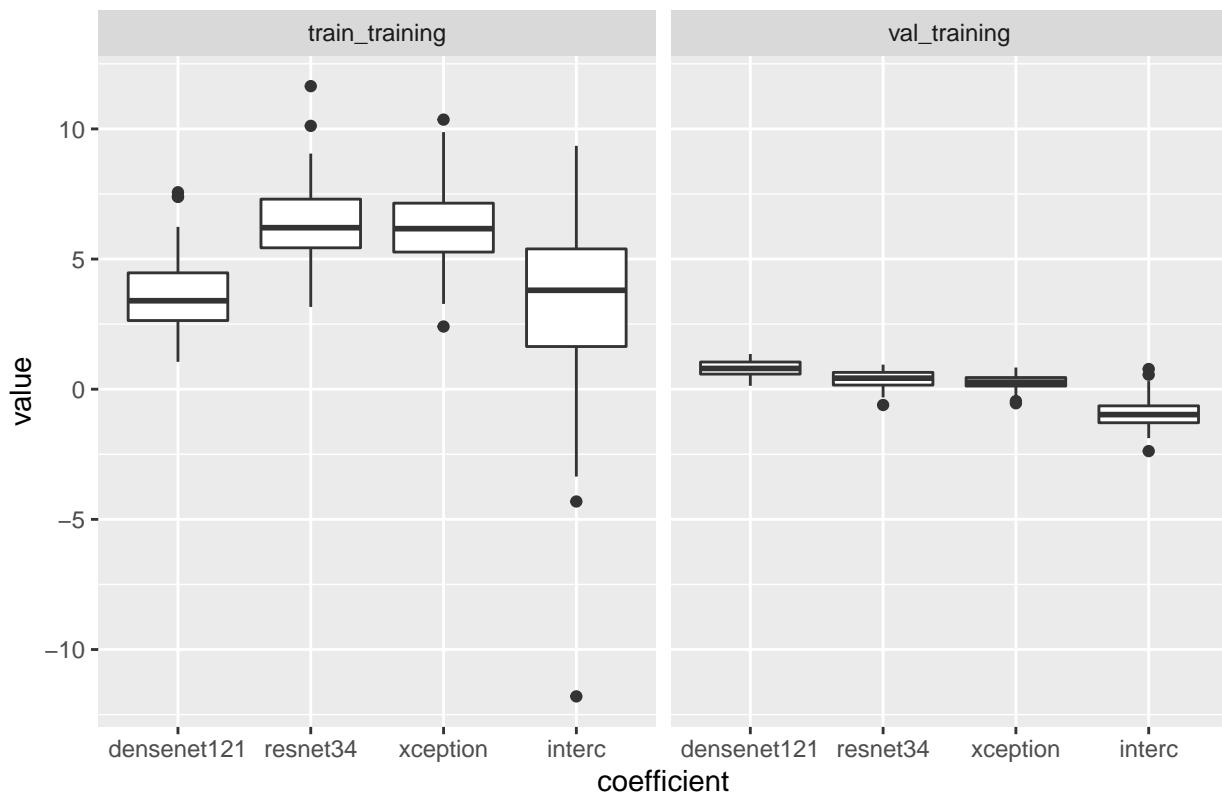
## Coefficients for class 9 vs 11



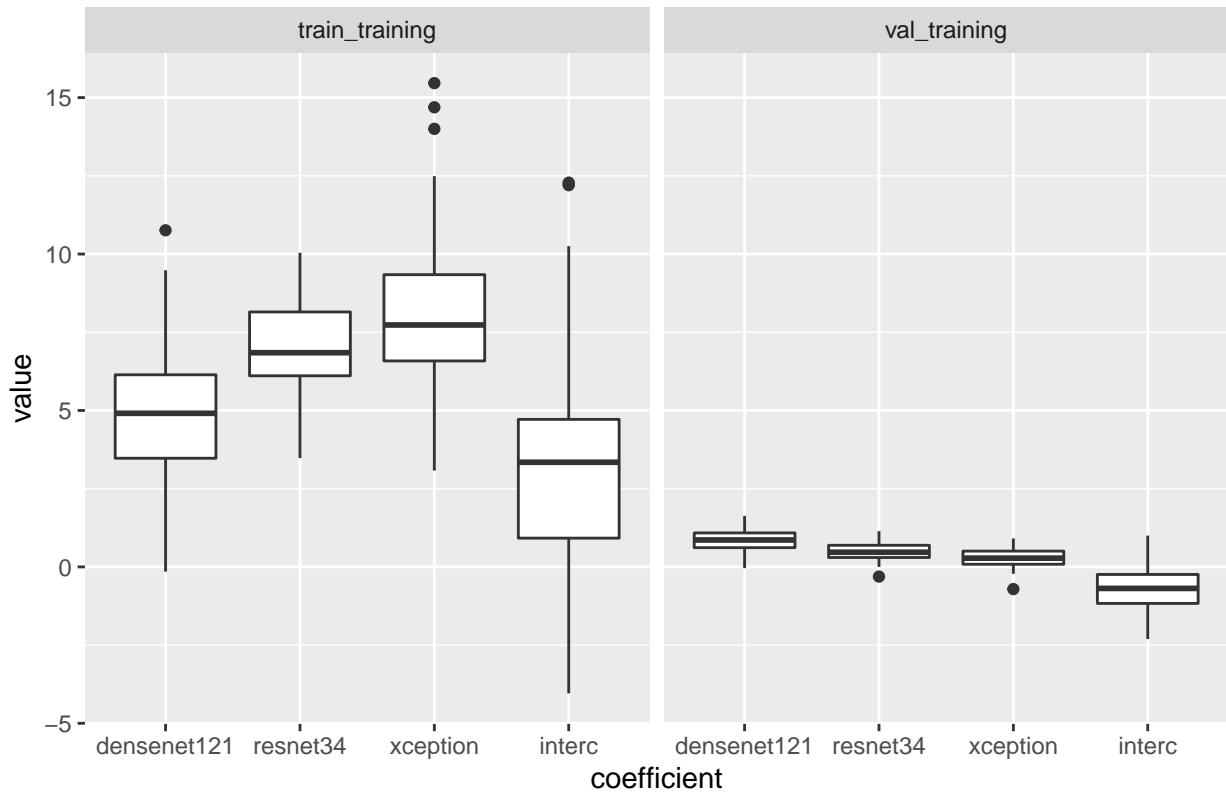
## Coefficients for class 9 vs 12



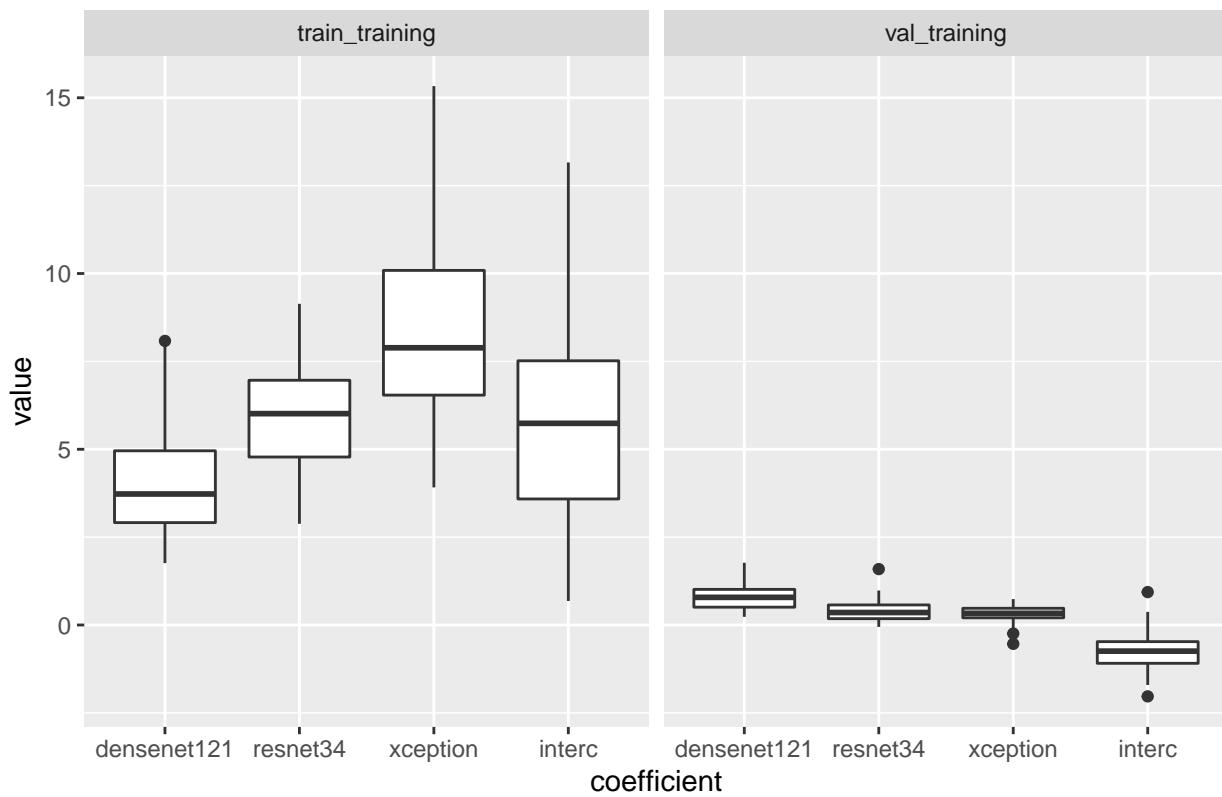
### Coefficients for class 9 vs 13



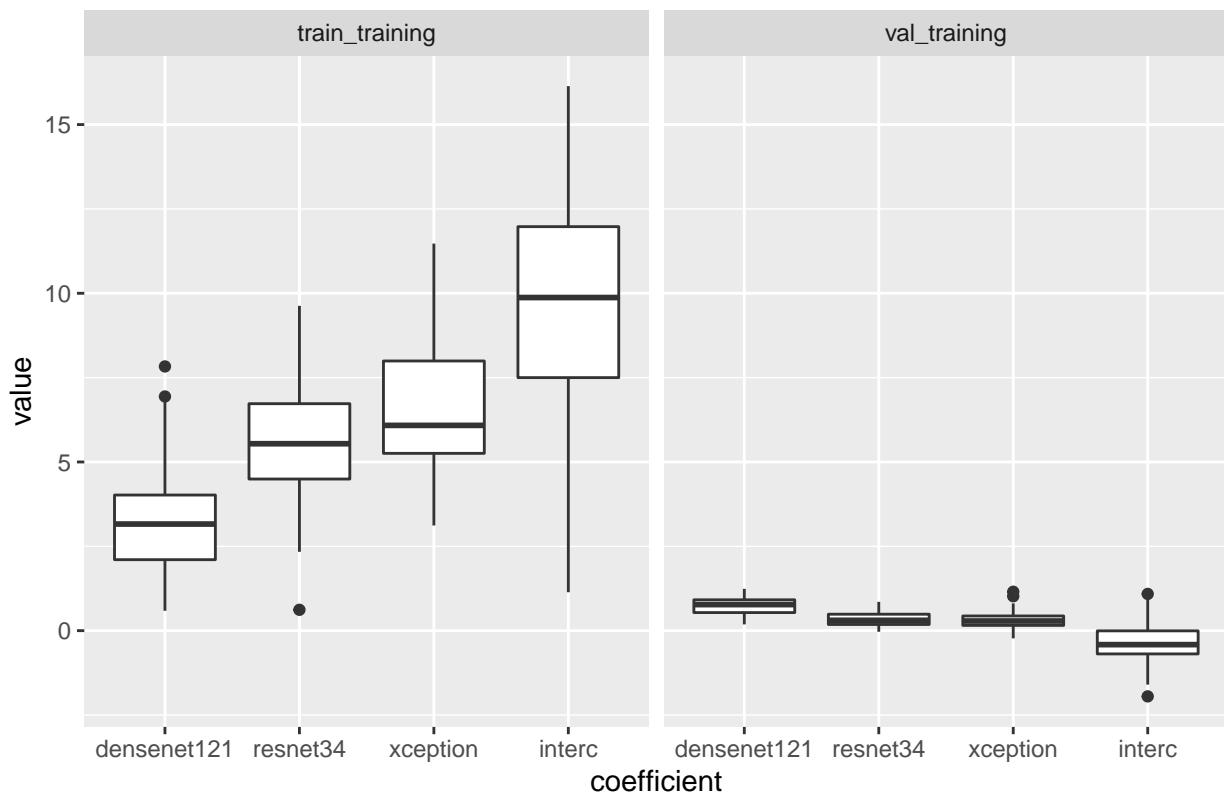
### Coefficients for class 9 vs 14



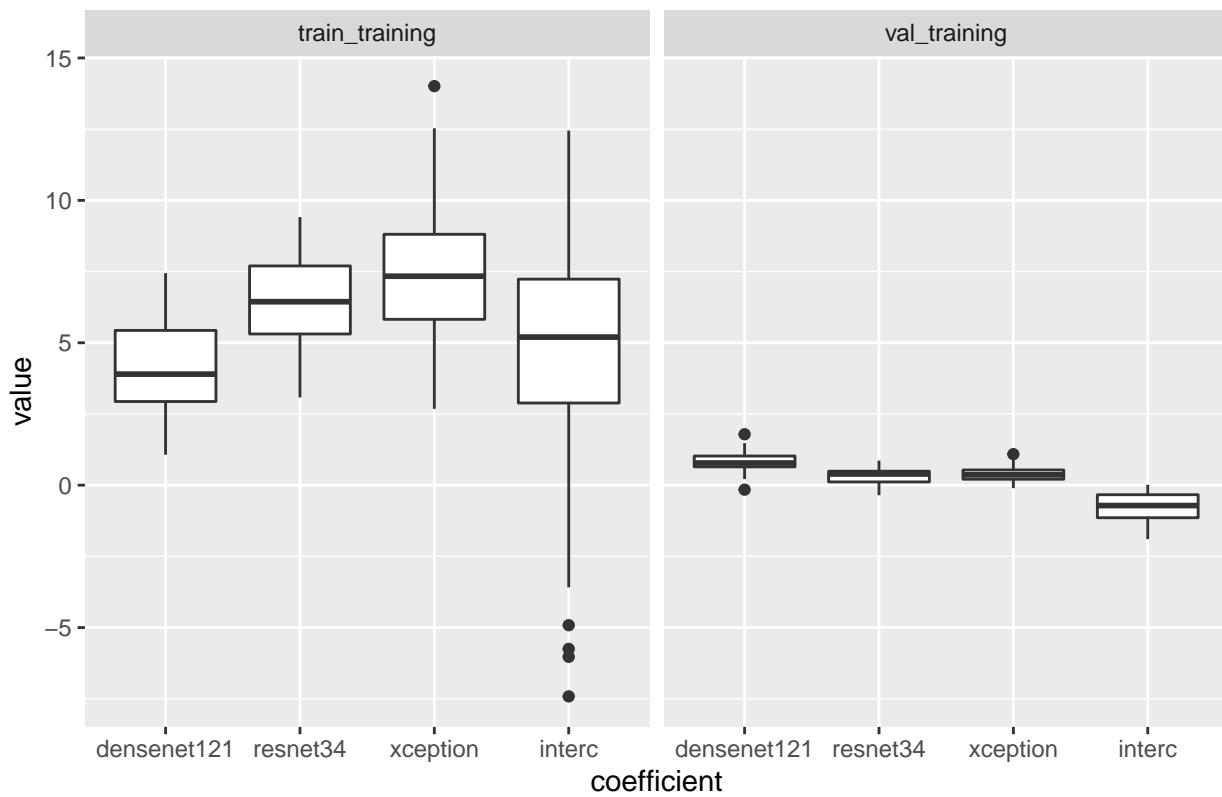
### Coefficients for class 9 vs 15



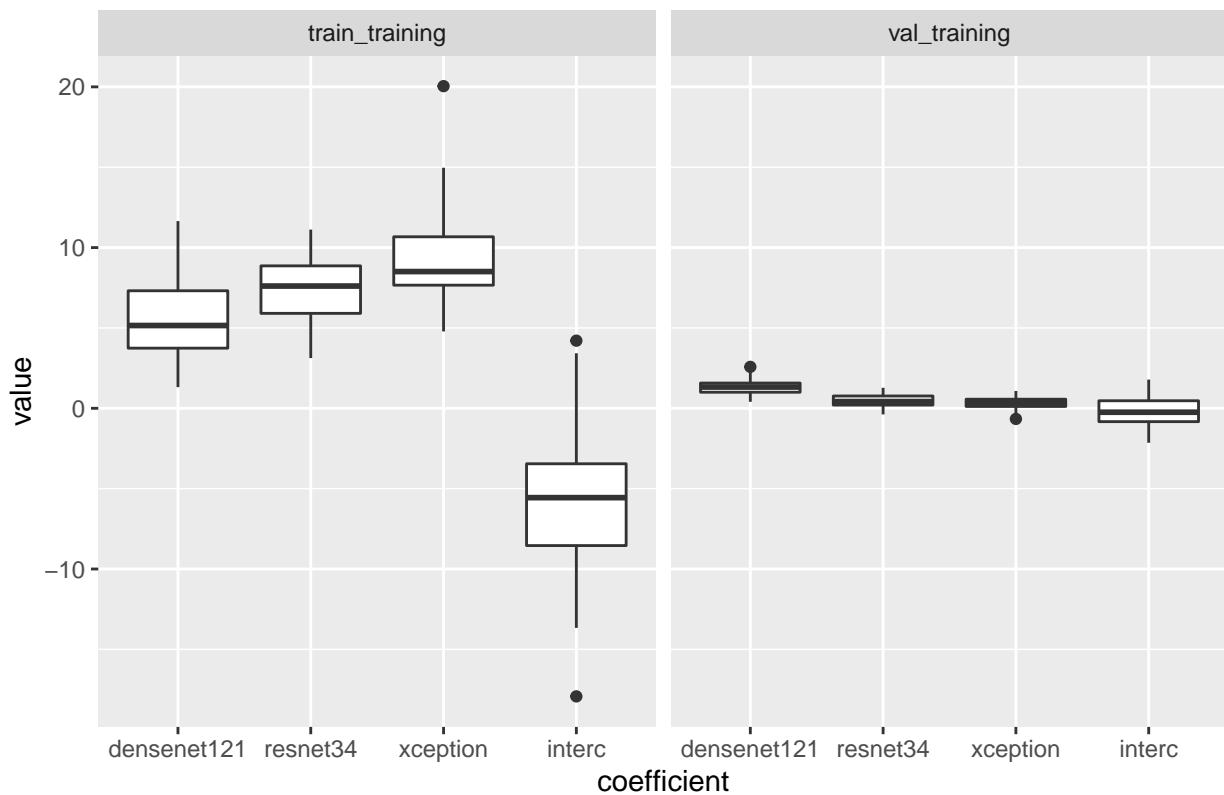
### Coefficients for class 9 vs 16



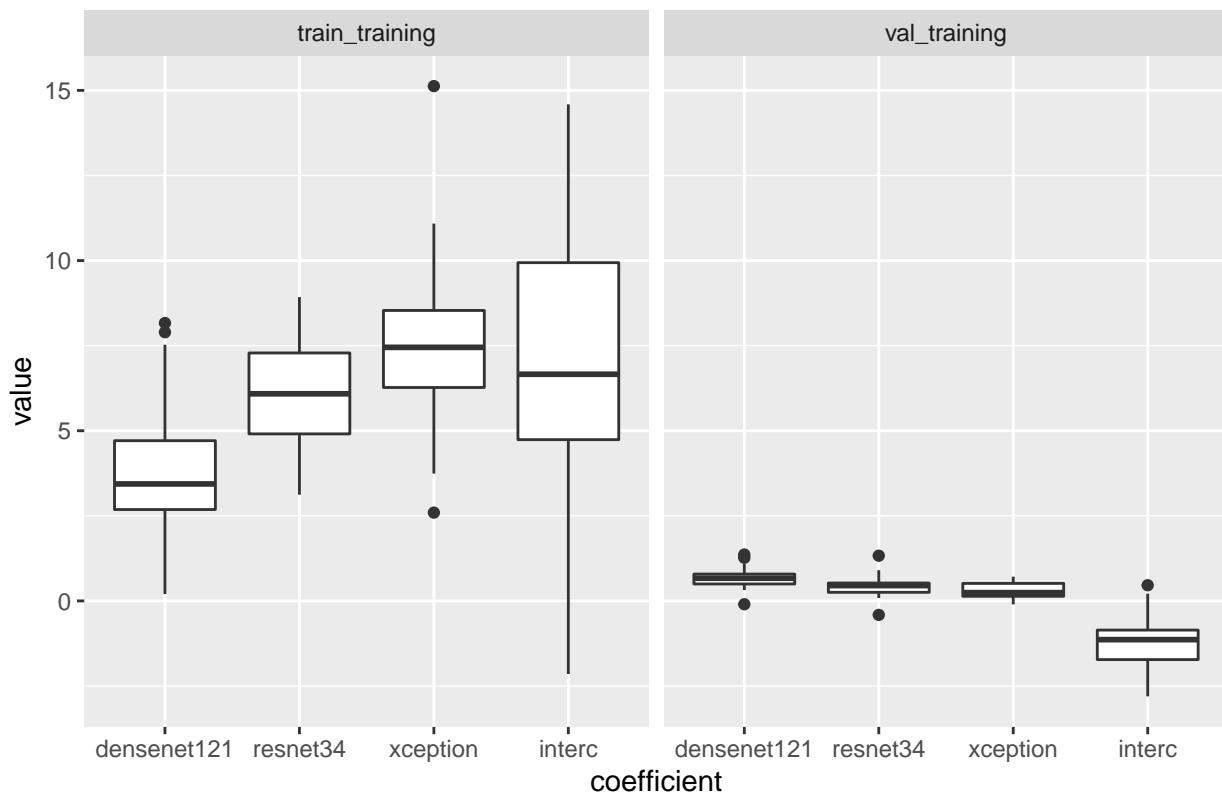
### Coefficients for class 9 vs 17



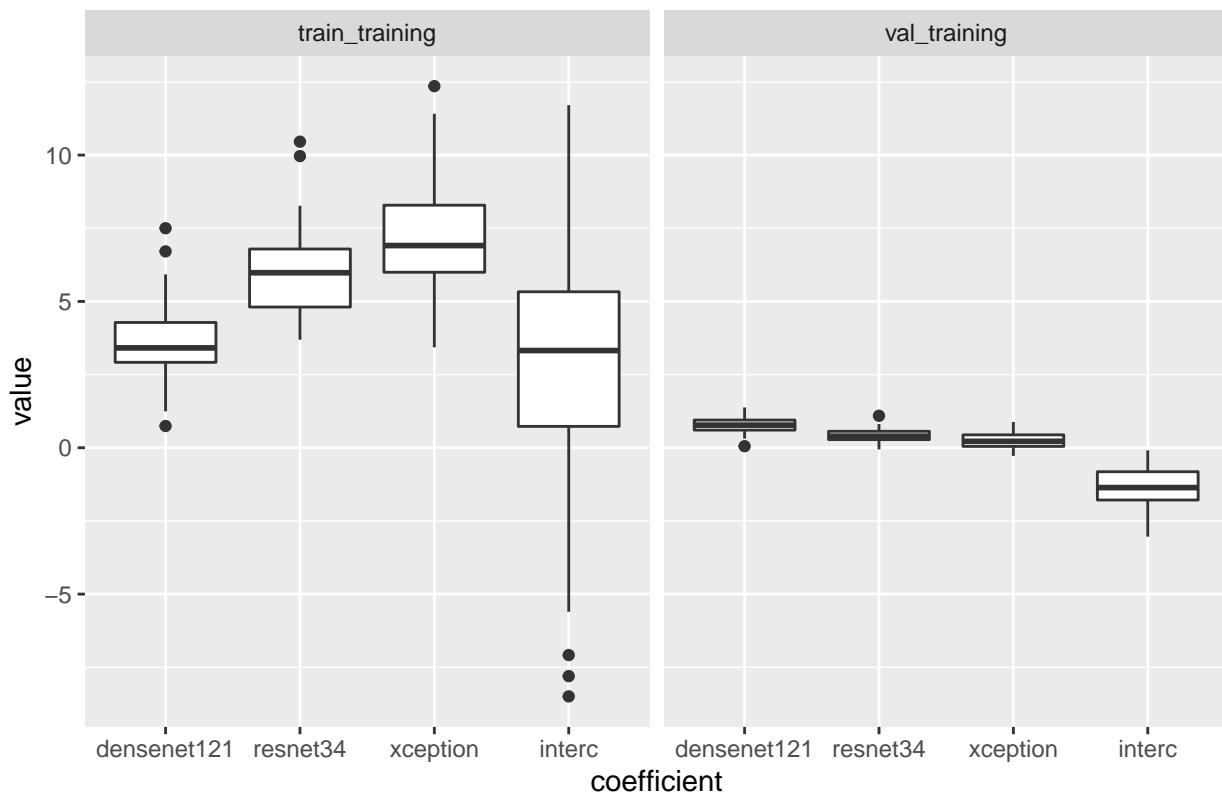
### Coefficients for class 9 vs 18



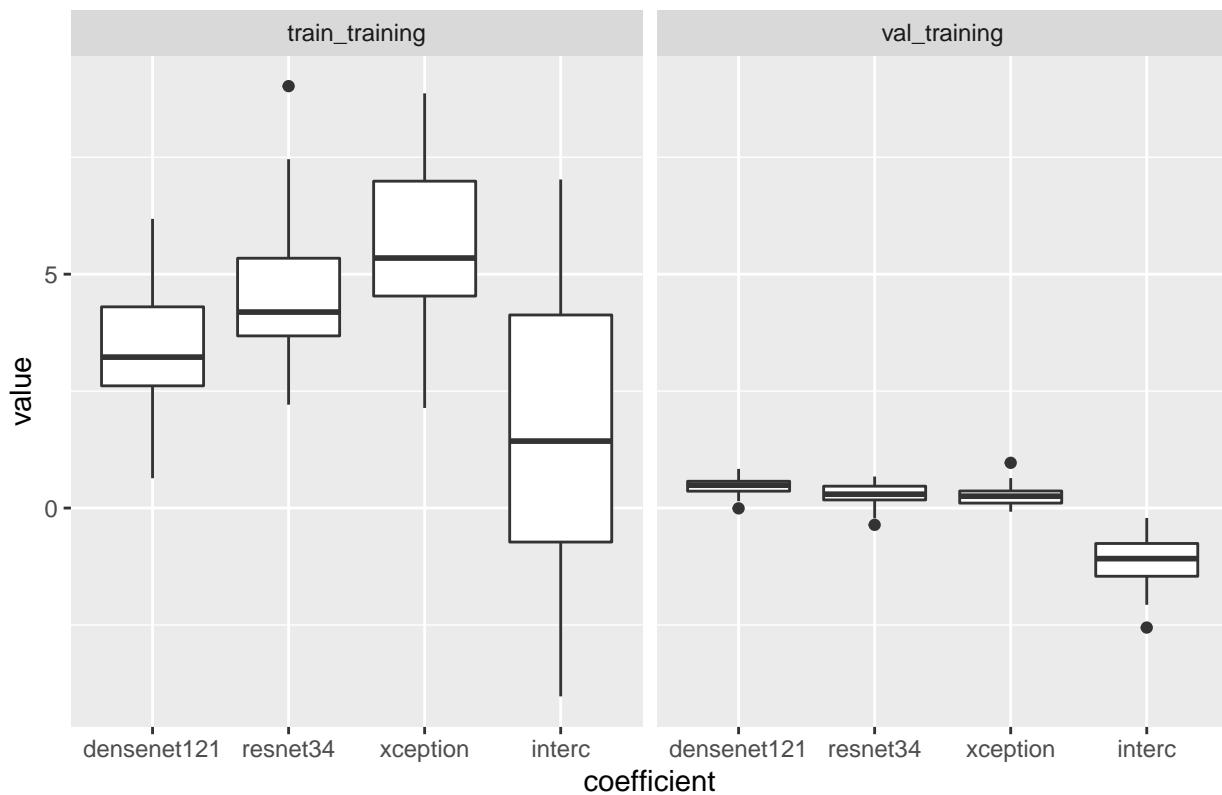
### Coefficients for class 9 vs 19



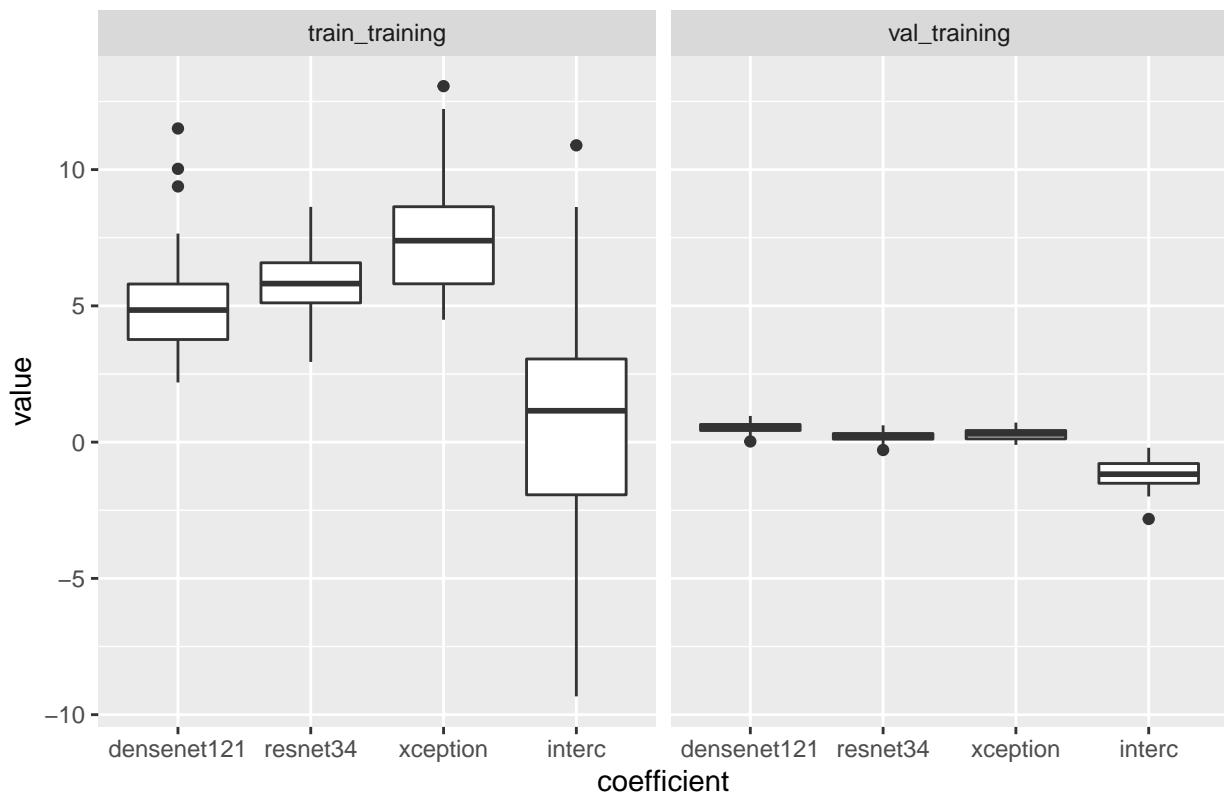
### Coefficients for class 9 vs 20



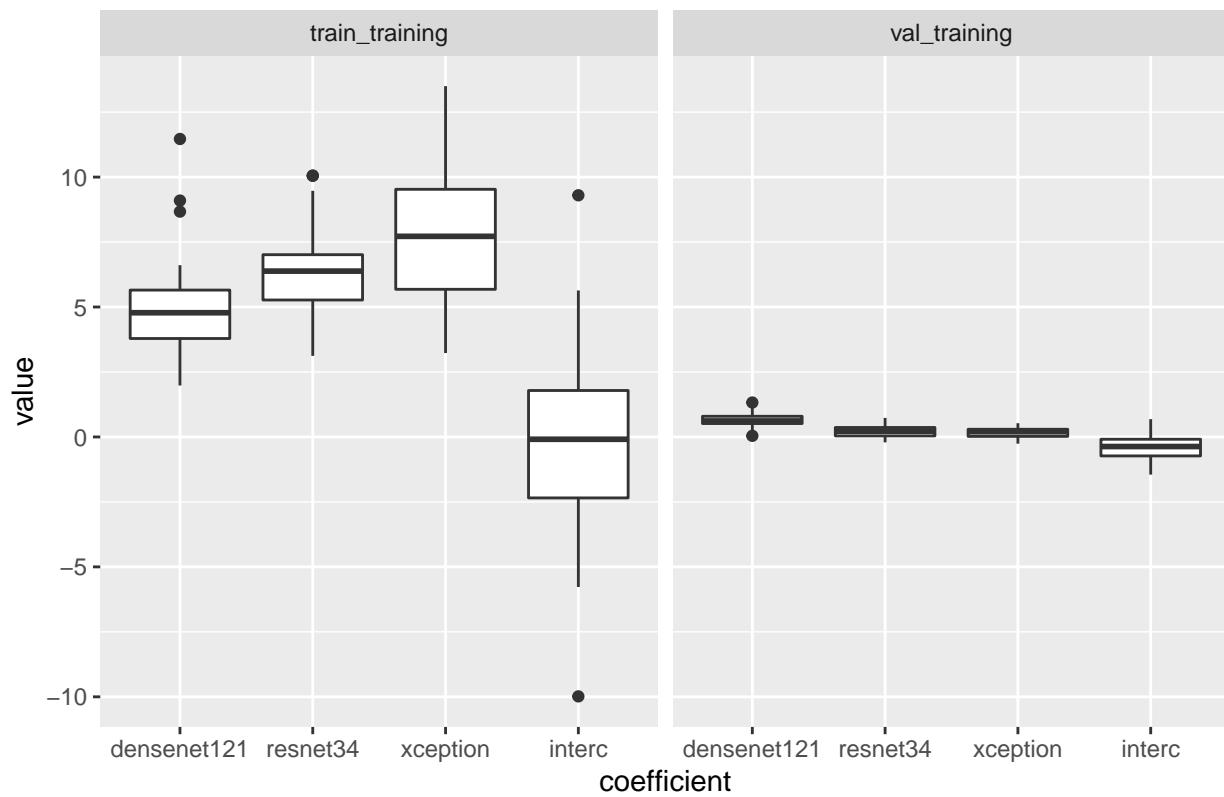
## Coefficients for class 10 vs 11



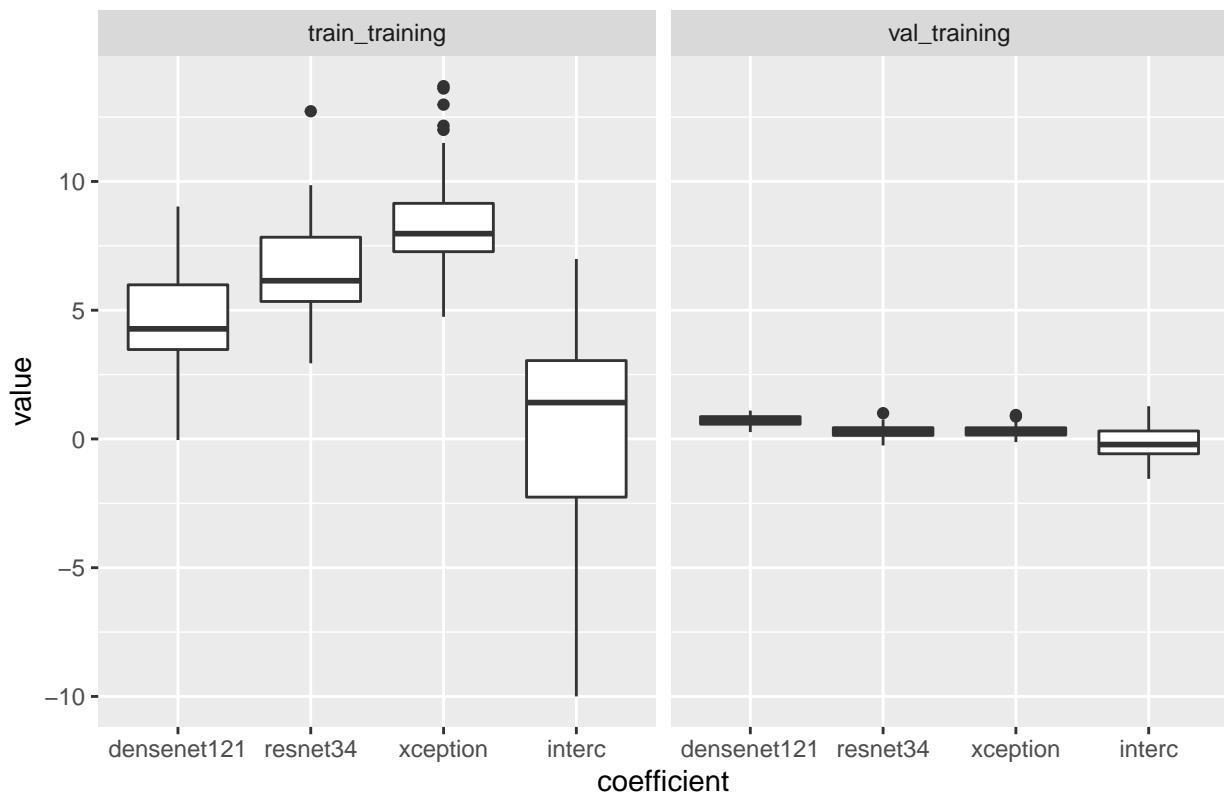
## Coefficients for class 10 vs 12



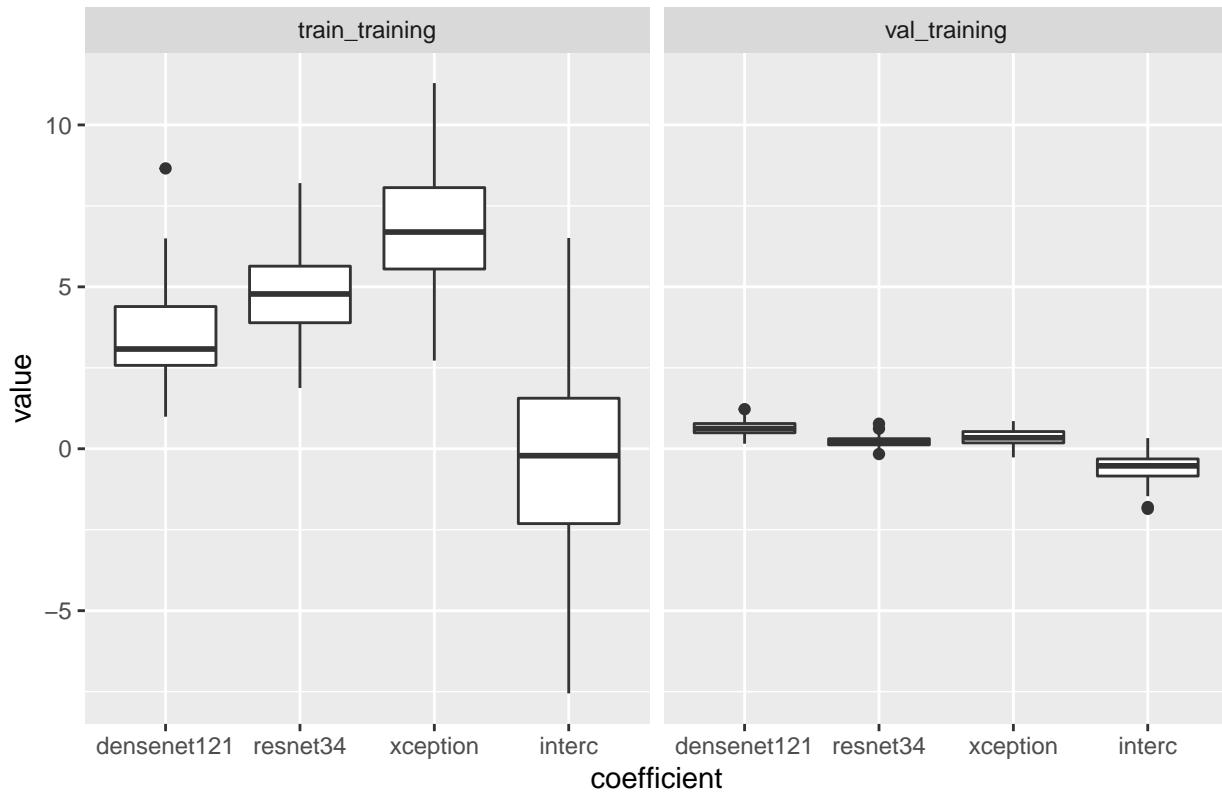
## Coefficients for class 10 vs 13



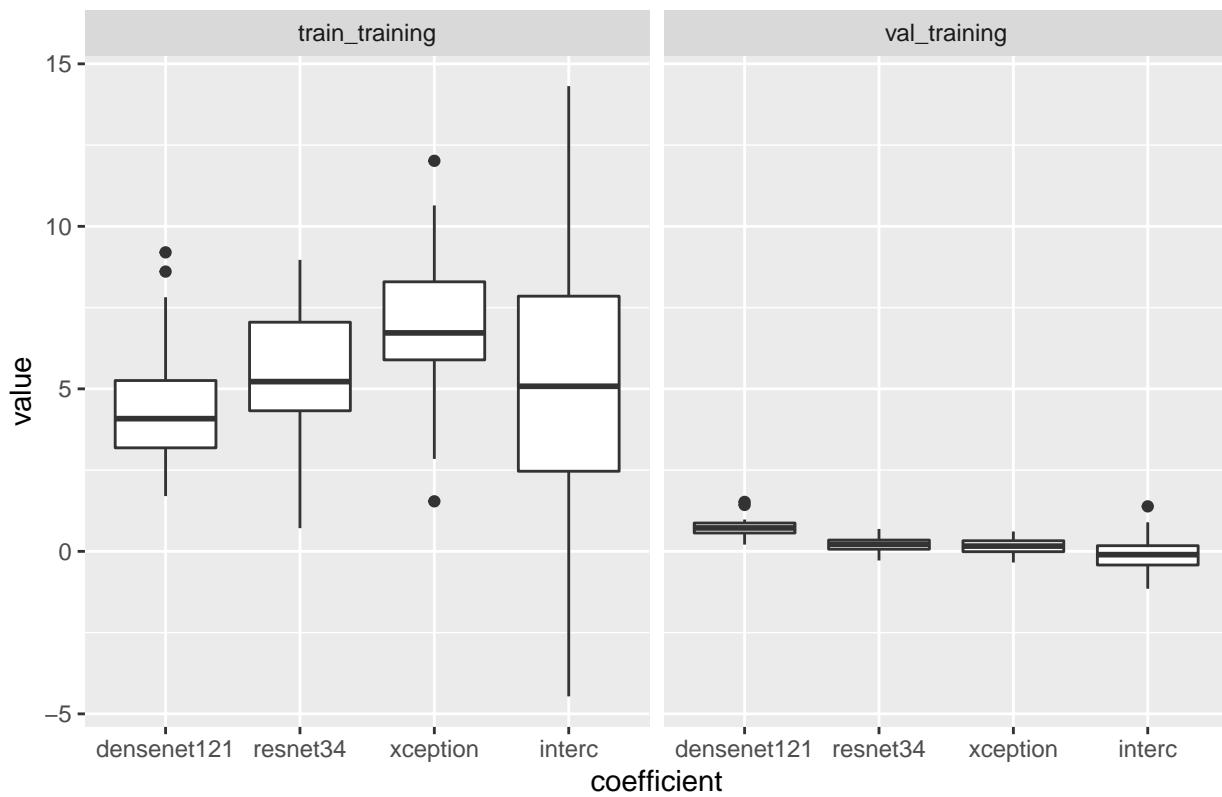
## Coefficients for class 10 vs 14



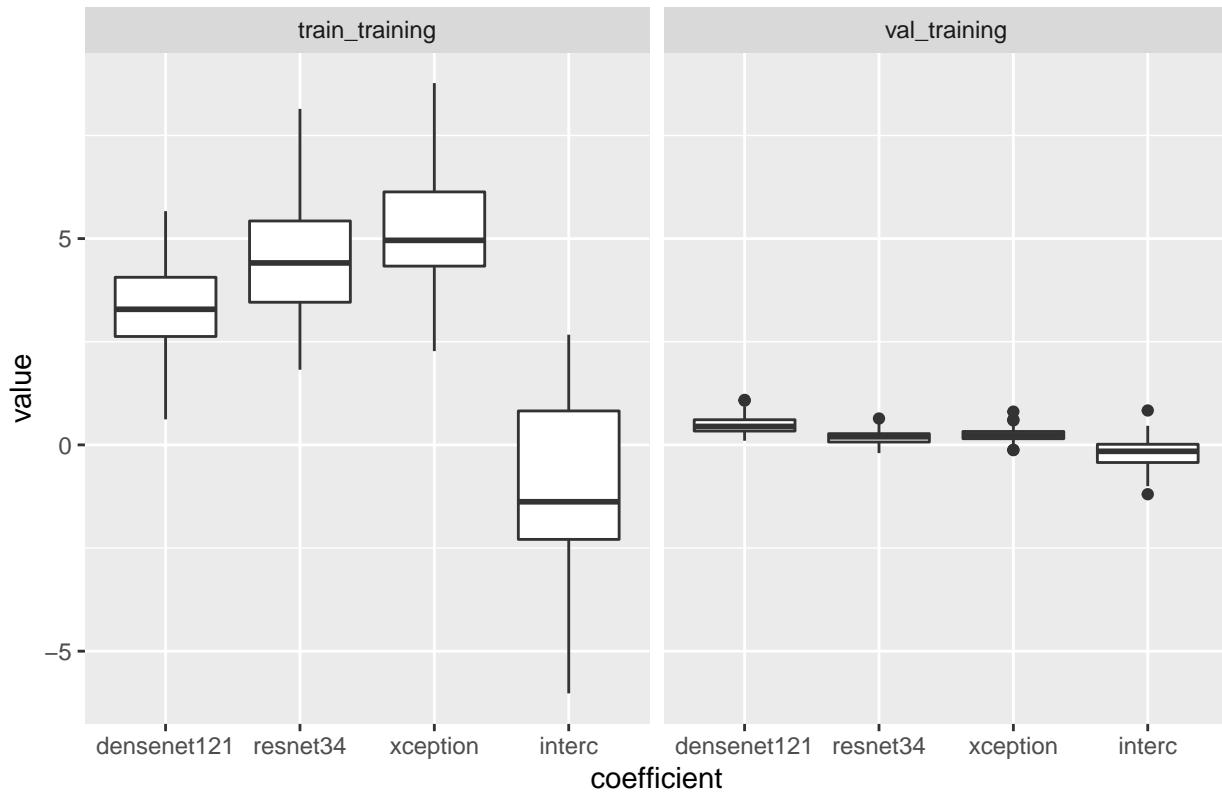
## Coefficients for class 10 vs 15



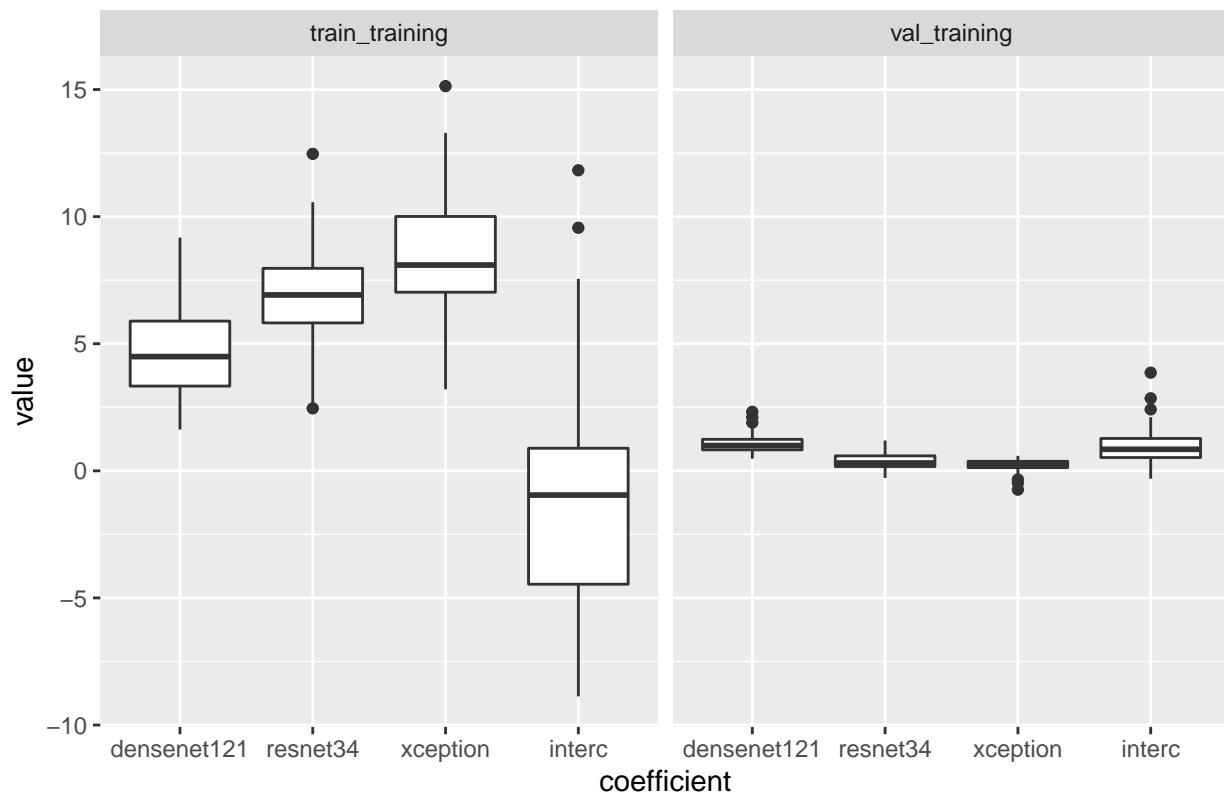
### Coefficients for class 10 vs 16



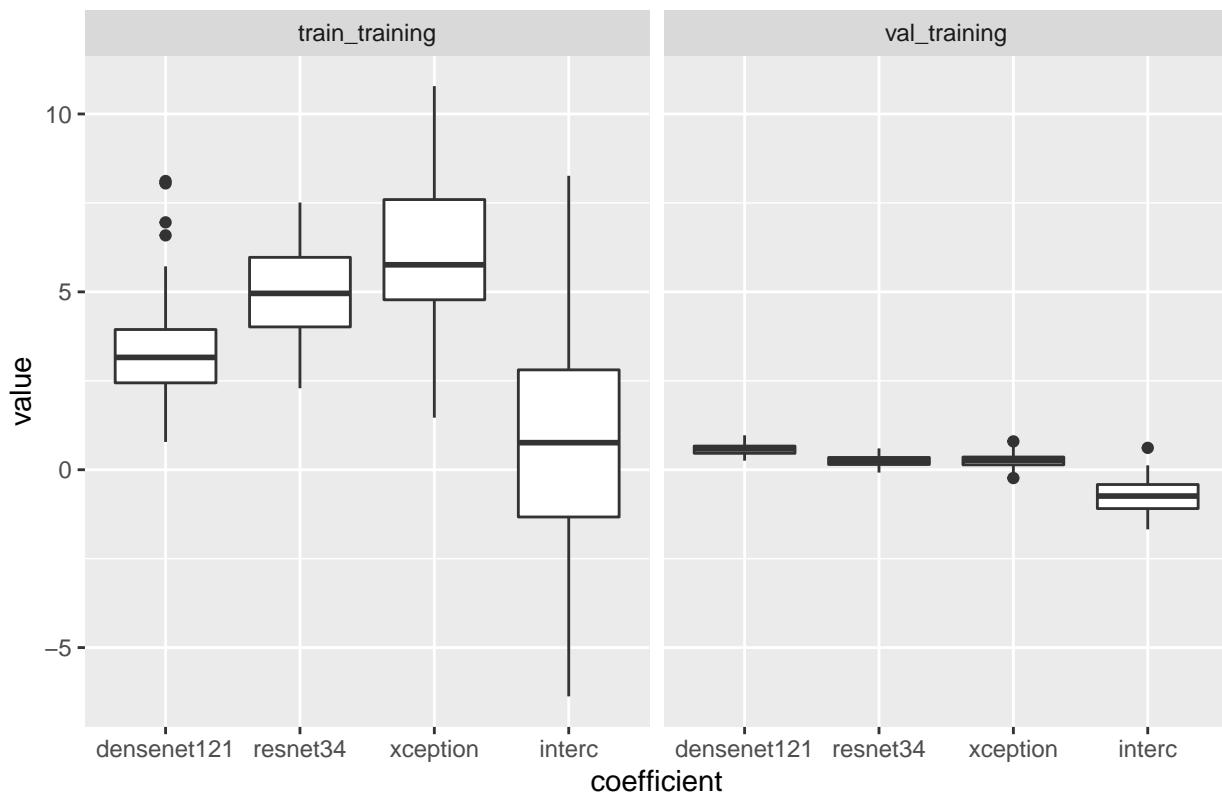
## Coefficients for class 10 vs 17



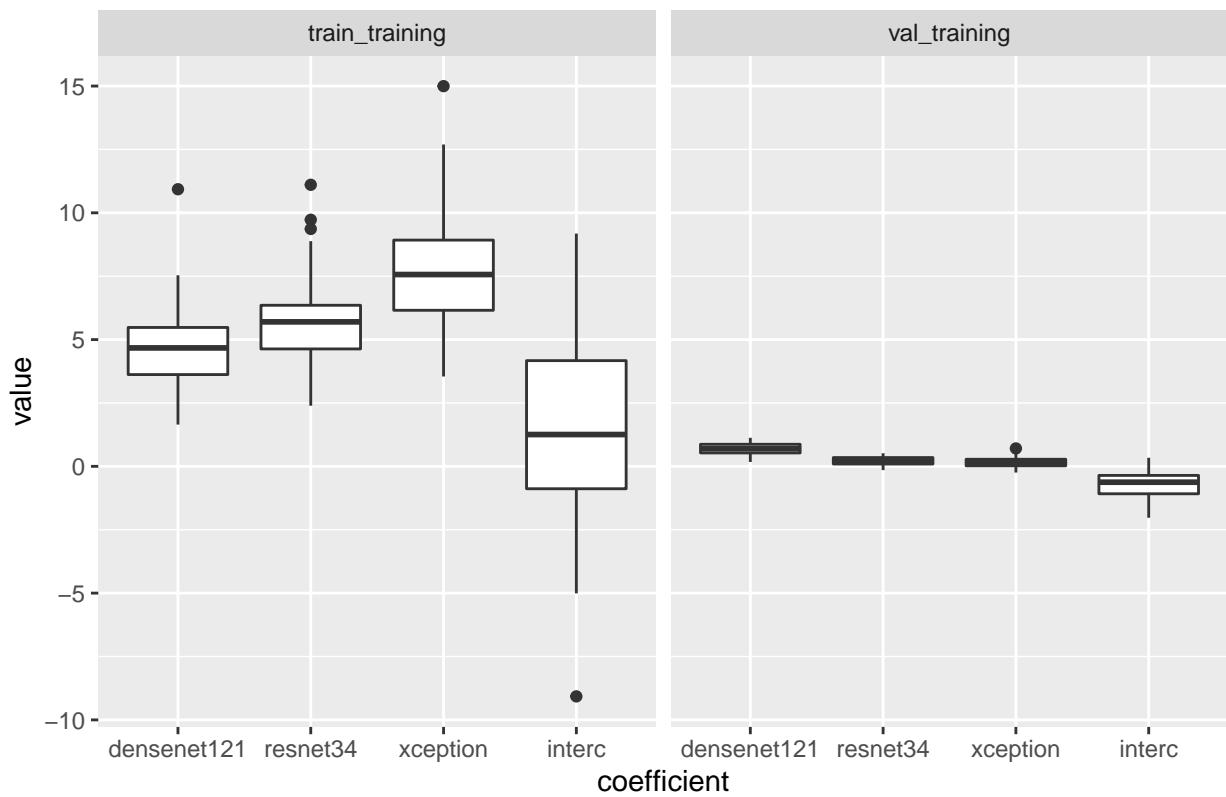
## Coefficients for class 10 vs 18



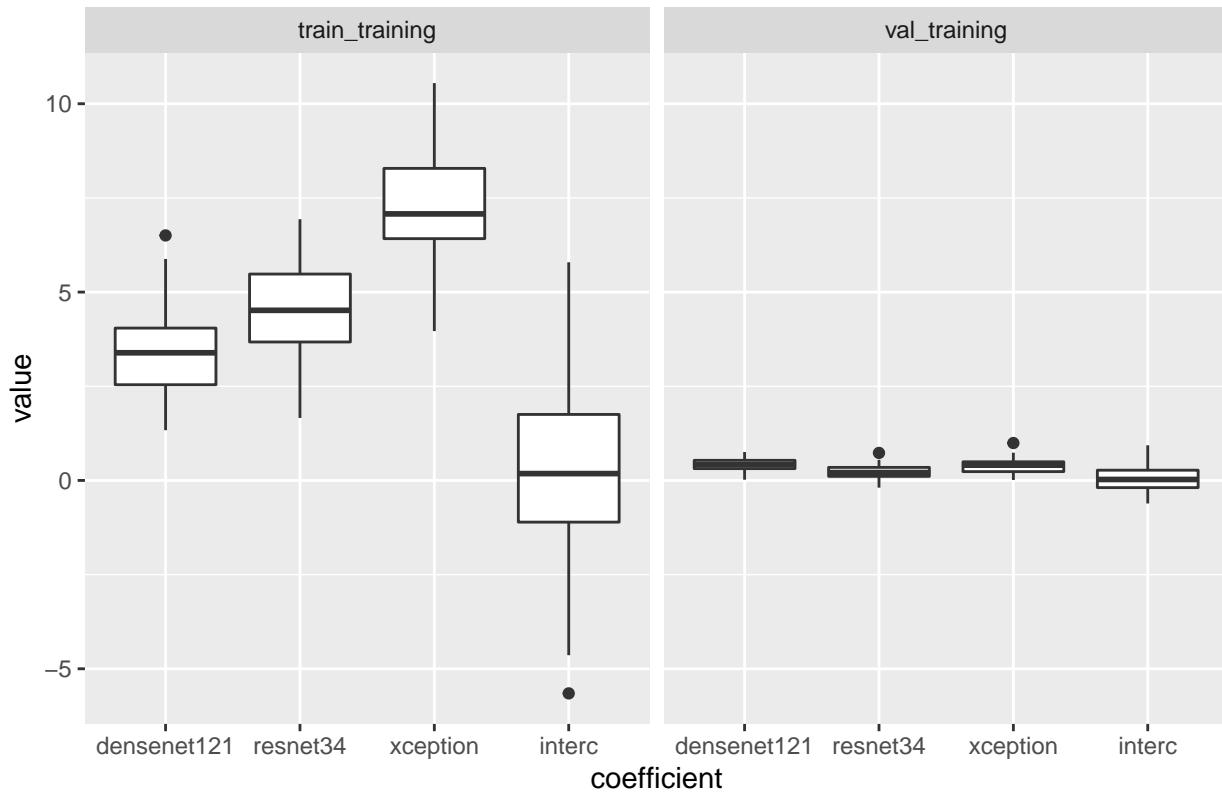
### Coefficients for class 10 vs 19



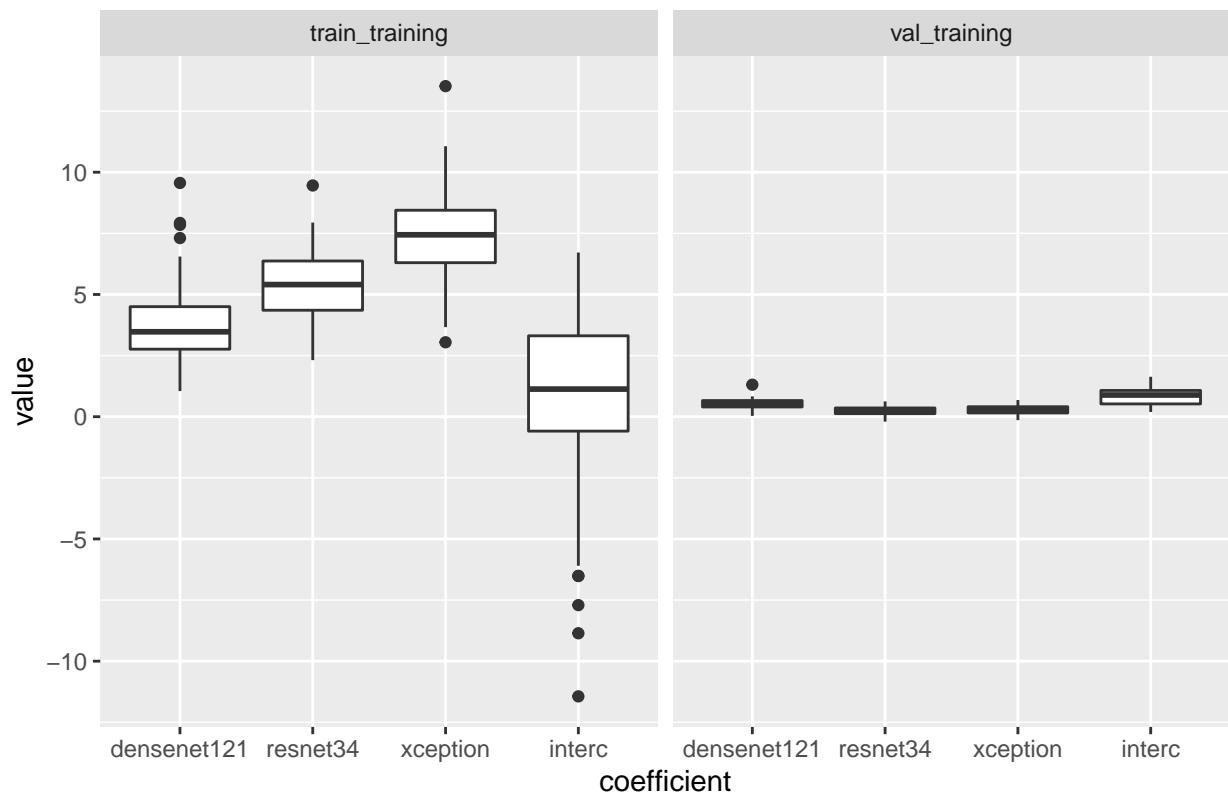
## Coefficients for class 10 vs 20



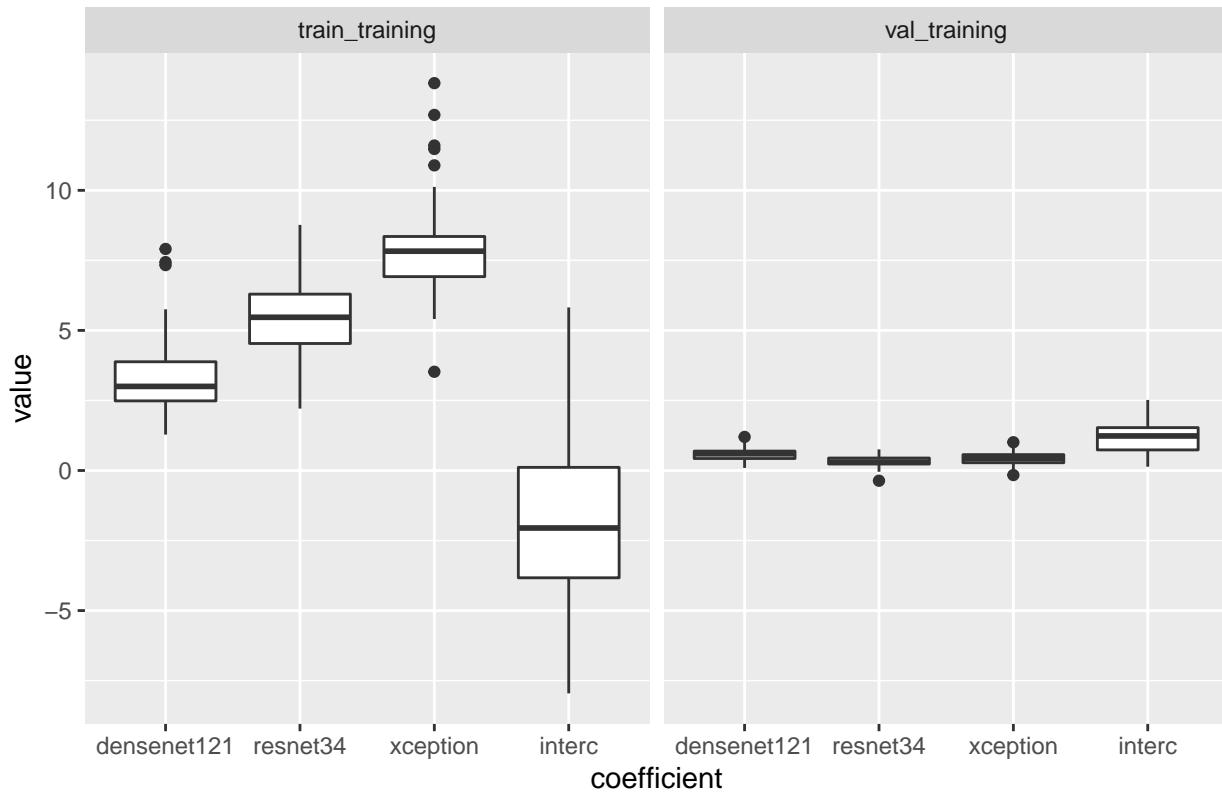
## Coefficients for class 11 vs 12



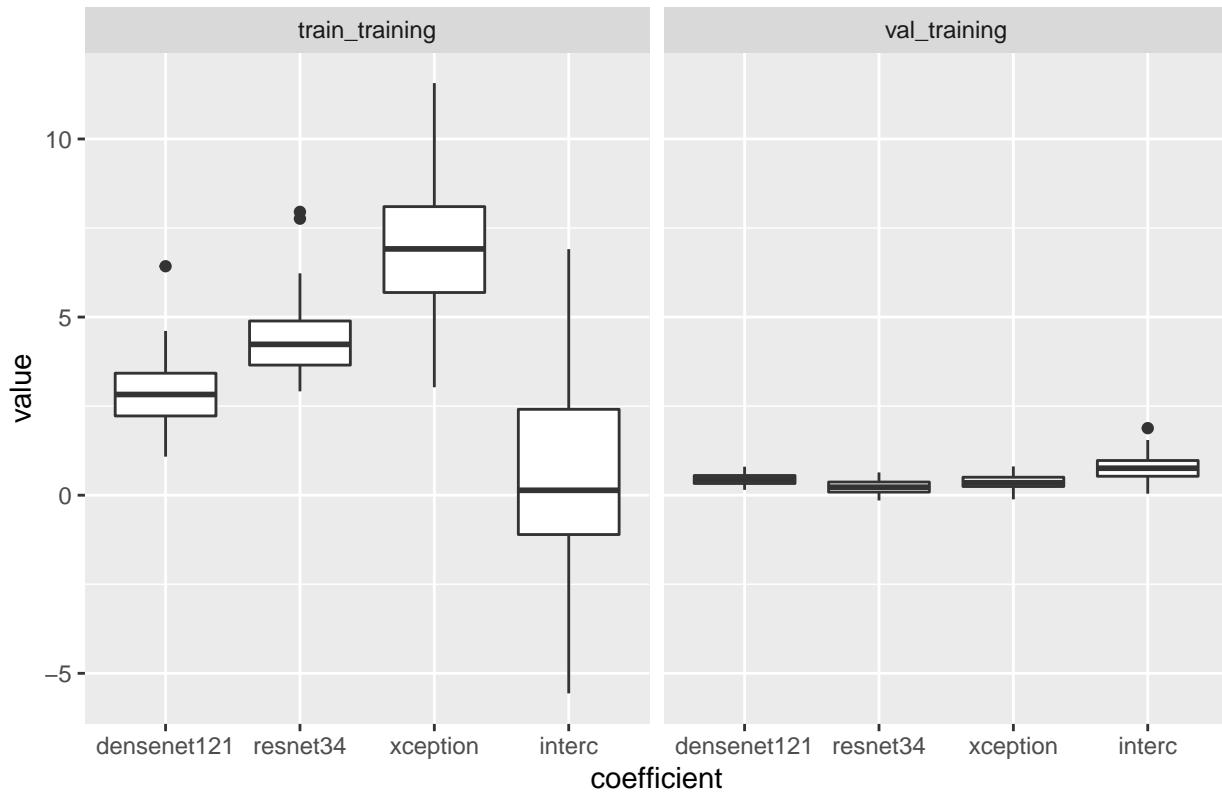
## Coefficients for class 11 vs 13



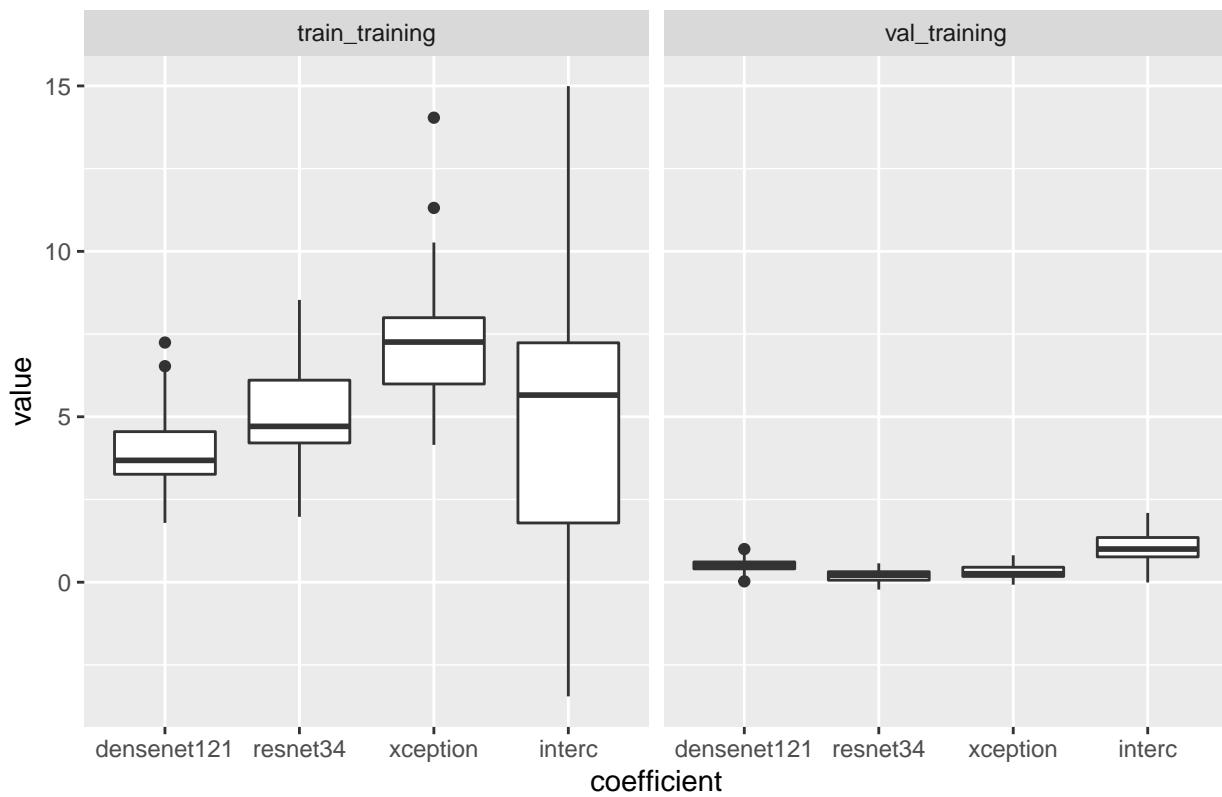
## Coefficients for class 11 vs 14



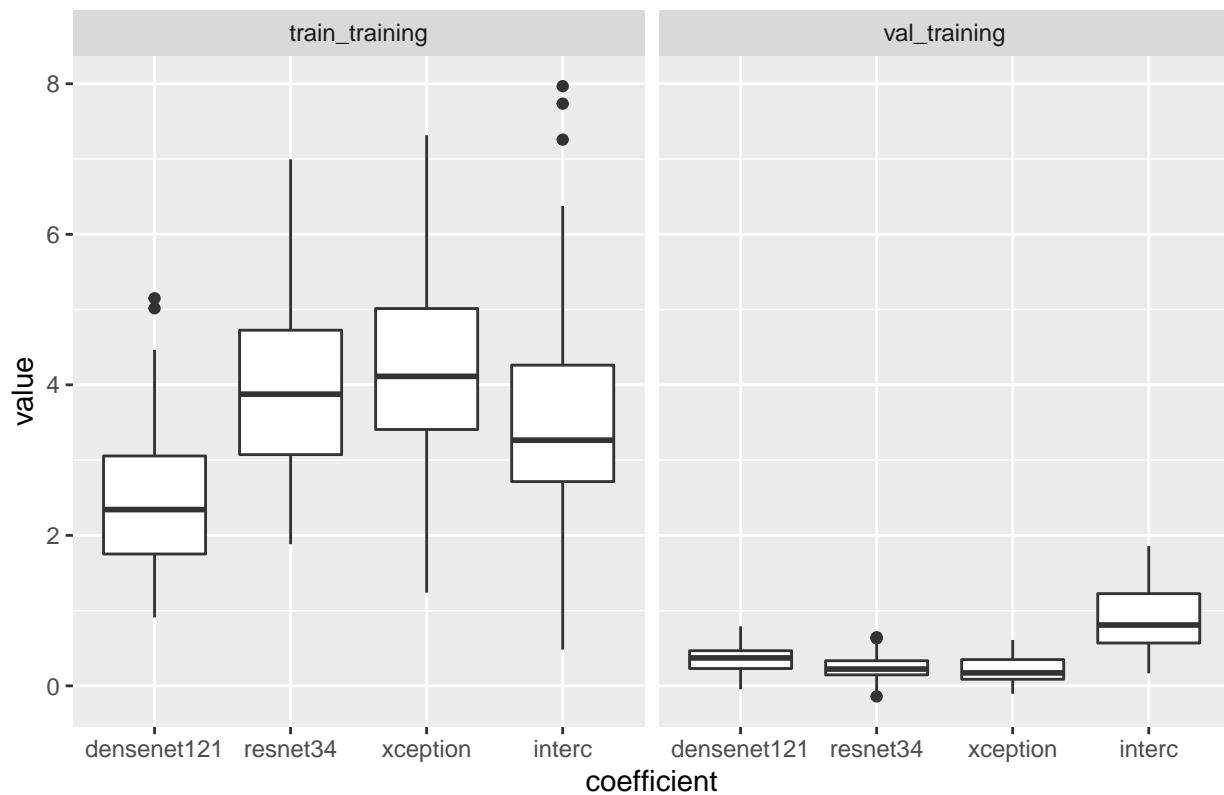
## Coefficients for class 11 vs 15



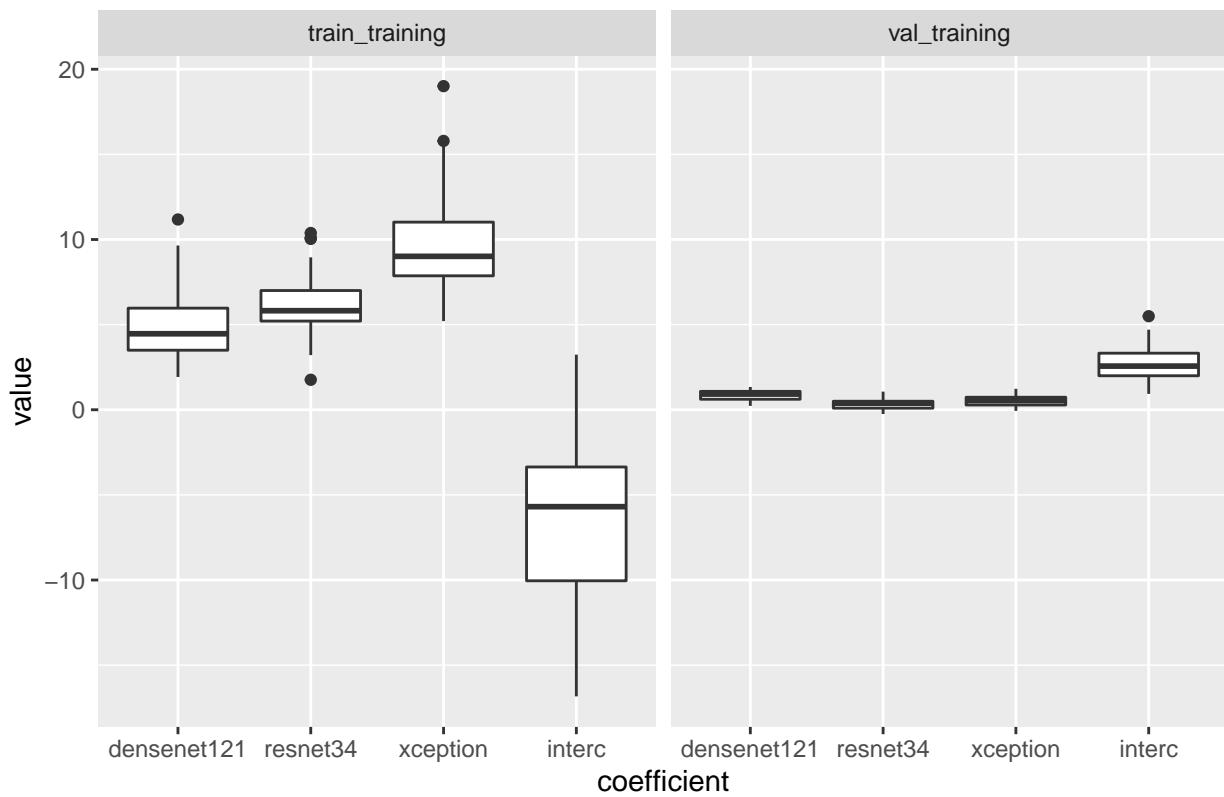
## Coefficients for class 11 vs 16



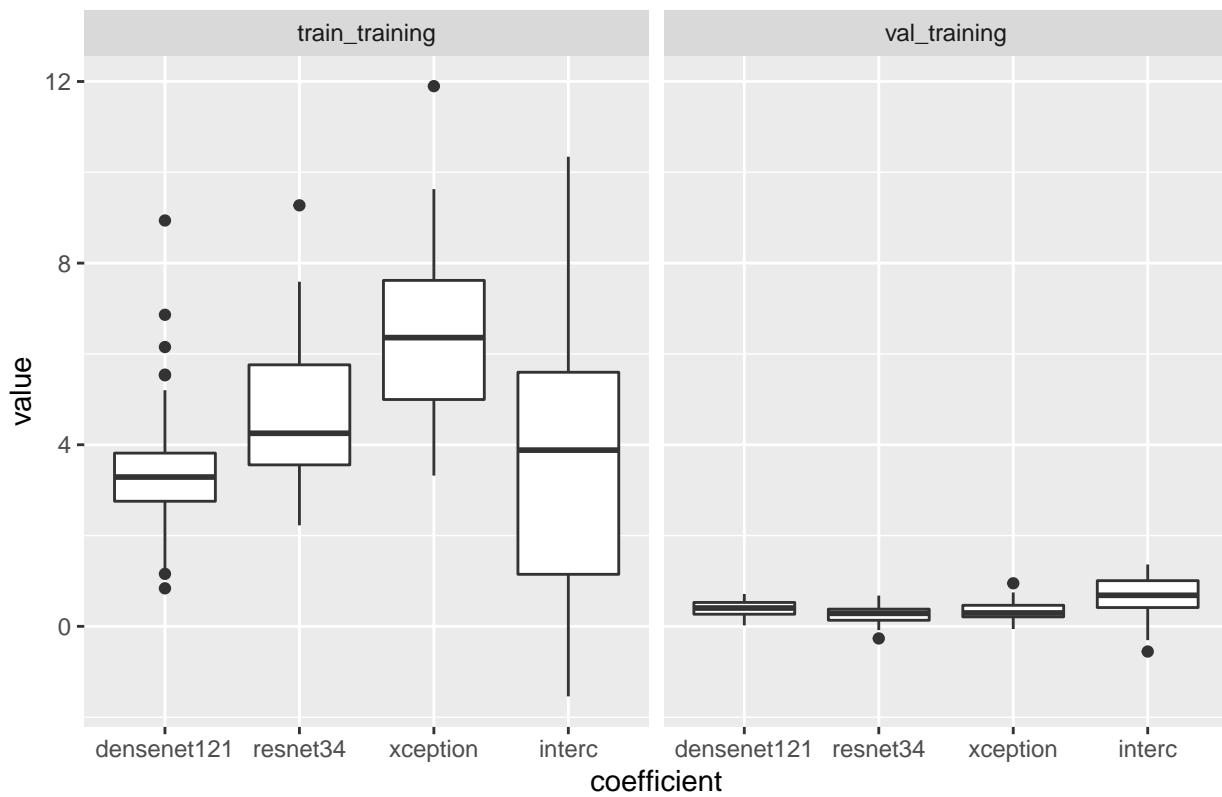
### Coefficients for class 11 vs 17



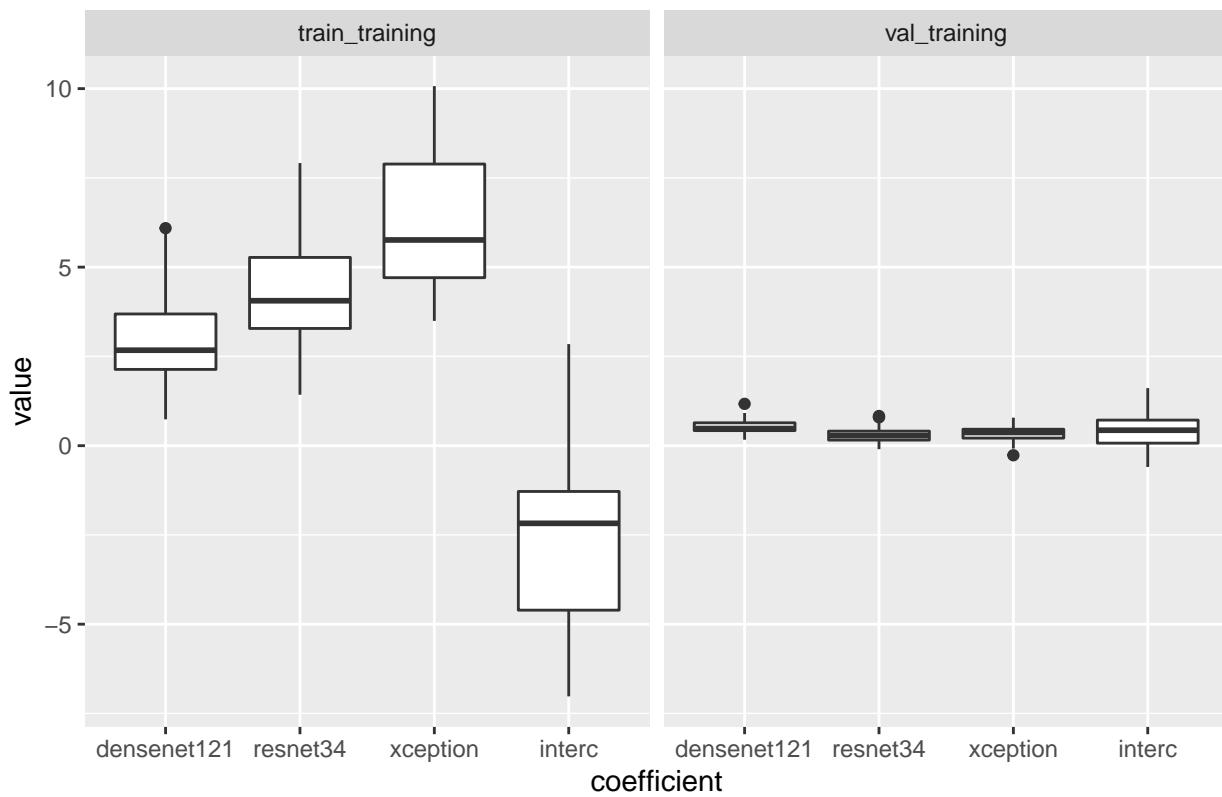
### Coefficients for class 11 vs 18



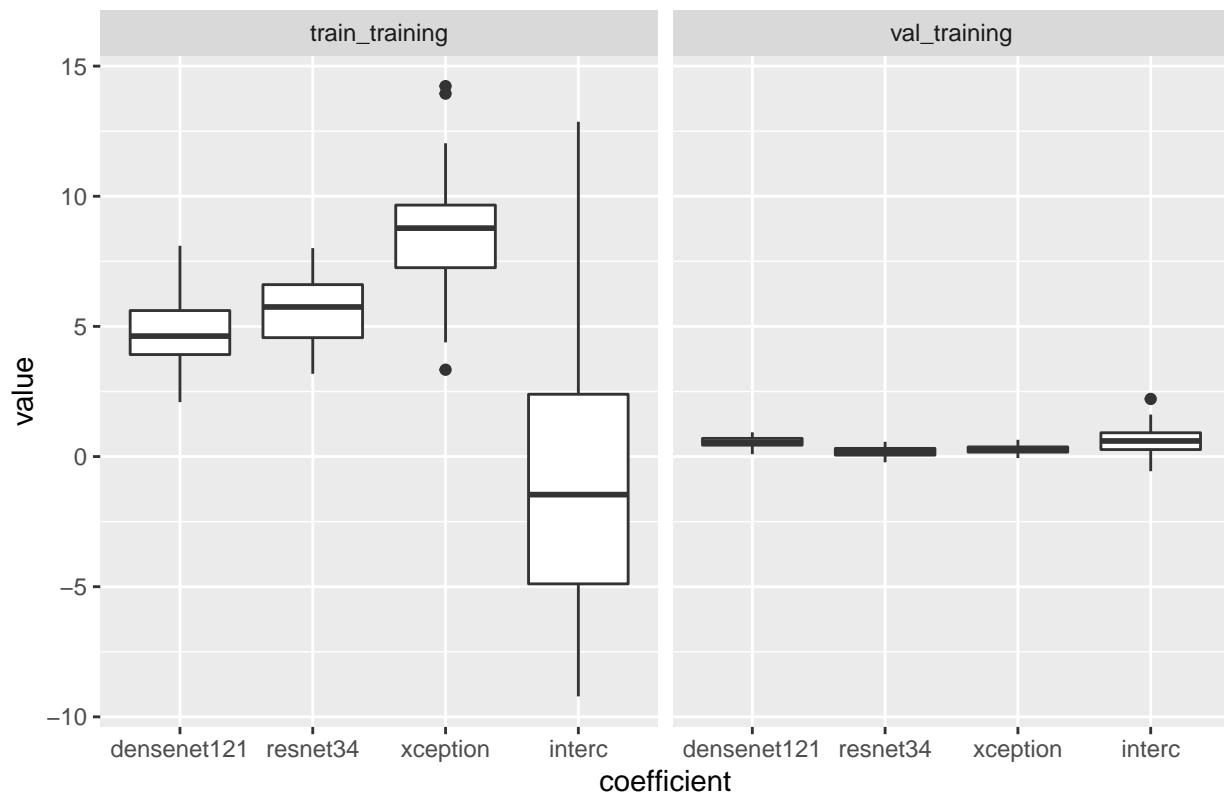
## Coefficients for class 11 vs 19



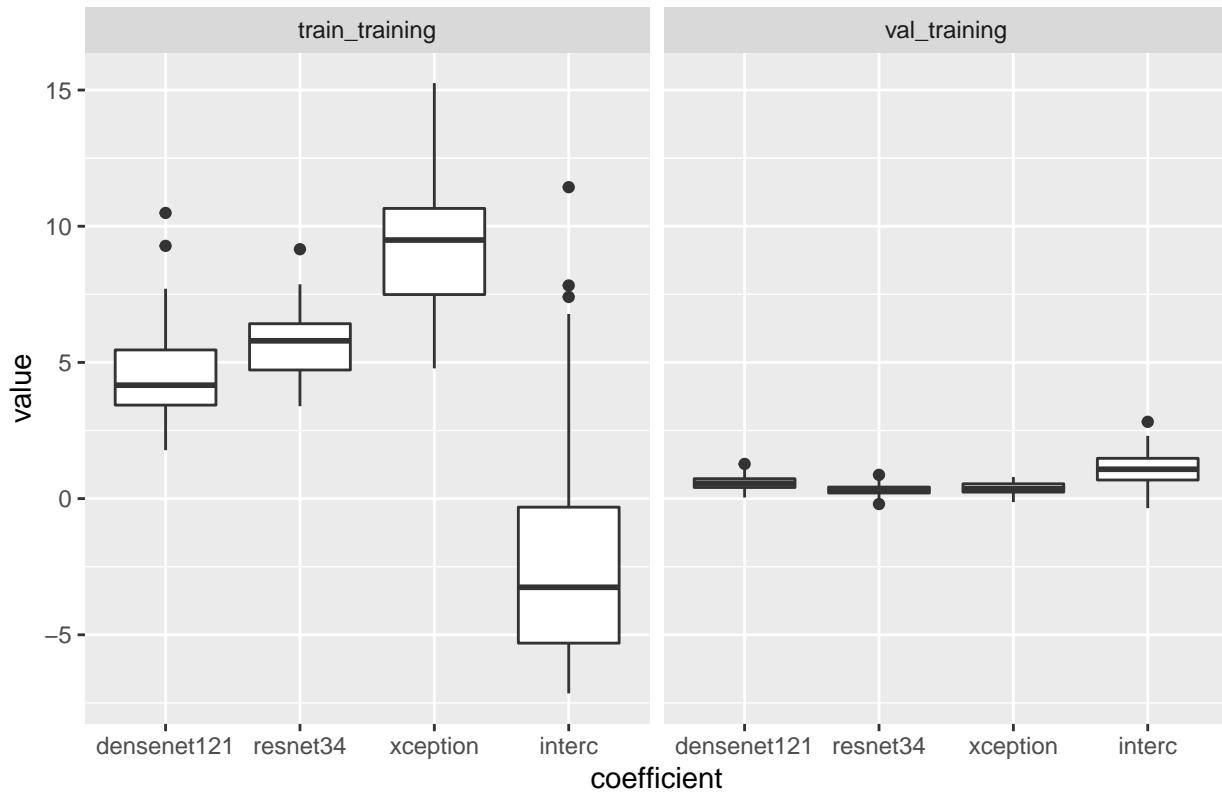
### Coefficients for class 11 vs 20



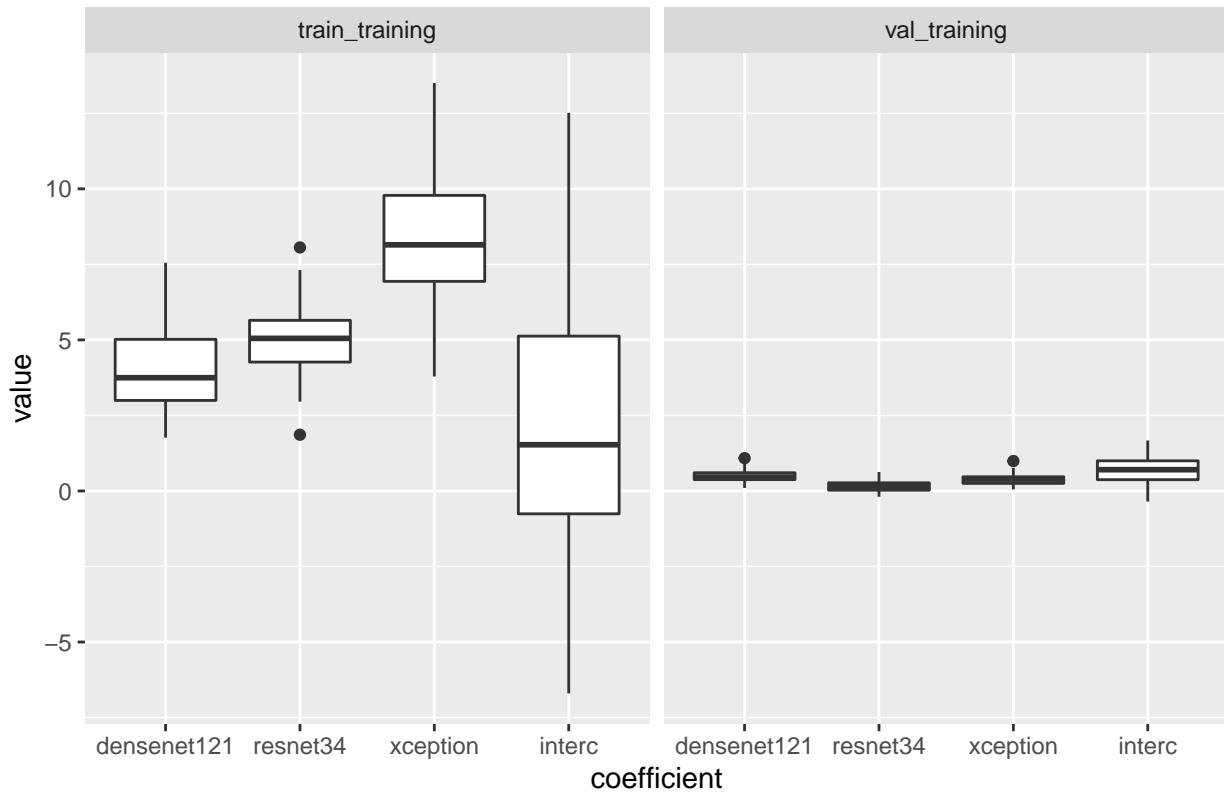
### Coefficients for class 12 vs 13



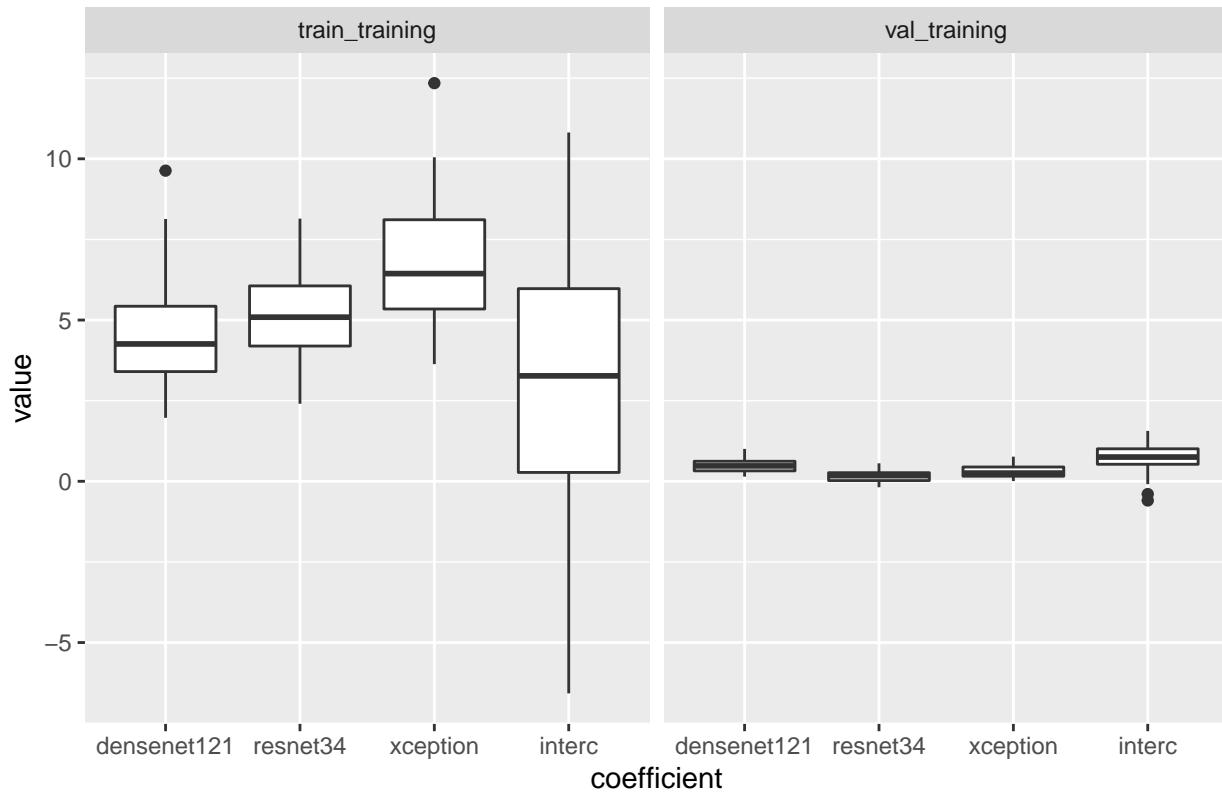
### Coefficients for class 12 vs 14



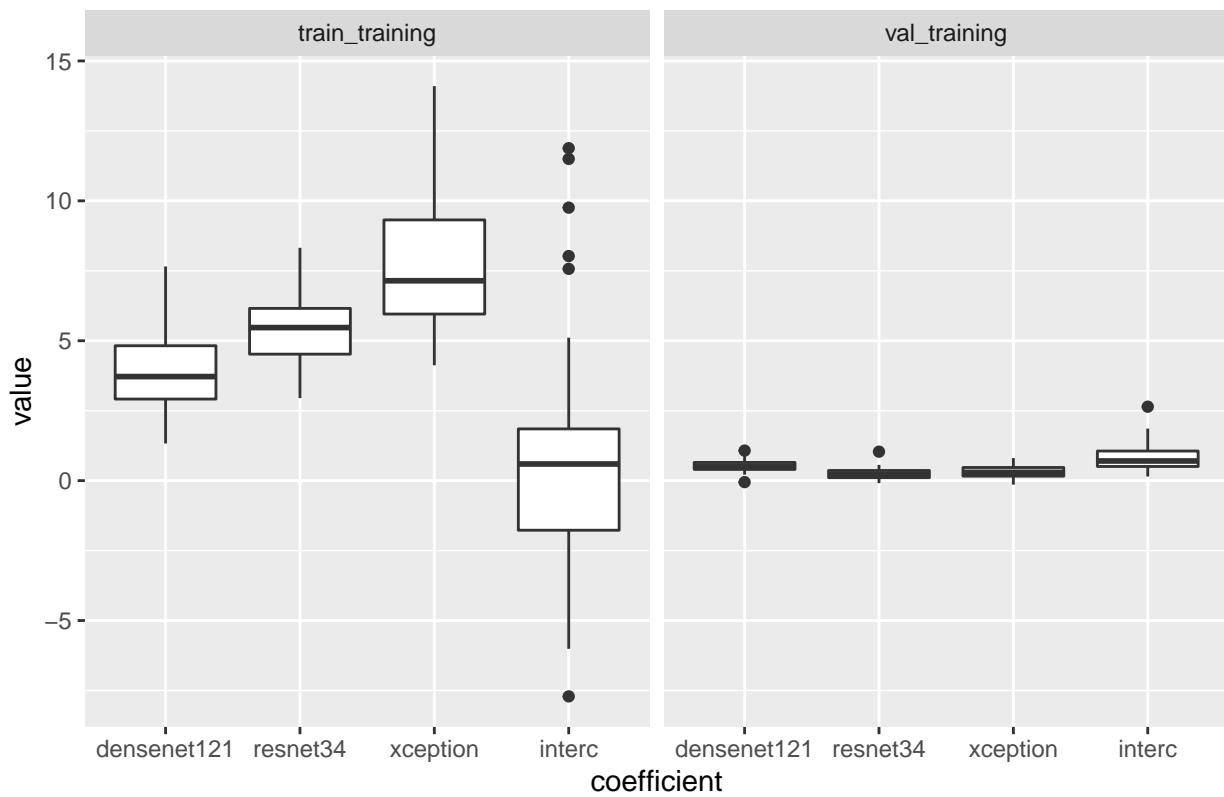
## Coefficients for class 12 vs 15



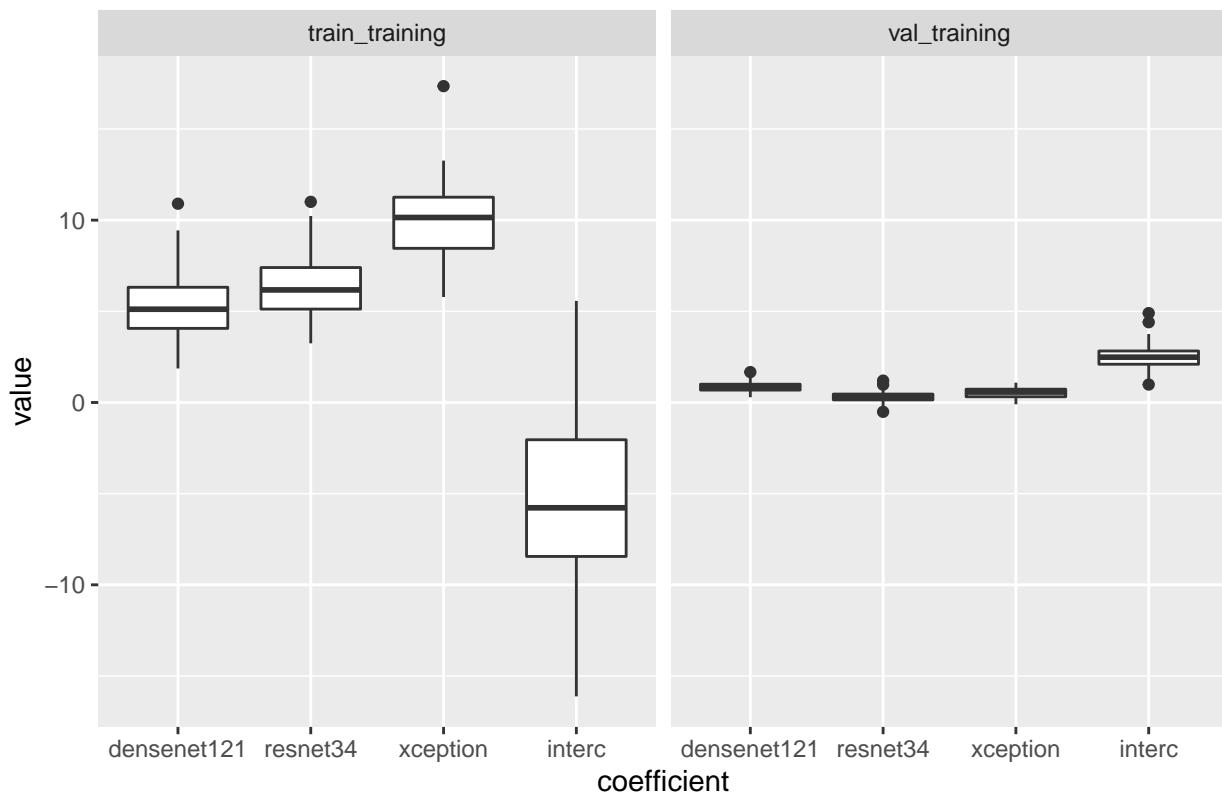
## Coefficients for class 12 vs 16



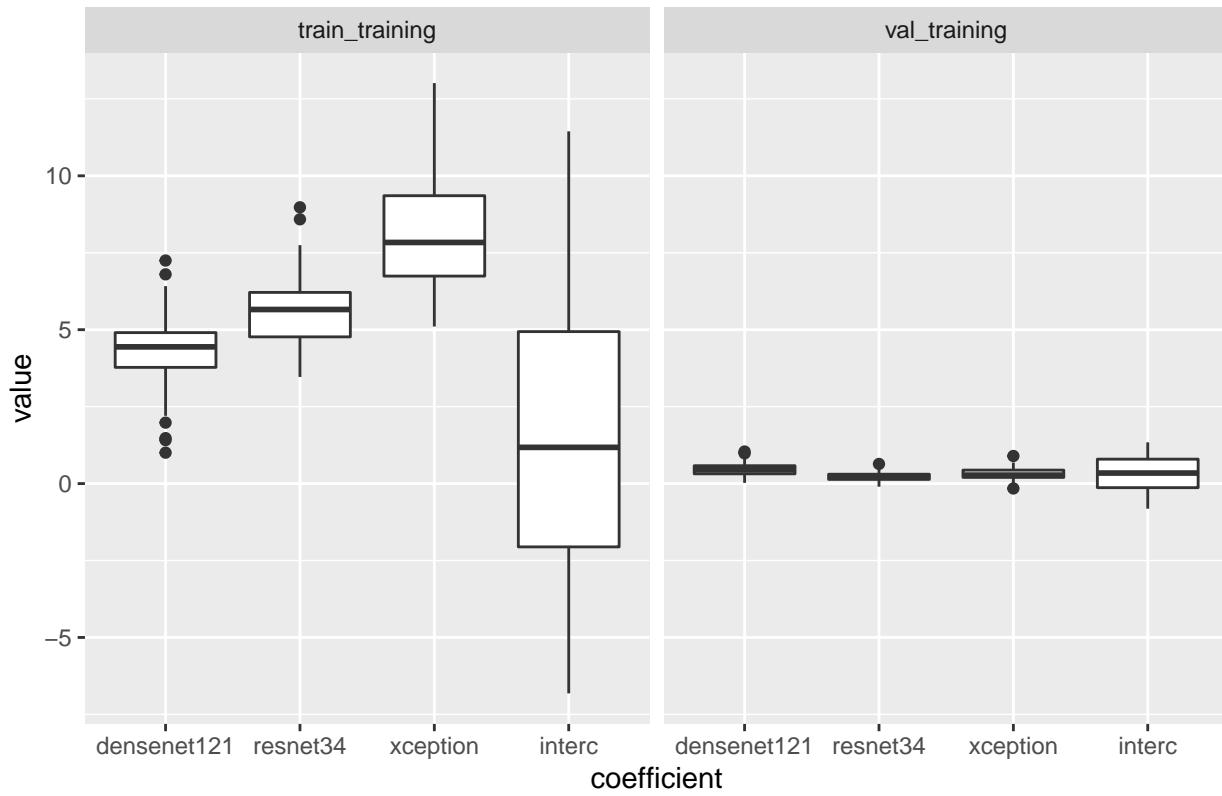
### Coefficients for class 12 vs 17



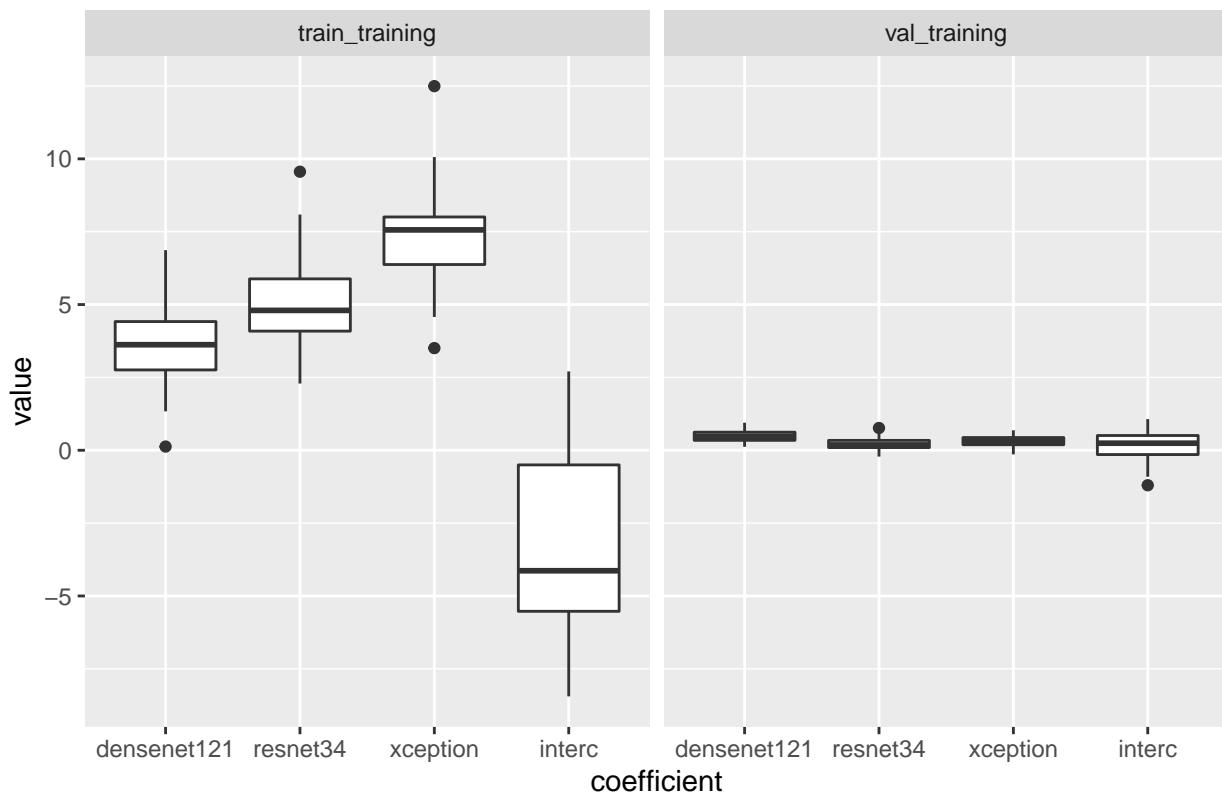
## Coefficients for class 12 vs 18



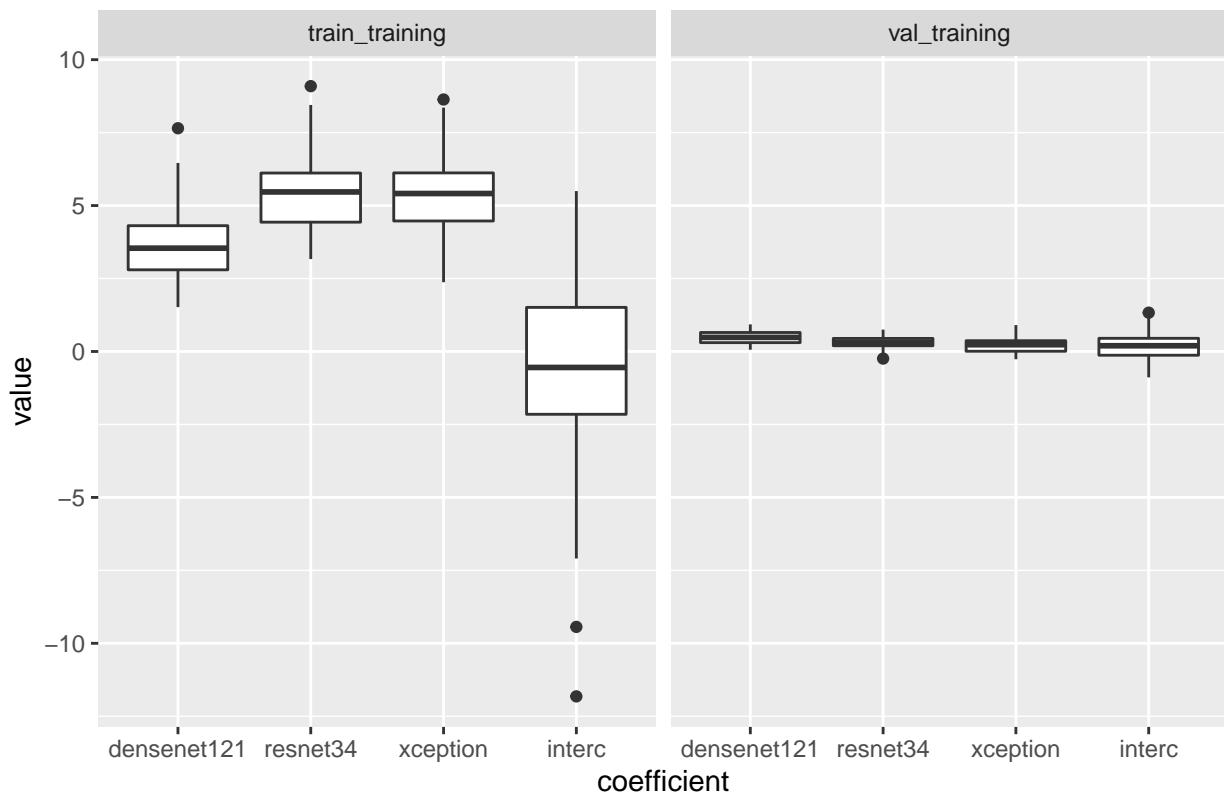
## Coefficients for class 12 vs 19



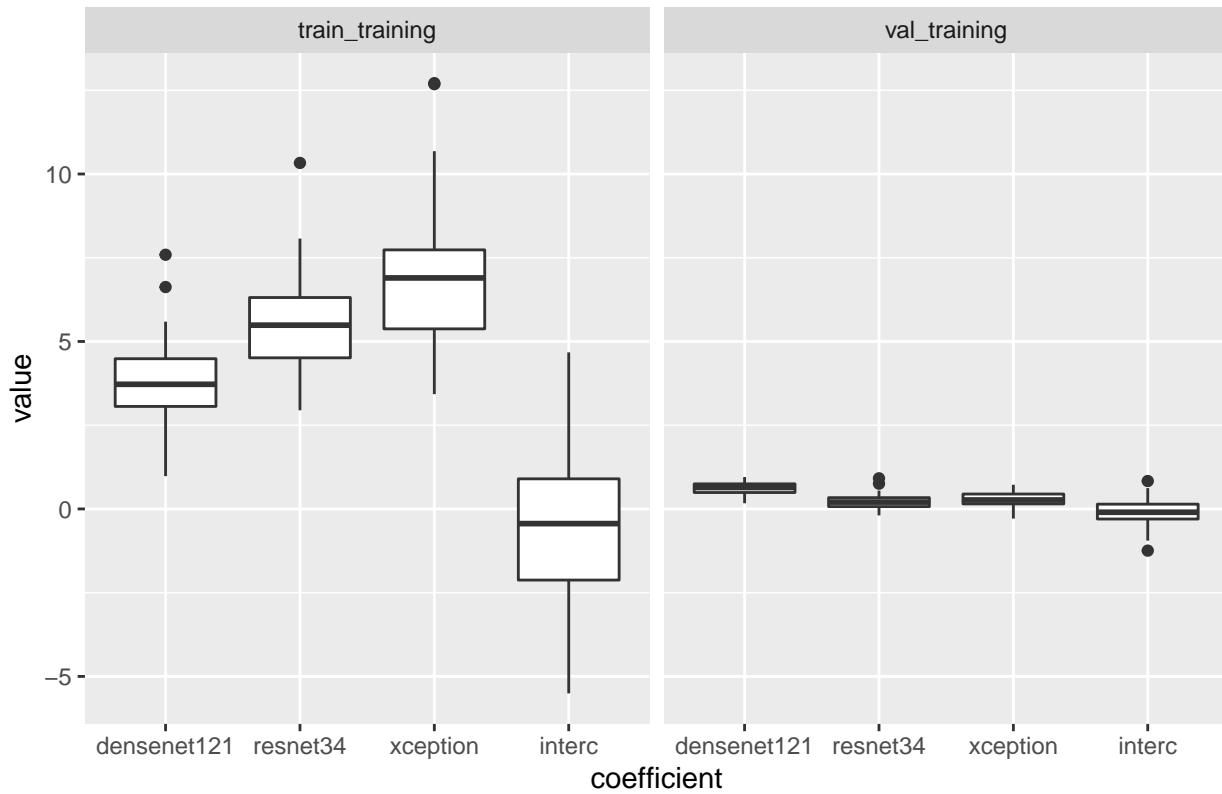
### Coefficients for class 12 vs 20



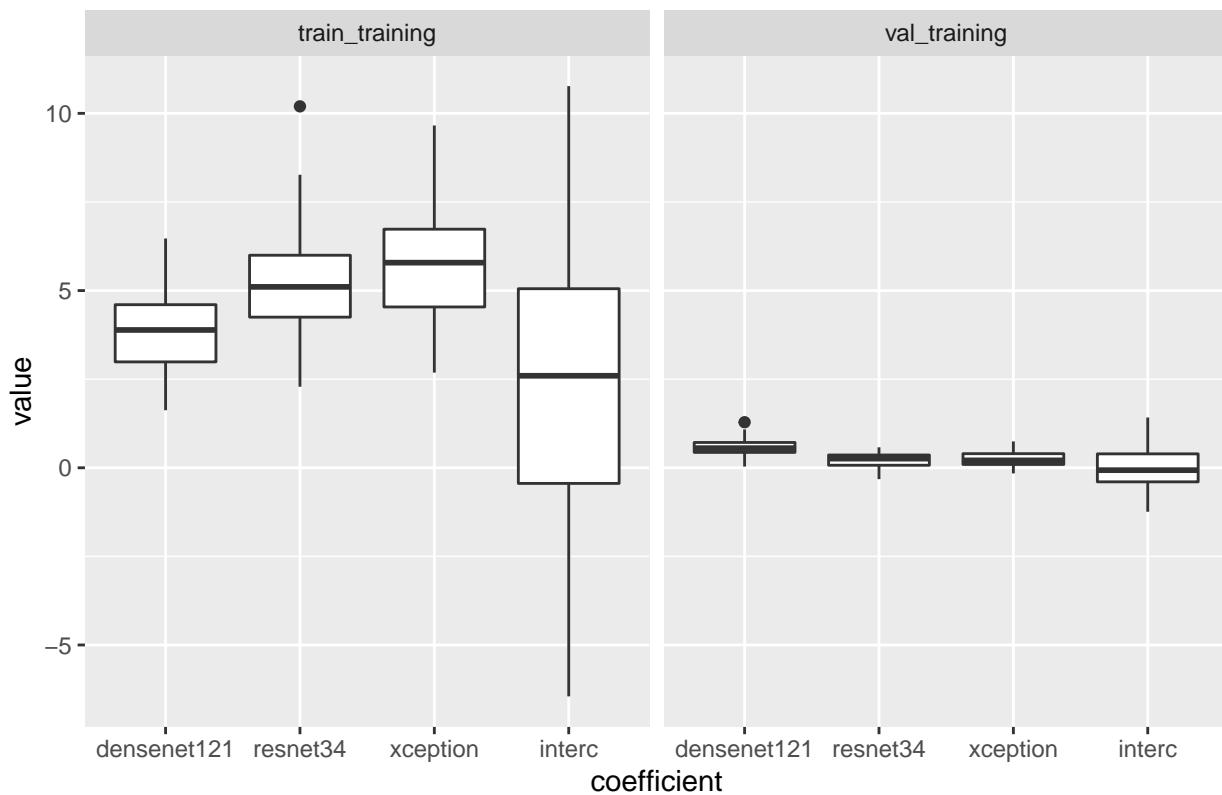
### Coefficients for class 13 vs 14



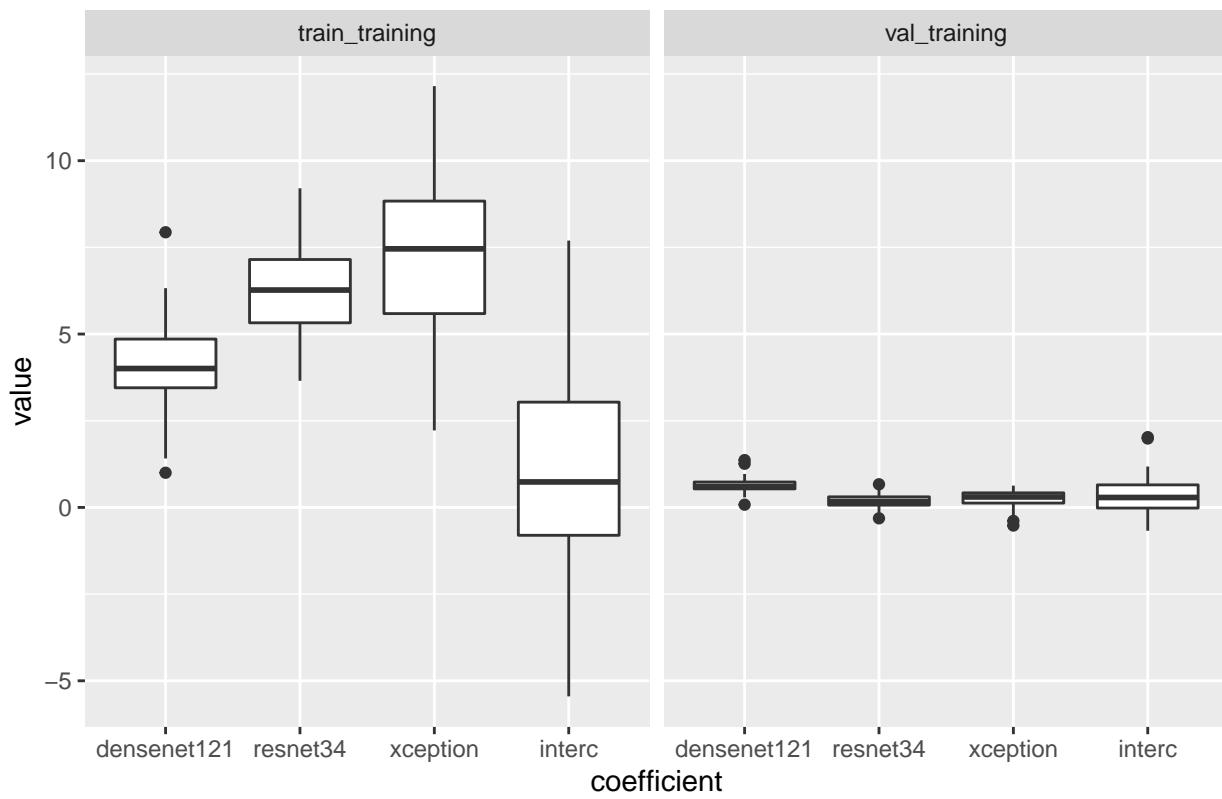
### Coefficients for class 13 vs 15



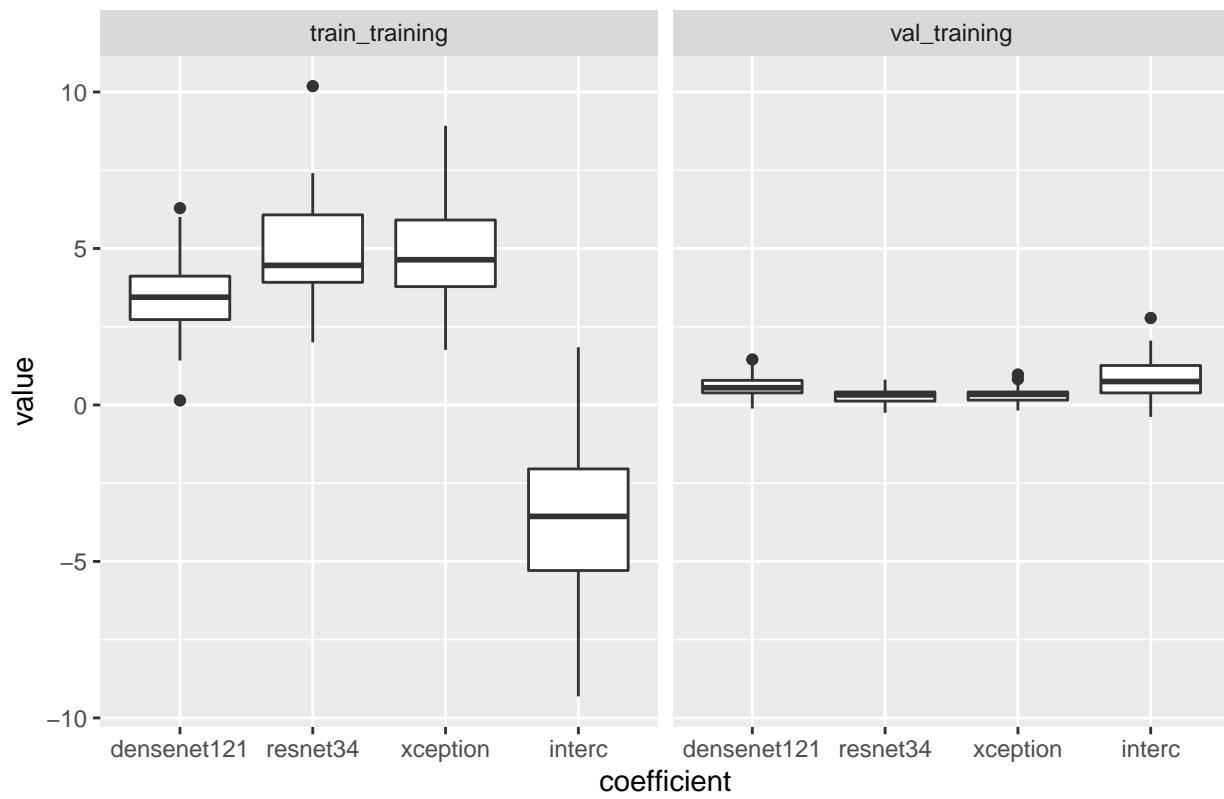
### Coefficients for class 13 vs 16



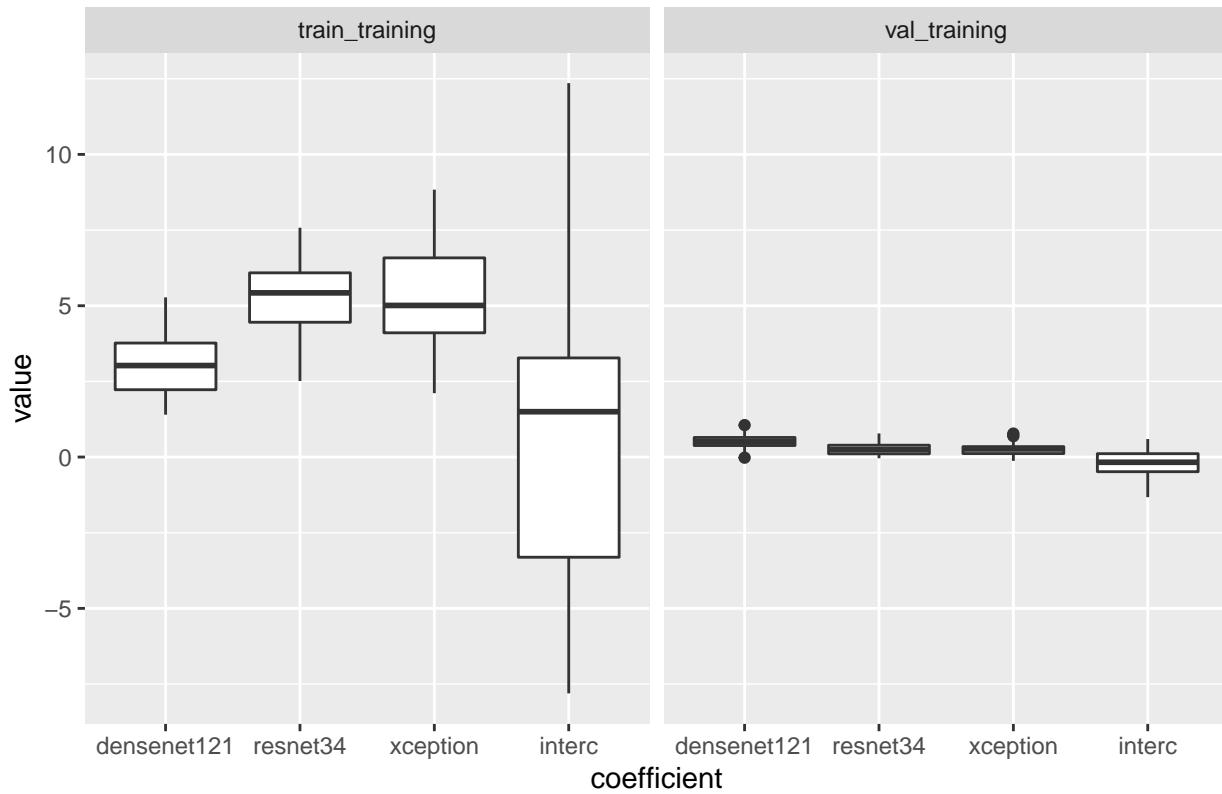
### Coefficients for class 13 vs 17



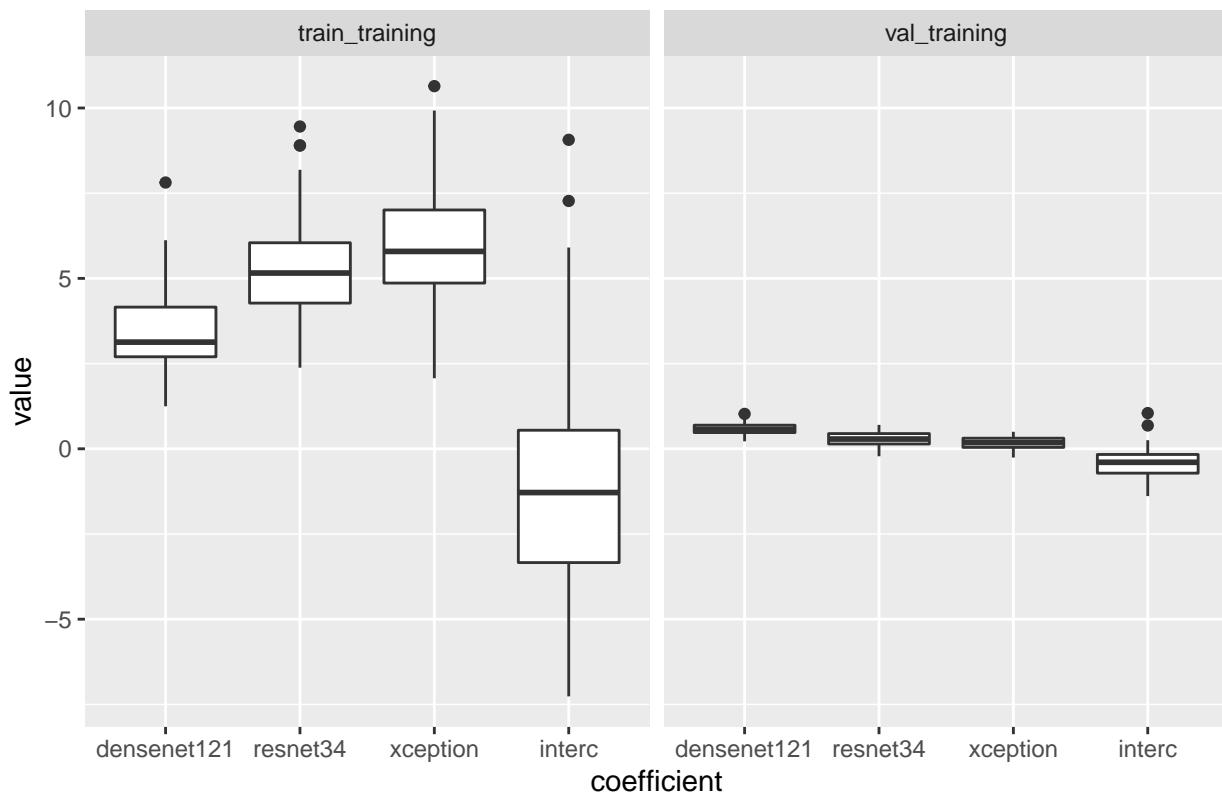
### Coefficients for class 13 vs 18



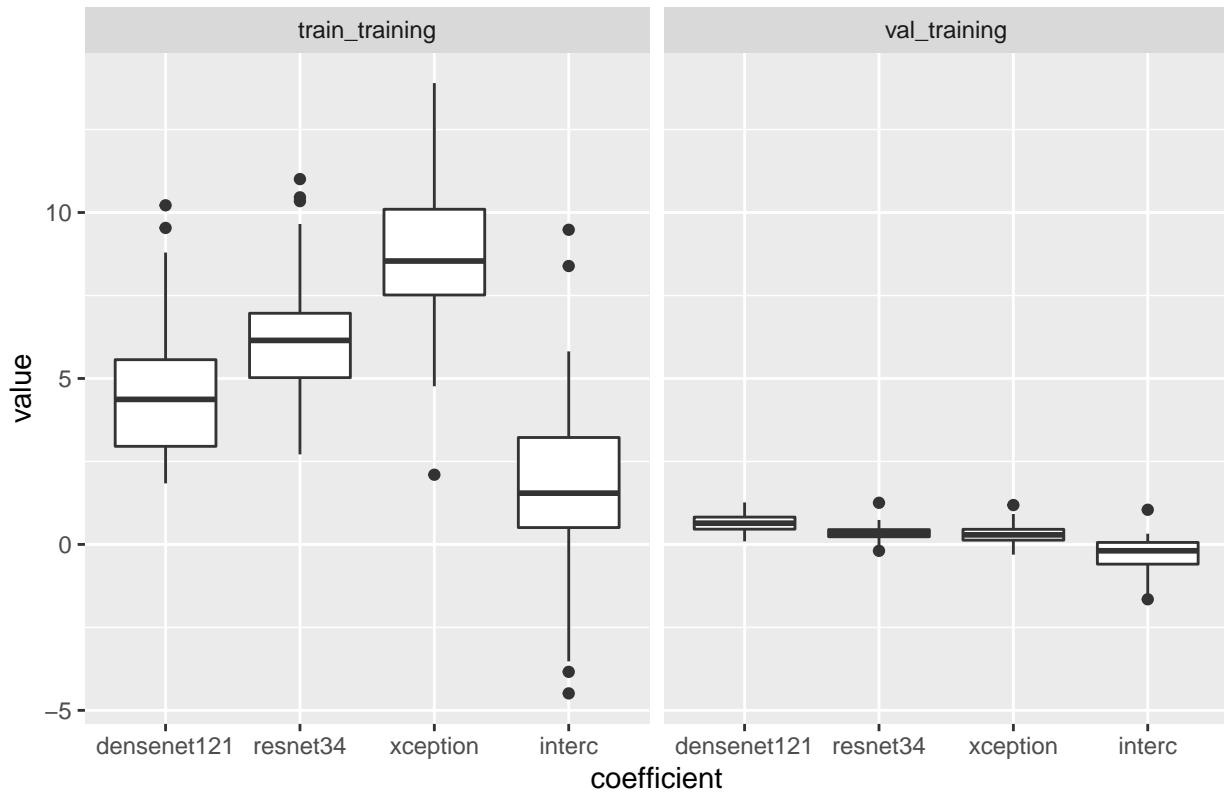
## Coefficients for class 13 vs 19



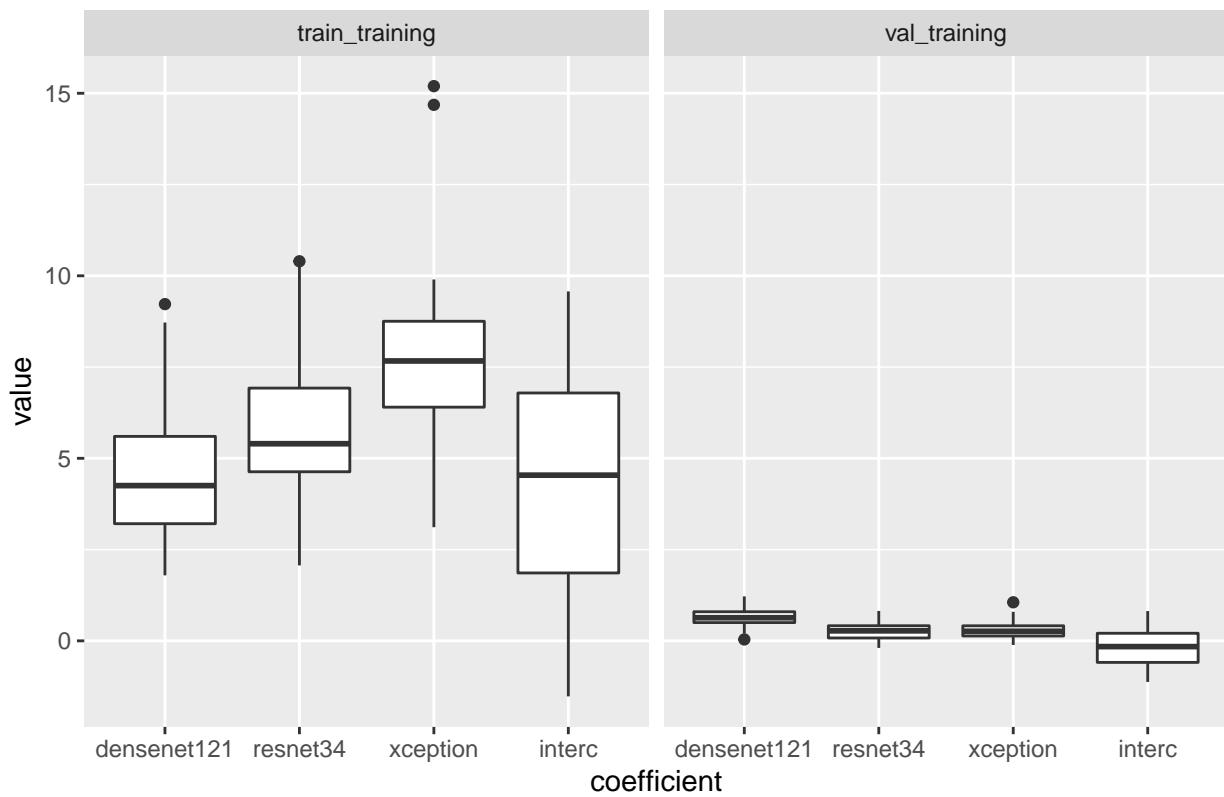
## Coefficients for class 13 vs 20



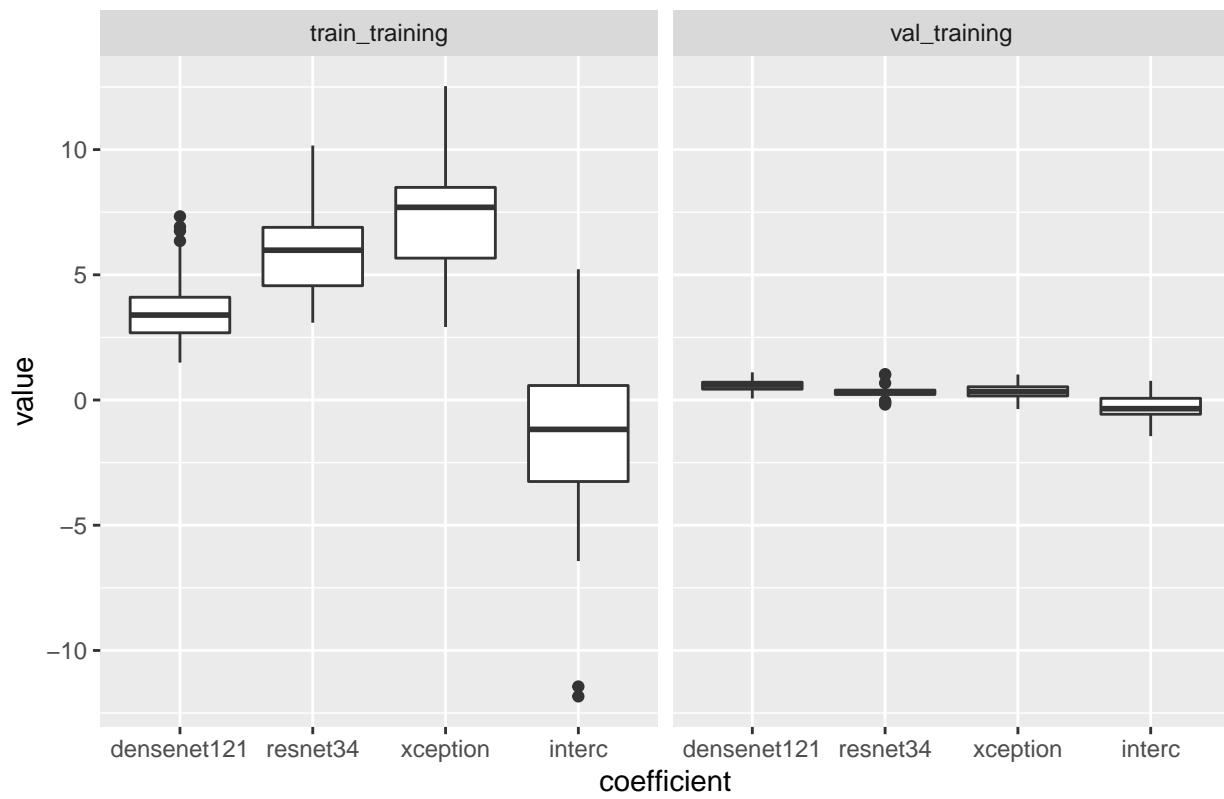
## Coefficients for class 14 vs 15



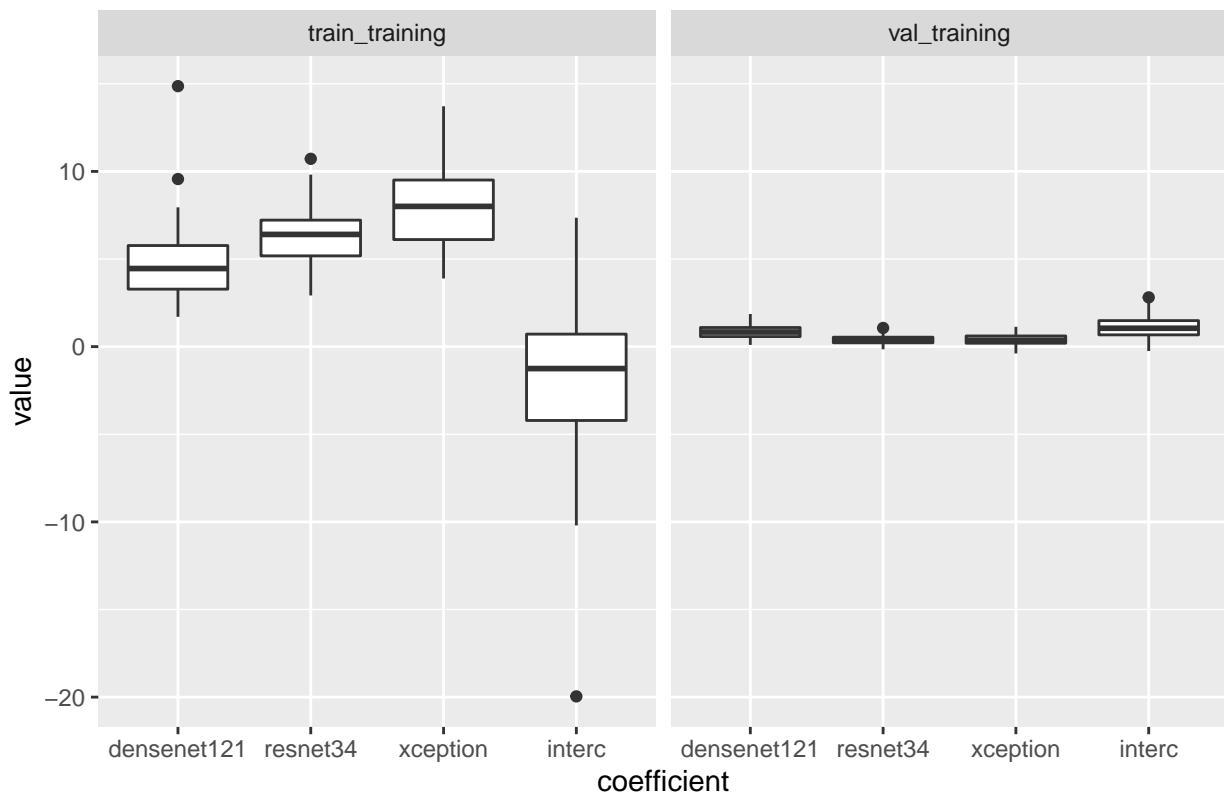
### Coefficients for class 14 vs 16



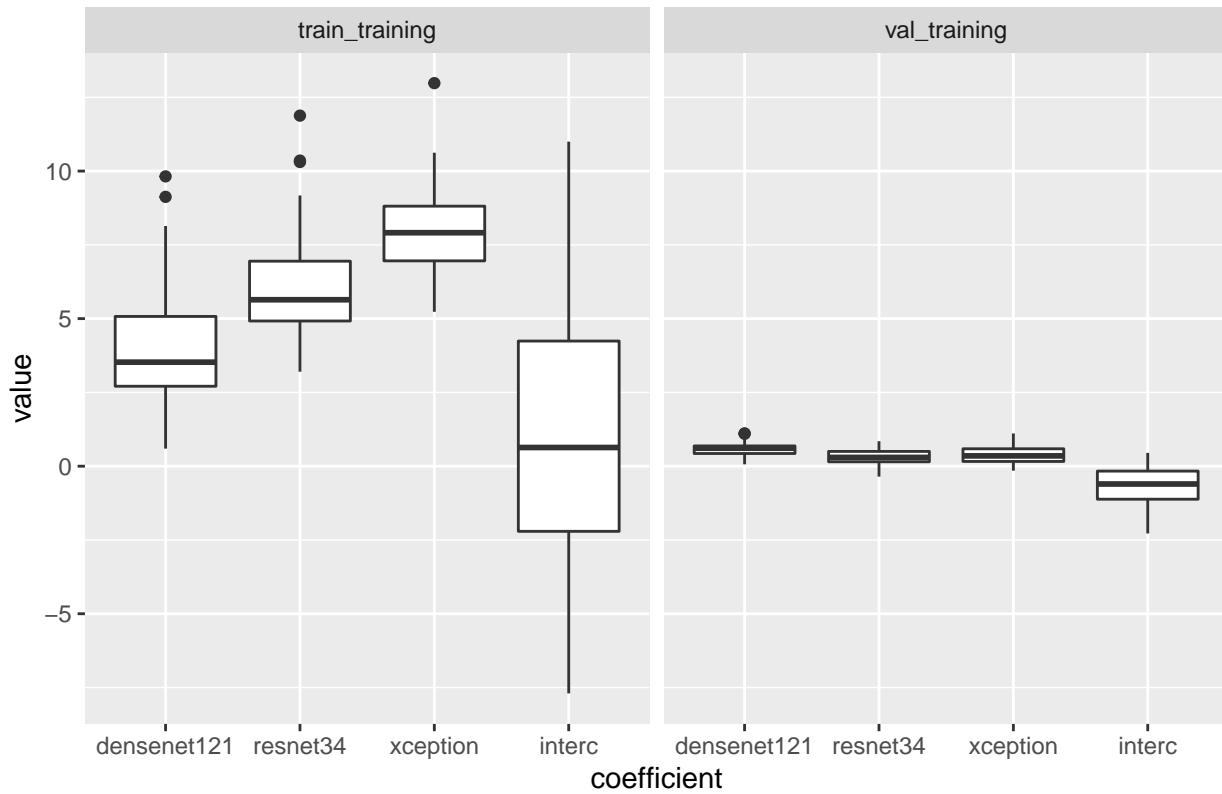
## Coefficients for class 14 vs 17



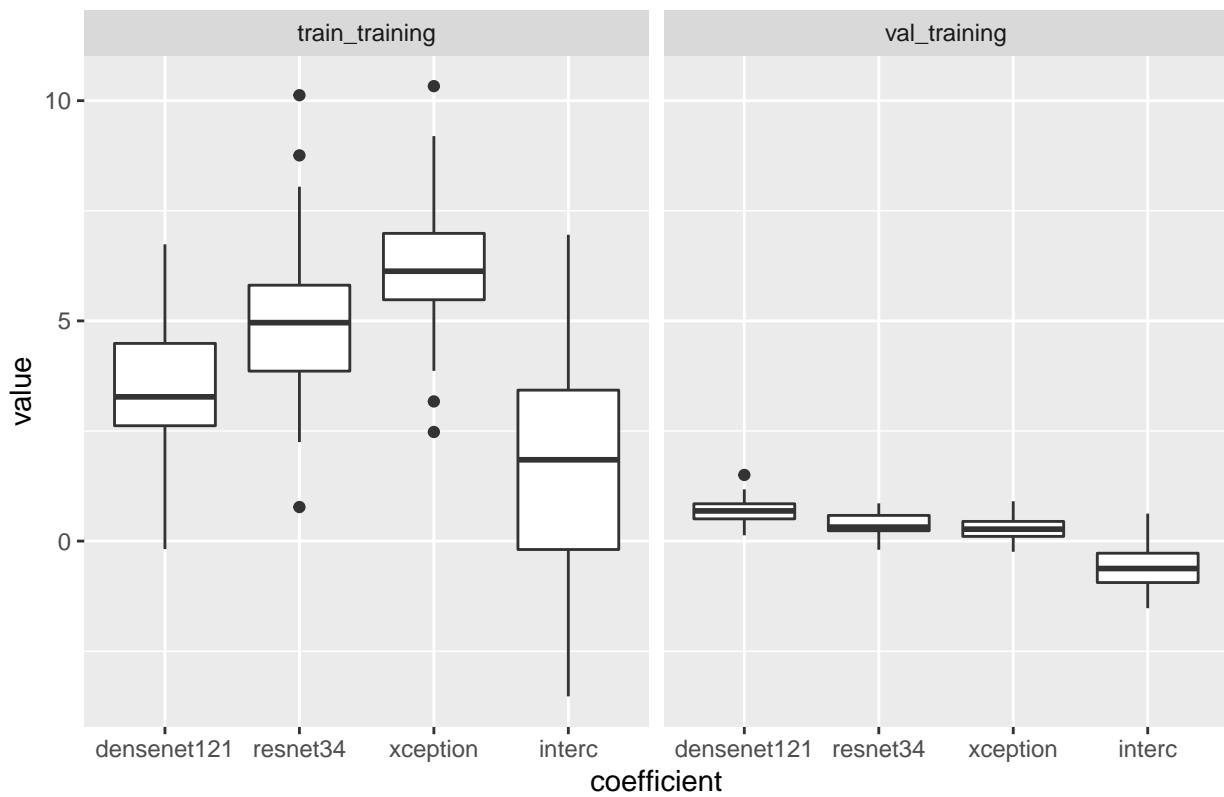
## Coefficients for class 14 vs 18



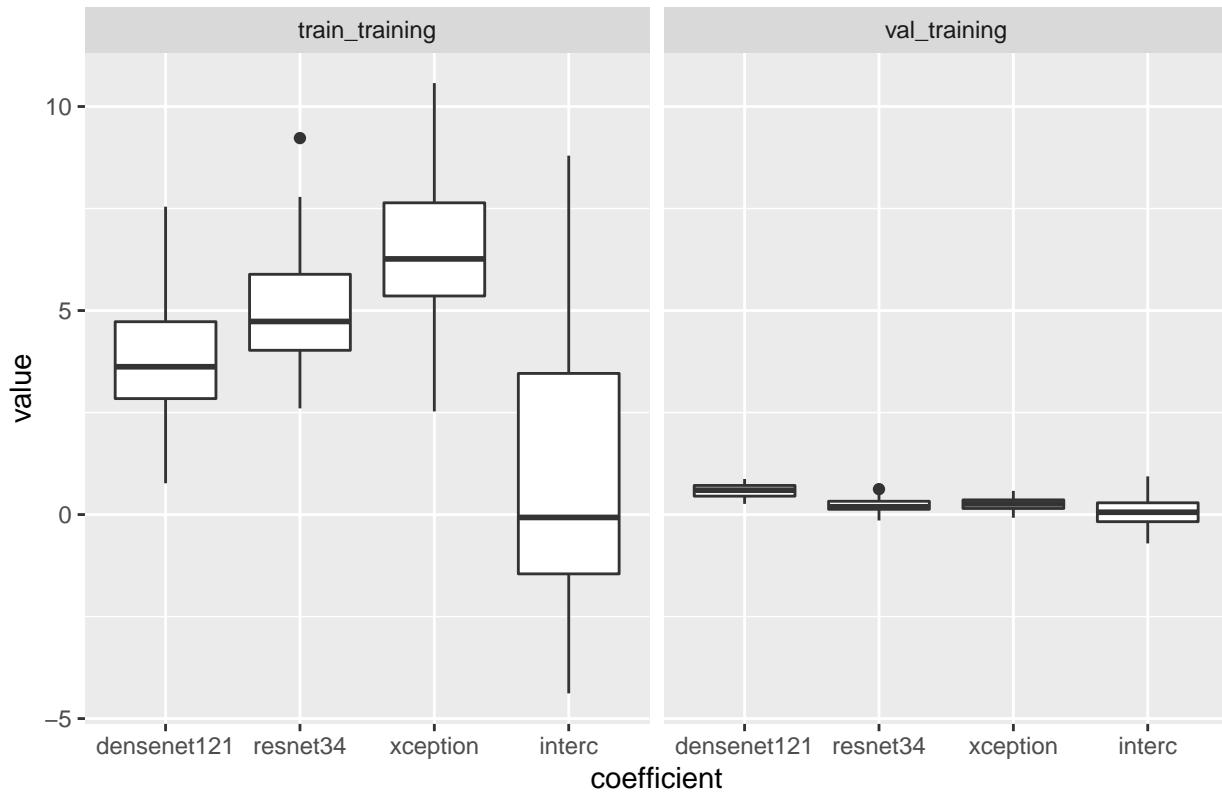
## Coefficients for class 14 vs 19



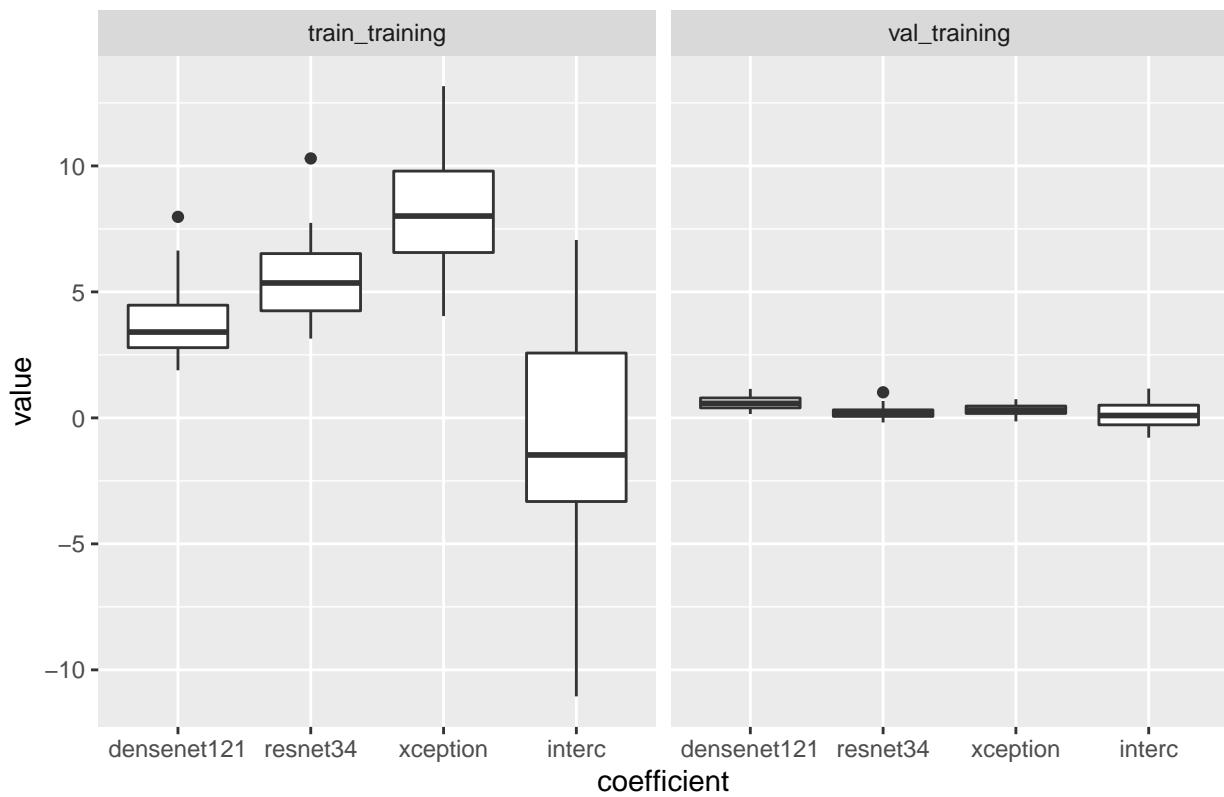
### Coefficients for class 14 vs 20



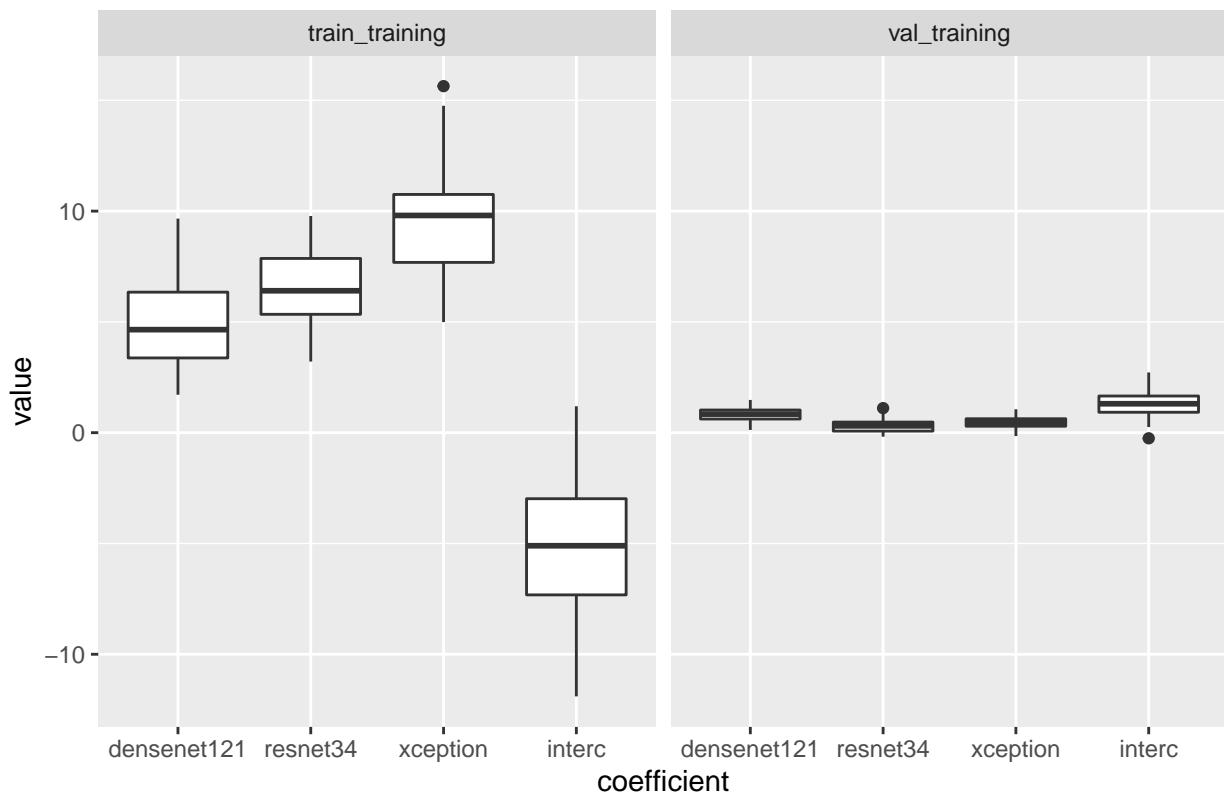
## Coefficients for class 15 vs 16



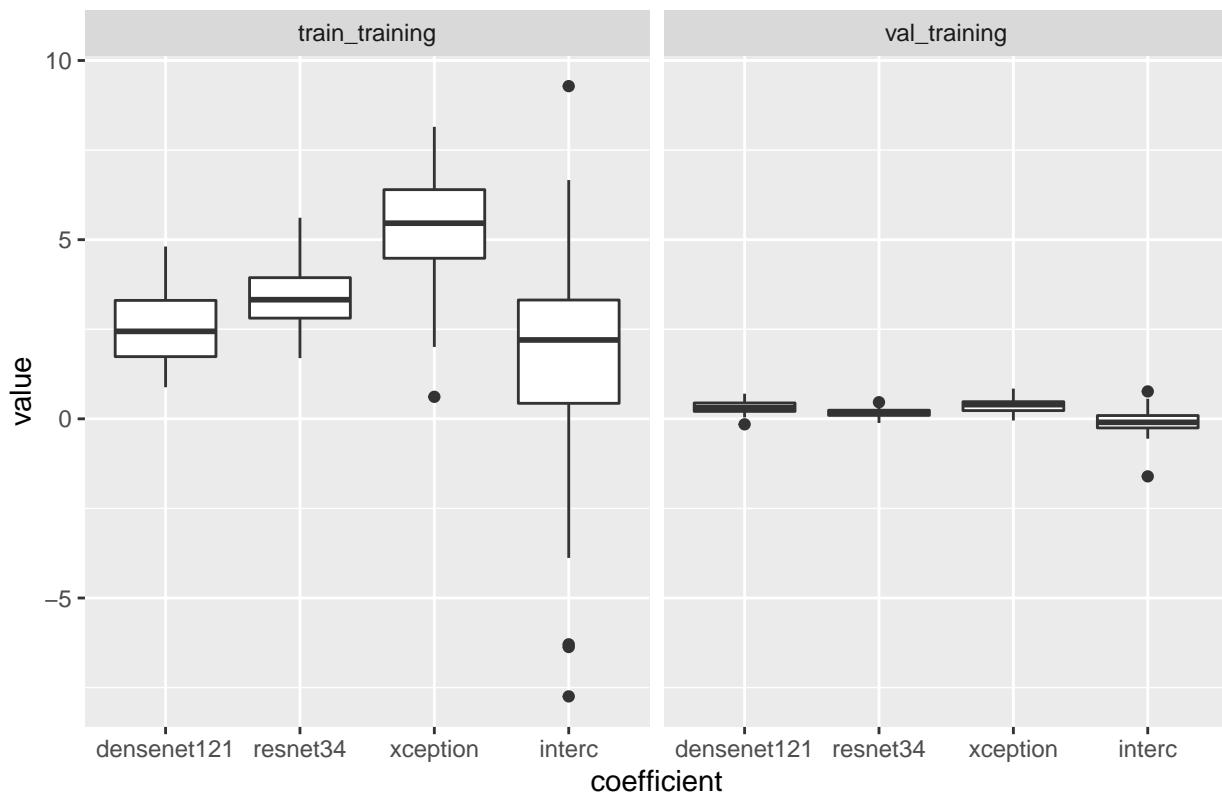
## Coefficients for class 15 vs 17



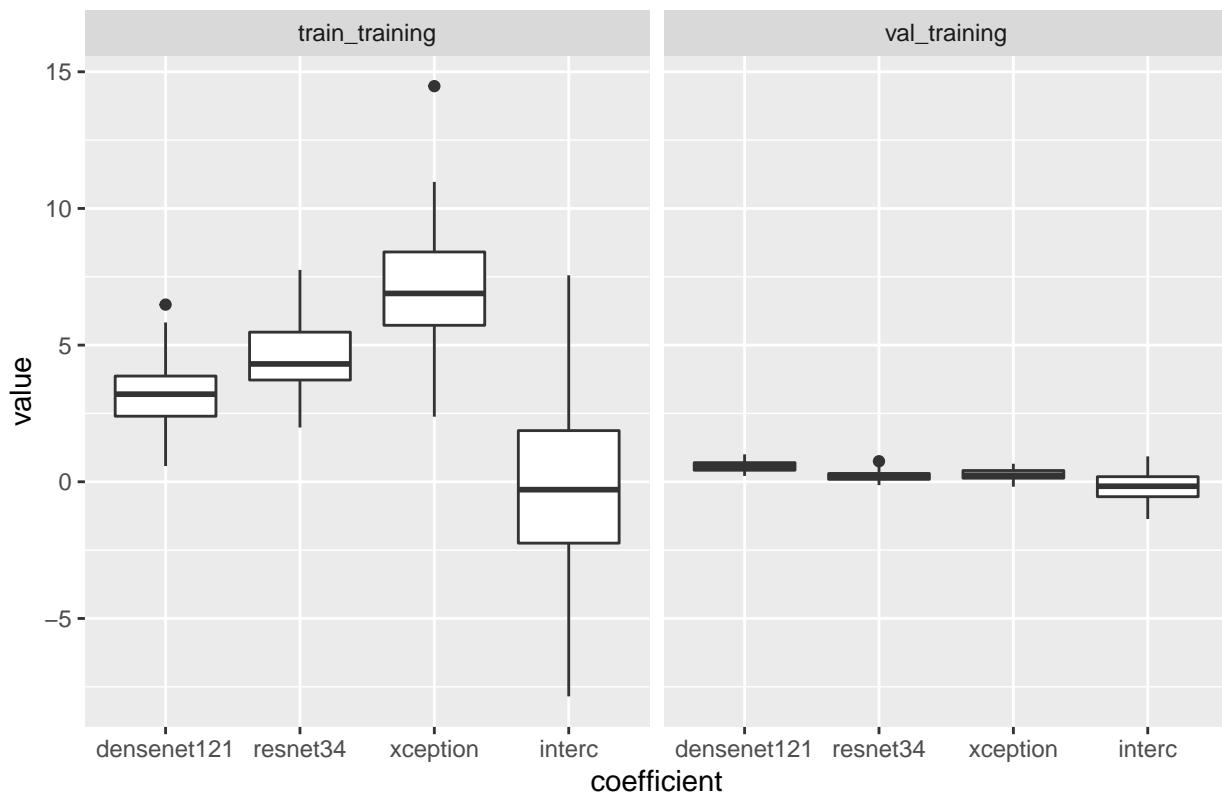
## Coefficients for class 15 vs 18



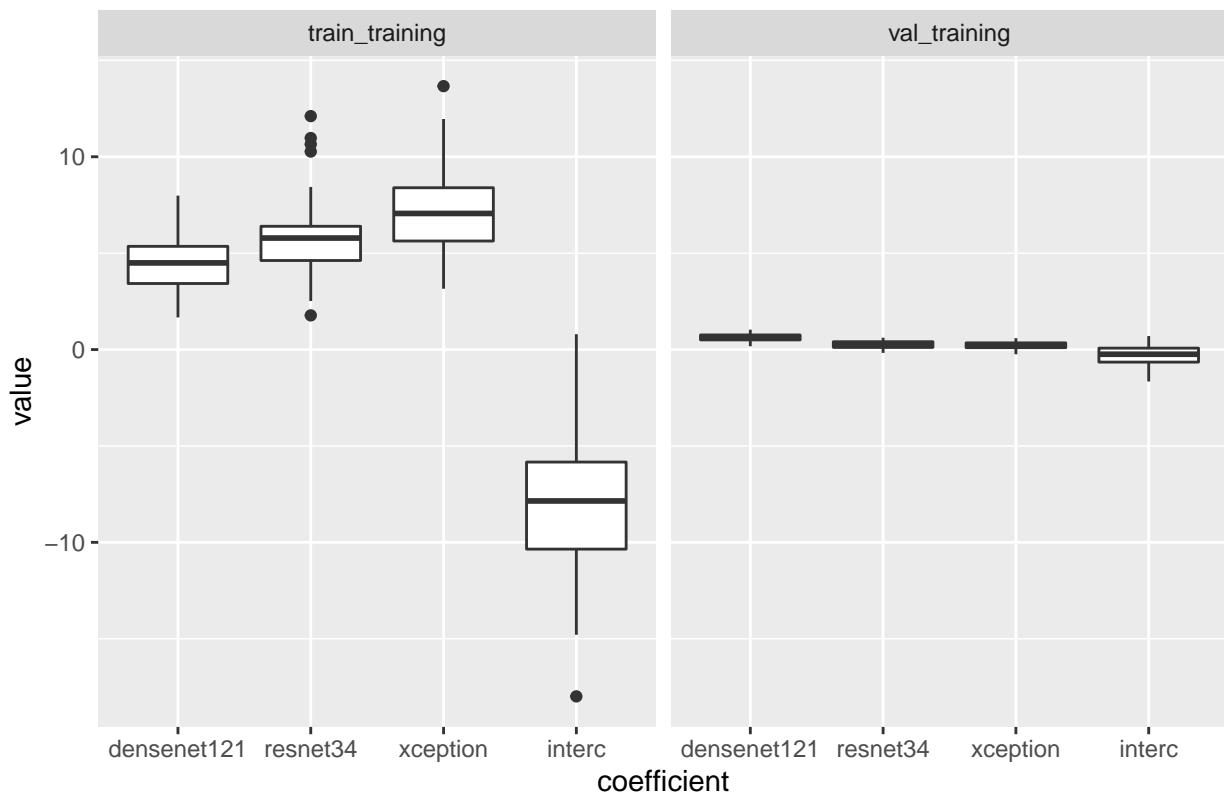
### Coefficients for class 15 vs 19



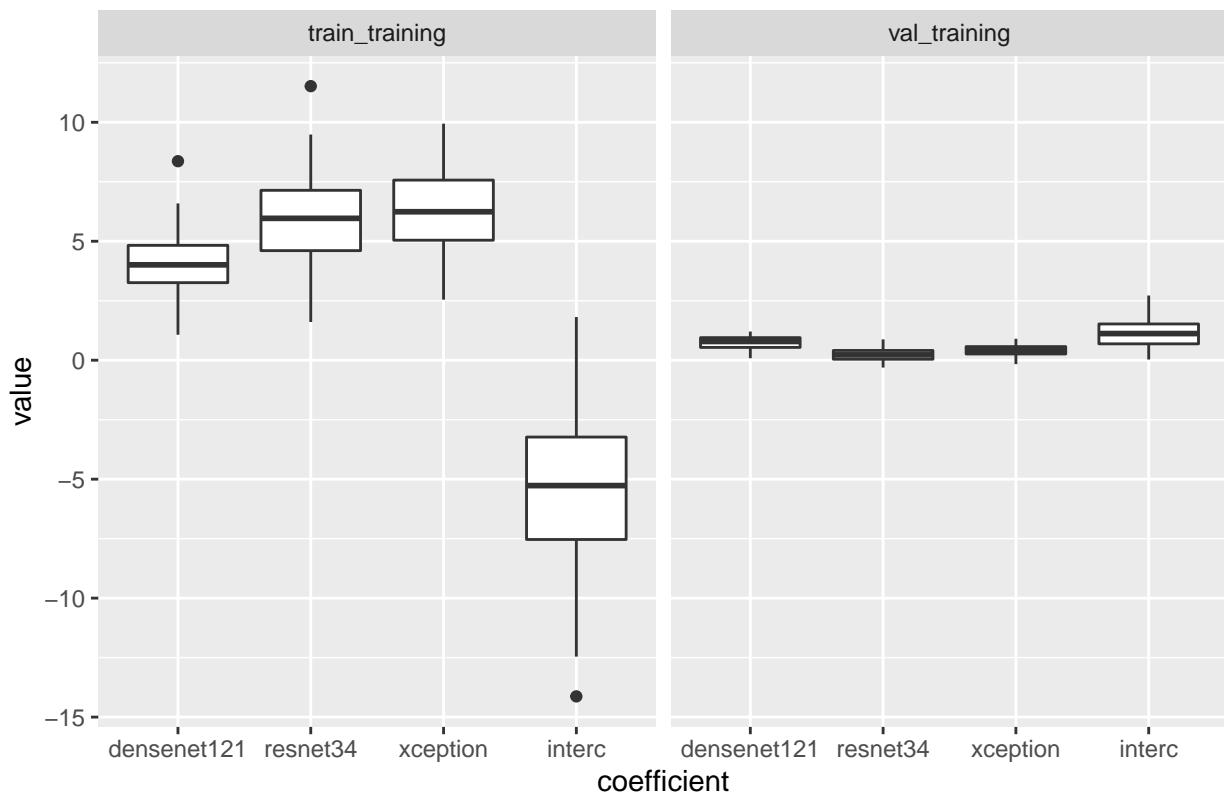
### Coefficients for class 15 vs 20



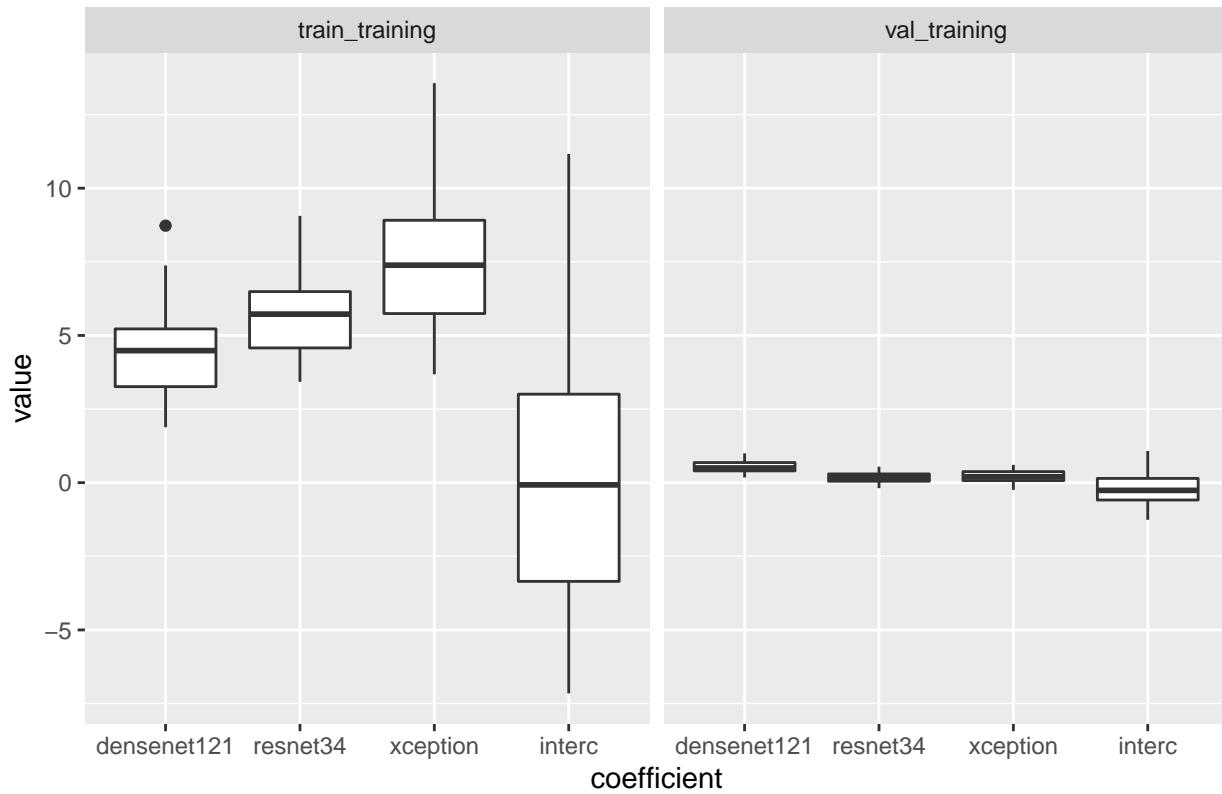
## Coefficients for class 16 vs 17



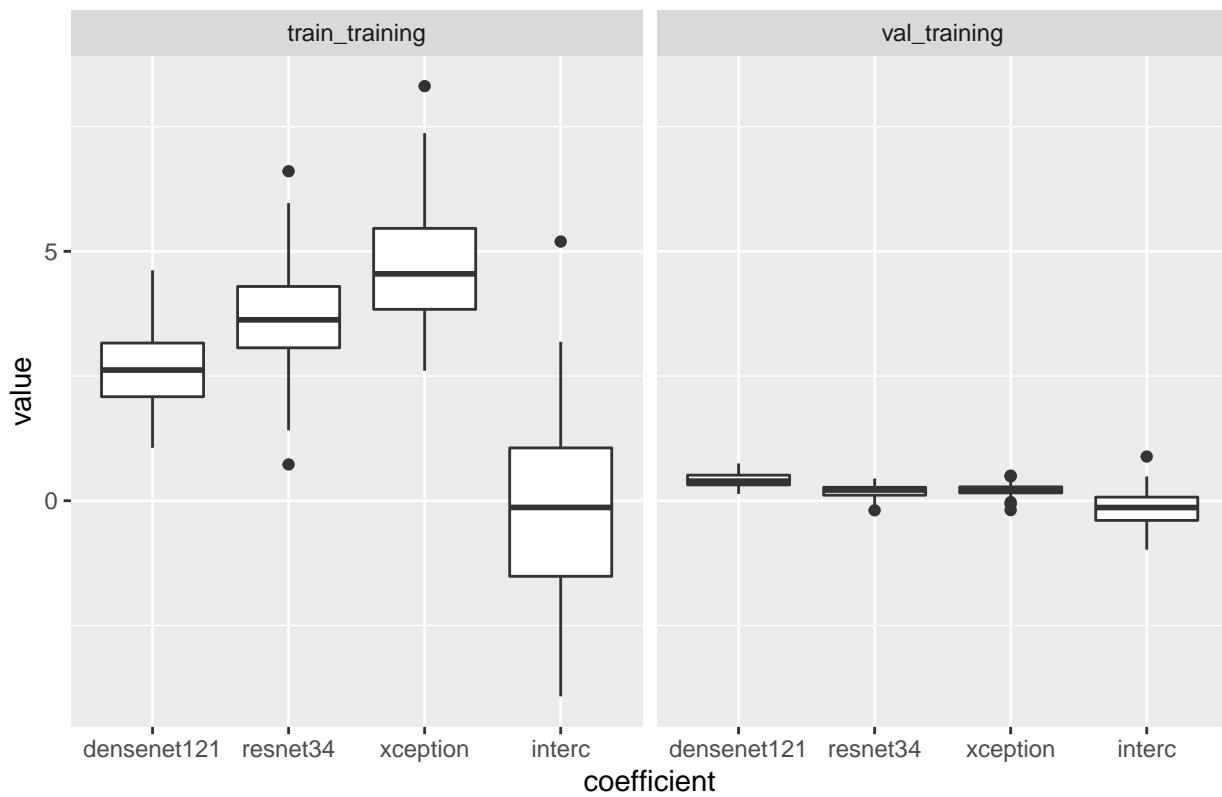
### Coefficients for class 16 vs 18



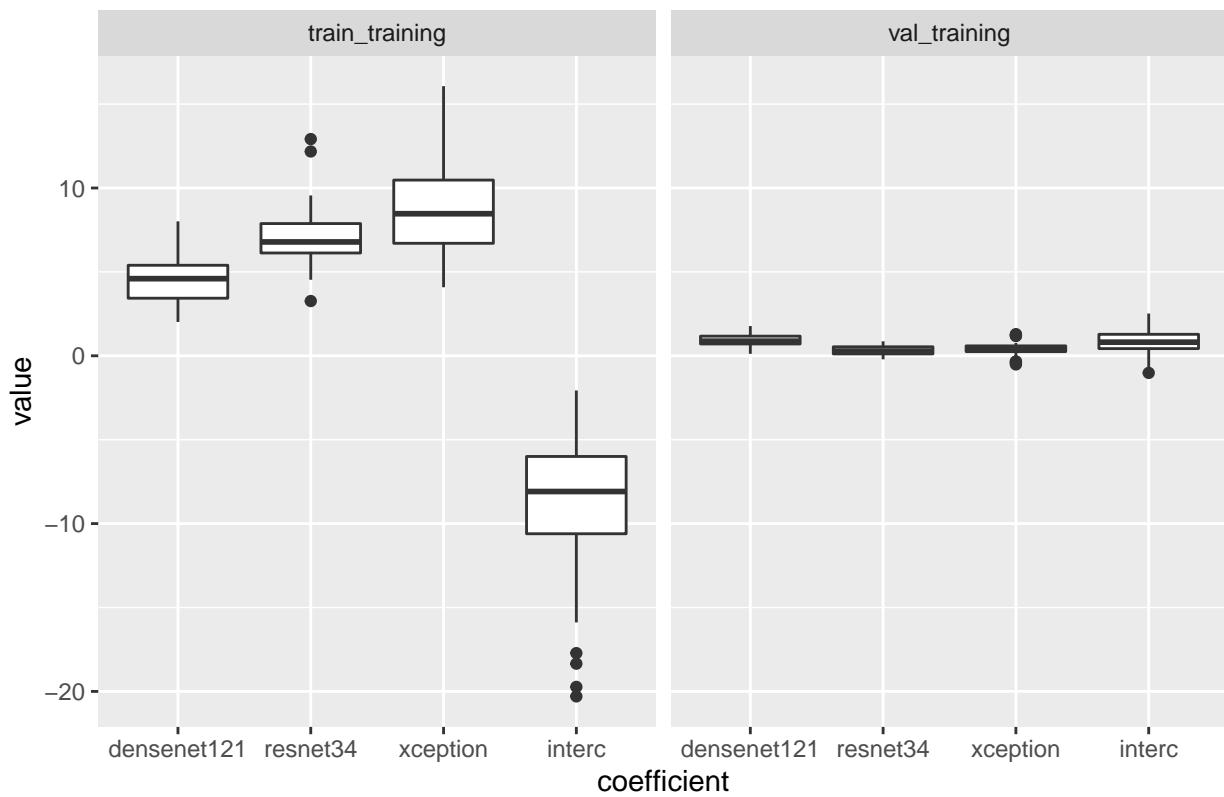
## Coefficients for class 16 vs 19



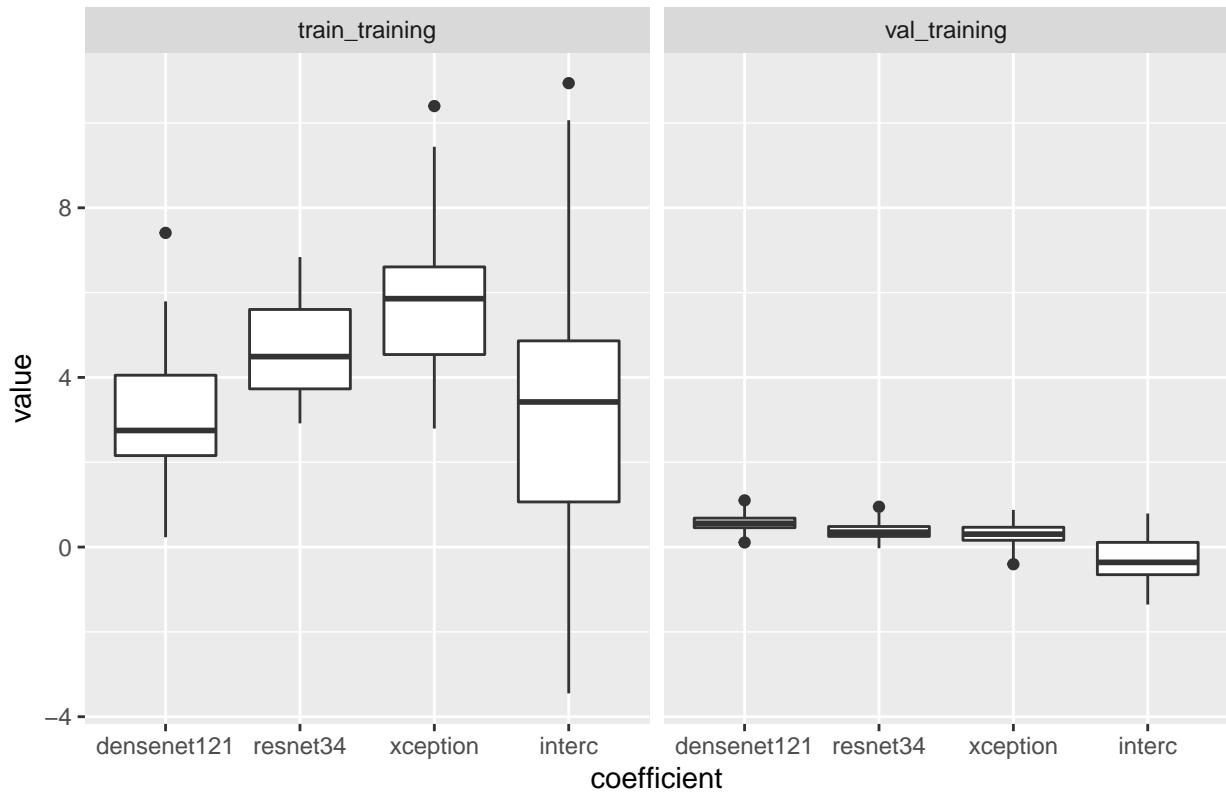
## Coefficients for class 16 vs 20



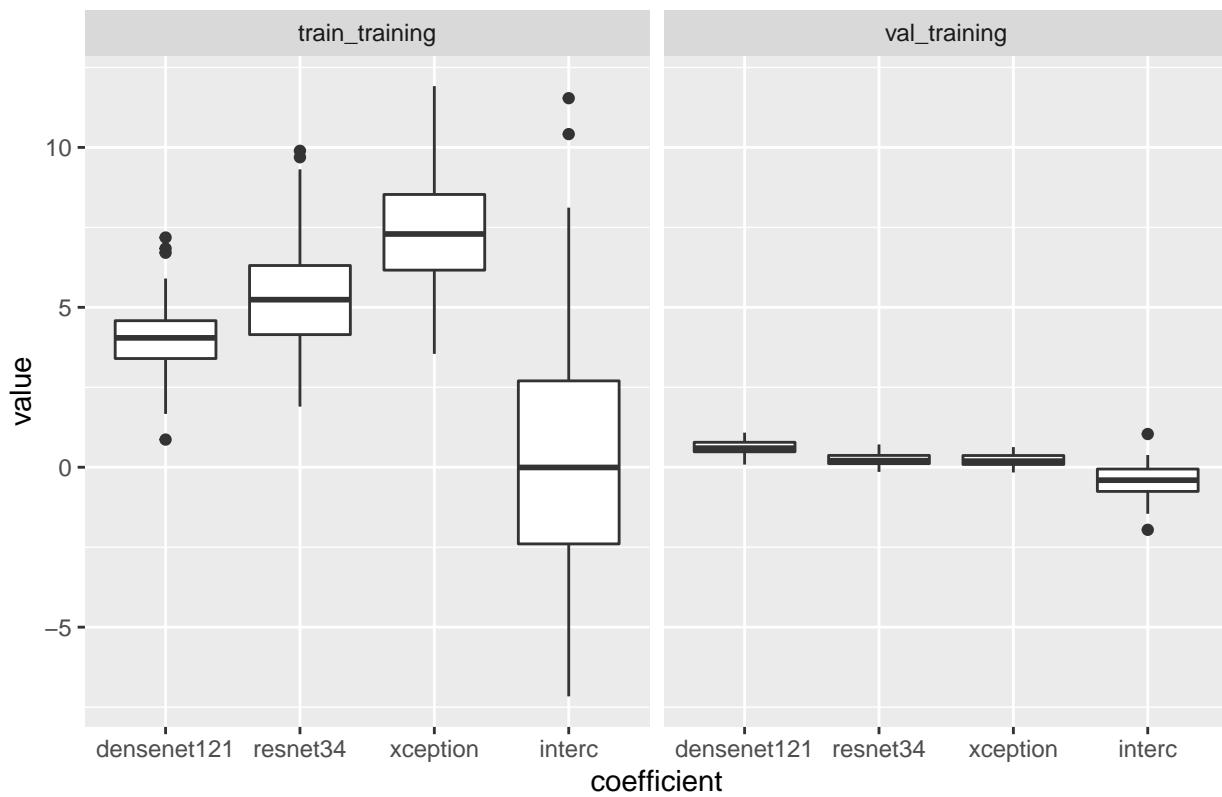
## Coefficients for class 17 vs 18



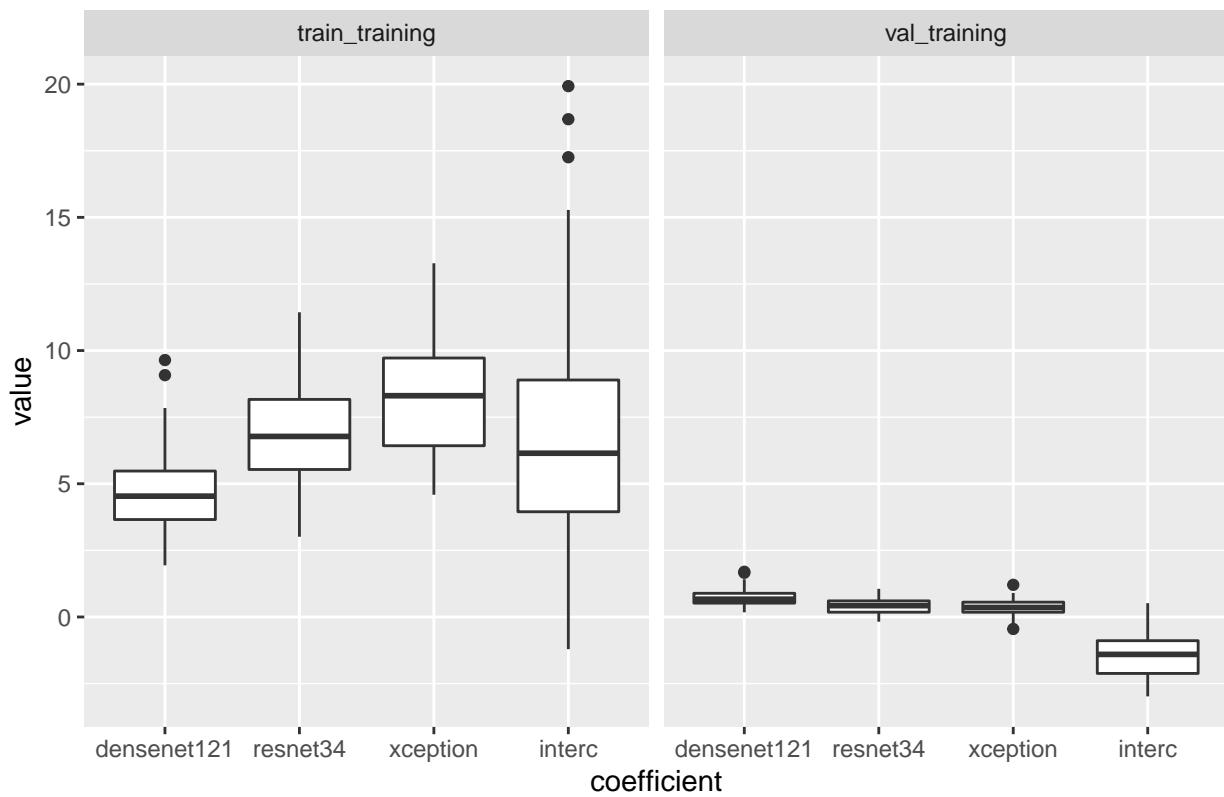
## Coefficients for class 17 vs 19



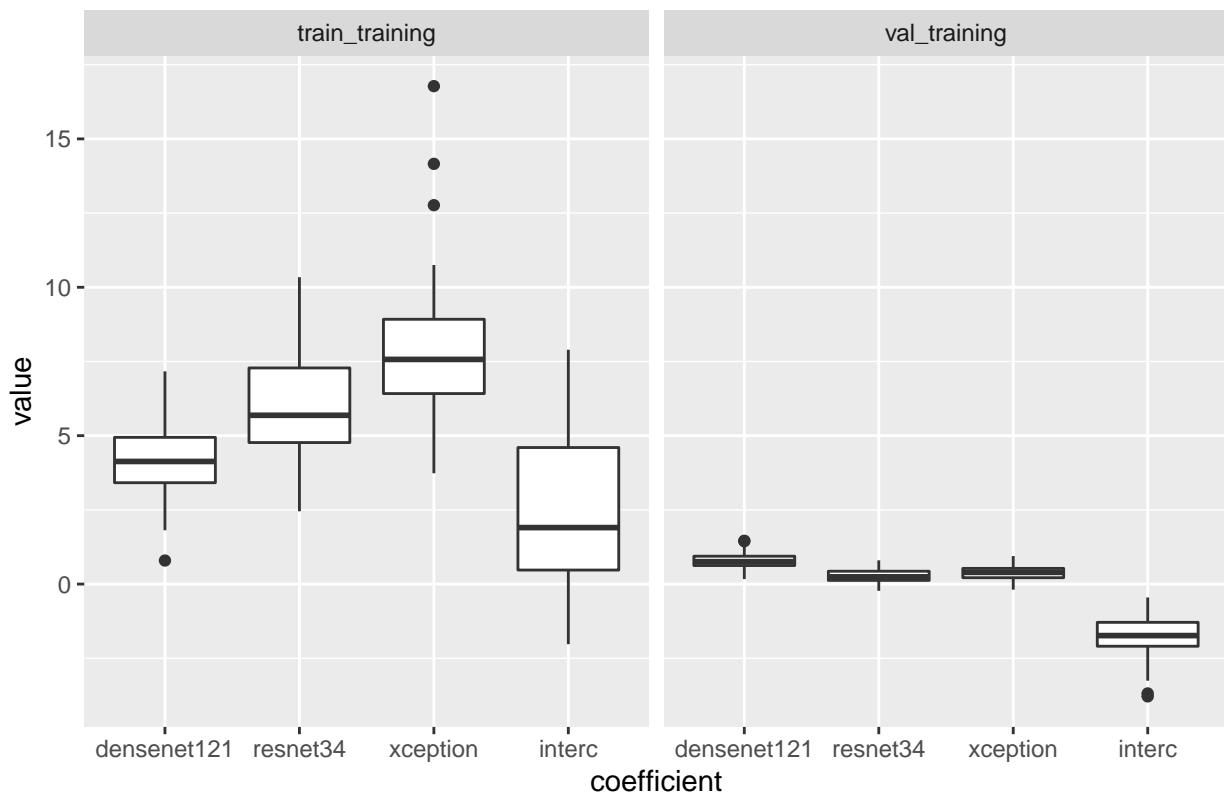
### Coefficients for class 17 vs 20



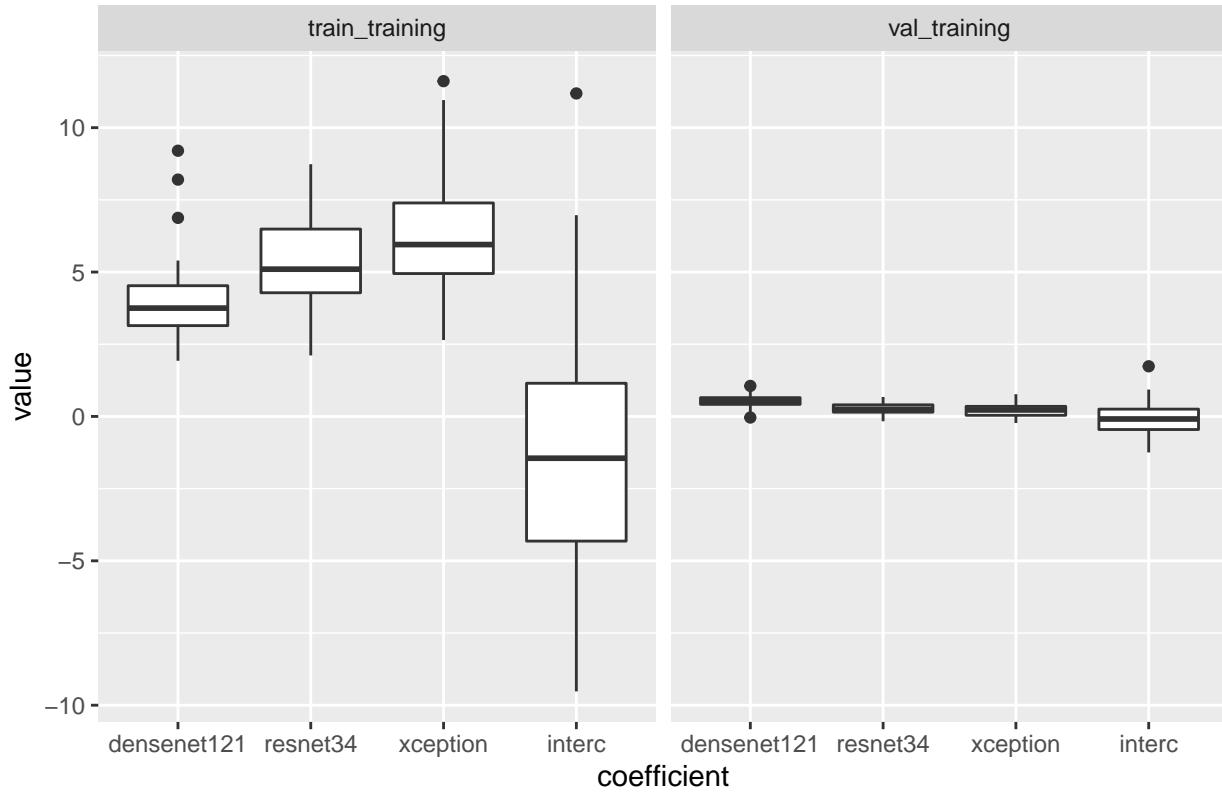
### Coefficients for class 18 vs 19



## Coefficients for class 18 vs 20



## Coefficients for class 19 vs 20



Coefficients of LDA trained on validation set have lower variance and more similar values across the networks.

For validation set trained LDAs, red - densenet seems to be dominant. On the other hand for train set trained LDAs blue - xception has higher values.

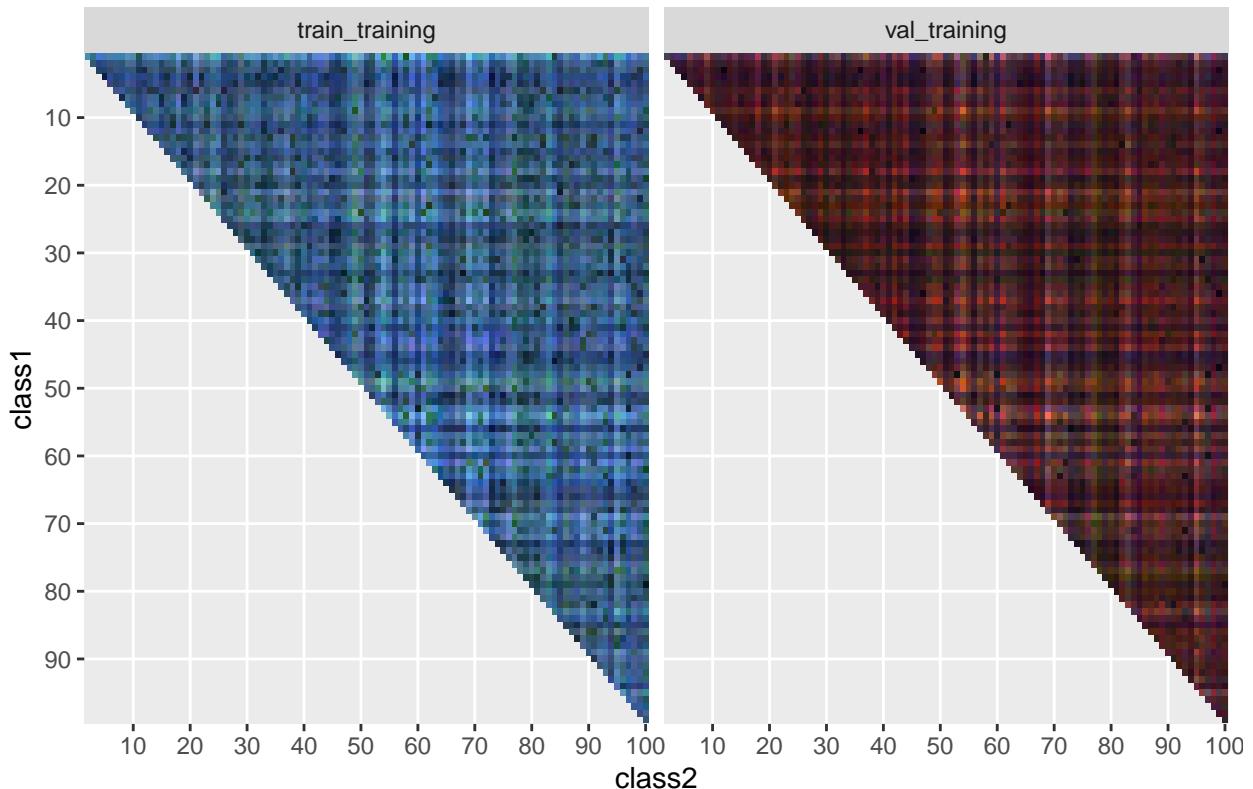
```
avg_lda_coefs <- lda_coefs %>% filter(coefficient != "interc") %>% group_by(class1, class2, precision, ...)

## `summarise()` has grouped output by 'class1', 'class2', 'precision', 'train_type'. You can override this behavior by setting `add` to TRUE.

avg_lda_coefs_vt <- avg_lda_coefs %>% filter(train_type=="val_training")
avg_lda_coefs_tt <- avg_lda_coefs %>% filter(train_type=="train_training")
avg_lda_coefs_vt$value <- avg_lda_coefs_vt$value - min(avg_lda_coefs_vt$value)
avg_lda_coefs_vt$value <- avg_lda_coefs_vt$value / max(avg_lda_coefs_vt$value)
avg_lda_coefs_tt$value <- avg_lda_coefs_tt$value - min(avg_lda_coefs_tt$value)
avg_lda_coefs_tt$value <- avg_lda_coefs_tt$value / max(avg_lda_coefs_tt$value)
avg_lda_coefs <- rbind(avg_lda_coefs_vt, avg_lda_coefs_tt)
avg_lda_c_w <- pivot_wider(avg_lda_coefs, names_from = coefficient, values_from = value)
avg_lda_c_w[, c("class1", "class2")] <- lapply(avg_lda_c_w[, c("class1", "class2")], as.factor)
avg_lda_c_w$top_net <- factor(c("densenet121", "resnet34", "xception"))[max.col(as.matrix(avg_lda_c_w[, ...])]

raster_plot <- ggplot(avg_lda_c_w) +
  geom_tile(aes(x=class2, y=class1, fill=rgb(densenet121, resnet34, xception))) +
  scale_y_discrete(limits=rev, breaks=seq(0, classes, 10)) + scale_x_discrete(breaks=seq(0, classes, 10))
raster_plot
```

RGB image formed from lda coefficients for networks densenet, resnet, xception

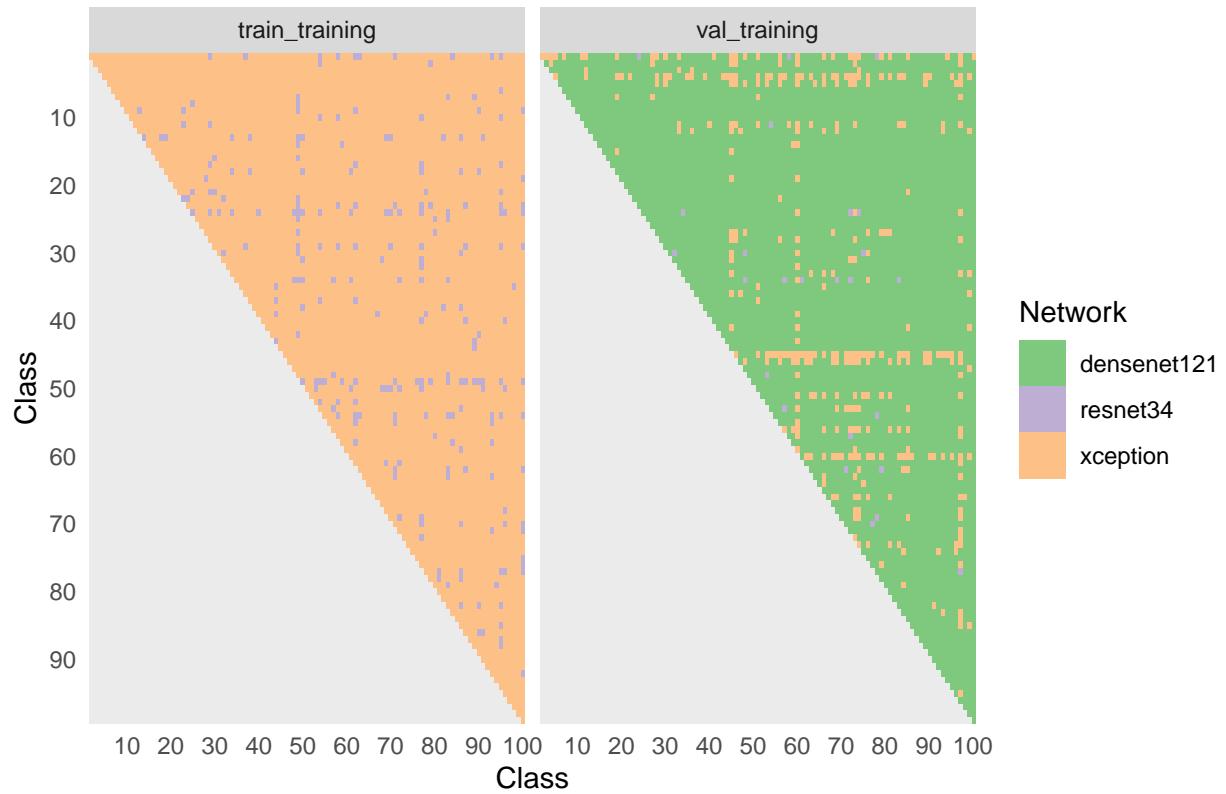


For validation set trained LDAs, red - densenet seems to be dominant. On the other hand for train set trained LDAs blue - xception has higher values.

```
coefs_grid <- ggplot(avg_lda_c_w, aes(x=class2, y=class1, fill=top_net)) +
  geom_raster() +
  scale_fill_brewer(type="qual") +
  facet_wrap(~train_type) +
  scale_y_discrete(breaks=seq(0, classes, 10), limits=rev) +
  scale_x_discrete(breaks=seq(0, classes, 10)) +
  guides(fill=guide_legend(title="Network")) +
  xlab("Class") +
  ylab("Class") +
  ggtitle("Network with highest lda weight for class pairs") +
  theme(plot.title = element_text(hjust = 0.5),
        axis.ticks = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank())

coefs_grid
```

### Network with highest lda weight for class pairs



LDAs trained on nn train set are dominated by xception. LDAs trained on validation set by densenet.