Alignment

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```
library(tidyverse) # version 2.0.0
library(magrittr) # version 2.0.3
library(nparLD) # version 2.2
library(rstatix) # version 0.7.2
select <- dplyr::select # make sure we're using tidyverse's version of select...
```

Load the data.

```
data <- read_csv('../data/alignment_original.csv', show_col_types = FALSE)
```

Pivot the data longer.

```
data %<>% pivot_longer(cols = -c(Musician, sub, scramble),
                       names_to = 'level', values_to = 'value')
```

Make sure non-musicians and musicians are labelled with different numbers.

```
data %<>% mutate(sub = ifelse(Musician == 'Yes', sub, sub + 45))
```

```
data %<>% mutate(level = factor(level, levels = c(1,2,3,4,5,8,16), ordered = TRUE))
```

For comparisons across levels, look at nested structure only (levels 2, 4, 8, 16).

```
data_nested <- data %>%
  filter(!level %in% c(1,3,5))
```

Alignment above chance (all levels, all conditions)

At each level, which values are above chance?

```
stat.test <- data %>%
  group_by(scramble, level) %>%
  t_test(value ~ 1) %>%
  adjust_pvalue(method = "BH") %>%
  add_significance() %>%
  arrange(scramble, level)
```

```
print(stat.test, n = nrow(stat.test))
```

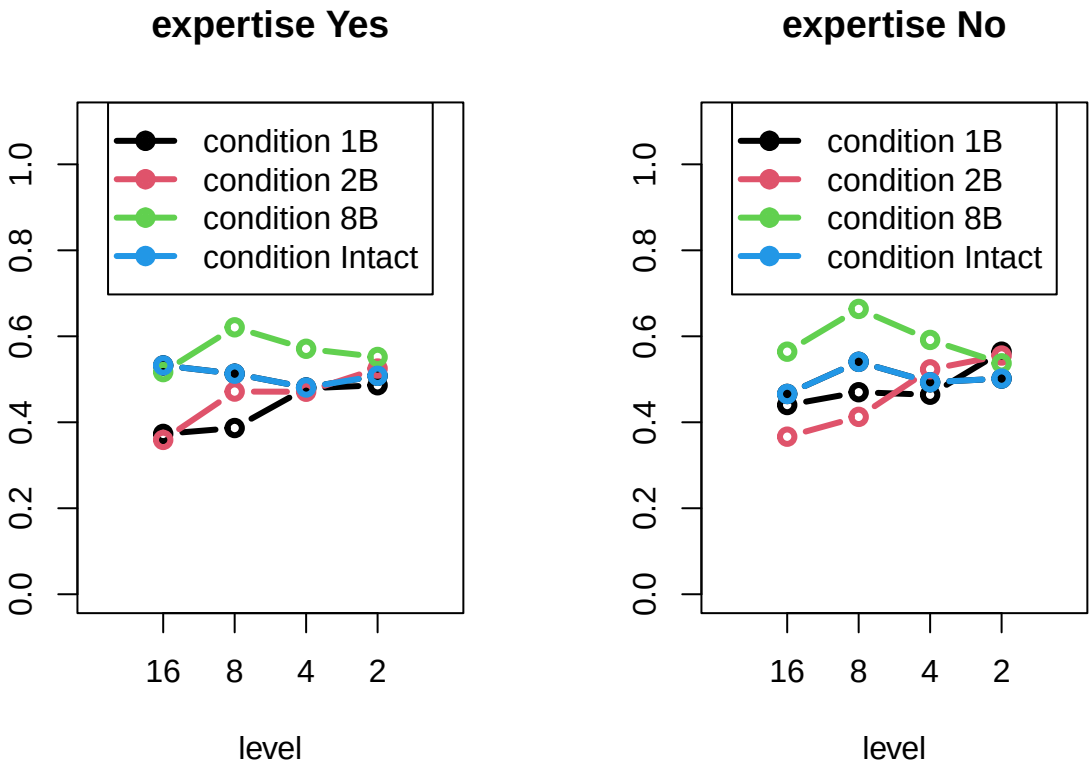
```
## # A tibble: 28 x 11
##    scramble level .y.   group1 group2         n statistic    df        p   p.adj
##    <chr>    <ord> <chr> <chr>  <chr>      <int>     <dbl> <dbl>    <dbl>   <dbl>
##  1 1B       1     value 1      null model    90    1.24      89  2.17e-1 3.80e-1
##  2 1B       2     value 1      null model    90    1.42      89  1.58e-1 3.40e-1
##  3 1B       3     value 1      null model    90   -0.703     89  4.84e-1 6.78e-1
##  4 1B       4     value 1      null model    90   -0.227     89  8.21e-1 8.56e-1
##  5 1B       5     value 1      null model    90   -0.0541    89  9.57e-1 9.57e-1
##  6 1B       8     value 1      null model    90   -0.724     89  4.71e-1 6.78e-1
##  7 1B       16    value 1      null model    90   -1.34      89  1.84e-1 3.43e-1
##  8 2B       1     value 1      null model    90    2.60      89  1.1 e-2 4.84e-2
##  9 2B       2     value 1      null model    90    2.56      89  1.21e-2 4.84e-2
## 10 2B       3     value 1      null model    90    0.457     89  6.49e-1 7.27e-1
## 11 2B       4     value 1      null model    90    1.38      89  1.72e-1 3.43e-1
## 12 2B       5     value 1      null model    90    1.54      89  1.26e-1 2.94e-1
## 13 2B       8     value 1      null model    90    0.222     89  8.25e-1 8.56e-1
## 14 2B       16    value 1      null model    90   -3.51      89  7.17e-4 6.69e-3
## 15 8B       1     value 1      null model    90    0.960     89  3.4 e-1 5.37e-1
## 16 8B       2     value 1      null model    90    2.39      89  1.88e-2 6.58e-2
## 17 8B       3     value 1      null model    90   -2.15      89  3.45e-2 8.78e-2
## 18 8B       4     value 1      null model    90    4.00      89  1.33e-4 1.86e-3
## 19 8B       5     value 1      null model    90   -2.82      89  5.9 e-3 3.30e-2
## 20 8B       8     value 1      null model    90    5.67      89  1.76e-7 4.93e-6
## 21 8B       16    value 1      null model    90    3.40      89  9.94e-4 6.96e-3
## 22 Intact   1     value 1      null model    90    0.948     89  3.45e-1 5.37e-1
## 23 Intact   2     value 1      null model    90    0.483     89  6.3 e-1 7.27e-1
## 24 Intact   3     value 1      null model    90   -0.607     89  5.45e-1 7.27e-1
## 25 Intact   4     value 1      null model    90    0.513     89  6.09e-1 7.27e-1
## 26 Intact   5     value 1      null model    90   -0.529     89  5.98e-1 7.27e-1
## 27 Intact   8     value 1      null model    90    2.26      89  2.65e-2 8.24e-2
## 28 Intact   16    value 1      null model    90    2.21      89  2.97e-2 8.32e-2
## # i 1 more variable: p.adj.signif <chr>
```

(Tables 2b, 3b, 4b, and 5b)

Three-way non-parametric ANOVA-type test

```
attach(data_nested)
# scramble is a within-subject factor ("time1") - all subjects hear all conditions
# level is the other within-subject factor ("time2") - all levels are analyzed
# expertise is the between-subject factor ("group") - subjects are either musicians or non-musicians
f1.ld.f2(value, time1=scramble, time2=level, group=Musician, subject=sub,
         time1.name="condition", time2.name="level", group.name="expertise",
         description=FALSE)$ANOVA.test
```

```
##  F1 LD F2 Model
##  ----------------------
##  Check that the order of the time1, time2, and group levels are correct.
##  Time1 level:   Intact 8B 2B 1B
##  Time2 level:   16 8 4 2
##  Group level:   Yes No
##  If the order is not correct, specify the correct order in time1.order, time2.order, or group.order.
```




```
##                                Statistic       df      p-value
## expertise                     0.44259896 1.000000 5.058707e-01
## condition                     5.47169164 2.837922 1.187934e-03
## level                        12.14236604 2.207242 2.101213e-06
## expertise:condition           0.30589978 2.837922 8.101321e-01
## level:condition               6.67491862 6.591107 1.402596e-07
## expertise:level               0.05267404 2.207242 9.599410e-01
## expertise:condition:level     1.70118403 6.591107 1.085679e-01
```

- No three-way interaction between scramble condition, level, and expertise group: $F(6.6) = 1.70$, $p = .11$
- Main effect of condition: $F(2.8) = 5.47$, $p = .0012$
- Main effect of level: $F(2.2) = 12.14$, $p < .001$

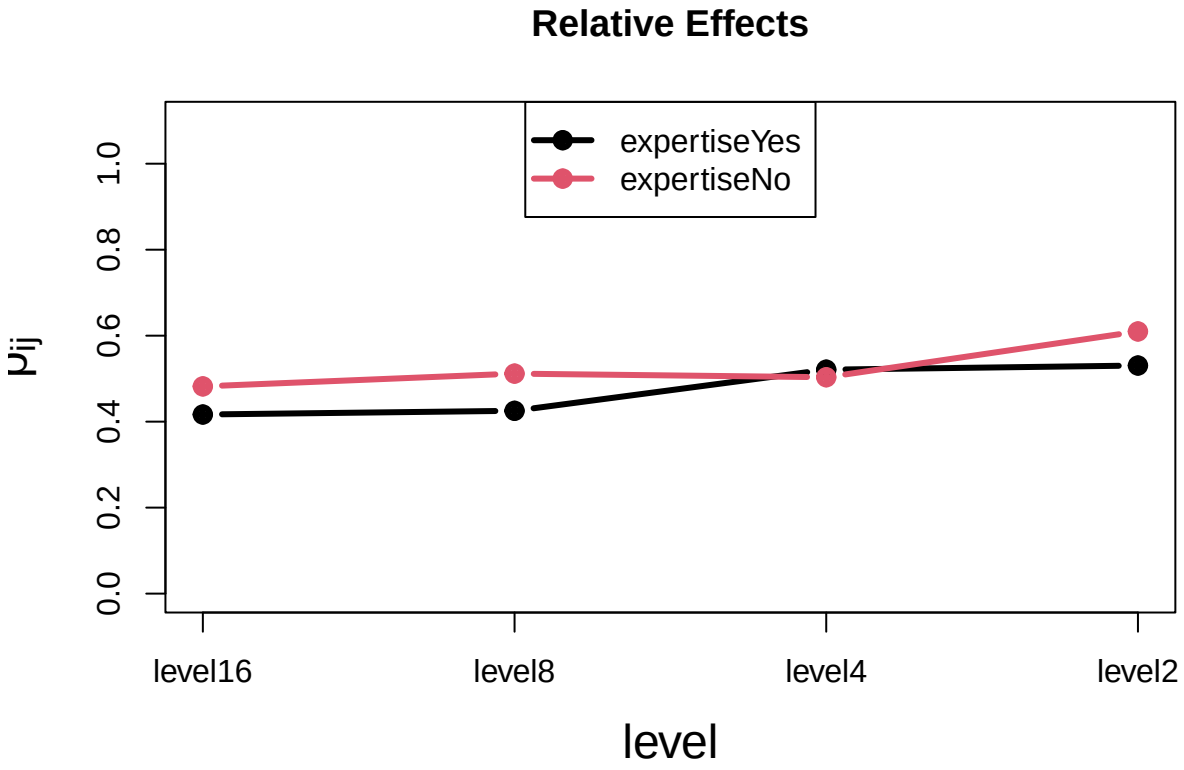
- Interaction between condition and level: $F(6.6) = 6.67$, $p < .001$)
- No main effect of expertise: $F(1) = .443$, $p = .51$

Post-hoc tests: comparison of levels (1B)

```
data_nested_1B <- filter(data_nested, scramble == '1B')
```

```
attach(data_nested_1B)
f1.ld.f1(value, time=level, group=Musician, subject=sub,
         time.name="level", group.name="expertise",
         description=FALSE)$ANOVA.test
```

```
##  F1 LD F1 Model
##  ----------------------
##  Check that the order of the time and group levels are correct.
##  Time level:   16 8 4 2
##  Group level:   Yes No
##  If the order is not correct, specify the correct order in time.order or group.order.
```




```
##                 Statistic       df      p-value
## expertise        1.214858 1.000000 0.2703721048
## level            6.691004 2.319821 0.0006477899
## expertise:level  1.345994 2.319821 0.2602197563
```

Main effect of level: $F(2.3) = 6.69$, $p < .001$

```r
pairwise.wilcox.test(data_nested_1B$value, data_nested_1B$level,
                     p.adjust.method = "bonferroni", paired=TRUE)
```

```
##
##  Pairwise comparisons using Wilcoxon signed rank test with continuity correction
##
## data:  data_nested_1B$value and data_nested_1B$level
##
##    2    4    8
## 4  0.46 -    -
## 8  0.11 1.00 -
## 16 0.24 1.00 1.00
##
## P value adjustment method: bonferroni
```

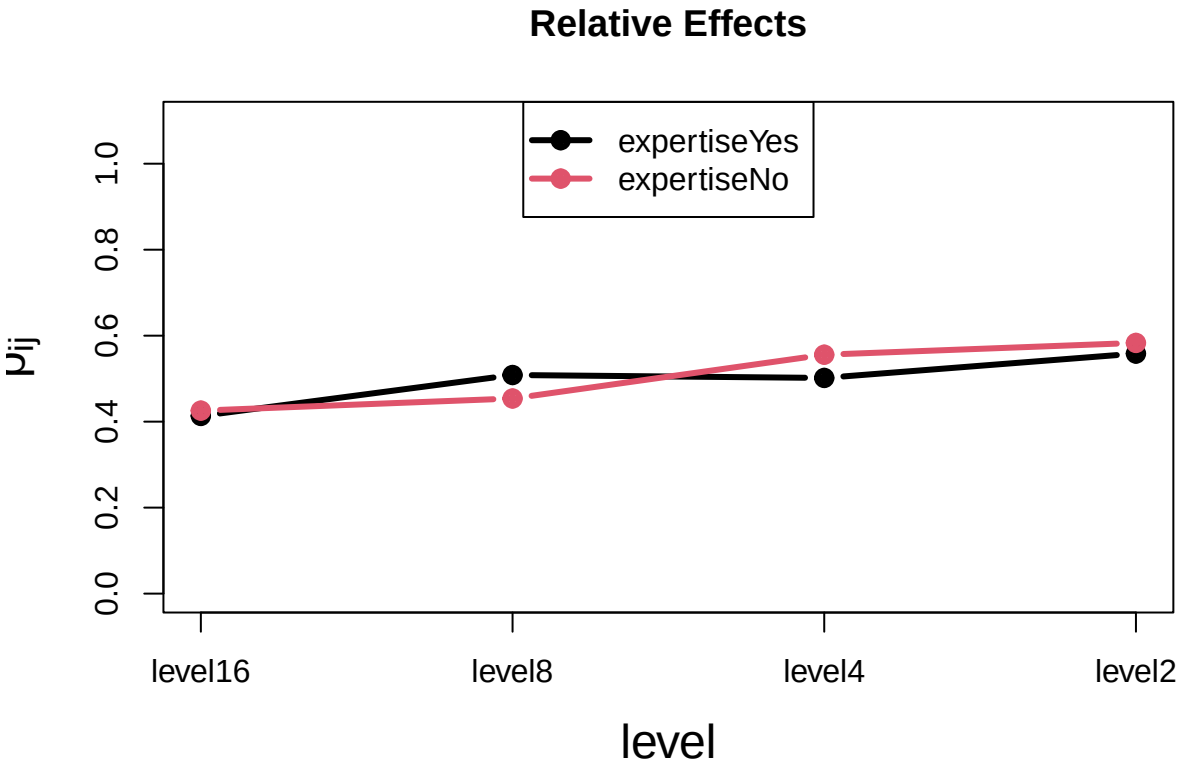
No significant differences between levels (Table S2a).

Post-hoc tests: comparison of levels (2B)

```
data_nested_2B <- filter(data_nested, scramble == '2B')
```

```
attach(data_nested_2B)
f1.ld.f1(value, time=level, group=Musician, subject=sub,
         time.name="level", group.name="expertise",
         description=FALSE)$ANOVA.test
```

```
##  F1 LD F1 Model
##  ----------------------
##  Check that the order of the time and group levels are correct.
##  Time level:   16 8 4 2
##  Group level:   Yes No
##  If the order is not correct, specify the correct order in time.order or group.order.
```




```
##                   Statistic       df      p-value
## expertise        0.03190762 1.000000 8.582306e-01
## level           12.55569528 2.518499 3.123497e-07
## expertise:level  1.56841932 2.518499 2.017197e-01
```

Main effect of level: $F(2.5) = 12.56$, $p < .001$

```r
pairwise.wilcox.test(data_nested_2B$value, data_nested_2B$level,
                     p.adjust.method = "bonferroni", paired=TRUE)
```

```
##
##  Pairwise comparisons using Wilcoxon signed rank test with continuity correction
##
## data:  data_nested_2B$value and data_nested_2B$level
##
##    2       4      8
## 4  1.0000  -      -
## 8  0.0450  1.0000 -
## 16 6.3e-05 0.0034 0.1704
##
## P value adjustment method: bonferroni
```

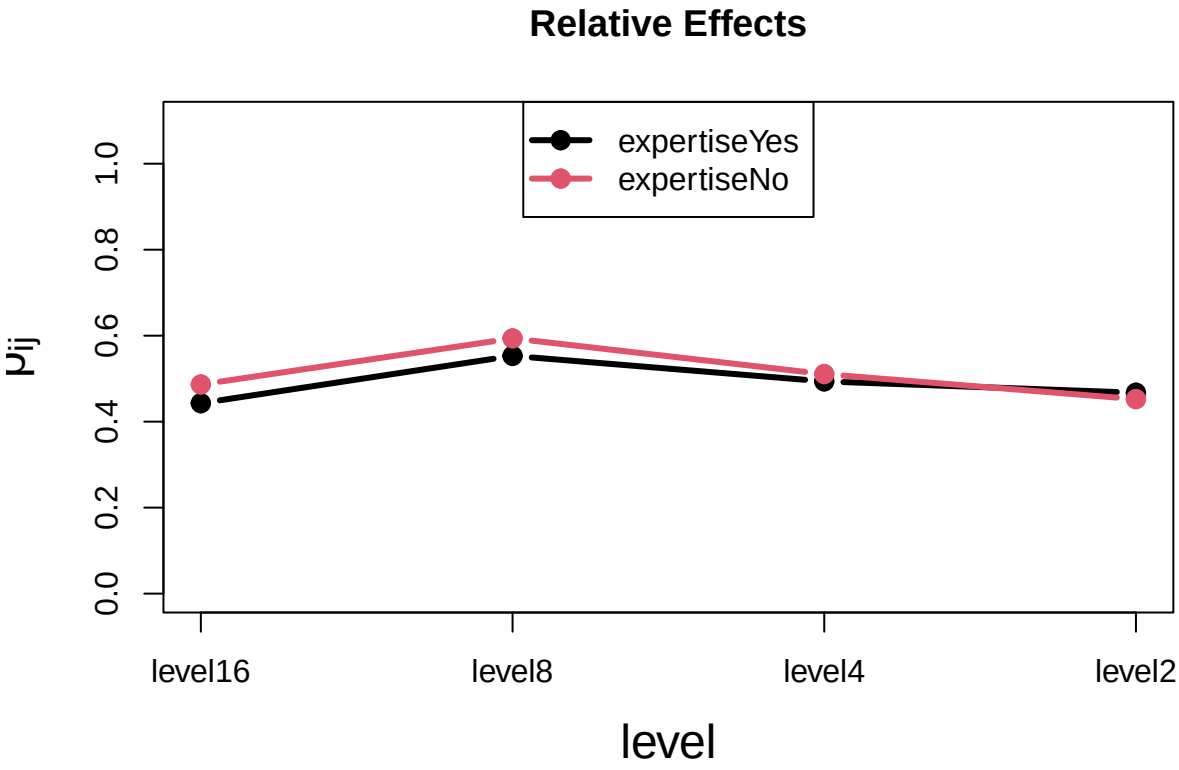
Greater at the 2-bar level than at the 8-bar ($p = .045$) or 16-bar ($p < .001$) level, and greater at the 4-bar level than the 16-bar level ($p = .0034$) (Table S3a).

Post-hoc tests: comparison of levels (8B)

```
data_nested_8B <- filter(data_nested, scramble == '8B')
```

```
attach(data_nested_8B)
f1.ld.f1(value, time=level, group=Musician, subject=sub,
         time.name="level", group.name="expertise",
         description=FALSE)$ANOVA.test
```

```
##  F1 LD F1 Model
##  ----------------------
##  Check that the order of the time and group levels are correct.
##  Time level:   16 8 4 2
##  Group level:   Yes No
##  If the order is not correct, specify the correct order in time.order or group.order.
```




```
##                 Statistic      df      p-value
## expertise        0.1582626 1.00000 6.907611e-01
## level           11.1093984 2.23516 5.824035e-06
## expertise:level  0.7403047 2.23516 4.908957e-01
```

Main effect of level: $F(2.2) = 11.11$, $p < .001$

```r
pairwise.wilcox.test(data_nested_8B$value, data_nested_8B$level,
                     p.adjust.method = "bonferroni", paired=TRUE)
```

```
##
##  Pairwise comparisons using Wilcoxon signed rank test with continuity correction
##
## data:  data_nested_8B$value and data_nested_8B$level
##
##    2       4       8
## 4  0.00029 -       -
## 8  1.2e-07 3.6e-09 -
## 16 0.63593 1.00000 0.00310
##
## P value adjustment method: bonferroni
```

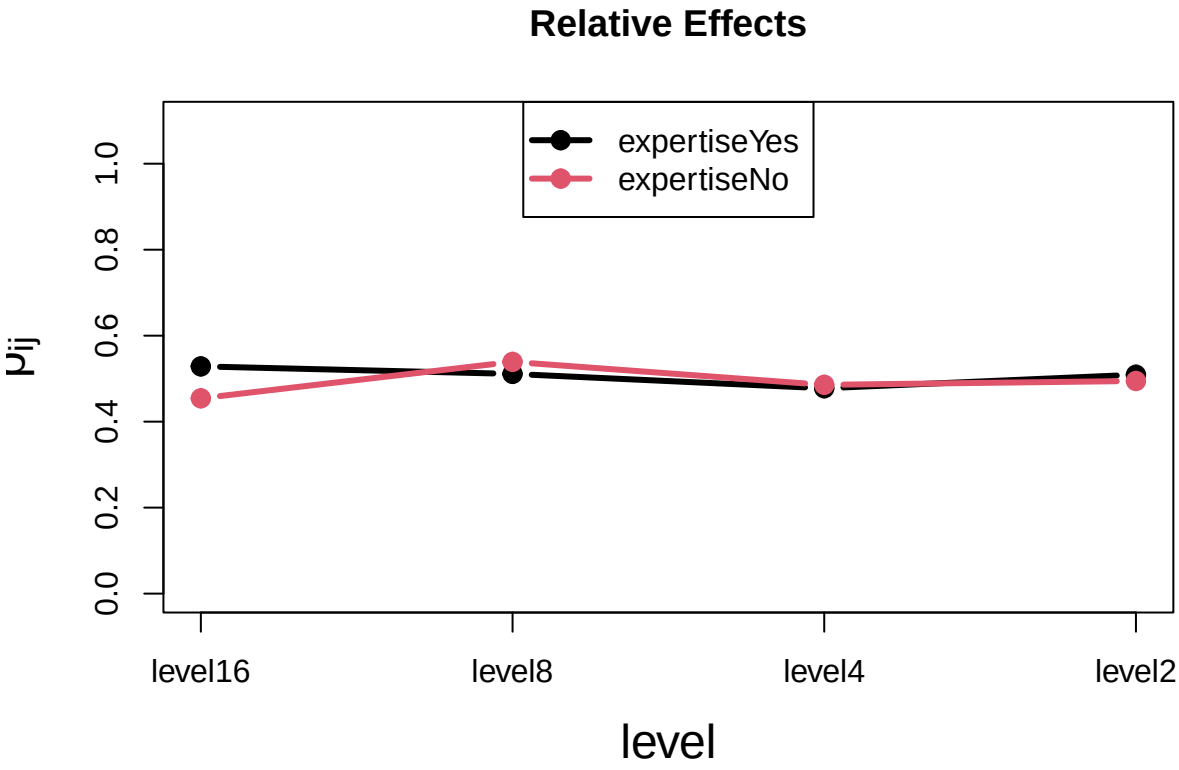
Greater at the 8-bar level than all other levels (2-bar level: $p < .001$, 4-bar level: $p < .001$, 16-bar level: $p = .0031$), and values at the 4-bar level were greater than at the 2-bar level ($p < .001$) (Table S4a).

Post-hoc tests: comparison of levels (Intact)

```
data_nested_I <- filter(data_nested, scramble == 'Intact')
```

```
attach(data_nested_I)
f1.ld.f1(value, time=level, group=Musician, subject=sub,
         time.name="level", group.name="expertise",
         description=FALSE)$ANOVA.test
```

```
##  F1 LD F1 Model
##  ----------------------
##  Check that the order of the time and group levels are correct.
##  Time level:   16 8 4 2
##  Group level:   Yes No
##  If the order is not correct, specify the correct order in time.order or group.order.
```




```
##                  Statistic       df   p-value
## expertise       0.06975625 1.000000 0.7916920
## level           0.83000943 2.144412 0.4431917
## expertise:level 1.17022200 2.144412 0.3123488
```

No main effect of level: $F(2.1) = .830$, $p = .443$

```r
pairwise.wilcox.test(data_nested_I$value, data_nested_I$level,
                     p.adjust.method = "bonferroni", paired=TRUE)
```

```
##
##  Pairwise comparisons using Wilcoxon signed rank test with continuity correction
##
## data:  data_nested_I$value and data_nested_I$level
##
##    2      4      8
## 4  1.0000 -      -
## 8  0.2999 0.0093 -
## 16 1.0000 0.2816 1.0000
##
## P value adjustment method: bonferroni
```

Greater at the 8-bar level than the 4-bar level (p = .0093) (Table S5a).

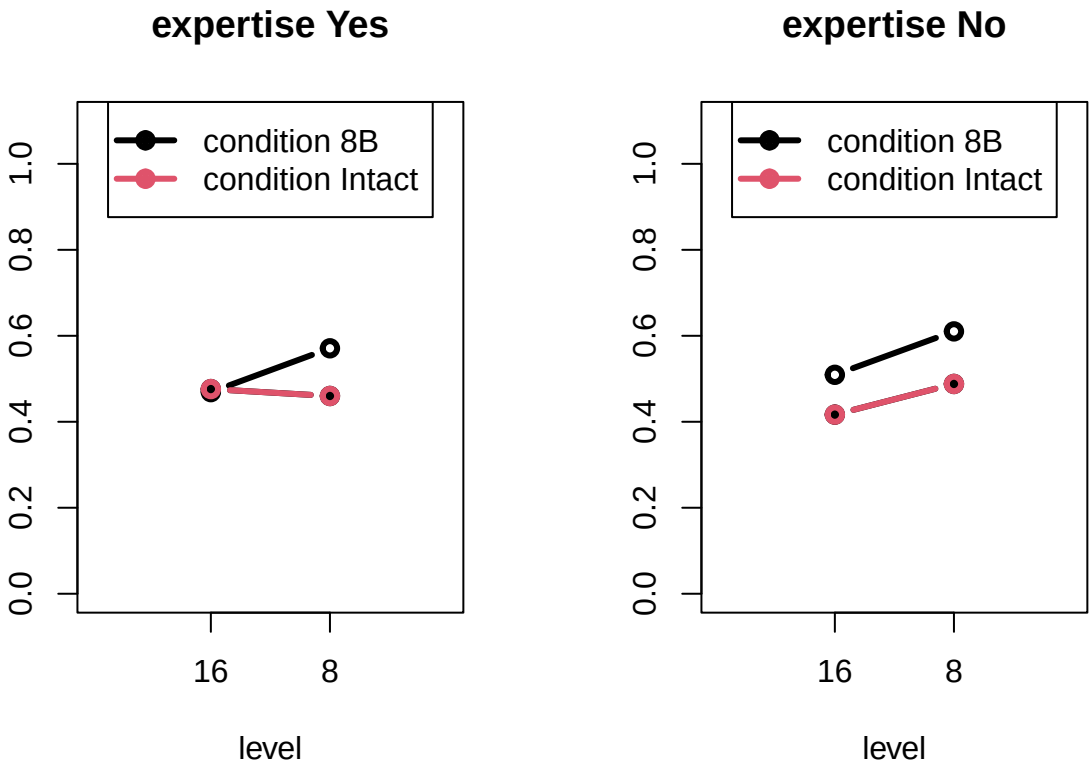
Interaction between 8B and Intact for 8-bar and 16-bar levels

Look at both groups side by side.

```
long_filtered <- data_nested %>%
  filter(scramble %in% c("8B", "Intact"),
         level %in% c(8,16))

attach(long_filtered)
f1.ld.f2(value, time1=scramble, time2=level, group=Musician, subject=sub,
      time1.name="condition", time2.name="level", group.name="expertise",
      description=FALSE)$ANOVA.test
```

```
##  F1 LD F2 Model
##  ----------------------
##  Check that the order of the time1, time2, and group levels are correct.
##  Time1 level:   Intact 8B
##  Time2 level:   16 8
##  Group level:   Yes No
##  If the order is not correct, specify the correct order in time1.order, time2.order, or group.order.
```



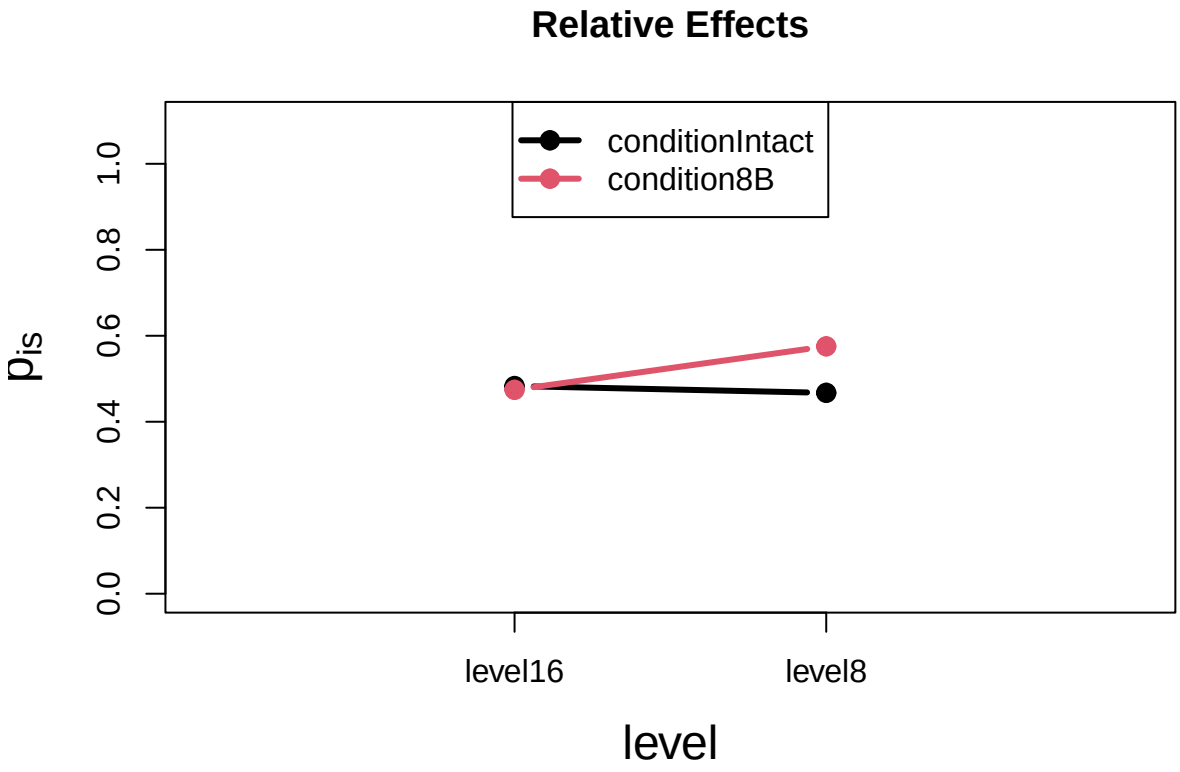

```
##                              Statistic df      p-value
## expertise                   0.07955022  1 7.779079e-01
## condition                   5.01934551  1 2.506564e-02
## level                      15.72032633  1 7.343082e-05
## expertise:condition         0.60940381  1 4.350124e-01
## level:condition             5.04059918  1 2.475992e-02
## expertise:level             1.76008757  1 1.846136e-01
## expertise:condition:level   1.80754513  1 1.788030e-01
```

Musicians only

```
M_long_filtered <- data_nested %>%
  filter(scramble %in% c("8B", "Intact"),
         level %in% c(8,16),
         Musician == "Yes")

attach(M_long_filtered)
ld.f2(value, time1=scramble, time2=level, subject=sub,
      time1.name="condition", time2.name="level",
      description=FALSE)$ANOVA.test
```

```
##  LD F2 Model
##  -----------------------
##  Check that the order of the time1 and time2 levels are correct.
##  Time1 level:   Intact 8B
##  Time2 level:   16 8
##  If the order is not correct, specify the correct order in time1.order or time2.order.
```




```
##                 Statistic df     p-value
## condition        1.101523  1 0.293932175
## level            3.083488  1 0.079090750
## condition:level  9.967330  1 0.001593424
```

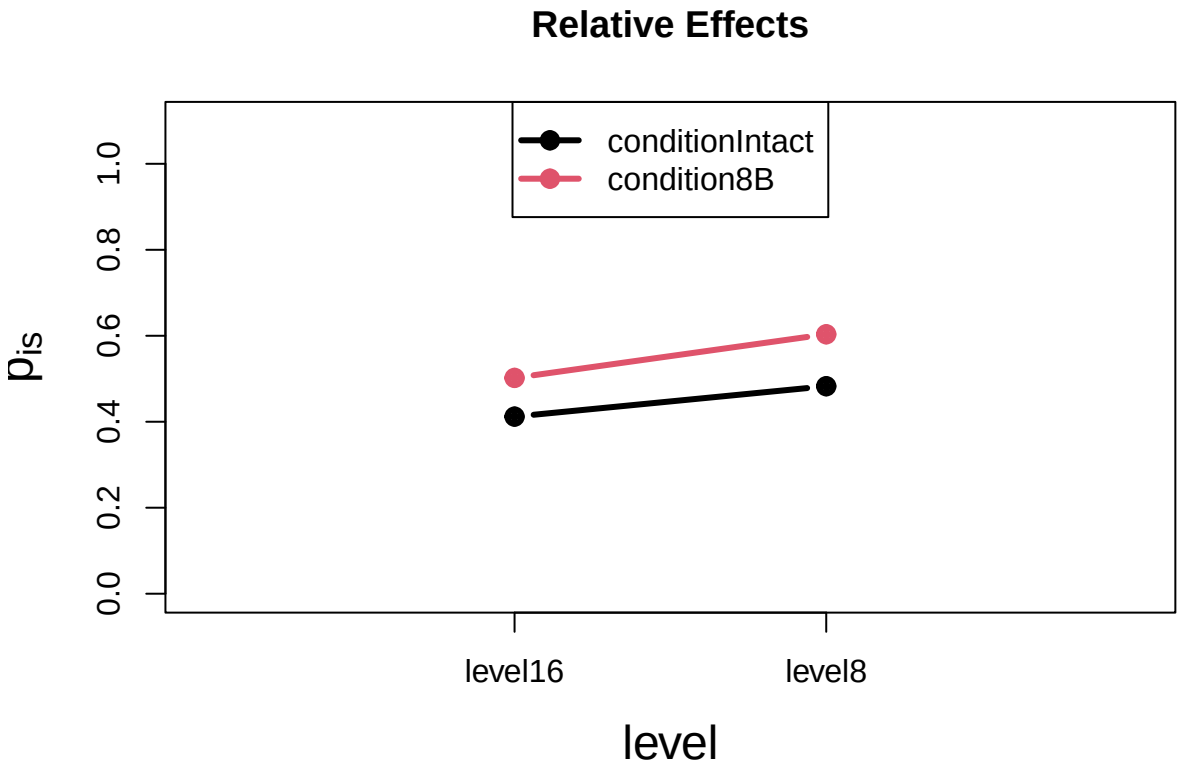
Significant interaction between condition and level for musicians: $F(1) = 9.97$, $p = .0016$

Non-musicians

```
NM_long_filtered <- data_nested %>%
  filter(scramble %in% c("8B", "Intact"),
         level %in% c(8,16),
         Musician == "No")

attach(NM_long_filtered)
ld.f2(value, time1=scramble, time2=level, subject=sub,
      time1.name="condition", time2.name="level",
      description=FALSE)$ANOVA.test
```

```
##  LD F2 Model
##  -----------------------
##  Check that the order of the time1 and time2 levels are correct.
##  Time1 level:   Intact 8B
##  Time2 level:   16 8
##  If the order is not correct, specify the correct order in time1.order or time2.order.
```




```
##                 Statistic df      p-value
## condition        4.019885  1 0.0449667706
## level           15.067288  1 0.0001037457
## condition:level  0.331159  1 0.5649773963
```

Interaction was not significant for non-musicians: $F(1) = 0.331$, $p = .57$