Psych201a, Problem Set 2: Tidying Data

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In this assignment we'll learn about `dplyr` and `tidyr`, two packages from the `tidyverse` that allow elegant and easily understandable data tidying and manipulation. We'll do this by working through the steps of loading an actual dataset, tidying it up, and carrying out some basic analyses.

The dataset we're using comes from the OSF Reproduciblity project replication of a study by Maya Tamir, Christopher Mitchell, and James Gross ("Hedonic and Instrumental Motives in Anger Regulation," Tamir, Mitchell, and Gross, Psychological Science, 2008). You can find the replication report here, and the original paper here. The replication tests two hypotheses from the original paper:

1) Rating hypothesis: Participants will prefer listening to angry music (or recalling an anger-inducing experience) before playing a confrontational (violent) game, but will prefer listening to exciting or neutral music (or recalling a calm experience) before a neutral

game. This is assessed through preference ratings where the participants read a description of a game, and then are asked to rate on a likert scale.

2) Performance hypothesis: Subjects would perform better after listening to angry music on a confrontational game (not one of the ones described in the materials for the previous hypothesis, to avoid contamination), but would perform better on a non-confrontational game (again, not described in the materials for hypothesis 1) after listening to non-angry music. This is computed by having the subjects play without music for 5 minutes, and then after/with music for 5 minutes, and comparing change scores depending on the music type.

First, let's load the libraries we're going to use.

```r
library(foreign) # for reading spss formatted data
library(tidyr)
library(dplyr)
```

```
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
```

```r
library(stringr) # useful for some string manipulation
library(ggplot2)
```

Load Data

```r
d = read.spss("Tamiretal2008ReplicationData.sav", to.data.frame=T)
```

Take a look at the data structure:

```r
head(d)
```

```
  Subject Cond                                                    Exper
1       1    2 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
2       2    3 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
3       3    1 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
4       4    4 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
5       5    5 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
6       6    6 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
      Inifile        Date  Time Game1Angry1 Game1Angry2 Game1Angry3
1 default.mlp 13642819200 40781           6           6           5
2 default.mlp 13642819200 50753           7           7           7
3 default.mlp 13642819200 54540           6           5           7
4 default.mlp 13642905600 34952           4           1           1
5 default.mlp 13642905600 49095           6           6           7
6 default.mlp 13642905600 59714           5           5           6
  Game1AngryFriends Game1AngryStrangers Game1CalmFriends Game1CalmStrangers
1                 2                   5                2                  2
2                 7                   7                6                  6
3                 2                   2                2                  2
4                 6                   6                2                  1
5                 6                   6                2                  2
6                 3                   4                5                  4
  Game1ExcitedFriends Game1ExcitedStrangers Game1Exciting1 Game1Exciting2
1                   1                     2              3              2
2                   6                     6              5              3
3                   2                     2              2              3
4                   3                     4              5              4
5                   5                     5              1              3
6                   6                     4              3              2
  Game1Exciting3 Game1Intro Game1Neutral1 Game1Neutral2 Game1Neutral3
1              6         ok             2             4             4
2              2         ok             1             1             1
3              4         ok             1             2             3
4              5         ok             1             2             2
5              2         ok             3             2             4
6              4         ok             2             2             4
  Game2Angry1 Game2Angry2 Game2Angry3 Game2AngryFriends Game2AngryStrangers
1           6           4           6                 3                   6
2           7           6           7                 6                   7
3           5           3           6                 3                   3
4           6           2           6                 3                   6
```

```
5           5           6           6                 5                   6
6           6           5           6                 3                   5
  Game2CalmFriends Game2CalmStrangers Game2ExcitedFriends Game2ExcitedStrangers
1                1                  2                   1                     1
2                2                  3                   5                     5
3                3                  3                   3                     3
4                1                  1                   2                     4
5                1                  1                   4                     4
6                3                  2                   5                     4
  Game2Exciting1 Game2Exciting2 Game2Exciting3 Game2Intro Game2Neutral1
1              3              2              4         ok             1
2              5              2              1         ok             1
3              2              5              2         ok             4
4              3              2              2         ok             1
5              1              2              2         ok             4
6              2              2              3         ok             2
  Game2Neutral2 Game2Neutral3 Game3Angry1 Game3Angry2 Game3Angry3
1             3             1           2           2           3
2             1             2           6           3           5
3             3             1           2           2           3
4             1             3           2           1           6
5             4             5           3           5           6
6             3             4           2           2           5
  Game3AngryFriends Game3AngryStrangers Game3CalmFriends Game3CalmStrangers
1                 3                   2                7                  6
2                 3                   2                6                  5
3                 4                   4                3                  3
4                 5                   4                2                  2
5                 1                   3                5                  5
6                 1                   1                4                  3
  Game3ExcitedFriends Game3ExcitedStrangers Game3Exciting1 Game3Exciting2
1                   6                     5              2              2
2                   6                     5              4              3
3                   4                     4              3              6
4                   5                     6              3              1
5                   6                     5              3              1
6                   4                     2              1              2
  Game3Exciting3 Game3Intro Game3Neutral1 Game3Neutral2 Game3Neutral3
1              3         ok             5             6             5
2              3         ok             2             1             5
3              2         ok             2             3             3
4              3         ok             2             2             6
5              3         ok             2             4             5
```

```
6              2         ok             5             4             4
  Game4Angry1 Game4Angry2 Game4Angry3 Game4AngryFriends Game4AngryStrangers
1           2           2           2                 2                   2
2           2           5           2                 4                   4
3           5           2           2                 4                   5
4           1           1           2                 1                   1
5           3           4           3                 2                   3
6           2           3           3                 1                   2
  Game4CalmFriends Game4CalmStrangers Game4ExcitedFriends Game4ExcitedStrangers
1                5                  5                   7                     4
2                2                  4                   3                     4
3                2                  4                   4                     5
4                2                  2                   4                     4
5                5                  5                   5                     6
6                4                  4                   5                     4
  Game4Exciting1 Game4Exciting2 Game4Exciting3 Game4Intro Game4Neutral1
1              5              5              2         ok             1
2              1              2              6         ok             5
3              7              4              5         ok             3
4              6              6              6         ok             4
5              1              5              5         ok             4
6              2              4              3         ok             3
  Game4Neutral2 Game4Neutral3 MusicSelectionEnd MusicSelectionInstrx
1             5             2                ok                   ok
2             5             2                ok                   ok
3             2             4                ok                   ok
4             5             2                ok                   ok
5             2             5                ok                   ok
6             5             5                ok                   ok
  RecallSelectionEnd RecallSelectionInstrx Subject2 Cond2
1                 ok                    ok        1     2
2                 ok                    ok        2     3
3                 ok                    ok        3     1
4                 ok                    ok        4     4
5                 ok                    ok        5     5
6                 ok                    ok        6     6
                                                  Exper_A   Inifile_A
1 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
2 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
3 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
4 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
5 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
6 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
```

```
       Date_A Time_A DescribeMusic HowActiveAngry1 HowActiveAngry2
1 13642819200  43151             2               4               4
2 13642819200  53012             3               5               5
3 13642819200  57041             2               4               4
4 13642905600  37630             3               5               3
5 13642905600  51434             2               5               4
6 13642905600  62320             3               3               3
  HowActiveAngry3 HowActiveExciting1 HowActiveExciting2 HowActiveExciting3
1               4                  5                  4                  5
2               5                  5                  2                  4
3               4                  2                  1                  3
4               3                  5                  5                  5
5               5                  3                  3                  3
6               2                  3                  3                  4
  HowActiveNeutral1 HowActiveNeutral2 HowActiveNeutral3 HowAngryAngry1
1                 2                 2                 2              5
2                 2                 2                 1              5
3                 1                 2                 1              4
4                 2                 2                 1              3
5                 2                 1                 1              2
6                 1                 2                 1              2
  HowAngryAngry2 HowAngryAngry3 HowAngryExciting1 HowAngryExciting2
1              4              4                 3                 4
2              5              5                 4                 3
3              4              4                 3                 1
4              2              3                 1                 1
5              2              3                 2                 2
6              2              2                 2                 1
  HowAngryExciting3 HowAngryNeutral1 HowAngryNeutral2 HowAngryNeutral3
1                 3                2                2                1
2                 3                2                1                1
3                 3                1                1                2
4                 1                2                1                1
5                 1                1                1                1
6                 1                1                1                1
  HowExcitedAngry1 HowExcitedAngry2 HowExcitedAngry3 HowExcitedExciting1
1                4                3                3                   4
2                5                5                5                   4
3                3                3                2                   2
4                4                1                3                   4
5                4                4                5                   3
6                5                2                3                   3
  HowExcitedExciting2 HowExcitedExciting3 HowExcitedNeutral1 HowExcitedNeutral2
```

```
1                   4                   4                   2                  2
2                   2                   4                   3                  2
3                   2                   3                   2                  1
4                   3                   5                   2                  2
5                   3                   3                   2                  1
6                   2                   4                   1                  1
  HowExcitedNeutral3 HowPleasantAngry1 HowPleasantAngry2 HowPleasantAngry3
1                  2                 1                 2                 1
2                  1                 1                 2                 1
3                  2                 2                 2                 4
4                  1                 1                 1                 3
5                  3                 4                 3                 2
6                  2                 2                 2                 3
  HowPleasantExciting1 HowPleasantExciting2 HowPleasantExciting3
1                    2                    2                    1
2                    1                    4                    3
3                    2                    2                    2
4                    4                    4                    3
5                    1                    1                    2
6                    3                    3                    4
  HowPleasantNeutral1 HowPleasantNeutral2 HowPleasantNeutral3 MusicRatingEnd
1                   5                   4                   5             ok
2                   4                   4                   4             ok
3                   2                   2                   1             ok
4                   2                   4                   5             ok
5                   1                   1                   5             ok
6                   3                   3                   4             ok
  MusicRatingInstrx WhichGames aboutyou age distractions endinstructions
1                ok         ok       ok  18           ok              ok
2                ok         ok       ok  20           ok              ok
3                ok         ok       ok  18           ok              ok
4                ok         ok       ok  18           ok              ok
5                ok         ok       ok  18           ok              ok
6                ok         ok       ok  19           ok              ok
  ethnicity overlooking race sex whatabout year Subject3 DDNoMusicLevel
1         2          ok    2   1        ok    1        1              3
2         2          ok    2   2        ok    2        2              3
3         2          ok    2   1        ok    1        3              2
4         2          ok    2   1        ok    1        4              3
5         2          ok    2   1        ok    1        5              3
6         2          ok    2   1        ok    1        6              3
  DDNoMusicScore DDMusicLevel DDMusicScore SOFNoMusicEnemies
1              0            3          830                22
```

```
2             20           3          2930                18
3           1250           3           370                15
4           1742           3          1921                 3
5             60           3          1750                18
6            840           3          1380                23
  SOFNoMusicFriendlies SOFNoMusicTime SOFMusicEnemies SOFMusicFriendlies
1                    2          24360              19                  0
2                    1          23580              18                  2
3                    0          15300              23                  1
4                    0           5280              19                  0
5                    2          19140              23                  3
6                    1          23220              24                  0
  SOFMusicTime                           GameComments
1        23340
2        22500
3        24300
4        16860 Participant died, restart
5        20820 Error in game towards the end of time
6        23400
  DoNotUseVideoGamePerformanceData ConfrontationalAngryMusicScore
1                               NA                       5.500000
2                               NA                       6.833333
3                               NA                       5.333333
4                                1                       3.333333
5                                1                       6.000000
6                               NA                       5.500000
  ConfrontationalExcitingMusicScore ConfrontationalNeutralMusicScore
1                          3.333333                         2.500000
2                          3.000000                         1.166667
3                          3.000000                         2.333333
4                          3.500000                         1.666667
5                          1.833333                         3.666667
6                          2.666667                         2.833333
  ConfrontationalAngryRecallScore ConfrontationalExcitingRecallScore
1                            3.75                               1.25
2                            7.00                               5.75
3                            2.25                               2.25
4                            6.00                               3.50
5                            6.00                               4.75
6                            3.75                               5.00
  ConfrontationalNeutralRecallScore NonconfrontationalAngryMusicScore
1                              2.00                          2.166667
2                              5.25                          3.833333
```

```
3                              2.25                          2.666667
4                              1.50                          2.166667
5                              1.75                          4.000000
6                              4.00                          2.833333
  NonconfrontationalExcitingMusicScore NonconfrontationalNeutralMusicScore
1                             3.166667                            4.000000
2                             3.166667                            3.333333
3                             4.500000                            2.833333
4                             4.166667                            3.500000
5                             3.000000                            3.666667
6                             2.333333                            4.333333
  NonconfrontationalAngryRecallScore NonconfrontationalExcitingRecallScore
1                               2.50                                  5.25
2                               3.00                                  5.25
3                               4.25                                  4.25
4                               3.75                                  5.00
5                               2.00                                  5.75
6                               1.25                                  3.50
  NonconfrontationalNeutralRecallScore ConfrontationalAngerScore
1                                 6.25                       4.8
2                                 5.25                       6.9
3                                 3.25                       4.1
4                                 2.00                       4.4
5                                 5.00                       6.0
6                                 3.75                       4.8
  ConfrontationalExcitingScore ConfrontationalNeutralScore
1                          2.5                         2.3
2                          4.1                         2.8
3                          2.7                         2.3
4                          3.5                         1.6
5                          3.0                         2.9
6                          3.6                         3.3
  NonconfrontationalAngerScore NonconfrontationalExcitingScore
1                          2.3                             4.0
2                          3.5                             4.0
3                          3.3                             4.4
4                          2.8                             4.5
5                          3.2                             4.1
6                          2.2                             2.8
  NonconfrontationalNeutralScore Usable DoNotUse
1                            4.9      1       NA
2                            4.1      0        1
3                            3.0      1       NA
```

```
4                           2.9      1       NA
5                           4.2      1       NA
6                           4.1      1       NA

1
2 Female participant (this is a males only study)
3
4
5
6
  DinerDashWithMusicScore DinerDashWithoutMusicScore MusicCondition
1                    5830                       5000       Exciting
2                    7930                       5020        Neutral
3                    5370                       1250          Anger
4                    6921                       6742          Anger
5                    6750                       5060       Exciting
6                    6380                       5840        Neutral
  ZDinerDashWithMusicScore ZDinerDashWithoutMusicScore ZSOFNoMusicEnemies
1              -0.07333283                   0.2692740          0.7501199
2                       NA                          NA                 NA
3              -0.73344247                  -2.8616517         -0.1401958
4               1.49227504                   1.7236934         -1.6664514
5               1.24688645                   0.3193688          0.2413681
6               0.71592870                   0.9706014          0.8773079
  ZSOFMusicEnemies DinerDashDifferenceScore SOFDifferenceScore
1       -0.2020329               -0.3426068        -0.95215278
2               NA                       NA                 NA
3        0.3183548                2.1282092         0.45855062
4       -0.2020329               -0.2314183         1.46441854
5        0.3183548                0.9275176         0.07698673
6        0.4484517               -0.2546727        -0.42885618
  PleasantScoreForAngryMusic PleasantScoreForExcitingMusic
1                   1.333333                      1.666667
2                   1.333333                      2.666667
3                   2.666667                      2.000000
4                   1.666667                      3.666667
5                   3.000000                      1.333333
6                   2.333333                      3.333333
  PleasantScoreForNeutralMusic AngryScoreForAngryMusic
1                     4.666667                4.333333
2                     4.000000                5.000000
3                     1.666667                4.000000
4                     3.666667                2.666667
```

```
5                     2.333333                2.333333
6                     3.333333                2.000000
  AngryScoreForExcitingMusic AngryScoreForNeutralMusic
1                   3.333333                  1.666667
2                   3.333333                  1.333333
3                   2.333333                  1.333333
4                   1.000000                  1.333333
5                   1.666667                  1.000000
6                   1.333333                  1.000000
  ExcitedScoreForExcitingMusic ExcitedScoreForNeutralMusic
1                     4.000000                    2.000000
2                     3.333333                    2.000000
3                     2.333333                    1.666667
4                     4.000000                    1.666667
5                     3.000000                    2.000000
6                     3.000000                    1.333333
  ActiveScoreForExcitingMusic ActiveScoreForNeutralMusic
1                    4.666667                   2.000000
2                    3.666667                   1.666667
3                    2.000000                   1.333333
4                    5.000000                   1.666667
5                    3.000000                   1.333333
6                    3.333333                   1.333333
  ExcitedScoreForAngryMusic ActiveScoreForAngryMusic
1                  3.333333                 4.000000
2                  5.000000                 5.000000
3                  2.666667                 4.000000
4                  2.666667                 3.666667
5                  4.333333                 4.666667
6                  3.333333                 2.666667
```

This data is what we call **wide form** – each subject is a single row, and the columns represent different observations. This is a somewhat inconvenient way of representing the data, for example if we wanted to do the same operation to each likert rating (for example normalize it to be in the range 0-1), we'd have to do it on each of the 40 or so rating columns. To avoid this, our eventual goal will be to convert the data into **long form**, where each row is a single observation.

For now, take a look at the column names to get a better idea of what all is in the dataset.

```
#colnames(d)
```

And see if you can figure out what range the likert scores are in. What's the highest number on the likert scale, and what's the lowest? (Hint, `d$Game1Angry1` is one of the likert rating columns, and you may want to use `unique`)

```
unique(d$Game1Angry1)
```

```
[1]  6  7  4  5  3  2  1 NA
```

Highest number: 7 Lowest number: 1

cleaning up a bit

First, we'll get rid of rows and columns of the data that we don't need.

filter out excluded rows

First, we need to `filter` out any rows that should be excluded. According to the report, there are two exclusions:

> "exclude data from participant 2 and participant 23 participant 2 is female, and this is a males only study participant 23 was set up on part 2 of the study (the music ratings) twice and never did part 1"

You can see participant 23's data and the fact that they did not do part 1 by looking at the last rows of the dataframe:

```
tail(d)
```

```
   Subject Cond                                                   Exper
86      87    1 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
87      88    6 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
88      89    2 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
89      90    3 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part1.exp
90      23   NA
91      23   NA
       Inifile        Date  Time Game1Angry1 Game1Angry2 Game1Angry3
86 default.mlp 13644633600 40065           1           3           4
87 default.mlp 13644633600 51237           7           7           5
88 default.mlp 13644633600 54293           7           6           6
89 default.mlp 13644633600 58190           5           5           5
```

```
90                      NA    NA          NA          NA          NA
91                      NA    NA          NA          NA          NA
   Game1AngryFriends Game1AngryStrangers Game1CalmFriends Game1CalmStrangers
86                 6                   7                1                  1
87                 4                   1                4                  4
88                 7                   5                3                  2
89                 7                   7                1                  1
90                NA                  NA               NA                 NA
91                NA                  NA               NA                 NA
   Game1ExcitedFriends Game1ExcitedStrangers Game1Exciting1 Game1Exciting2
86                   1                     1              1              1
87                   7                     4              7              7
88                   7                     6              3              5
89                   4                     1              1              1
90                  NA                    NA             NA             NA
91                  NA                    NA             NA             NA
   Game1Exciting3 Game1Intro Game1Neutral1 Game1Neutral2 Game1Neutral3
86              1         ok             2             2             3
87              6         ok             2             1             1
88              2         ok             1             2             1
89              1         ok             1             1             6
90             NA                       NA            NA            NA
91             NA                       NA            NA            NA
   Game2Angry1 Game2Angry2 Game2Angry3 Game2AngryFriends Game2AngryStrangers
86           5           5           7                 1                   7
87           7           7           4                 1                   1
88           6           4           6                 7                   2
89           5           1           7                 7                   7
90          NA          NA          NA                NA                  NA
91          NA          NA          NA                NA                  NA
   Game2CalmFriends Game2CalmStrangers Game2ExcitedFriends
86                4                  4                   2
87                5                  6                   7
88                3                  1                   7
89                1                  1                   1
90               NA                 NA                  NA
91               NA                 NA                  NA
   Game2ExcitedStrangers Game2Exciting1 Game2Exciting2 Game2Exciting3
86                     2              5              1              1
87                     4              7              1              1
88                     5              1              3              1
89                     4              3              2              2
90                    NA             NA             NA             NA
```

```
91                    NA             NA             NA             NA
   Game2Intro Game2Neutral1 Game2Neutral2 Game2Neutral3 Game3Angry1 Game3Angry2
86         ok             1             1             1           5           3
87         ok             1             1             1           2           1
88         ok             1             2             2           2           4
89         ok             1             3             1           1           1
90                       NA            NA            NA          NA          NA
91                       NA            NA            NA          NA          NA
   Game3Angry3 Game3AngryFriends Game3AngryStrangers Game3CalmFriends
86           6                 1                   2                5
87           7                 1                   1                7
88           4                 1                   1                6
89           5                 2                   2                7
90          NA                NA                  NA               NA
91          NA                NA                  NA               NA
   Game3CalmStrangers Game3ExcitedFriends Game3ExcitedStrangers Game3Exciting1
86                  6                   4                     2              1
87                  2                   7                     3              2
88                  4                   3                     6              5
89                  6                   7                     7              2
90                 NA                  NA                    NA             NA
91                 NA                  NA                    NA             NA
   Game3Exciting2 Game3Exciting3 Game3Intro Game3Neutral1 Game3Neutral2
86              1              1         ok             5             1
87              1              1         ok             4             6
88              5              6         ok             4             1
89              1              1         ok             4             4
90             NA             NA                       NA            NA
91             NA             NA                       NA            NA
   Game3Neutral3 Game4Angry1 Game4Angry2 Game4Angry3 Game4AngryFriends
86             2           3           1           4                 1
87             2           2           1           7                 3
88             6           1           1           1                 1
89             7           1           3           1                 3
90            NA          NA          NA          NA                NA
91            NA          NA          NA          NA                NA
   Game4AngryStrangers Game4CalmFriends Game4CalmStrangers Game4ExcitedFriends
86                   1                7                  7                   7
87                   4                2                  6                   7
88                   1                7                  5                   7
89                   3                5                  4                   7
90                  NA               NA                 NA                  NA
91                  NA               NA                 NA                  NA
```

```
   Game4ExcitedStrangers Game4Exciting1 Game4Exciting2 Game4Exciting3
86                     7              2              5              5
87                     7              4              1              2
88                     5              5              4              7
89                     7              2              4              5
90                    NA             NA             NA             NA
91                    NA             NA             NA             NA
   Game4Intro Game4Neutral1 Game4Neutral2 Game4Neutral3 MusicSelectionEnd
86         ok             5             5             4                ok
87         ok             5             3             1                ok
88         ok             5             5             3                ok
89         ok             1             2             5                ok
90                       NA            NA            NA
91                       NA            NA            NA
   MusicSelectionInstrx RecallSelectionEnd RecallSelectionInstrx Subject2 Cond2
86                   ok                 ok                    ok       87     1
87                   ok                 ok                    ok       88     6
88                   ok                 ok                    ok       89     2
89                   ok                 ok                    ok       90     3
90                                                                     23     1
91                                                                     23     1
                                                          Exper_A   Inifile_A
86 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
87 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
88 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
89 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
90 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
91 C:\\Users\\msplab\\Desktop\\Study 151\\Study151Part2.exp default.mlp
        Date_A Time_A DescribeMusic HowActiveAngry1 HowActiveAngry2
86 13644633600  42314             2               5               5
87 13644633600  53402             2               5               5
88 13644633600  56552             2               5               3
89 13644633600  60558             2               5               5
90 13643078400  61329             2               4               5
91 13643078400  63502             2               4               3
   HowActiveAngry3 HowActiveExciting1 HowActiveExciting2 HowActiveExciting3
86               4                  5                  5                  5
87               5                  5                  5                  5
88               4                  4                  5                  5
89               3                  5                  5                  5
90               5                  3                  3                  3
91               5                  4                  3                  5
   HowActiveNeutral1 HowActiveNeutral2 HowActiveNeutral3 HowAngryAngry1
```

```
86                 1                 1                 1              3
87                 2                 2                 1              5
88                 1                 2                 1              5
89                 1                 1                 1              5
90                 3                 4                 3              3
91                 4                 4                 2              2
   HowAngryAngry2 HowAngryAngry3 HowAngryExciting1 HowAngryExciting2
86              5              1                 1                 1
87              5              1                 3                 1
88              5              4                 2                 3
89              5              3                 3                 1
90              3              2                 3                 2
91              3              2                 3                 3
   HowAngryExciting3 HowAngryNeutral1 HowAngryNeutral2 HowAngryNeutral3
86                 1                1                5                1
87                 2                1                1                1
88                 1                1                1                1
89                 1                1                1                1
90                 2                2                2                2
91                 1                2                2                1
   HowExcitedAngry1 HowExcitedAngry2 HowExcitedAngry3 HowExcitedExciting1
86                4                4                4                   3
87                5                5                5                   5
88                5                5                4                   3
89                5                5                5                   4
90                4                4                5                   5
91                3                3                3                   3
   HowExcitedExciting2 HowExcitedExciting3 HowExcitedNeutral1
86                   4                   4                  1
87                   5                   5                  1
88                   4                   5                  2
89                   5                   4                  1
90                   5                   3                  3
91                   5                   4                  3
   HowExcitedNeutral2 HowExcitedNeutral3 HowPleasantAngry1 HowPleasantAngry2
86                  2                  1                 3                 3
87                  5                  5                 1                 1
88                  2                  1                 3                 3
89                  1                  2                 2                 1
90                  4                  4                 1                 1
91                  4                  3                 2                 2
   HowPleasantAngry3 HowPleasantExciting1 HowPleasantExciting2
86                 4                    2                    4
```

```
87                 5                    5                    5
88                 2                    3                    3
89                 3                    1                    5
90                 1                    1                    2
91                 1                    2                    5
   HowPleasantExciting3 HowPleasantNeutral1 HowPleasantNeutral2
86                    3                   3                   3
87                    2                   5                   5
88                    5                   4                   4
89                    2                   4                   4
90                    1                   3                   3
91                    3                   5                   5
   HowPleasantNeutral3 MusicRatingEnd MusicRatingInstrx WhichGames aboutyou age
86                   2             ok                ok         ok       ok  20
87                   5             ok                ok         ok       ok  18
88                   5             ok                ok         ok       ok  18
89                   5             ok                ok         ok       ok  18
90                   3             ok                ok         ok       ok  20
91                   1             ok                ok         ok       ok  20
   distractions endinstructions ethnicity overlooking race sex whatabout year
86           ok              ok         2          ok    2   1        ok    2
87           ok              ok         2          ok    1   1        ok    1
88           ok              ok         2          ok    2   1        ok    1
89           ok              ok         2          ok    2   1        ok    1
90           ok              ok         2          ok    1   1        ok    2
91           ok              ok         2          ok    1   1        ok    2
   Subject3 DDNoMusicLevel DDNoMusicScore DDMusicLevel DDMusicScore
86       87              3              0            3          170
87       88              3              0            3          866
88       89              2           3280            3          820
89       90              2           3040            3            0
90       23              2           3990            3          750
91       23             NA             NA           NA           NA
   SOFNoMusicEnemies SOFNoMusicFriendlies SOFNoMusicTime SOFMusicEnemies
86                15                    0          13140              25
87                24                    0          23460              27
88                 7                    0           8880              31
89                22                    2          28440              26
90                 9                    2          19260              18
91                NA                   NA             NA              NA
   SOFMusicFriendlies SOFMusicTime                           GameComments
86                  1        23160 Participant died, restart
87                  0        22380
```

```
88                  0        23100
89                  0        25500
90                  2        24120
91                 NA           NA
   DoNotUseVideoGamePerformanceData ConfrontationalAngryMusicScore
86                                1                       4.166667
87                               NA                       6.166667
88                                1                       5.833333
89                               NA                       4.666667
90                               NA                             NA
91                               NA                             NA
   ConfrontationalExcitingMusicScore ConfrontationalNeutralMusicScore
86                          1.666667                         1.666667
87                          4.833333                         1.166667
88                          2.500000                         1.500000
89                          1.666667                         2.166667
90                                NA                               NA
91                                NA                               NA
   ConfrontationalAngryRecallScore ConfrontationalExcitingRecallScore
86                            6.50                               1.25
87                            2.50                               5.50
88                            5.25                               6.25
89                            7.00                               3.25
90                              NA                                 NA
91                              NA                                 NA
   ConfrontationalNeutralRecallScore NonconfrontationalAngryMusicScore
86                              1.75                          3.666667
87                              4.50                          3.333333
88                              2.25                          2.166667
89                              1.00                          2.000000
90                                NA                                NA
91                                NA                                NA
   NonconfrontationalExcitingMusicScore NonconfrontationalNeutralMusicScore
86                             2.500000                            3.666667
87                             1.833333                            3.500000
88                             5.333333                            4.000000
89                             2.500000                            3.833333
90                                   NA                                  NA
91                                   NA                                  NA
   NonconfrontationalAngryRecallScore NonconfrontationalExcitingRecallScore
86                               1.25                                  4.25
87                               1.75                                  6.00
88                               1.00                                  4.25
```

```
89                               2.25                                  7.00
90                                 NA                                    NA
91                                 NA                                    NA
   NonconfrontationalNeutralRecallScore ConfrontationalAngerScore
86                                 5.75                       5.1
87                                 5.50                       4.7
88                                 5.25                       5.6
89                                 6.00                       5.6
90                                   NA                        NA
91                                   NA                        NA
   ConfrontationalExcitingScore ConfrontationalNeutralScore
86                          1.5                         1.7
87                          5.1                         2.5
88                          4.0                         1.8
89                          2.3                         1.7
90                           NA                          NA
91                           NA                          NA
   NonconfrontationalAngerScore NonconfrontationalExcitingScore
86                          2.7                             3.2
87                          2.7                             3.5
88                          1.7                             4.9
89                          2.1                             4.3
90                           NA                              NA
91                           NA                              NA
   NonconfrontationalNeutralScore Usable DoNotUse
86                            4.5      1       NA
87                            4.3      1       NA
88                            4.5      1       NA
89                            4.7      1       NA
90                             NA      0        1
91                             NA      0        1

86
87
88
89
90 Participant 23 was set up on part 2 of the survey when he was supposed to be set up on par
91 Participant 23 was set up on part 2 of the survey when he was supposed to be set up on par
   DinerDashWithMusicScore DinerDashWithoutMusicScore MusicCondition
86                    5170                       5000          Anger
87                    5866                       5000        Neutral
88                    5820                       3280       Exciting
89                    5000                       3040        Neutral
```

```
90                    5750                       3990           <NA>
91                      NA                         NA           <NA>
   ZDinerDashWithMusicScore ZDinerDashWithoutMusicScore ZSOFNoMusicEnemies
86              -1.02044667                   0.2692740         -0.1401958
87              -0.02167208                   0.2692740          1.0044959
88              -0.08768304                  -1.1667773         -1.1576995
89              -1.26440023                  -1.3671565          0.7501199
90              -0.18813451                  -0.5739887         -0.9033236
91                       NA                          NA                 NA
   ZSOFMusicEnemies DinerDashDifferenceScore SOFDifferenceScore
86        0.5785486               -1.2897207         0.71874445
87        0.8387424               -0.2909461        -0.16575340
88        1.3591301                1.0790942         2.51682964
89        0.7086455                0.1027563        -0.04147439
90       -0.3321298                0.3858541         0.57119384
91               NA                       NA                 NA
   PleasantScoreForAngryMusic PleasantScoreForExcitingMusic
86                   3.333333                      3.000000
87                   2.333333                      4.000000
88                   2.666667                      3.666667
89                   2.000000                      2.666667
90                   1.000000                      1.333333
91                   1.666667                      3.333333
   PleasantScoreForNeutralMusic AngryScoreForAngryMusic
86                     2.666667                3.000000
87                     5.000000                3.666667
88                     4.333333                4.666667
89                     4.333333                4.333333
90                     3.000000                2.666667
91                     3.666667                2.333333
   AngryScoreForExcitingMusic AngryScoreForNeutralMusic
86                   1.000000                  2.333333
87                   2.000000                  1.000000
88                   2.000000                  1.000000
89                   1.666667                  1.000000
90                   2.333333                  2.000000
91                   2.333333                  1.666667
   ExcitedScoreForExcitingMusic ExcitedScoreForNeutralMusic
86                     3.666667                    1.333333
87                     5.000000                    3.666667
88                     4.000000                    1.666667
89                     4.333333                    1.333333
90                     4.333333                    3.666667
```

```
91                     4.000000                    3.333333
   ActiveScoreForExcitingMusic ActiveScoreForNeutralMusic
86                    5.000000                   1.000000
87                    5.000000                   1.666667
88                    4.666667                   1.333333
89                    5.000000                   1.000000
90                    3.000000                   3.333333
91                    4.000000                   3.333333
   ExcitedScoreForAngryMusic ActiveScoreForAngryMusic
86                  4.000000                 4.666667
87                  5.000000                 5.000000
88                  4.666667                 4.000000
89                  5.000000                 4.333333
90                  4.333333                 4.666667
91                  3.000000                 4.000000
```

Notice that participant 23 has missing values for part 1.

The researchers have made a column called `DoNotUse` based on their exclusion criteria. Use this column to filter the dataframe! Try running this code

Hint: enter `?dplyr::filter` into the console to check the documentation. What happens to na values?

```
?dplyr::filter
head(d$DoNotUse)
```

```
[1] NA  1 NA NA NA NA
```

```
filtered_d = d |> filter(is.na(DoNotUse))
# your code here: exclude subjecDoNotUse# your code here: exclude subjects that are marked a
```

It's good practice to assign a new variable name (in this case `filtered_d`) to a data frame when you change it in an important way, or apply a code chunk that shouldn't be run twice. This helps prevent you seeing different results when you run your code in chunks (and might run one multiple times, or skip it, etc.) vs. knit the document.

Get rid of unnecessary columns

The dataset contains a bunch of columns we don't care about: * The dataset contains three subject columns, which are identical except for a single NA which is not mentioned in the protocol, and so is likely an error. * Columns telling us the path to the executable run for each part of the experiment, we don't really care about that. * Etc.

To get rid of these, we'll use the `select` function to take only the columns we need.

```
filtered_d = filtered_d |>
  select(c("Subject", "Cond"), # Generally important columns for both hypotheses
         contains("Game"), # we want all the game columns for hypothesis 1
         -contains("Intro"), -c("WhichGames", "GameComments"), # except these
         starts_with("DinerDashWith"), c("SOFMusicEnemies", "SOFNoMusicEnemies")) # These col
#c is vector
```

Even better, let's split this into separate data frames for hypothesis 1 and hypothesis 2, since they are different types of experiments with different measurements, and therefore different analyses that will need to be performed. Now that we've cleaned up the data, this is pretty easy to do! We'll just drop the columns that are for the other hypothesis. The `select` function lets us choose which columns to remove (instead of which to keep) by putting a minus sign in front of them. First, let's create a dataset for the rating hypothesis by getting rid of the game performance columns:

```
rating_hyp_d = filtered_d |>
  filter(is.na(DoNotUseVideoGamePerformanceData)) %>% # first, let's get rid of the subjects
  select(-DoNotUseVideoGamePerformanceData, # now get rid of that column
         -starts_with("DinerDash"), # and the other columns we don't need
         -starts_with("SOF"))
```

Now you try! Fill in the selection criteria to get rid of the "Game" columns, which we don't need for the performance hypothesis. (It's simpler than the code block above, because you don't need to do a `filter` first, only a `select`.)

```
performance_hyp_d = filtered_d |>
  filter(is.na(DoNotUseVideoGamePerformanceData)) |>
  select(
    -DoNotUseVideoGamePerformanceData,
         -starts_with("Game")) # your code here: remove the columns containing "Game" in the
```

Converting to long form

Now we want to convert the data to long form, to make the rest of our manipulations easier. To do this, we can use `pivot_longer` on the target columns. This will take many columns, and change the column names into entries in a "key" column, while the values that were in the original column will be turned into entries in a "value" column. It's easiest to see with an example:

```
tiny_demo_d = head(performance_hyp_d, 2) # get just the first two subjects performance data,
```

First, take a look at the original wide-form data:

```
tiny_demo_d
```

```
  Subject Cond DinerDashWithMusicScore DinerDashWithoutMusicScore
1       1    2                    5830                       5000
2       3    1                    5370                       1250
  SOFMusicEnemies SOFNoMusicEnemies
1              19                22
2              23                15
```

Now, take a look at the long-form version:

```
tiny_demo_d |> pivot_longer(cols=-c("Subject", "Cond"), # this tells it to transform all colu
                             names_to='Measurement',
                             values_to='Value')
```

```
# A tibble: 8 x 4
  Subject  Cond Measurement                Value
    <dbl> <dbl> <chr>                      <dbl>
1       1     2 DinerDashWithMusicScore     5830
2       1     2 DinerDashWithoutMusicScore  5000
3       1     2 SOFMusicEnemies               19
4       1     2 SOFNoMusicEnemies             22
5       3     1 DinerDashWithMusicScore     5370
6       3     1 DinerDashWithoutMusicScore  1250
7       3     1 SOFMusicEnemies               23
8       3     1 SOFNoMusicEnemies             15
```

See how the columns have been converted into rows (except for the two we excluded), and the dataset has gone from wide to long?

Now let's actually convert the performance dataset

```
performance_hyp_long_d = performance_hyp_d |>
  pivot_longer(cols=-c("Subject", "Cond"),
               names_to='Measurement',
               values_to='Score')

head(performance_hyp_long_d)
```

```
# A tibble: 6 x 4
  Subject  Cond Measurement                Score
    <dbl> <dbl> <chr>                      <dbl>
1       1     2 DinerDashWithMusicScore     5830
2       1     2 DinerDashWithoutMusicScore  5000
3       1     2 SOFMusicEnemies               19
4       1     2 SOFNoMusicEnemies             22
5       3     1 DinerDashWithMusicScore     5370
6       3     1 DinerDashWithoutMusicScore  1250
```

And you can convert the rating dataset! (Call the "Key" column "Measurement" and call the "Value" column "Rating", so that the code below will work)

```
rating_hyp_long_d = rating_hyp_d |>
  pivot_longer(cols=-c("Subject", "Cond"),
               names_to='Measurement',
               values_to='Rating')
    ## your code here
head(rating_hyp_long_d)
```

```
# A tibble: 6 x 4
  Subject  Cond Measurement         Rating
    <dbl> <dbl> <chr>                <dbl>
1       1     2 Game1Angry1              6
2       1     2 Game1Angry2              6
3       1     2 Game1Angry3              5
4       1     2 Game1AngryFriends        2
5       1     2 Game1AngryStrangers      5
6       1     2 Game1CalmFriends         2
```

Splitting columns

The measurement column in each dataset now contains a bunch of different types of information. Really, we would like these to be separate columns. For example, we could have one column telling you which video-game it is, and one telling you whether there was music. Tidyverse contains some handy features for splitting columns, but unfortunately the measurement names here are not well suited to it (if the different types of information were always the same length, or were separated by a symbol like “.” or “_“, it would be easy). Thus we’ll have to do a bit of manual testing. We can use the `mutate` function in dplyr to create new columns as functions of old ones (or alter existing columns). We’ll also use the `grepl` function, which lets us test whether a *regular expression* (a fancy type of search pattern) is contained in a column name. For most your purposes, you can probably just use grepl to search for strings, but there are some other quite useful functions in regular expressions, like the”or” ” function (`|`) we use below.

But first, a quick tiny demo about how mutate generally works:

```
tiny_demo_mutate <- head(performance_hyp_long_d, 10)
tiny_demo_mutate
```

```
# A tibble: 10 x 4
   Subject  Cond Measurement                 Score
     <dbl> <dbl> <chr>                       <dbl>
 1       1     2 DinerDashWithMusicScore      5830
 2       1     2 DinerDashWithoutMusicScore   5000
 3       1     2 SOFMusicEnemies                19
 4       1     2 SOFNoMusicEnemies              22
 5       3     1 DinerDashWithMusicScore      5370
 6       3     1 DinerDashWithoutMusicScore   1250
 7       3     1 SOFMusicEnemies                23
 8       3     1 SOFNoMusicEnemies              15
 9       6     6 DinerDashWithMusicScore      6380
10       6     6 DinerDashWithoutMusicScore   5840
```

```
tiny_demo_mutate = tiny_demo_mutate |>
  mutate(

  )
```

Cool, let’s go back to the data:

```
performance_hyp_long_d = performance_hyp_long_d |>
  mutate(
    # create a new variable that will say whether the measurement was of the game soldier of
    ConfrontationalGame = grepl("SOF", Measurement),

    # creates a new column named WithMusic, which is False if the measurement contains *eithe
    WithMusic = !grepl("NoMusic|WithoutMusic", Measurement),

    # Get rid of uninterpretable condition labels
    Cond = ifelse(Cond > 3, Cond - 3, Cond),

    # Get rid of uninterpretable condition labels
    MusicCondition = factor(Cond, levels = 1:3, labels = c("Anger", "Exciting", "Neutral"))
    )
```

```
# Note: You can also do steps 3 and 4 (Cond and MusicCondition) in one step with the followi
# MusicCondition = factor(ifelse(Cond > 3, Cond - 3, Cond),
#                          levels = 1:3, labels = c("Anger", "Exciting", "Neutral"))

# Instead of passing in the already-modified "Cond" column, this changes the Cond values and
# those changed values to create the Music Condition levels.

# I prefer to go one step at a time for readability and teaching purposes, but I figured I w
```

Now you can help! For the rating dataset, write a test on a measurement name, using `grepl` or `%in%` to figure out whether it's a recall or a music rating. Your new `IsRecall` column should be true if the measurement name contain either "Friends" or "Strangers".

```
rating_hyp_long_d = rating_hyp_long_d |>
  mutate(
    IsRecall = grepl("Friends|Strangers", Measurement)
  )
```

Here are a couple other useful ways of manipulating columns. (You won't remember all the functions you see here now, but that's okay. You can always reference this tutorial later if there's something you need to figure out how to do.)

```
rating_hyp_long_d = rating_hyp_long_d |>
  mutate(
    # Pulls out the game number
    GameNumber = as.numeric(substr(rating_hyp_long_d$Measurement, 5, 5)),

    # We can then use that new GameNumber Column right away
    # Games 1 and 2 are confrontational, Games 3 and 4 are not
    ConfrontationalGame = GameNumber <= 2,

    # Now that we have added the game number and whether it is confrontational elsewhere,
    # we can just pull out the emotion! Let's do it in two steps:

    # Grab the string of emotions
    Emotion = str_extract(Measurement, "Angry|Neutral|Excited|Exciting|Calm"),

    # Clean up annoying labeling using TWO ifelse statements

    # The data uses "Excited" and "Exciting" to describe the same music
    # Similar with "Calm" and "Neutral"
    Emotion = ifelse(Emotion == "Excited", "Exciting",
              ifelse(Emotion == "Calm", "Neutral", Emotion))
    )
```

Groups, Summaries, and Results

Performance Hypothesis

For the performance data, we need to do a little bit of manipulation of the columns in order to get to the performance measures the experimenters actually used. Because they want to compare changes in performance across games that have very different scoring systems, the easiest solution is to compare z-scores. The way they did this was to z-score performance before music, z-score performance after music, and then create a difference measure which is a difference of z-scores. (To my mind, this is actually not quite the correct way to analyze this data, but like the replication we will follow the original authors.)

We'll add a new z-scored value column. However, we have to be careful! We want to z-score within *groups* of the rows, that are all the same type of measurement. For example, we want to z-score the "DinnerDashWithMusic" scores with respect to eachother, but **not** with respect to the scores from the other game, for example. We can use the `group_by` function to set groups, and then all the changes we apply will only occur within those groups until we `ungroup` the dataset.

To make this more concrete, let's see how the `group_by` function can let us compute means within different groups, for example mean scores on the two different games.

```
performance_hyp_long_d |>
  group_by(ConfrontationalGame, WithMusic) |>
  summarize(AvgScore = mean(Score, na.rm=T)) # the na.rm tells R to ignore NA values
```

```
`summarise()` has grouped output by 'ConfrontationalGame'. You can override
```

```
using the `.groups` argument.
```

```
# A tibble: 4 x 3
# Groups:   ConfrontationalGame [2]
  ConfrontationalGame WithMusic AvgScore
  <lgl>               <lgl>        <dbl>
1 FALSE               FALSE       4687.
2 FALSE               TRUE        5930.
3 TRUE                FALSE         20.6
4 TRUE                TRUE          24.1
```

This makes it clear why we can't just z-score the games together! The scores are very different between games. So let's z-score within groups (using the `scale` function):

```
performance_hyp_long_d = performance_hyp_long_d |>
  group_by(ConfrontationalGame, WithMusic) |> # we're going to compute four sets of z-scores
  mutate(z_scored_performance = scale(Score)) |>
  ungroup()
```

Rating Hypothesis

The rating hypothesis analysis also requires some grouped manipulation. The experimenters collected repeated measures on ratings in each emotion category and each music/recall category from each game. For this analysis, they averaged all the ratings over the following two variables: the given emotion and the game type, to produce a nice summary. Your job is to implement this, calling the new variable MeanRating, and save the summarized data in a new data frame called `rating_summary_d`. (Hint: use a `group_by` and a `summarize`.)

```
rating_summary_d = rating_hyp_long_d |>
  group_by(Emotion, ConfrontationalGame)|>
  summarize(MeanRating = mean(Rating, na.rm=T), .groups = "keep")
```

Let's take a look at the result:

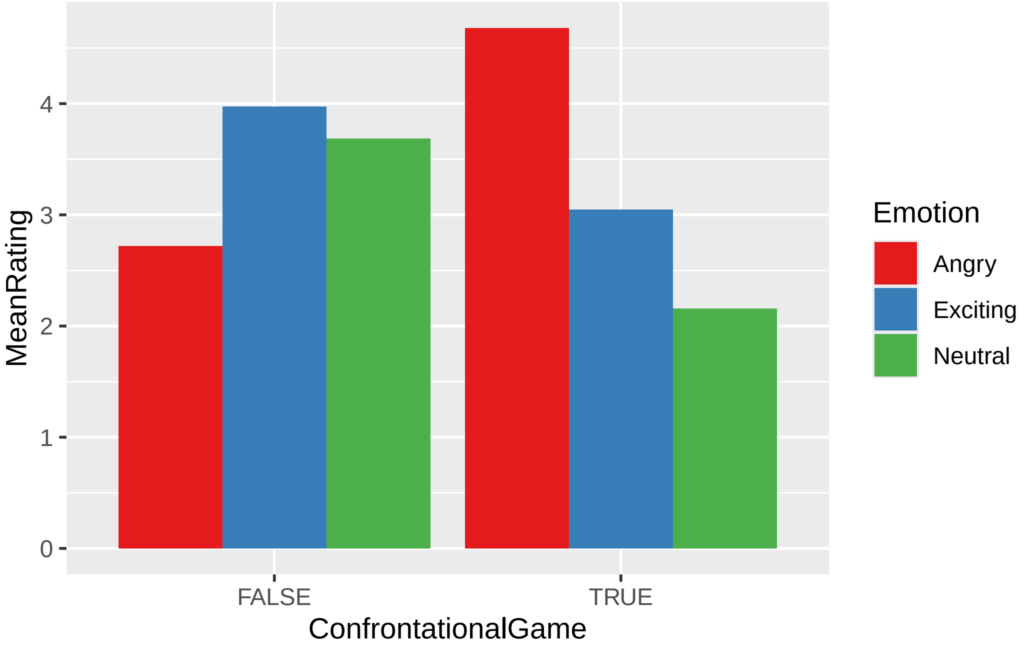
```
rating_summary_d
```

```
# A tibble: 6 x 3
# Groups:   Emotion, ConfrontationalGame [6]
  Emotion  ConfrontationalGame MeanRating
  <chr>    <lgl>                    <dbl>
```

```
1 Angry    FALSE                         2.72
2 Angry    TRUE                          4.68
3 Exciting FALSE                         3.97
4 Exciting TRUE                          3.05
5 Neutral  FALSE                         3.68
6 Neutral  TRUE                          2.16
```

And a simple bar plot (don't worry too much about what exactly this code is doing):

```
ggplot(rating_summary_d, aes(x=ConfrontationalGame, y=MeanRating, fill=Emotion)) +
  geom_bar(position="dodge", stat="identity") +
  scale_fill_brewer(palette="Set1")
```



Up to reordering (and the fact that we didn't compute error bars), this is a pretty decent replication of Fig. 1 from the original Tamir et al. paper. The ratings were highest for Angry in the confrontational game, and lowest for Angry in the non-confrontational game.

Performance Hypothesis (Continued)

There are still a few more steps to go for the performance hypothesis. We need to take a difference score to see how people improved from before hearing the music to after, and then see if the improvement is larger if they heard music congruent with the type of game.

To compute the difference score, we have to make our data a bit wider. We now want to subtract the pre-music scores from the post-music scores, which is easiest to do if they are in two different columns. To do this we'll use the `pivot_wider` function (which is more or less the opposite of `pivot_longer`)

```
performance_diff_d = performance_hyp_long_d |>
  # re-label variable so code is easier to read
  mutate(WithMusic = factor(WithMusic, levels=c(F, T), labels=c("PreMusic", "PostMusic"))) |
  # now we remove columns we don't need (why might this be?)
  select(-c("Score", "Measurement")) |>
  pivot_wider(names_from=WithMusic,
              values_from=z_scored_performance) |>
  mutate(ImprovementScore=PostMusic-PreMusic)
```

Let's take a look at the end result:

```
performance_diff_d
```

```
# A tibble: 94 x 7
   Subject  Cond ConfrontationalGame MusicCondition PostMusic[,1] PreMusic[,1]
     <dbl> <dbl> <lgl>               <fct>                  <dbl>        <dbl>
 1       1     2 FALSE               Exciting             -0.150         0.265
 2       1     2 TRUE                Exciting             -1.30          0.317
 3       3     1 FALSE               Anger                -0.844        -2.91
 4       3     1 TRUE                Anger                -0.283        -1.29
 5       6     3 FALSE               Neutral               0.679         0.975
 6       6     3 TRUE                Neutral              -0.0272        0.546
 7       9     2 FALSE               Exciting              0.770         1.50
 8       9     2 TRUE                Exciting             -2.07         -0.599
 9      10     1 FALSE               Anger                -0.678        -1.44
10      10     1 TRUE                Anger                -0.0272       -1.06
# i 84 more rows
# i 1 more variable: ImprovementScore <dbl[,1]>
```

If you don't understand every step of that code (or any other `dplyr` code), it can be helpful to look at the result of running just the first line, then just the first two lines, and so on.

Now we're finally to reproduce Fig. 2 from Tamir et al., we just need to get the mean differences within each game and each kind of music, and save them to a variable called `MeanImprovementScore`:

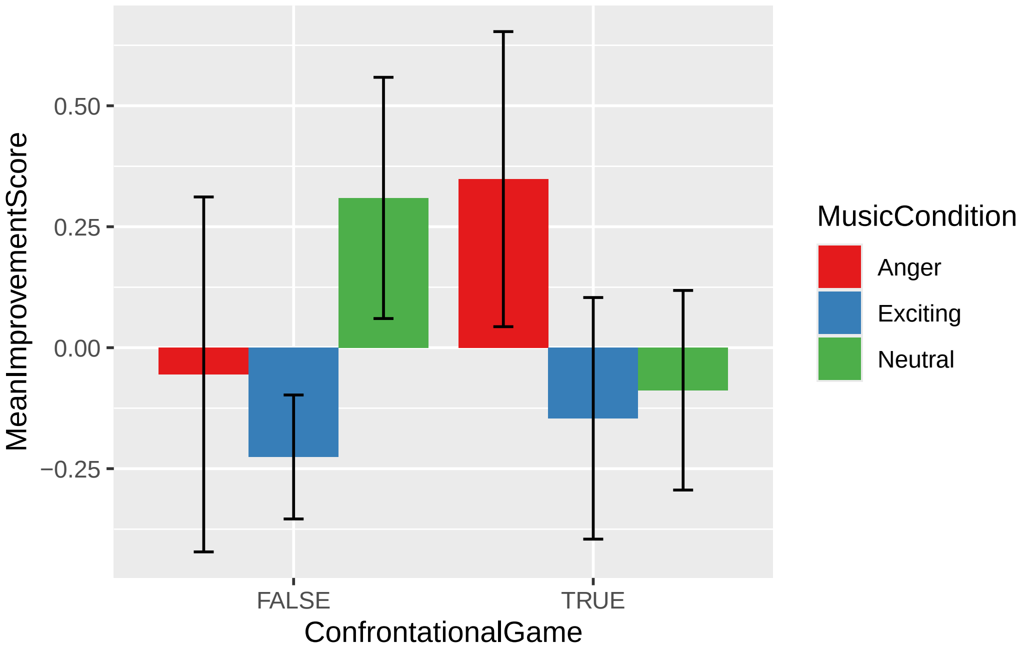
```
performance_summary_d = performance_diff_d |>
  group_by(MusicCondition, ConfrontationalGame)|>
  summarize(MeanImprovementScore = mean(ImprovementScore, na.rm=T),
            sd = sd(ImprovementScore),
            n = n(),
            se = sd/sqrt(n),
            .groups = "keep")
```

```
performance_summary_d
```

```
# A tibble: 6 x 6
# Groups:   MusicCondition, ConfrontationalGame [6]
  MusicCondition ConfrontationalGame MeanImprovementScore    sd     n    se
  <fct>          <lgl>                              <dbl> <dbl> <int> <dbl>
1 Anger          FALSE                            -0.0552 1.27     12 0.367
2 Anger          TRUE                              0.348  1.06     12 0.305
3 Exciting       FALSE                            -0.226  0.558    19 0.128
4 Exciting       TRUE                             -0.146  1.09     19 0.250
5 Neutral        FALSE                             0.310  0.997    16 0.249
6 Neutral        TRUE                             -0.0879 0.825    16 0.206
```

and plot it!

```
ggplot(performance_summary_d, aes(x=ConfrontationalGame, y=MeanImprovementScore, fill=MusicCo
  geom_bar(position="dodge", stat= "identity") +
  geom_errorbar(aes(ymin = MeanImprovementScore - se, ymax=MeanImprovementScore + se),
    position = position_dodge(0.9), width = 0.2) +
  scale_fill_brewer(palette="Set1")
```



(Bonus: also calculate the SEM in the summary data, and then add errorbars to the plot with `geom_errorbar`!)

Not quite as exact a replication of the effect as Fig. 1. This concurs with the replication report, which says that the hypothesis 1 effect replicated, but hypothesis 2 did not.