Here we have it, the last meet of the State-Off semi-final round, where California (1) takes on the Cinderella story that is Pennsylvania (5) for a trip to the finals. Don't forget to update your version of `SwimmeR` to 0.4.1, because we'll be using some newly released functions. We'll also do some more plotting/data-vis and use `prop.test` to do some statistical work with the results, this time looking at grade distributions across events.

```
library(SwimmeR)
library(dplyr)
library(purrr)
library(tidyr)
library(stringr)
library(flextable)
library(ggplot2)
```

My `flextable` styling function is still working great sicne I made it [last week](#) so why mess with a good thing? Here it is again.

```
flextable_style <- function(x) {
  x %>%
    flextable() %>%
    bold(part = "header") %>% # bolds header
    bg(bg = "#D3D3D3", part = "header") %>% # puts gray background behind the
header row
    autofit()
}
```

Getting Results

[As discussed previously](#) we'll just grab clean results that I'm hosting on github rather than going through the exercise of reimporting them with `SwimmeR`.

```
California_Link <-
  "https://raw.githubusercontent.com/gpilgrim2670/Pilgrim_Data/master/CA_States_2019.csv"
California_Results <- read.csv(url(California_Link)) %>%
  mutate(State = "CA")

Pennsylvania_Link <-
  "https://raw.githubusercontent.com/gpilgrim2670/Pilgrim_Data/master/PA_States_2020.csv"
Pennsylvania_Results <- read.csv(url(Pennsylvania_Link)) %>%
  mutate(State = "PA")

Results <- California_Results %>%
  bind_rows(Pennsylvania_Results) %>%
  mutate(Gender = case_when(
    str_detect(Event, "Girls") == TRUE ~ "Girls",
    str_detect(Event, "Boys") == TRUE ~ "Boys"
  )) %>%
  filter(str_detect(Event, "Swim-off") == FALSE)
```

Scoring the Meet

```
Results_Final <- results_score(
  results = Results,
  events = unique(Results$Event),
  meet_type = "timed_finals",
  lanes = 8,
```

```
  scoring_heats = 2,
  point_values = c(20, 17, 16, 15, 14, 13, 12, 11, 9, 7, 6, 5, 4, 3, 2, 1)
)

Scores <- Results_Final %>%
  group_by(State, Gender) %>%
  summarise(Score = sum(Points))

Scores %>%
  arrange(Gender, desc(Score)) %>%
  ungroup() %>%
  flextable_style()
```

State	Gender	Score
CA	Boys	1641
PA	Boys	684
CA	Girls	1629
PA	Girls	696

```
Scores %>%
  group_by(State) %>%
  summarise(Score = sum(Score)) %>%
  arrange(desc(Score)) %>%
  ungroup() %>%
  flextable_style()
```

State	Score
CA	3270
PA	1380

Pennsylvania's charmed run through (one round of) the State-Off Tournament has come to an end, with California dominating both the boys and girls meets, and winning the overall handily.

Swimmers of the Meet

Swimmer of the Meet criteria is the same as it's been for the entire State-Off. First we'll look for athletes who have won two events, thereby scoring a the maximum possible forty points. In the event of a tie, where multiple athletes win two events, we'll use All-American standards as a tiebreaker. Will anyone join Lillie Nordmann as a multiple Swimmer of the Meet winner?

```
Cuts_Link <-
  "https://raw.githubusercontent.com/gpilgrim2670/Pilgrim_Data/master/State_Cuts.csv"
Cuts <- read.csv(url(Cuts_Link))

Cuts <- Cuts %>% # clean up Cuts
  filter(Stroke %!in% c("MR", "FR", "11 Dives")) %>% # %!in% is now included in
SwimmeR
  rename(Gender = Sex) %>%
  mutate(
    Event = case_when((Distance == 200 & #match events
                         Stroke == 'Free') ~ "200 Yard Freestyle",
                      (Distance == 200 &
                         Stroke == 'IM') ~ "200 Yard IM",
                      (Distance == 50 &
                         Stroke == 'Free') ~ "50 Yard Freestyle",
```

```
                        (Distance == 100 &
                           Stroke == 'Fly') ~ "100 Yard Butterfly",
                        (Distance == 100 &
                           Stroke == 'Free') ~ "100 Yard Freestyle",
                        (Distance == 500 &
                           Stroke == 'Free') ~ "500 Yard Freestyle",
                        (Distance == 100 &
                           Stroke == 'Back') ~ "100 Yard Backstroke",
                        (Distance == 100 &
                           Stroke == 'Breast') ~ "100 Yard Breaststroke",
                        TRUE ~ paste(Distance, "Yard", Stroke, sep = " ")
    ),

    Event = case_when(
      Gender == "M" ~ paste("Boys", Event, sep = " "),
      Gender == "F" ~ paste("Girls", Event, sep = " ")
    )
  )

Ind_Swimming_Results <- Results_Final %>%
  filter(str_detect(Event, "Diving|Relay") == FALSE) %>% # join
Ind_Swimming_Results and Cuts
  left_join(Cuts %>% filter((Gender == "M" &
                               Year == 2020) |
                              (Gender == "F" &
                                 Year == 2019)) %>%
              select(AAC_Cut, AA_Cut, Event),
            by = 'Event')

Swimmer_Of_Meet <- Ind_Swimming_Results %>%
  mutate(
    AA_Diff = (Finals_Time_sec - sec_format(AA_Cut)) / sec_format(AA_Cut),
    Name = str_to_title(Name)
  ) %>%
  group_by(Name) %>%
  filter(n() == 2) %>% # get swimmers that competed in two events
  summarise(
    Avg_Place = sum(Place) / 2,
    AA_Diff_Avg = round(mean(AA_Diff, na.rm = TRUE), 3),
    Gender = unique(Gender),
    State = unique(State)
  ) %>%
  arrange(Avg_Place, AA_Diff_Avg) %>%
  group_split(Gender) # split out a dataframe for boys (1) and girls (2)
```

Boys

```
Swimmer_Of_Meet[[1]] %>%
  slice_head(n = 5) %>%
  select(-Gender) %>%
  ungroup() %>%
  flextable_style()
```

Name	Avg_Place	AA_Diff_Avg	State
Brownstead, Matt	1.0	-0.050	PA
Mefford, Colby	1.5	-0.027	CA

Name	Avg_Place	AA_Diff_Avg	State
Hu, Ethan	2.0	-0.052	CA
Jensen, Matthew	2.0	-0.038	PA
Faikish, Sean	2.0	-0.032	PA

Turns out yes, Matt Brownstead from Pennsylvania joins Lillie in the multiple winners club. As we discussed previously Matt broke the national high school record in the 50 free, so that guaranteed him one win. He also won the 100 free – the only boy here to win two events. We don't even need to go to the All-American tie breaker, but it is worth noting that Ethan Hu outperformed Matt by that metric. Pennsylvania also managed three of the top five finishers here – very nice!

```
Results_Final %>%
  filter(Name == "Brownstead, Matt") %>%
  select(Place, Name, School, Finals_Time, Event) %>%
  arrange(desc(Event)) %>%
  ungroup() %>%
  flextable_style()
```

Place	Name	School	Finals_Time	Event
1	Brownstead, Matt	State College-06	19.24	Boys 50 Yard Freestyle
1	Brownstead, Matt	State College-06	43.29	Boys 100 Yard Freestyle

---

Girls

```
Swimmer_Of_Meet[[2]] %>%
  slice_head(n = 5) %>%
  select(-Gender) %>%
  ungroup() %>%
  flextable() %>%
  bold(part = "header") %>%
  bg(bg = "#D3D3D3", part = "header") %>%
  autofit()
```

Name	Avg_Place	AA_Diff_Avg	State
Hartman, Zoie	1.0	-0.047	CA
Ristic, Ella	1.0	-0.023	CA
Tuggle, Claire	1.5	-0.031	CA
Delgado, Anicka	1.5	-0.023	CA
Kosturos, Sophi	2.0	-0.021	CA

Zoie Hartman heads a California sweep of the girls swimmer of the meet top 5 while also winning her second swimmer of the meet crown.

```
Results_Final %>%
  filter(Name == "Hartman, Zoie") %>%
  select(Place, Name, School, Finals_Time, Event) %>%
  arrange(desc(Event)) %>%
  ungroup() %>%
  flextable_style()
```

Place	Name	School	Finals_Time	Event
1	Hartman, Zoie	Monte Vista_NCS	1:55.29	Girls 200 Yard IM
1	Hartman, Zoie	Monte Vista_NCS	59.92	Girls 100 Yard Breaststroke

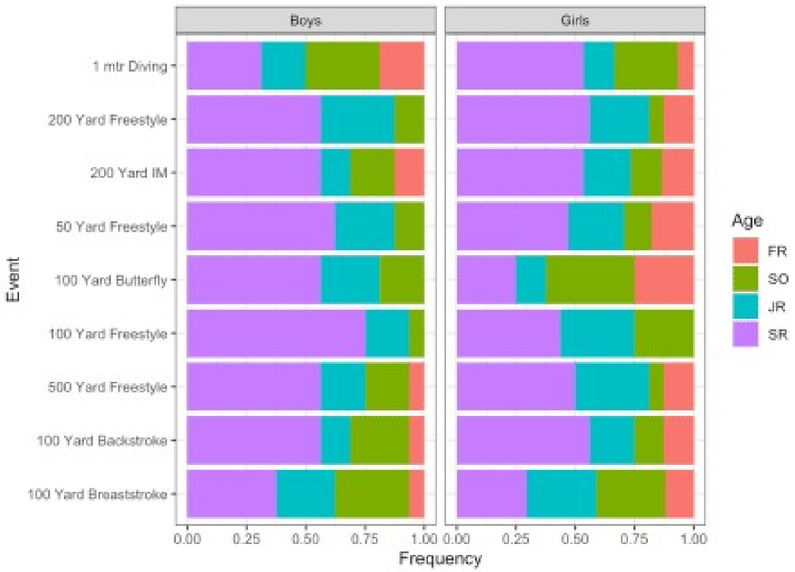
Performances By Grade

It might be interesting to see what fraction of athletes from each grade compete in various events. We might hypothesize that sprint events, like the 50 freestyle in particular, would have a higher percentage of older athletes, who benefit from extra years of growth, muscle development etc. `SwimmeR` can capture grade (or age) values, assuming they're present in the original results. In this case we do have grade values, so let's take a look.

```
Results_Grade <- Results_Final %>%
  filter(is.na(Grade) == FALSE,
         Grade %!in% c("ST", "1")) %>% # remove nonsense values
  mutate(
    Grade = case_when(
      # regularize encoding of grade values
      Grade == "9" ~ "FR",
      Grade == "10" ~ "SO",
      Grade == "11" ~ "JR",
      Grade == "12" ~ "SR",
      TRUE ~ Grade
    )
  ) %>%
  mutate(Grade = factor(Grade, levels = c("FR", "SO", "JR", "SR"))) %>% # factor
to order grade levels
  filter(str_detect(Event, "Relay") == FALSE) %>% # remove relays since they
don't have grades
  mutate(Event = str_remove(Event, "Girls |Boys "),
         Event = factor(Event, levels = rev(unique(
           # order events by meet order, in this case with diving first
           str_remove(unique(Results$Event), "Girls |Boys ")
         ))))

Results_Grade_Sum <- Results_Grade %>%
  group_by(Event, Gender, Grade) %>%
  summarise(Numb = n()) %>% # number of athletes for each event/gender/grade
combintation
  ungroup() %>%
  group_by(Event, Gender) %>%
  mutate(Percentage = Numb / sum(Numb)) # percentage of athletes in each grade
for each event/gender combination

Results_Grade_Sum %>%
  ggplot() +
  geom_col(aes(x = Event, y = Percentage, fill = Grade)) +
  coord_flip() +
  facet_wrap(. ~ Gender) +
  theme_bw() +
  labs(y = "Frequency")
```



That's a lovely plot (if I do say so myself). Interestingly, the 50 freestyle doesn't appear to be the most senior heavy event for boys or girls. It would be nice though to have the data in a table form to aid in taking a closer look, so let's work on that.

Tables

```
# Split results by gender, creating a list of two dataframes
Results_Grade_Gender <- Results_Grade_Sum %>%
  ungroup() %>%
  group_by(Gender) %>%
  group_split()

# function to apply to both dataframes that will produce columns with
percentages for each grade and event
Grade_Fill <- function(x) {
  x <- x %>%
    mutate(Percentage = round(Percentage, 2)) %>%
    pivot_wider(names_from = Grade, values_from = Percentage) %>%
    select(-Numb) %>%
    group_by(Event) %>%
    fill(everything(), .direction = "updown") %>%
    unique() %>%
    mutate(Event = factor(Event, levels = unique(str_remove(unique(
Results$Event), "Girls |Boys ")))) %>%
    mutate_if(is.numeric, ~replace(., is.na(.), 0))

  return(x)
}

# map Grade_Fill function over list of dataframes
Results_Grade_Gender <- Results_Grade_Gender %>%
  map(Grade_Fill)

# print boys table
Results_Grade_Gender[[1]] %>%
  arrange(Event) %>%
  flextable_style()
```

Event	Gender	FR	SO	JR	SR

Event	Gender	FR	SO	JR	SR
1 mtr Diving	Boys	0.19	0.31	0.19	0.31
200 Yard Freestyle	Boys	0.00	0.12	0.31	0.56
200 Yard IM	Boys	0.12	0.19	0.12	0.56
50 Yard Freestyle	Boys	0.00	0.12	0.25	0.62
100 Yard Butterfly	Boys	0.00	0.19	0.25	0.56
100 Yard Freestyle	Boys	0.00	0.06	0.19	0.75
500 Yard Freestyle	Boys	0.06	0.19	0.19	0.56
100 Yard Backstroke	Boys	0.06	0.25	0.12	0.56
100 Yard Breaststroke	Boys	0.06	0.31	0.25	0.38

```
# print girls table
Results_Grade_Gender[[2]] %>%
  arrange(Event) %>%
  flextable_style()
```

Event	Gender	FR	SO	JR	SR
1 mtr Diving	Girls	0.07	0.27	0.13	0.53
200 Yard Freestyle	Girls	0.12	0.06	0.25	0.56
200 Yard IM	Girls	0.13	0.13	0.20	0.53
50 Yard Freestyle	Girls	0.18	0.12	0.24	0.47
100 Yard Butterfly	Girls	0.25	0.38	0.12	0.25
100 Yard Freestyle	Girls	0.00	0.25	0.31	0.44
500 Yard Freestyle	Girls	0.12	0.06	0.31	0.50
100 Yard Backstroke	Girls	0.12	0.12	0.19	0.56
100 Yard Breaststroke	Girls	0.12	0.29	0.29	0.29

There's been a rumor going around that "seniors rule" and I gotta say, these results are pushing me towards believing it. On the boys side seniors have the highest percentage representation in every event (although admittedly tied with sophomores (?) in diving). On the girls side seniors again dominated, although sophomores had the most representatives in the 100 butterfly and the 100 breaststroke was a three way tie between sophomores (again with the sophomores…), juniors and seniors.

Let's check this out a bit further though. We can use `prop.test` to check whether or not a given population proportion matches what we expect. For starters let's define "ruling" as being over represented in an event or in the meet. More formally, we can set up a null hypothesis, where the null value for population proportion (the percentage of athletes in a given event who are seniors) is 0.25. We can then accept or reject that null hypothesis based on a significance level. We'll choose the standard 0.5 as a significance level. Running `prop.test` will give us (among other things) a p value, which we can compare to our significance level. If the p value is less than our significance level of 0.5 we can reject the null hypothesis and conclude that their are more seniors than we would expect. If there are more seniors than than an underlying 1/4 probability would suggest we can confirm an instance of seniors "ruling".

```
Prop_Test_Results <- Results_Grade_Sum %>%
  group_by(Event, Gender) %>%
  mutate(Total_Athletes = sum(Numb)) %>%
  filter(Grade == "SR") %>% # only testing seniors
  rowwise() %>%
  mutate(P_Val = prop.test(Numb, Total_Athletes, p = 0.25)$p.value[1]) # run
prop test and extract p values

Prop_Test_Results_Gender <- Prop_Test_Results %>%
```

```
  ungroup() %>%
  group_by(Gender) %>%
  group_split()
```

We can look at each event for boys and girls, and highlight (in red) p values that are less than our significance value of 0.5, meaning that for those events. We'll collect a list of rows meeting each criteria (greater or less than our significance value) and then use `flextable::bg` to provide the appropriate background fill color.

Please note, the number of athletes in an event can be more than 16 in the event of a tie, or less than 16 for the purposes of this analysis if an athlete didn't have their grade specified.

Boys Proportion Test

```
row_id_accept_boys <- # values where P_Val is greater or equal to than the significance value, should be green, fail to reject null hypothesis
  with(Prop_Test_Results_Gender[[1]], round(P_Val, 2) >= 0.5)
row_id_reject_boys <- # values where P_Val is less than the significance value, should be red, reject null hypothesis
  with(Prop_Test_Results_Gender[[1]], round(P_Val, 2) < 0.5)
col_id <- c("P_Val") # which column to change background color in

Prop_Test_Results_Gender[[1]] %>%
  arrange(rev(Event)) %>%
  flextable_style() %>%
  bg(i = row_id_accept_boys,
     j = col_id,
     bg = "green",
     part = "body") %>%
  bg(i = row_id_reject_boys,
     j = col_id,
     bg = "red",
     part = "body") %>%
  colformat_num(j = "P_Val",
                big.mark = ",",
                digits = 3) %>%
  autofit()
```

Event	Gender	Grade	Numb	Percentage	Total_Athletes	P_Val
1 mtr Diving	Boys	SR	5	0.3125	16	0.773
200 Yard Freestyle	Boys	SR	9	0.5625	16	0.009
200 Yard IM	Boys	SR	9	0.5625	16	0.009
50 Yard Freestyle	Boys	SR	10	0.6250	16	0.001
100 Yard Butterfly	Boys	SR	9	0.5625	16	0.009
100 Yard Freestyle	Boys	SR	12	0.7500	16	0.000
500 Yard Freestyle	Boys	SR	9	0.5625	16	0.009
100 Yard Backstroke	Boys	SR	9	0.5625	16	0.009
100 Yard Breaststroke	Boys	SR	6	0.3750	16	0.386

Girls Proportion Test

```
row_id_accept_girls <- # values where P_Val is greater or equal to than the significance value, should be green, fail to reject null
  with(Prop_Test_Results_Gender[[2]], round(P_Val, 2) >= 0.5)
```

```
row_id_reject_girls <- # values where P_Val is less than the significance value,
should be red, reject null hypothesis
  with(Prop_Test_Results_Gender[[2]], round(P_Val, 2) < 0.5)
col_id <- c("P_Val") # which column to change background color in

Prop_Test_Results_Gender[[2]] %>%
  arrange(rev(Event)) %>%
  flextable_style() %>%
  bg(i = row_id_accept_girls,
     j = col_id,
     bg = "green",
     part = "body") %>%
  bg(i = row_id_reject_girls,
     j = col_id,
     bg = "red",
     part = "body") %>%
  colformat_num(j = "P_Val",
                big.mark = ",",
                digits = 3) %>%
  autofit()
```

Event	Gender	Grade	Numb	Percentage	Total_Athletes	P_Val
1 mtr Diving	Girls	SR	8	0.5333333	15	0.025
200 Yard Freestyle	Girls	SR	9	0.5625000	16	0.009
200 Yard IM	Girls	SR	8	0.5333333	15	0.025
50 Yard Freestyle	Girls	SR	8	0.4705882	17	0.069
100 Yard Butterfly	Girls	SR	4	0.2500000	16	1.000
100 Yard Freestyle	Girls	SR	7	0.4375000	16	0.149
500 Yard Freestyle	Girls	SR	8	0.5000000	16	0.043
100 Yard Backstroke	Girls	SR	9	0.5625000	16	0.009
100 Yard Breaststroke	Girls	SR	5	0.2941176	17	0.889

Overall Proportion Test

In 15/18 (0.83%) of events the p-value is less than 0.5, meaning we can reject the null hypothesis for those events. There really are more seniors than a simple 1/4 probability would indicate, so in 83% of events seniors really do rule. We can also check for the whole meet:

```
Results_Grade_Sum %>%
  ungroup() %>%
  mutate(Total_Athletes = sum(Numb)) %>%
  filter(Grade == "SR") %>%
  mutate(Total_Seniors = sum(Numb)) %>%
  select(Total_Seniors, Total_Athletes) %>%
  unique() %>%
  mutate(P_Val = prop.test(Total_Seniors, Total_Athletes, p = 0.25)$p.value[1])
%>%
  flextable_style()
```

Total_Seniors	Total_Athletes	P_Val
144	288	2.24775e-22

The p value (2.24e-22) is much less than 0.5 so we can reject the null hypothesis and conclude that at least as far as this meet is concerned seniors really do rule. Now if only there was some way to find out if O'Doyle also actually rules…

In Closing

Many thanks to all of you for joining us in another round of the State-Off here at Swimming + Data Science. Next week the final State-Off Champion will be crowned. Let's update our bracket and prepare ourselves for a 1-2 matchup between California (1) and Texas (2)!

```
draw_bracket(
  teams = c(
    "California",
    "Texas",
    "Florida",
    "New York",
    "Pennsylvania",
    "Illinois",
    "Ohio",
    "Georgia"
  ),
  round_two = c("California", "Texas", "Florida", "Pennsylvania"),
  round_three = c("California", "Texas"),
  title = "Swimming + Data Science High School Swimming State-Off",
  text_size = 0.9
)
```