Validation results

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```
# get total # of clips from each recording
complete2 <- complete %>%
  group_by(id) %>%
  distinct(file_name, .keep_all = T) %>%
  mutate(num_clips = NROW(Media)*2)

clips <- complete2 %>%
  select(id, num_clips) %>%
  distinct(id, .keep_all = T)

data <- merge(clips, random, by='id')
data2 <- rbind(data, complete2)
```

```
data3 <- data2 %>%
  group_by(method, id) %>%
  mutate(num_clips_drawn = (NROW(file_name))) %>%
  mutate(percen_ofallclips_drawn=(NROW(file_name)/num_clips)*100) # sanity check - complete method shou
```

```
data_annon <- data3 %>%
 gather("addressee", "language", Adult2OtherChild, Adult2Others, Adult2TargetChild, Adult2unsure, Other
  filter(language=='Mixed' | language=='Spanish' | language=='English/Quechua' | language =='Unsure') %
  group_by(id, method) %>%
  distinct_at(., vars(file_name, language), .keep_all = T) %>% # don't record multiple speakers speakin
  mutate(total_annotations = NROW(file_name)) # N of annotations made; distinct from N of speech clips

# separately, calculate the num and % of annotated clips
data_annon_cts <- data_annon %>%
  group_by(id, method) %>%
  distinct(file_name, .keep_all = T) %>%
  mutate(speech_clips = NROW(file_name)) %>% # N of unique clips annotated - NOT the # of annotations
  mutate(percen_ofallclips_annon=(NROW(file_name)/num_clips)*100) %>% # % of total clips annotated
  select(speech_clips, percen_ofallclips_annon, id, method, file_name, num_clips_drawn, percen_ofallcli


for_speech_clips <- data_annon_cts %>%
  select(id, method, speech_clips) %>%
  distinct_at(., vars(id, method), .keep_all = T)

# first load in the complete files so we can estimate the # of available clips
all <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Meg_data/1032_config.csv')
all2 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Meg_data/1060_config.csv')
all3 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Meg_data/1075_config.csv')
```

```
all4 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Meg_data/1077_config.csv')
all5 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Meg_data/1081_config.csv')
all6 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Anele_data/179config.csv')
all7 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Anele_data/198config.csv')
all8 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Anele_data/199config.csv')
all9 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Anele_data/261config.csv')
all10 <- read.csv('/Users/megcychosz/Google Drive/biling_CDS/Anele_data/267config.csv')
config_files <- rbind(all, all2, all3, all4, all5, all6, all7, all8, all9, all10)

# calculate the num and % of all clips available for annotation
data_avbl <- config_files %>%
  group_by(id) %>%
  distinct(file_name, .keep_all = T) %>% # duplicates bc drawn with replacement
  mutate(voc = if_else(percents_voc > 0, "1", "0")) %>% # turn percents_voc binary
  filter(sleeping=='1' | researcher_present == '1' | voc == '0') %>%
  count() %>%
  rename(not_avl_clips = n) %>%
  merge(., data_annon, by=c('id')) %>%
  mutate(avbl_clips = num_clips - not_avl_clips) %>% # clips that were *available* for annotation out o
  merge(., for_speech_clips, by=c('id', 'method')) %>% # N of unique clips annotated - NOT the # of ann
  mutate(percen_avl_annon = (speech_clips / avbl_clips)*100) %>% # the # of clips annotated / # of avbl
  distinct_at(., vars(id, method), .keep_all = T) %>%
  group_by(method) %>%
  mutate(avbl_clips = paste(speech_clips, "(",round(percen_avl_annon,2),"%)")) %>%
  ungroup()%>%
  select(avbl_clips, id, method) %>%
  pivot_wider(names_from=method, values_from=c("avbl_clips"))
```

```
percen_tbl <- data_annon_cts %>%
  select(-file_name) %>%
  distinct_at(., vars(id,method), .keep_all = T) %>%
  mutate(clips_drawn = paste(num_clips_drawn,"(",round(percen_ofallclips_drawn,2),"%)")) %>%
  mutate(clips_annon = paste(speech_clips,"(",round(percen_ofallclips_annon,2),"%)")) %>%
  select(-num_clips_drawn, -percen_ofallclips_annon, -speech_clips, -percen_ofallclips_drawn) %>%
  relocate(c(id, method, clips_drawn, clips_annon)) %>%
  pivot_wider(names_from=method, values_from=c("clips_drawn", "clips_annon")) %>%
  merge(., data_avbl, by=c('id'))

percen_tbl$id <- plyr::mapvalues(percen_tbl$id,
                                 from=c('267-12mo', '261-8mo', '199', '198-9mo', '179', '1081', '1077',
           to=c('Spanish-English (267)', 'Spanish-English (261)','Spanish-English (199)',
  'Spanish-English (198)', 'Spanish-English (179)', 'Quechua-Spanish (1081)', 'Quechua-Spanish (1077)',

# actually decided to split this table and move part to the appendix
clip_annon_tbl <- percen_tbl %>%
  select(id, clips_annon_random, clips_annon_complete) %>%
  arrange(desc(id))

knitr::kable(clip_annon_tbl, caption = 'Number of clips annotated by child and annotation method.',
             booktabs=T,
             row.names = FALSE,
             col.names = c("Corpus (ID)", "Random", "Complete")) %>% # "
  kable_styling() %>%
```

```
  add_header_above(c(" " = 1, "# of clips annotated (% of total clips)" = 2)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

\begin{table}[!h]
\caption{(#tab:% drawn and annotated table)Number of clips annotated by child and annotation method.}

	# of clips annotated (% of total clips)	
Corpus (ID)	Random	Complete
Spanish-English (267)	101 (5.26 %)	274 (14.27 %)
Spanish-English (261)	92 (4.79 %)	294 (15.31 %)
Spanish-English (199)	118 (6.15 %)	467 (24.32 %)
Spanish-English (198)	81 (4.22 %)	302 (15.73 %)
Spanish-English (179)	120 (6.25 %)	633 (32.97 %)
Quechua-Spanish (1081)	92 (7.5 %)	285 (23.25 %)
Quechua-Spanish (1077)	83 (7.23 %)	355 (30.92 %)
Quechua-Spanish (1075)	81 (8.69 %)	199 (21.35 %)
Quechua-Spanish (1060)	111 (10.51 %)	405 (38.35 %)
Quechua-Spanish (1032)	97 (5.05 %)	372 (19.38 %)

\end{table}

```
clip_drawn_avbl_tbl <- percen_tbl %>%
  select(-clips_annon_random, -clips_annon_complete) %>%
  relocate(id, clips_drawn_random, clips_drawn_complete, random, complete) %>%
  arrange(desc(id))

knitr::kable(clip_drawn_avbl_tbl, caption = 'Number of clips drawn and number of clips annotated, by ch
             booktabs=T,
             row.names = FALSE,
             col.names = c("Corpus (ID)", "Random", "Complete", "Random", "Complete")) %>% # "
  kable_styling() %>%
  add_header_above(c(" " = 1, "# of clips drawn (% of total clips)" = 2, "# of clips annotated (% of ava
  kableExtra::kable_styling(latex_options = "hold_position")
```

\begin{table}[!h]
\caption{(#tab:% drawn and annotated table)Number of clips drawn and number of clips annotated, by child and annotation method.}

	# of clips drawn (% of total clips)		# of clips annotated (% of available clips)	
Corpus (ID)	Random	Complete	Random	Complete
Spanish-English (267)	345 (17.97 %)	960 (50 %)	101 (13.1 %)	274 (35.54 %)
Spanish-English (261)	290 (15.1 %)	960 (50 %)	92 (8.18 %)	294 (26.13 %)
Spanish-English (199)	192 (10 %)	960 (50 %)	118 (10.61 %)	467 (42 %)
Spanish-English (198)	284 (14.79 %)	960 (50 %)	81 (7.96 %)	302 (29.67 %)
Spanish-English (179)	192 (10 %)	960 (50 %)	120 (8.05 %)	633 (42.48 %)
Quechua-Spanish (1081)	249 (20.31 %)	613 (50 %)	92 (13.83 %)	285 (42.86 %)
Quechua-Spanish (1077)	137 (11.93 %)	574 (50 %)	83 (8.15 %)	355 (34.84 %)
Quechua-Spanish (1075)	267 (28.65 %)	466 (50 %)	81 (14.21 %)	199 (34.91 %)
Quechua-Spanish (1060)	154 (14.58 %)	528 (50 %)	111 (12.01 %)	405 (43.83 %)
Quechua-Spanish (1032)	263 (13.7 %)	960 (50 %)	97 (10.16 %)	372 (38.95 %)

\end{table}

0.0.1 Language categories across random and full methods

```
lang_annon <- data_annon %>%
  filter(language=='Mixed' | language=='Spanish' | language=='English/Quechua') %>% # only clips where
  group_by(id, method) %>%
  distinct_at(., vars(file_name, language), .keep_all = T) %>% # don't record multiple speakers speakin
  mutate(total_lang_annotations = NROW(file_name)) # N of language annotations made; distinct from N of

que <- lang_annon %>%
  group_by(id, method) %>%
  filter(language=='English/Quechua') %>%
  group_by(method) %>%
  distinct(file_name, .keep_all = T) %>%
  group_by(id, method) %>% # irrespective of speaker/addressee; by-child only
  mutate(n_que=n()) %>%
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_que = n_que / total_lang_annotations) # compute que/eng ratio

span <- lang_annon %>%
  group_by(id, method) %>%
  filter(language=='Spanish') %>%
  group_by(method) %>%
  distinct(file_name, .keep_all = T) %>%
  group_by(id, method) %>%
  mutate(n_span = n())  %>%
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_span = n_span / total_lang_annotations) # compute span ratio

mixed <- lang_annon %>%
  group_by(id, method) %>%
  filter(language=='Mixed') %>%
  group_by(method) %>%
  distinct(file_name, .keep_all = T) %>%
  group_by(id, method) %>%
  mutate(n_mxd = n())  %>%
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_mxd = n_mxd / total_lang_annotations) # compute mixed ratio
```

```
# now simulate 100 minority lang estimates from each child
# take however many clips were used to compute the randomly-sampled estimate
# then compute the prop. of those that are spanish/quechua
# repeat 100X

# total_reg_annotations refers to the # of clips used to estimate language prop
# get that variable
random_lang_clips <- lang_annon %>%
  filter(method=='random') %>%
  distinct_at(., vars(id), .keep_all = T) %>%
  ungroup() %>%
  select(id, total_lang_annotations)

sim_lang_data <- lang_annon %>%
  filter(method=='complete') %>% # we're only sampling from all-day annotations
```

```
  select(-total_lang_annotations) %>% # this is the # of all-day clips annotated and we want # of rando
  merge(., random_lang_clips, by='id') %>%
  group_by(id) %>%
  replicate(100, ., simplify = FALSE) %>% # simulate 100 collections of random clips
  map_dfr(~ sample_n(., total_lang_annotations), .id = "simulation") # sample the same # of clips per s

# now compute the Quechua estimate for the Bolivia corpus
que_sim_results <- sim_lang_data %>%
  filter(language=='English/Quechua' & location=='Bolivia') %>%
  group_by(id, simulation) %>%
  distinct(file_name, .keep_all = T) %>%
  mutate(n_que=n()) %>%
  distinct(id, .keep_all = T) %>%
  mutate(percen_que = n_que / total_lang_annotations) # compute que/to all else

# and the Spanish estimate for the US corpus
span_sim_results <- sim_lang_data %>%
  filter(language=='Spanish' & location=='US') %>%
  group_by(id, simulation) %>%
  distinct(file_name, .keep_all = T) %>%
  mutate(n_span=n()) %>%
  distinct(id, .keep_all = T) %>%
  mutate(percen_span = n_span / total_lang_annotations) # compute span/to all else

# now some descriptive stats from those results
# by corpus
que_sim_stats <- que_sim_results %>%
  ungroup() %>%
  summarize(mean_sim_que = round(mean(percen_que),2),
         sd_sim_que = round(sd(percen_que),2),
         min_sim_que = round(range(percen_que)[1],2),
         max_sim_que = round(range(percen_que)[2],2)) %>%
  mutate(sim_stat = paste(mean_sim_que,"(",sd_sim_que,")",min_sim_que,"-",max_sim_que)) %>%
  select(sim_stat)

span_sim_stats <- span_sim_results %>%
  ungroup() %>%
  summarize(mean_sim_span = round(mean(percen_span),2),
         sd_sim_span = round(sd(percen_span),2),
          min_sim_span = round(range(percen_span)[1],2),
         max_sim_span = round(range(percen_span)[2],2)) %>%
  mutate(sim_stat = paste(mean_sim_span,"(",sd_sim_span,")",min_sim_span,"-",max_sim_span)) %>%
  select(sim_stat)

# now the spanish estimate by individual child in US corpus
span_sim_child_stats <- span_sim_results %>%
  group_by(id) %>%
  summarize(mean_sim_span = round(mean(percen_span),2),
         sd_sim_span = round(sd(percen_span),2),
         min_sim_span = round(range(percen_span)[1],2),
         max_sim_span = round(range(percen_span)[2],2)) %>%
  mutate(sim_stat_child = paste(mean_sim_span,"(",sd_sim_span,")",min_sim_span,"-",max_sim_span)) %>%
  select(id, sim_stat_child)
```

```
vars <- data_annon_cts %>%
  select(percen_ofallclips_drawn, id, method) %>%
  colnames(.)

final_data <- span %>%
  merge(., data_annon_cts, by=vars) %>%
  select(id, num_clips, age_YYMMDD, gender, location, method, percen_span, speech_clips, percen_ofallcl

final_data2 <-
  merge(final_data, que, by=c('id', 'method', 'percen_ofallclips_drawn', 'gender', 'location', 'num_cli
  select(id, gender, location, method, percen_span, percen_que, num_clips, percen_ofallclips_drawn, spe

plot_data <-
  merge(final_data2, mixed, by=c('id', 'method', 'percen_ofallclips_drawn', 'gender', 'location', 'num_
  select(id, gender, location, method, percen_span, percen_que, percen_mxd, num_clips, percen_ofallclip

# sanity check: calculate percen mixed + spanish + english/quechua
plot_data$total <- plot_data$percen_mxd + plot_data$percen_span + plot_data$percen_que
```

```
# compute correlations
us_cor <- plot_data %>%
  distinct_at(., vars(method, id), .keep_all = T) %>%
  select(method, id, percen_span, location) %>%
  spread("method", "percen_span") %>%
  filter(location=='US') %>%
  summarize(., paste("r=",round(cor.test(complete, random)$estimate,2),",","p=",round(cor.test(complete

bo_cor <- plot_data %>%
  distinct_at(., vars(method, id), .keep_all = T) %>%
  select(method, id, percen_que, location) %>%
  spread("method", "percen_que") %>%
  filter(location=='Bolivia') %>%
  summarize(., paste("r=",round(cor.test(complete, random)$estimate,2),",","p=",round(cor.test(complete

# compute avg. %s of target lang categories
us_lang_tbl <- plot_data %>%
  filter(location=='US') %>%
  group_by(method) %>%
  summarize(avg=round(mean(percen_span),2),
            sd=round(sd(percen_span),2)) %>%
  mutate(stats=paste(avg,"(",sd,")")) %>%
  select(-avg, -sd) %>%
  spread(key='method', value = "stats")

bo_lang_tbl <- plot_data %>%
  filter(location=='Bolivia') %>%
  group_by(method) %>%
  summarize(avg=round(mean(percen_que),2),
            sd=round(sd(percen_que),2)) %>%
  mutate(stats=paste(avg,"(",sd,")")) %>%
  select(-avg, -sd) %>%
  spread(key='method', value = "stats")
```

```r
# calculate relative errors
us_rel_error <- plot_data %>%
  filter(location=='US') %>%
  group_by(method, id) %>%
  summarize(avg=mean(percen_span)) %>%
  spread(key='method', value='avg') %>%
   mutate(relative_error = ((abs((random - complete)) / complete)*100),
          avg_rel_error = round(mean(relative_error),2),
          sd_rel_error = round(sd(relative_error),2)) %>%
  mutate(rel_error_stats=paste(avg_rel_error,"(",sd_rel_error,")")) %>%
  distinct(rel_error_stats)

bo_rel_error <- plot_data %>%
  filter(location=='Bolivia') %>%
  group_by(method, id) %>%
  summarize(avg=mean(percen_que)) %>%
  spread(key='method', value='avg') %>%
  mutate(relative_error = ((abs((random - complete)) / complete)*100),
          avg_rel_error = round(mean(relative_error),2),
          sd_rel_error = round(sd(relative_error),2)) %>%
  mutate(rel_error_stats=paste(avg_rel_error,"(",sd_rel_error,")")) %>%
  distinct(rel_error_stats)

# add correlations to table - will make pretty below
us_lang_tbl2 <- cbind(us_lang_tbl, us_cor) %>%
  cbind(., us_rel_error) %>%
  cbind(., span_sim_stats) %>%
  mutate(Corpus = "Spanish-English (Spanish)") %>%
  relocate(c(Corpus, random, complete, rel_error_stats, sim_stat))

bo_lang_tbl2 <- cbind(bo_lang_tbl, bo_cor) %>%
  cbind(., bo_rel_error) %>%
  cbind(., que_sim_stats) %>%
  mutate(Corpus = "Quechua-Spanish (Quechua)") %>%
  relocate(c(Corpus, random, complete, rel_error_stats, sim_stat))

lang_tbl <- rbind(us_lang_tbl2, bo_lang_tbl2)
```

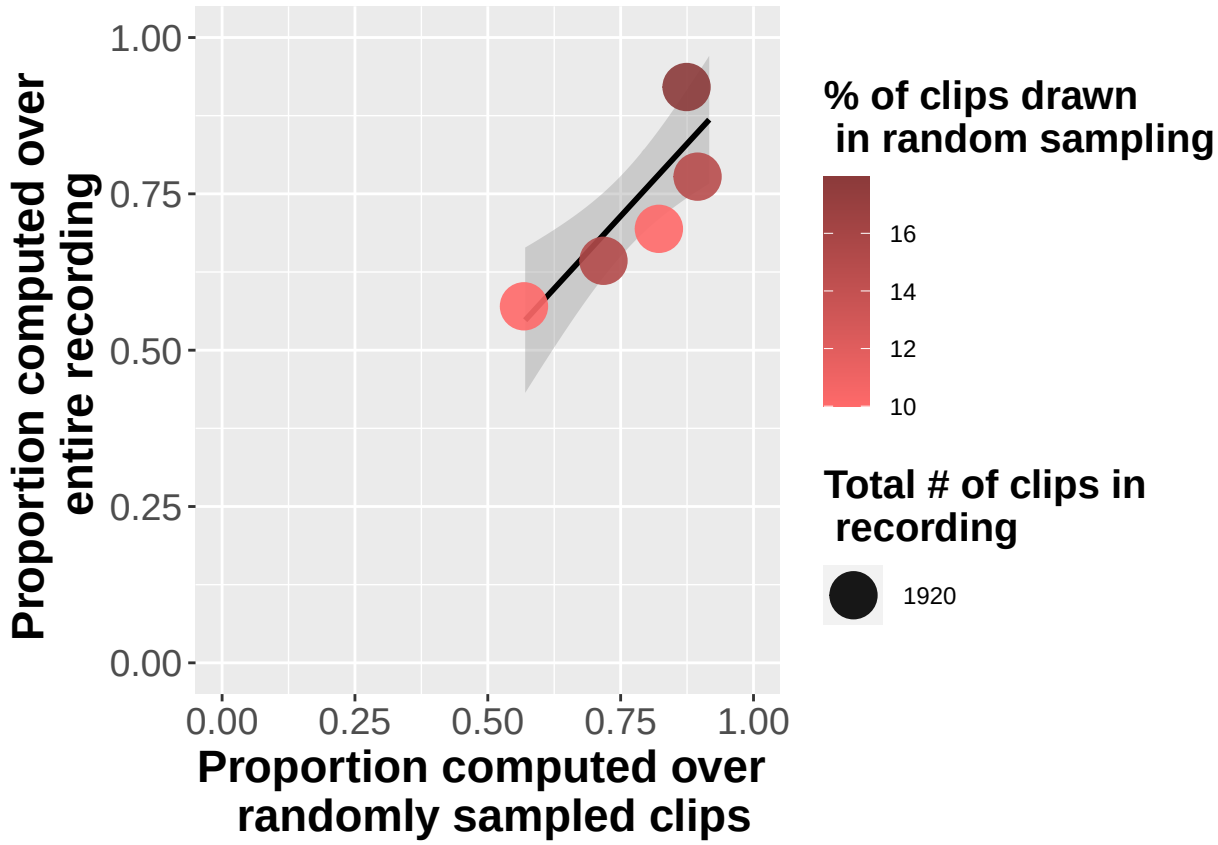
```r
knitr::kable(lang_tbl, caption = 'Average minority language estimates by corpus and annotation method.'
             booktabs=T,
             row.names = FALSE,
             col.names = c("Corpus (language)", "Random", "All-day", "Avg. relative error (SD)", "n=100
  column_spec(1, width = "5.5cm") %>%
    column_spec(4, width = "3cm") %>%
  column_spec(5:6, width = "4cm") %>%
  kable_styling() %>%
  add_header_above(c(" " = 1, "Annotation Method" = 2, " " = 3)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

```r
# for later
per_ann <- plot_data %>%
  filter(method=='random') %>%
  select(id, percen_ofallclips_drawn)
```

Table 1: (#tab:generate lang tables)Average minority language estimates by corpus and annotation method.

Corpus (language)	Annotation Method		Avg. relative error (SD)	n=100 simulations of random sampling Avg. (SD) Range	Cor esti
	Random	All-day			
Spanish-English (Spanish)	0.75 (0.13)	0.69 (0.12)	5.36 (4.82)	0.73 (0.13) 0.46 - 0.98	r=
Quechua-Spanish (Quechua)	0.48 (0.11)	0.5 (0.12)	11.02 (4.28)	0.48 (0.13) 0.22 - 0.75	r=

```
us_plot <- plot_data %>%
  filter(location=='US') %>%
  distinct_at(., vars(method, id), .keep_all = T)%>%
  select(-percen_que, -percen_ofallclips_drawn, -percen_mxd, -speech_clips, -total) %>%
  spread("method", "percen_span") %>%
  merge(., per_ann, by='id') %>%
  distinct(id, .keep_all = T) %>%
ggplot(., aes(random, complete)) +
  geom_smooth(method = "lm", color="black") +
  geom_jitter(aes(size=num_clips,color=round(percen_ofallclips_drawn,2)),alpha=.9,position = position_j
  scale_size_continuous(range = c(5, 9)) +
  scale_colour_gradient(low='indianred1', high = 'indianred4') +
  ylab("Proportion computed over \n entire recording") +
  xlab("Proportion computed over \n randomly sampled clips") +
  ylim(0,1) +
  xlim(0,1)+
  #facet_wrap(~location, scales = "free") +
  labs(col='% of clips drawn \n in random sampling') +
       #title = 'Proportion of Spanish clips \n in U.S. corpus') +
 theme(title = element_text(size=18, face="bold"),
   axis.text=element_text(size=14),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=15)) +
      guides(size=guide_legend(title="Total # of clips in \n recording"))
us_plot
```

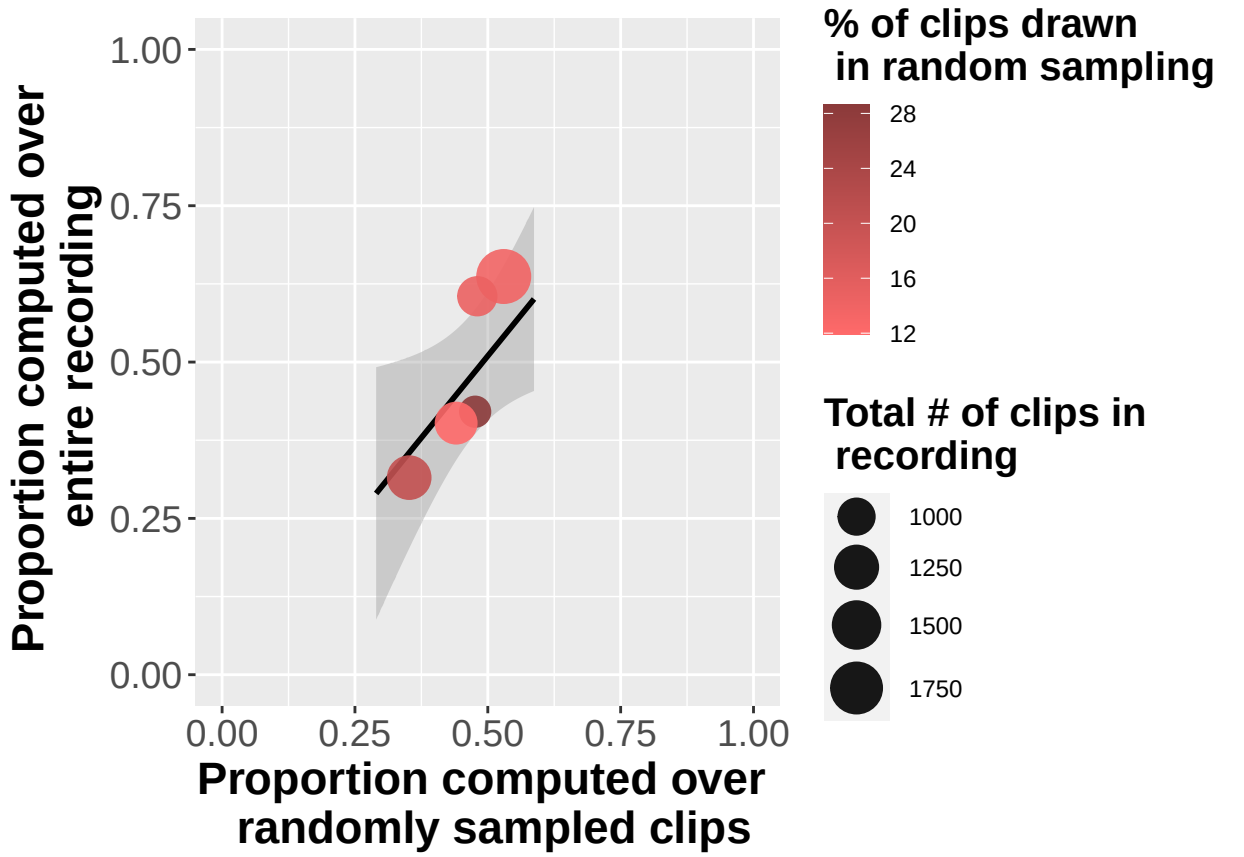



```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/us_plot.jpeg", height = 500, width = 600
us_plot
dev.off()
```

```
## pdf
##   2
```

```
bo_plot <- plot_data %>%
  filter(location=='Bolivia') %>%
  distinct_at(., vars(method, id), .keep_all = T) %>%
  select(-percen_span, -percen_ofallclips_drawn, -percen_mxd, -speech_clips, -total) %>%
  spread("method", "percen_que") %>%
  merge(., per_ann, by='id') %>%
  distinct(id, .keep_all = T) %>%
ggplot(., aes(random, complete)) +
  geom_smooth(method = "lm", color="black") +
  geom_jitter(aes(size=num_clips,color=round(percen_ofallclips_drawn,2)),alpha=.9,position = position_ji
  scale_size_continuous(range = c(5, 9)) +
  scale_colour_gradient(low='indianred1', high = 'indianred4') +
  ylab("Proportion computed over \n entire recording") +
  xlab("Proportion computed over \n randomly sampled clips") +
  ylim(0,1) +
  xlim(0,1)+
  #facet_wrap(~location, scales = "free") +
  labs(col='% of clips drawn \n in random sampling') +
       #title = 'Proportion of Quechua clips \n in Bolivian corpus') +
```

```
 theme(title = element_text(size=18, face="bold"),
   axis.text=element_text(size=14),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=15))+
       #legend.position = c(.8, .5)) +
      guides(size=guide_legend(title="Total # of clips in \n recording"))
bo_plot
```

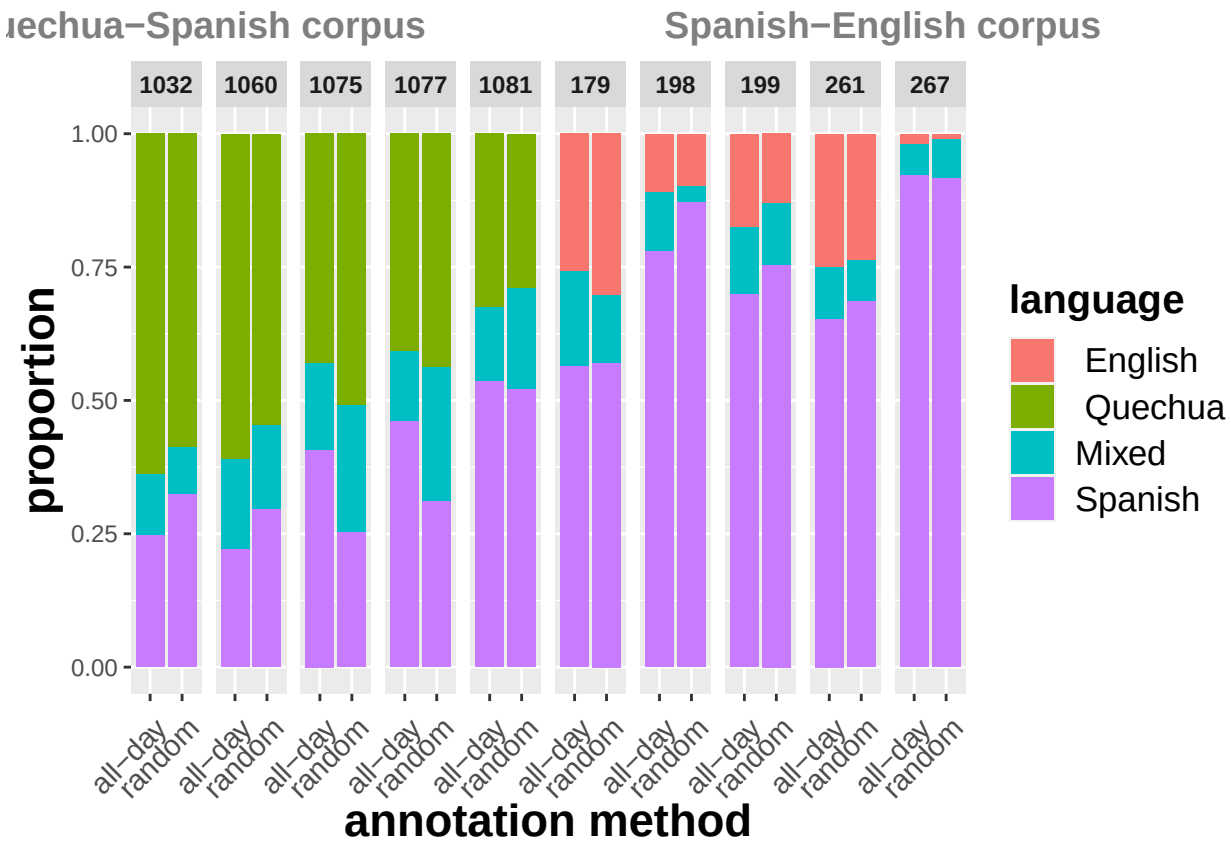



```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/bolivia_plot.jpeg", height = 500, width
bo_plot
dev.off()
```

```
## pdf
##   2
```

```
# finally, we want to actuallly plot the proportions of each language category by child and annotation
lang_props <- plot_data %>%
  gather("language", "proportion", percen_span, percen_que, percen_mxd) %>%
  distinct_at(., vars(id, proportion, language), .keep_all = T) %>%
  mutate(method=plyr::mapvalues(method, "complete", "all-day"),
         id=plyr::mapvalues(id, c("198-9mo", "261-8mo", "267-12mo"), c("198", "261", "267")),
         language=case_when(language=='percen_que' & location=='Bolivia' ~ " Quechua",
                            language=='percen_que' & location=='US' ~ ' English',
                            TRUE ~ as.character(language)),
         language=plyr::mapvalues(language, c("percen_mxd", "percen_span"), c("Mixed", "Spanish"))) %>%
  ggplot(., aes(fill=language, y=proportion, x=method)) +
```

```
  geom_bar(position='stack', stat='identity') +
  facet_grid(~id) +
  xlab('annotation method') +
    labs(subtitle = "Quechua-Spanish corpus                          Spanish-English corpus") +
  #labs(title="Proportion of language categories, by child and annotation method",
   #    subtitle = "Quechua-Spanish corpus                                    Spanish-English cor
  theme(axis.text.x = element_text(angle = 45, hjust = .9, vjust=.8, size=11),
        plot.title = element_text(face="bold"),
        plot.subtitle = element_text(color='gray50',hjust = .55, face='bold', size=14),
        axis.title=element_text(size=17,face="bold"),
        legend.title = element_text(size=15,face = "bold"),
        legend.text = element_text(size=13),
        strip.text.x = element_text(size=9, face="bold"))
lang_props
```




```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/stacked_lang_plot.jpeg", height = 500, w
lang_props
dev.off()
```

```
## pdf
##   2
```

0.0.2 Child-directed speech across random and full methods

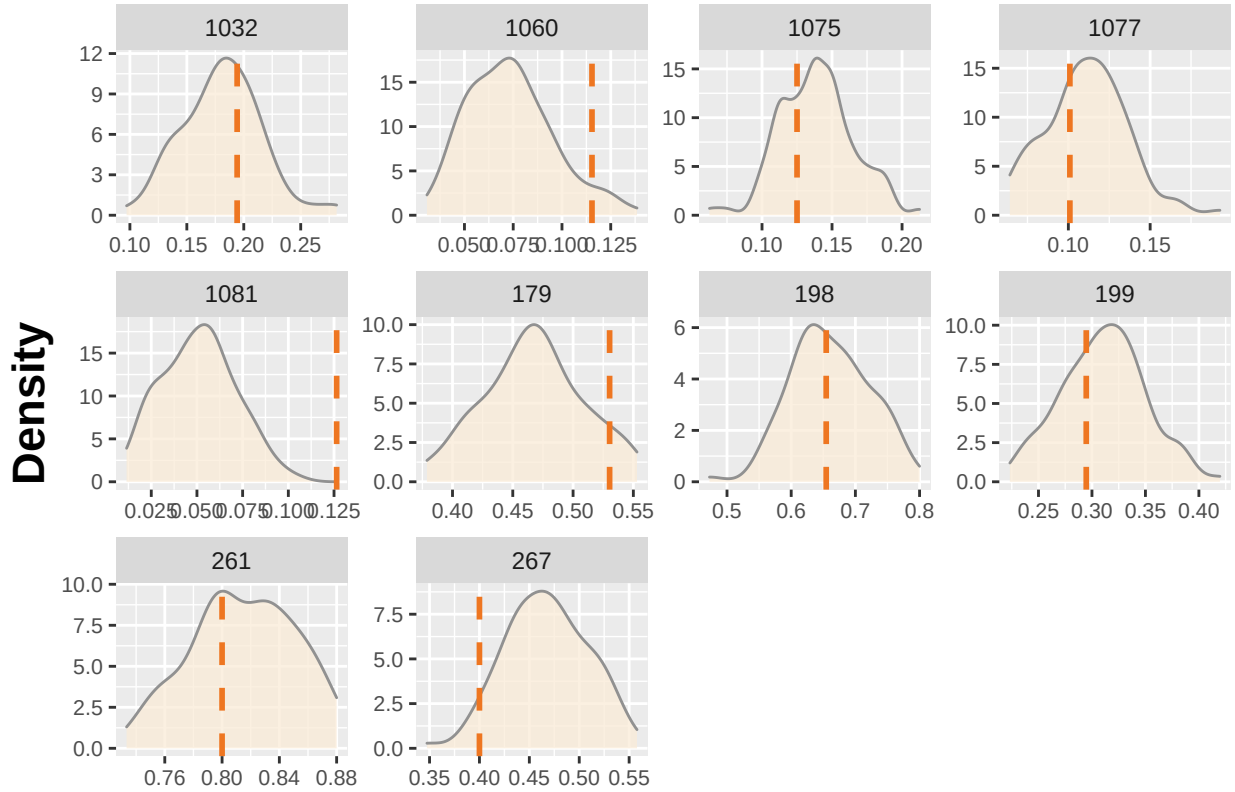
```
reg_annon <- data_annon %>%
  filter(addressee=='Adult2TargetChild' | addressee=='Otherchild2TargetChild' | addressee=='Adult2Others
  group_by(id, method) %>%
  distinct_at(., vars(file_name, addressee), .keep_all = T) %>% # don't record multiple speakers speaki
  mutate(total_reg_annotations = NROW(file_name))# N of register annotations made; distinct from N of s

cds <- reg_annon %>%
  group_by(id, method) %>%
  filter(addressee=='Adult2TargetChild' | addressee=='Otherchild2TargetChild') %>%
  group_by(id, method) %>%
  mutate(n_cds = n()) %>% # # of CDS clips
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_cds = n_cds / total_reg_annotations) %>%
  select(id, num_clips, age_YYMMDD, gender, location, method, percen_cds, n_cds, percen_ofallclips_drawn

ads <- reg_annon %>%
  filter(addressee=='Adult2Others' | addressee=='Otherchild2adults') %>%
  group_by(id, method) %>%
  mutate(n_ads = n()) %>% # # of ADS clips
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_ads = n_ads / total_reg_annotations) %>%
  select(id, num_clips, age_YYMMDD, gender, location, method, percen_ads, n_ads, percen_ofallclips_drawn

o_child <- reg_annon %>%
  filter(addressee=='Adult2OtherChild' | addressee=='Otherchild2OtherChild') %>%
  group_by(id, method) %>%
  mutate(n_ods = n()) %>% # # of ODS clips
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_ods = n_ods / total_reg_annotations) %>%
  select(id, num_clips, age_YYMMDD, gender, location, method, percen_ods, n_ods, percen_ofallclips_drawn

o2 <- merge(cds, ads, all=T)
o3 <- merge(o2, o_child, all = T)
o3[is.na(o3)] <- 0 # one child doesn't have any ODS

# sanity check
o3$total <- o3$percen_ods + o3$percen_ads + o3$percen_cds
```

```
set.seed(1234)
# now simulate 100 CDS estimates from each child
# take however many clips were used to compute the randomly-sampled estimate
# then compute the prop. of those that are CDS
# repeat 100X

# total_reg_annotations refers to the # of clips used to estimate speech register
# get that variable
random_clips <- reg_annon %>%
  filter(method=='random') %>%
  distinct_at(., vars(id), .keep_all = T) %>%
  ungroup() %>%
  select(id, total_reg_annotations)

sim_data <- reg_annon %>%
```

```
  filter(method=='complete') %>% # we're only sampling from all-day annotations
  select(-total_reg_annotations) %>% # this is the # of all-day clips annotated and we want # of random
  merge(., random_clips, by='id') %>%
  group_by(id) %>%
  replicate(100, ., simplify = FALSE) %>% # simulate 100 collections of random clips
  map_dfr(~ sample_n(., total_reg_annotations), .id = "simulation") # sample the same # of clips per si

# now compute the CDS estimate
cds_sim_results <- sim_data %>%
  group_by(id, simulation) %>%
  filter(addressee=='Adult2TargetChild' | addressee=='Otherchild2TargetChild') %>%
  mutate(n_cds = n()) %>% # # of CDS clips
  distinct(id, .keep_all = T) %>%
  mutate(percen_cds = n_cds / total_reg_annotations)

# now some descriptive stats from those results
cds_sim_stats <- cds_sim_results %>%
  group_by(id) %>%
  summarize(mean_sim_cds = round(mean(percen_cds),2),
         sd_sim_cds = round(sd(percen_cds),2),
         min_sim_cds = round(range(percen_cds)[1],2),
         max_sim_cds = round(range(percen_cds)[2],2)) %>%
  mutate(sim_stat = paste(mean_sim_cds,"(",sd_sim_cds,")",min_sim_cds,"-",max_sim_cds)) %>%
  select(id, sim_stat)

# now compute the ADS estimate
ads_sim_results <- sim_data %>%
  group_by(id, simulation) %>%
  filter(addressee=='Adult2Others' | addressee=='Otherchild2adults') %>%
  mutate(n_ads = n()) %>% # # of CDS clips
  distinct(id, .keep_all = T) %>%
  mutate(percen_ads = n_ads / total_reg_annotations)

# now some descriptive stats from those results
ads_sim_stats <- ads_sim_results %>%
  group_by(location) %>%
  summarize(mean_sim_ads = round(mean(percen_ads),2),
         sd_sim_ads = round(sd(percen_ads),2),
         min_sim_ads = round(range(percen_ads)[1],2),
         max_sim_ads = round(range(percen_ads)[2],2)) %>%
  mutate(sim_stat_ads = paste(mean_sim_ads,"(",sd_sim_ads,")",min_sim_ads,"-",max_sim_ads)) %>%
  select(location, sim_stat_ads)
```

```
#cds alone
cds_density <- o3 %>%
  filter(method=='random') %>%
  mutate(random_percencds_estimate=percen_cds) %>% # get the actual cds estimate from random sampling
  select(id, random_percencds_estimate) %>%
  merge(., cds_sim_results, by="id") %>%
  mutate(id=recode(id,"198-9mo"="198","261-8mo"="261","267-12mo"="267")) %>%
  ggplot(., aes(x=percen_cds)) +
  geom_density(fill="antiquewhite", color='gray57',alpha=.75) +
  facet_wrap(~id, scales="free") +
```

```
  geom_vline(aes(xintercept=random_percencds_estimate),
             color="chocolate2", linetype="dashed", size=1) +
  xlab("Estimates of child-directed speech quantity") +
  ylab("Density") +
  theme(axis.text=element_text(size=8),
      axis.title=element_text(size=17,face="bold"))
cds_density
```

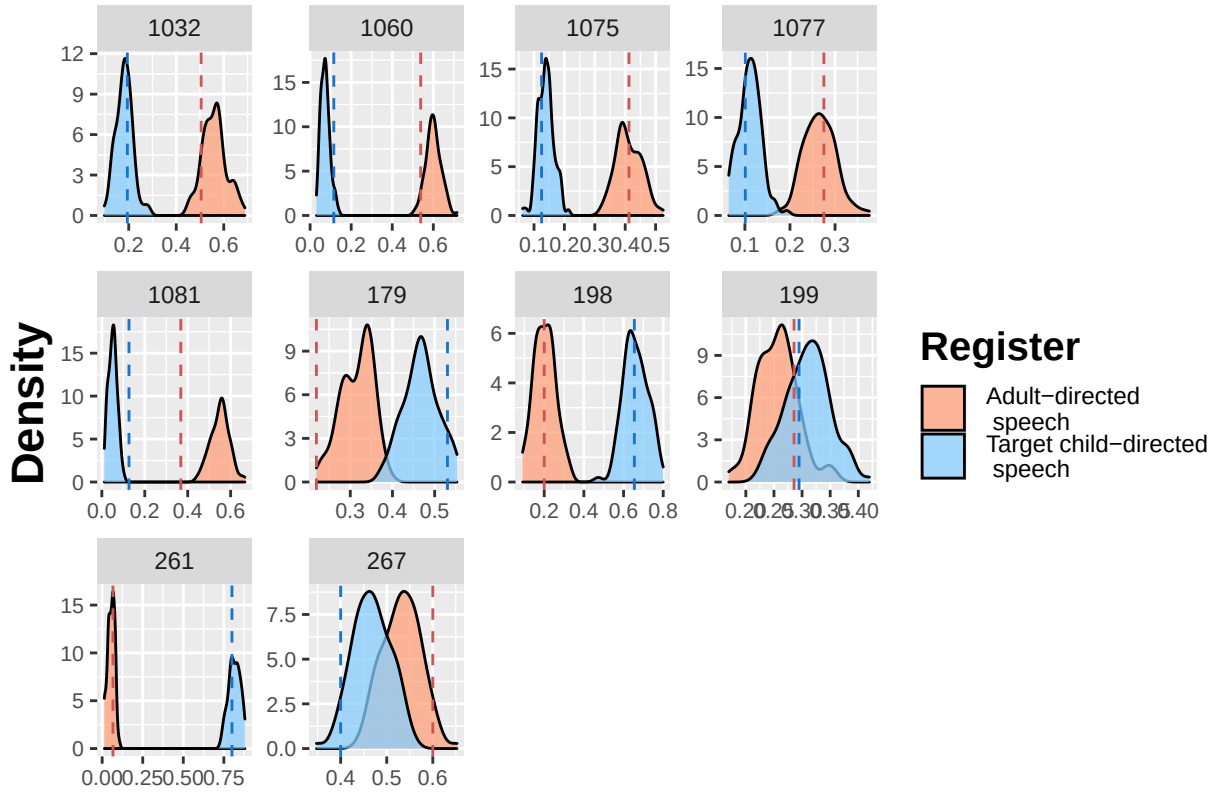



```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/cds_density_plot.jpeg", height = 400, w
cds_density
dev.off()
```

```
## pdf
##   2
```

```
reg_density <- o3 %>%
  filter(method=='random') %>%
  mutate(random_percencds_estimate=percen_cds) %>% # get the actual cds estimate from random sampling
  mutate(random_percenads_estimate=percen_ads) %>% # get the actual ads estimate from random sampling
  select(id, random_percencds_estimate, random_percenads_estimate) %>%
  merge(., cds_sim_results, by="id") %>%
  select(id, random_percenads_estimate, random_percencds_estimate, percen_cds, simulation) %>%
  merge(., ads_sim_results, by=c("simulation", "id")) %>%
  group_by(id) %>%
  mutate(avg_percen_cds = mean(percen_cds),
         avg_percen_ads = mean(percen_ads)) %>%
```

```
  ungroup() %>%
  gather("Register", "estimate", percen_cds, percen_ads) %>%
  mutate(Register=recode(Register, "percen_ads"='Adult-directed \n speech', "percen_cds"='Target child-d
  mutate(id=recode(id,"198-9mo"="198","261-8mo"="261","267-12mo"="267")) %>%
  ggplot(., aes(x=estimate, fill=Register)) +
  geom_density(alpha=.75) +
  scale_fill_manual(values=c("lightsalmon", "skyblue1")) +
  facet_wrap(~id, scales = "free") +
  geom_vline(aes(xintercept=random_percenads_estimate),
             color="indianred3", linetype="dashed", size=.5) +
    geom_vline(aes(xintercept=random_percencds_estimate),
             color="dodgerblue3", linetype="dashed", size=.5) +
    #geom_vline(aes(xintercept=avg_percen_ads),
             #color="indianred3", linetype="solid", size=.5) +
    #geom_vline(aes(xintercept=avg_percen_cds),
             #color="dodgerblue3", linetype="solid", size=.5) +
  xlab("Speech register estimates") +
  ylab("Density") +
  theme(axis.text=element_text(size=8),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(face="bold", size=15))
reg_density
```




```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/reg_density_plot.jpeg", height = 400, wi
reg_density
dev.off()
```

```
## pdf
##   2
```

```
# for later
percen_cds_df <- o3 %>%
  distinct_at(., vars(id, method), .keep_all = T) %>%
  filter(method=='random') %>%
  select(id, percen_ofallclips_drawn) # get the % of clips annotated for each id and method

cds_plot_data <- o3 %>%
  select(id, gender, location, num_clips, method, percen_cds) %>%
  spread("method", "percen_cds") %>%
  merge(., percen_cds_df, by='id')

# compute correlations
cds_cors <- cds_plot_data %>%
  group_by(location) %>%
  summarize(., paste("r=",round(cor.test(complete, random)$estimate,2),",","p=",round(cor.test(complete

# also do a correlation for both corpora
cds_cors_all <- cds_plot_data %>%
  summarize(., paste("r=",round(cor.test(complete, random)$estimate,2),",","p=",round(cor.test(complete

#reg_tbl <- o3 %>%
#  group_by(method, location) %>%
#  summarize(avg=round(mean(percen_cds),2),
#            sd=round(sd(percen_cds),2)) %>%
#  mutate(stats=paste(avg,"(",sd,")")) %>%
#  select(-avg, -sd) %>%
#  spread(key='method', value = "stats")

# calculate relative errors
cds_rel_error <- o3 %>%
  group_by(id) %>%
  #summarize(avg=mean(percen_cds)) %>%
  select(id,method,percen_cds,location) %>%
  spread(key='method', value='percen_cds') %>%
  mutate(relative_error = round(((abs(random - complete) / complete)*100),2)) %>%
  #mutate(avg_rel_error = round(mean(relative_error),2),
  #       sd_rel_error = round(sd(relative_error),2),
  #       rel_error_stats=paste(avg_rel_error,"(",sd_rel_error,")")) %>%
  distinct(relative_error, .keep_all = T)




# add correlations and simulated stats to table - will make pretty below
final_reg_tbl <- cds_rel_error %>%
  merge(., cds_cors, by='location') %>%
  merge(., cds_sim_stats, by='id')

final_reg_tbl$location <-
  plyr::mapvalues(final_reg_tbl$location,
                  from = c("Bolivia", "US"),
```

```
                  to =c("Quechua-Spanish", "Spanish-English"))

final_reg_tbl2 <- final_reg_tbl %>%
  mutate(random = round(random,2),
         complete = round(complete,2)) %>%
  mutate(corpus_id = paste(location,"(",id,")")) %>%
  select(-location, -id) %>%
  relocate(corpus_id, random, complete, relative_error, sim_stat)



knitr::kable(final_reg_tbl2, caption = 'Target child-directed speech estimates by child and annotation m
             booktabs=T,
             row.names = FALSE,
             col.names = c("Corpus (ID)", "Random", "All-day", "Relative error", "n=100 simulations of r
  column_spec(1, width = "4cm") %>% # force column headers onto two rows
  column_spec(4, width = "3cm") %>%
  column_spec(5:6, width = "4cm") %>%
  kable_styling() %>%
  add_header_above(c(" " = 1, "Annotation Method" = 2, " " = 3)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

Table 2: (#tab:cds proportion stats)Target child-directed speech estimates by child and annotation method.

Corpus (ID)	Annotation Method		Relative error	n=100 simulations of random sampling Avg. (SD) Range	Within-corpus correl between random and all-day estimates
	Random	All-day			
Quechua-Spanish (1032)	0.19	0.17	11.53	0.18 (0.03) 0.1 - 0.28	r= 0.64 , p= 0.24
Quechua-Spanish (1060)	0.12	0.07	55.09	0.07 (0.02) 0.03 - 0.14	r= 0.64 , p= 0.24
Quechua-Spanish (1075)	0.12	0.14	12.50	0.14 (0.03) 0.06 - 0.21	r= 0.64 , p= 0.24
Quechua-Spanish (1077)	0.10	0.11	10.48	0.11 (0.02) 0.06 - 0.19	r= 0.64 , p= 0.24
Quechua-Spanish (1081)	0.13	0.05	145.09	0.05 (0.02) 0.01 - 0.1	r= 0.64 , p= 0.24
Spanish-English (179)	0.53	0.47	13.24	0.47 (0.04) 0.38 - 0.55	r= 0.97 , p= 0.01
Spanish-English (198-9mo)	0.65	0.66	1.09	0.66 (0.06) 0.47 - 0.8	r= 0.97 , p= 0.01
Spanish-English (199)	0.29	0.31	6.06	0.31 (0.04) 0.22 - 0.42	r= 0.97 , p= 0.01
Spanish-English (261-8mo)	0.80	0.82	2.37	0.82 (0.04) 0.73 - 0.88	r= 0.97 , p= 0.01
Spanish-English (267-12mo)	0.40	0.47	15.23	0.47 (0.04) 0.35 - 0.56	r= 0.97 , p= 0.01

```
ads_plot_data <- o3 %>%
  #filter(location=='Bolivia') %>%
  select(id, gender, location, num_clips, method, percen_ads) %>%
  spread("method", "percen_ads") %>%
  merge(., percen_cds_df, by='id')

# compute correlations
ads_cors <- ads_plot_data %>%
```

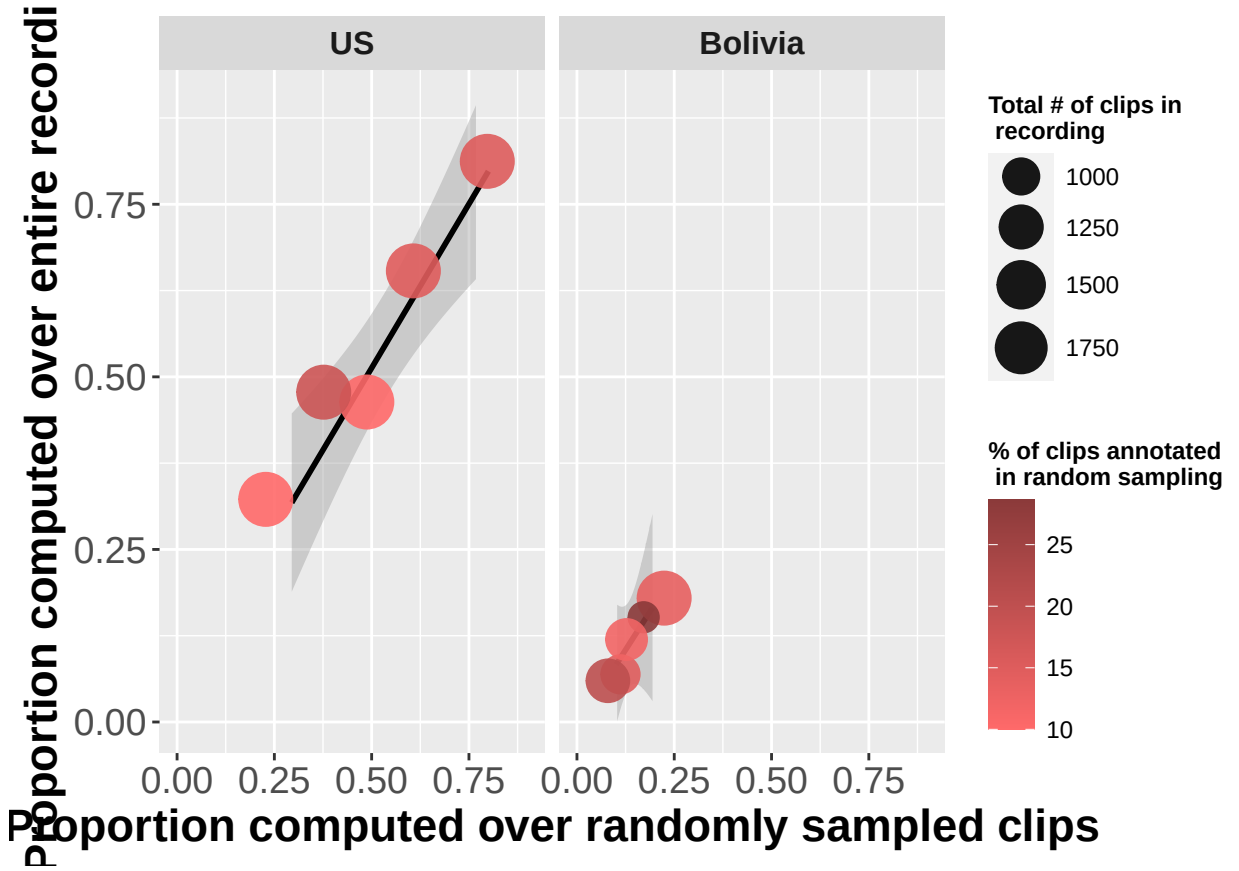
```
  group_by(location) %>%
  summarize(., paste("r=",round(cor.test(complete, random)$estimate,2),",","p=",round(cor.test(complete

reg_tbl <- o3 %>%
  group_by(method, location) %>%
  summarize(avg=round(mean(percen_ads),2),
            sd=round(sd(percen_ads),2)) %>%
  mutate(stats=paste(avg,"(",sd,")")) %>%
  select(-avg, -sd) %>%
  spread(key='method', value = "stats")

# calculate relative errors
ads_rel_error <- o3 %>%
  group_by(method, location, id) %>%
  summarize(avg=mean(percen_ads)) %>%
  spread(key='method', value='avg') %>%
  group_by(id) %>%
  mutate(relative_error = ((abs(random - complete) / complete)*100)) %>%
  ungroup() %>%
  group_by(location) %>%
  mutate(avg_rel_error = round(mean(relative_error),2),
         sd_rel_error = round(sd(relative_error),2),
         rel_error_stats=paste(avg_rel_error,"(",sd_rel_error,")")) %>%
  distinct(rel_error_stats)

# add correlations to table - will make pretty below
final_reg_tbl <- reg_tbl %>%
  merge(., ads_cors, by='location') %>%
  merge(., ads_rel_error, by='location') %>%
  merge(., ads_sim_stats, by='location') %>%
  relocate(location, random, complete, rel_error_stats, sim_stat_ads)

final_reg_tbl$location <-
  plyr::mapvalues(final_reg_tbl$location,
                  from = c("Bolivia", "US"),
                  to =c("Quechua-Spanish", "Spanish-English"))

knitr::kable(final_reg_tbl, caption = 'Average adult-directed speech estimates by corpus and annotation
             booktabs=T,
             row.names = FALSE,
             col.names = c("Corpus", "Random", "All-day", "Average relative error (SD)", "n=100 simulat
  column_spec(1, width = "3.5cm") %>%
  column_spec(4, width = "3cm") %>%
  column_spec(5:6, width = "4cm") %>%
  kable_styling() %>%
  add_header_above(c(" " = 1, "Annotation Method" = 2, " " = 3)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

```
# reorder location variable
cds_plot_data$location <- factor(cds_plot_data$location, levels = c("US", "Bolivia"))

cds_plot <- ggplot(cds_plot_data, aes(random, complete)) +
  geom_smooth(method = "lm", color="black") +
```

Table 3: (#tab:ads proportion stats)Average adult-directed speech estimates by corpus and annotation method.

Corpus	Annotation Method		Average relative error (SD)	n=100 simulations of random sampling Avg. (SD) Range	Correlation betw estimates
	Random	All-day			
Quechua-Spanish	0.42 (0.11)	0.48 (0.14)	12.17 (12.56)	0.48 (0.13) 0.18 - 0.72	r= 0.84 , p= 0.0
Spanish-English	0.27 (0.2)	0.27 (0.17)	17.57 (12.74)	0.27 (0.16) 0.01 - 0.65	r= 0.95 , p= 0.0

```
  geom_jitter(aes(size=num_clips,color=round(percen_ofallclips_drawn,2)),alpha=.9,position = position_j
  scale_size_continuous(range = c(5, 9)) +
  scale_colour_gradient(low='indianred1', high = 'indianred4') +
  ylab("Proportion computed over entire recording") +
  xlab("Proportion computed over randomly sampled clips") +
  ylim(0,0.9) +
  xlim(0,0.9)+
  facet_wrap(~location, scales = "fixed") +
  labs(col='% of clips annotated \n in random sampling') +
       #title = 'Proportion of child-directed speech clips \n in U.S. and Bolivian corpora') +
 theme(title = element_text(size=18, face="bold"),
   axis.text=element_text(size=14),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=9),
      #legend.position = c(.85, .55),
      strip.text.x = element_text(size=12, face="bold")) +
      guides(size=guide_legend(title="Total # of clips in \n recording"))
cds_plot
```

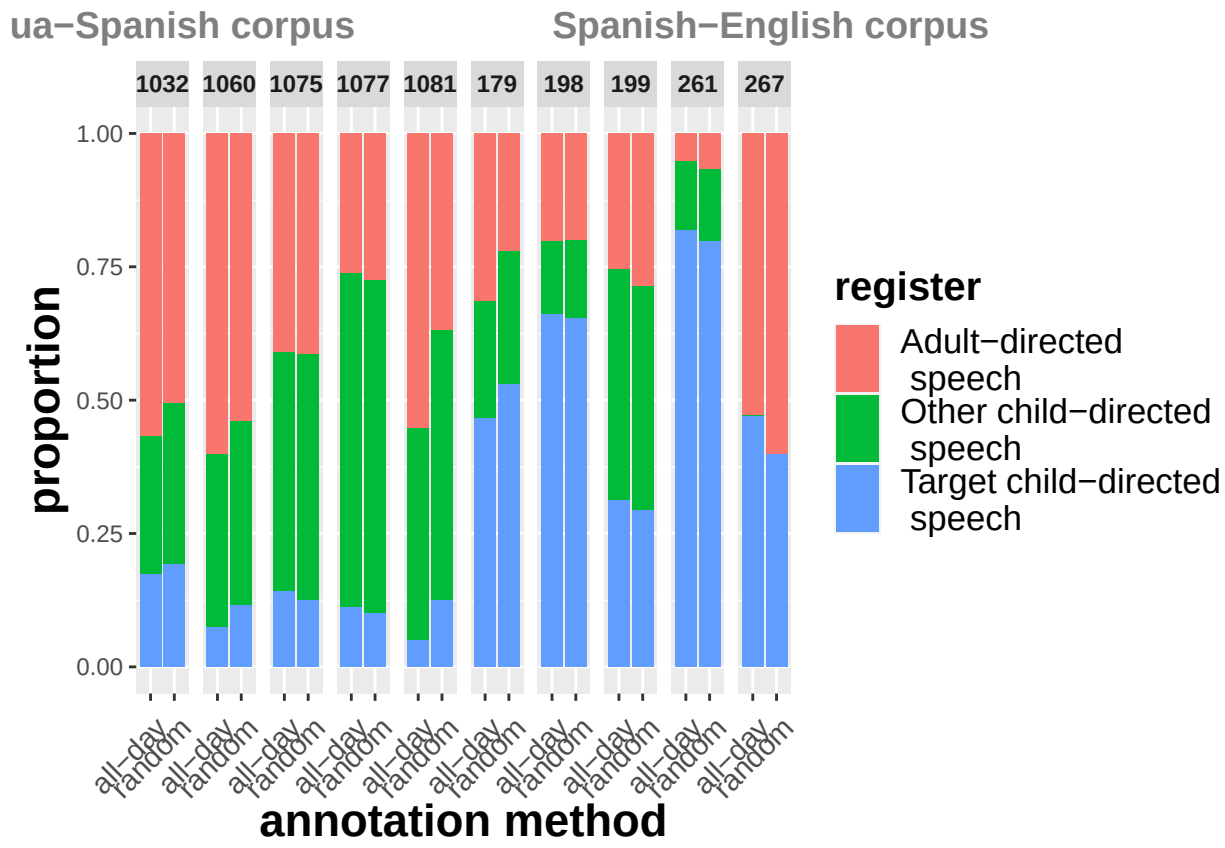



```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/cds_plot.jpeg", height = 500, width = 5
cds_plot
dev.off()
```

```
## pdf
##   2
```

```
# finally, we want to actuallly plot the proportions of each speech register category by child and anno
reg_props <- o3 %>%
  gather("register", "proportion", percen_cds, percen_ods, percen_ads) %>%
  distinct_at(., vars(id, proportion, register), .keep_all = T) %>%
  mutate(method=plyr::mapvalues(method, "complete", "all-day"),
         id=plyr::mapvalues(id, c("198-9mo", "261-8mo", "267-12mo"), c("198", "261", "267")),
         register=plyr::mapvalues(register, c("percen_cds", "percen_ods", "percen_ads"), c("Target chil
  ggplot(., aes(fill=register, y=proportion, x=method)) +
  geom_bar(position='stack', stat='identity') +
  facet_grid(~id) +
  xlab('annotation method') +
   labs(subtitle = "Quechua-Spanish corpus                    Spanish-English corpus") +
  #labs(title="Proportion of speech register categories, by child and annotation method",
       #subtitle = "Quechua-Spanish corpus                                    Spanish-English corpus
  theme(axis.text.x = element_text(angle = 45, hjust = .9, vjust=.8, size=11),
        plot.title = element_text(face="bold"),
        plot.subtitle = element_text(color='gray50',hjust = .55, face='bold', size=14),
        axis.title=element_text(size=17,face="bold"),
        legend.title = element_text(size=15,face = "bold"),
```

```
        legend.text = element_text(size=13),
        strip.text.x = element_text(size=9, face="bold"))
reg_props
```




```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/stacked_register_plot.jpeg", height = 5
reg_props
dev.off()
```

```
## pdf
##   2
```

0.0.3 Part III: language across random and questionnaire methods

```
# enter questionnaire estimates
ques <- data.frame("id"=c("179", "198-9mo", "199", "261-8mo", "267-12mo"),
                   "ques_est"=c(".71", ".57", ".94", ".69", ".87"))

ques_tbl <- plot_data %>%
  filter(location=='US') %>%
  merge(., ques, by='id') %>%
  distinct_at(., vars(method, id), .keep_all = T) %>%
  select(-percen_ofallclips_drawn, -percen_mxd, -percen_que, -speech_clips, -total, -gender, -location,
  mutate(percen_span = round(percen_span,2)) %>%
  spread("method", "percen_span") %>%
  merge(., span_sim_child_stats, by='id') %>%
  relocate(id, random, complete, sim_stat_child)
```

```
# compute correlations
ques_random_cors <- ques_tbl %>%
  mutate(ques_est = as.numeric(ques_est)) %>%
  summarize(., paste("r=",round(cor.test(ques_est, random)$estimate,2),",","p=",round(cor.test(ques_est
ques_complete_cors <- ques_tbl %>%
  mutate(ques_est = as.numeric(ques_est)) %>%
  summarize(., paste("r=",round(cor.test(ques_est, complete)$estimate,2),",","p=",round(cor.test(ques_es

# create table
knitr::kable(ques_tbl, caption = 'Spanish language estimates in U.S. corpus, by child and estimation me
             booktabs=T,
             row.names = FALSE,
             col.names = c("Child ID", "Random", "All-day", "n=100 simulations of random sampling Avg.
  column_spec(4:5, width = "4cm") %>%
  kable_styling() %>%
  add_header_above(c(" " = 1, "From daylong recording" = 3, " " = 1)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

Table 4: (#tab:make table for questionnaire method)Spanish language estimates in U.S. corpus, by child and estimation method.

Child ID	From daylong recording			Parental Questionnaire
	Random	All-day	n=100 simulations of random sampling Avg. (SD) Range	
179	0.57	0.57	0.57 (0.04) 0.46 - 0.67	.71
198-9mo	0.87	0.78	0.79 (0.04) 0.65 - 0.89	.57
199	0.76	0.70	0.71 (0.03) 0.63 - 0.78	.94
261-8mo	0.69	0.65	0.65 (0.05) 0.54 - 0.75	.69
267-12mo	0.92	0.92	0.92 (0.02) 0.88 - 0.98	.87

```
# we also want to know what the results are for the combination of CDS*Spanish, not just Spanish
reg_annon <- data_annon %>%
  filter(addressee=='Adult2TargetChild' | addressee=='Otherchild2TargetChild') %>% # only CDS clips
  group_by(id, method) %>%
  distinct_at(., vars(file_name, addressee), .keep_all = T) %>% # don't record multiple speakers speaki
  mutate(total_cds_annotations = NROW(file_name))#

span_cds_tbl <- reg_annon %>%
  group_by(id, method) %>%
  filter(addressee=='Adult2TargetChild' | addressee=='Otherchild2TargetChild' & location=='US') %>% # o
  merge(., ques, by='id') %>%
  filter(language=='Spanish') %>% # only Spanish clips
  group_by(id, method) %>%
  mutate(n_span_cds = n()) %>% # # of CDS clips where Spanish was spoken
  distinct_at(., vars(id, method), .keep_all = T) %>%
  mutate(percen_span_cds = round(n_span_cds / total_cds_annotations,2)) %>%
  select(method, percen_span_cds, id, ques_est) %>%
  spread("method", "percen_span_cds") %>%
  relocate(id, random, complete)
```

```r
# compute correlations
cor.test(as.numeric(span_cds_tbl$ques_est), span_cds_tbl$complete)
```

```
##
##  Pearson's product-moment correlation
##
## data:  as.numeric(span_cds_tbl$ques_est) and span_cds_tbl$complete
## t = 1.022, df = 3, p-value = 0.382
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.6781348  0.9600192
## sample estimates:
##       cor
## 0.5081637
```

```r
cor.test(as.numeric(span_cds_tbl$ques_est), span_cds_tbl$random)
```

```
##
##  Pearson's product-moment correlation
##
## data:  as.numeric(span_cds_tbl$ques_est) and span_cds_tbl$random
## t = 0.12188, df = 3, p-value = 0.9107
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.8656838  0.8969149
## sample estimates:
##       cor
## 0.0701952
```

```r
# simulate 100 estimates from random samples
# total_cds_annotations refers to the # of clips used to estimate CDS*spanish
# what prop. of totalCDS are spoken in Spanish?
random_cds_clips <- reg_annon %>%
  filter(method=='random' & location=='US') %>%
  distinct_at(., vars(id), .keep_all = T) %>%
  ungroup() %>%
  select(id, total_cds_annotations)

cdsspan_sim_data <- reg_annon %>%
  filter(method=='complete' & location=='US') %>% # we're only sampling from all-day annotations
  select(-total_cds_annotations) %>% # this is the # of all-day clips annotated and we want # of random
  merge(., random_cds_clips, by='id') %>%
  group_by(id) %>%
  replicate(100, ., simplify = FALSE) %>% # simulate 100 collections of random clips
  map_dfr(~ sample_n(., total_cds_annotations), .id = "simulation") # sample the same # of clips per si

# now compute the CDS*spanish estimate
cdsspan_sim_results <- cdsspan_sim_data %>%
  group_by(id, simulation) %>%
  filter(language=='Spanish') %>%
  mutate(n_cdsspan = n()) %>% # # of spanish clips amongst these CDS clips
  distinct(id, .keep_all = T) %>%
  mutate(percen_cdsspan = n_cdsspan / total_cds_annotations)
```

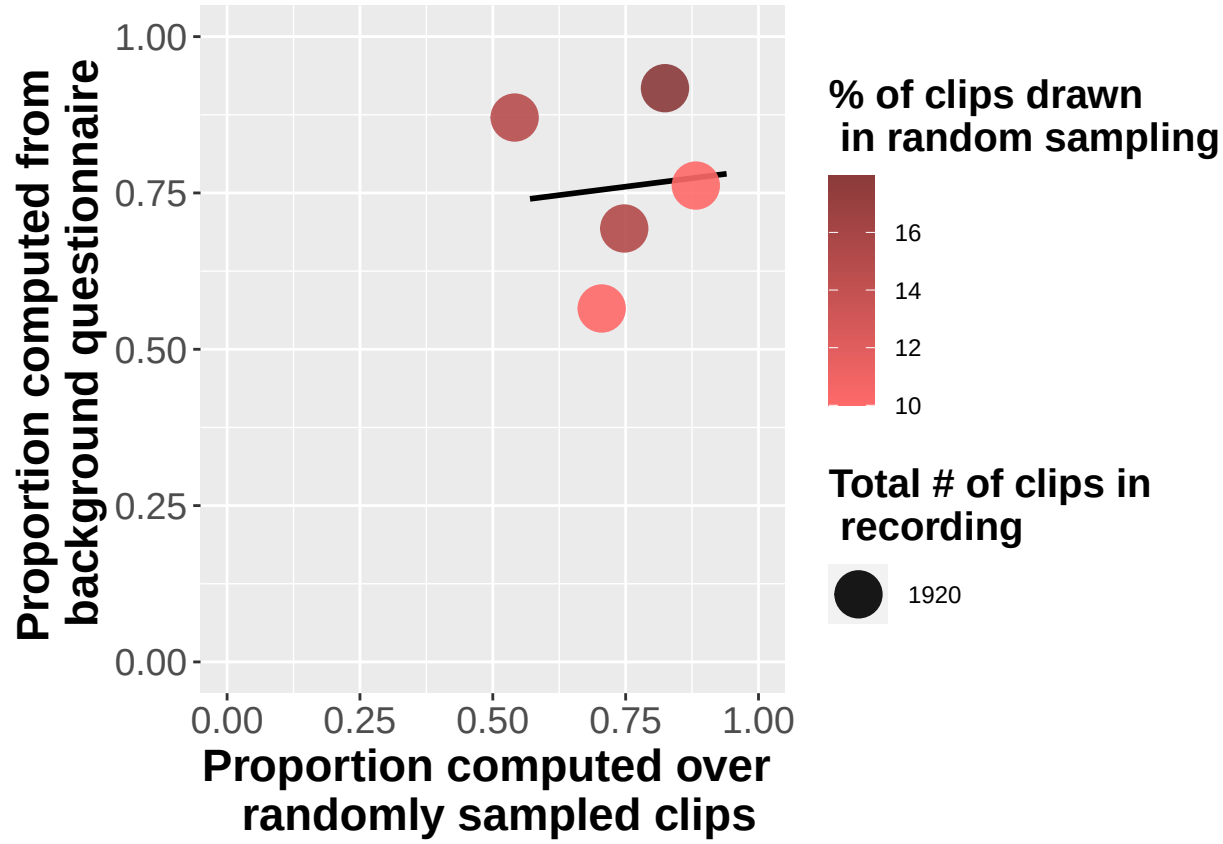
```r
# now some descriptive stats from those results
cdsspan_sim_stats <- cdsspan_sim_results %>%
  group_by(id) %>%
  summarize(mean_sim_cdsspan = round(mean(percen_cdsspan),2),
            sd_sim_cdsspan = round(sd(percen_cdsspan),2),
            min_sim_cdsspan = round(range(percen_cdsspan)[1],2),
            max_sim_cdsspan = round(range(percen_cdsspan)[2],2)) %>%
  mutate(sim_stat_cdsspan = paste(mean_sim_cdsspan,"(",sd_sim_cdsspan,")",min_sim_cdsspan,"-",max_sim_cd
  select(id, sim_stat_cdsspan)

# now combine the simulated data with the span*cds table
span_cds_tbl2 <- span_cds_tbl %>%
  merge(., cdsspan_sim_stats, by='id') %>%
  relocate(id, random, complete, sim_stat_cdsspan)


# create table
knitr::kable(span_cds_tbl2, caption = 'Spanish language in child-directed speech \n estimates in U.S. co
             booktabs=T,
             row.names = FALSE,
             col.names = c("Child ID", "Random", "All-day", "n=100 simulations of random sampling Avg.
  column_spec(1:3, width = "2cm") %>%
  column_spec(4:5, width = "4cm") %>%
  kable_styling() %>%
  add_header_above(c(" " = 1, "From daylong recording" = 3, " " = 1)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

Table 5: Spanish language in child-directed speech estimates in U.S. corpus, by child and estimation method.

	From daylong recording			
Child ID	Random	All-day	n=100 simulations of random sampling Avg. (SD) Range	Parental Questionnaire
179	0.53	0.52	0.52 (0.06) 0.41 - 0.69	.71
198-9mo	0.78	0.64	0.64 (0.07) 0.47 - 0.86	.57
199	0.64	0.66	0.66 (0.08) 0.45 - 0.85	.94
261-8mo	0.55	0.48	0.48 (0.05) 0.35 - 0.57	.69
267-12mo	0.82	0.87	0.86 (0.05) 0.74 - 0.97	.87

```r
# for later
per_ann <- plot_data %>%
  filter(method=='random' & location=='US') %>%
  select(id, percen_ofallclips_drawn)

ques_plot <- plot_data %>%
  filter(location=='US') %>%
  merge(., ques, by='id') %>%
  distinct_at(., vars(method, id), .keep_all = T) %>%
  select(-percen_que, -percen_ofallclips_drawn, -percen_mxd, -speech_clips, -total) %>%
  spread("method", "percen_span") %>%
```

```
  select(-complete) %>%
  merge(., per_ann, by='id') %>%
  distinct(id, .keep_all = T) %>%
ggplot(., aes(as.numeric(ques_est), random)) +
  geom_smooth(method = "lm", color="black", se=FALSE) +
  geom_jitter(aes(size=num_clips,color=round(percen_ofallclips_drawn,2)),alpha=.9,position = position_j
  scale_size_continuous(range = c(5, 9)) +
  scale_colour_gradient(low='indianred1', high = 'indianred4') +
  ylab("Proportion computed from \n background questionnaire") +
  xlab("Proportion computed over \n randomly sampled clips") +
  ylim(0,1) +
  xlim(0,1)+
  labs(col='% of clips drawn \n in random sampling') +
       #title = 'Proportion of Spanish clips \n in U.S. corpus: random sampling and background question
 theme(title = element_text(size=18, face="bold"),
   axis.text=element_text(size=14),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=15)) +
      guides(size=guide_legend(title="Total # of clips in \n recording"))
ques_plot
```




```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/ques_plot.jpeg", height = 500, width = 
ques_plot
dev.off()
```

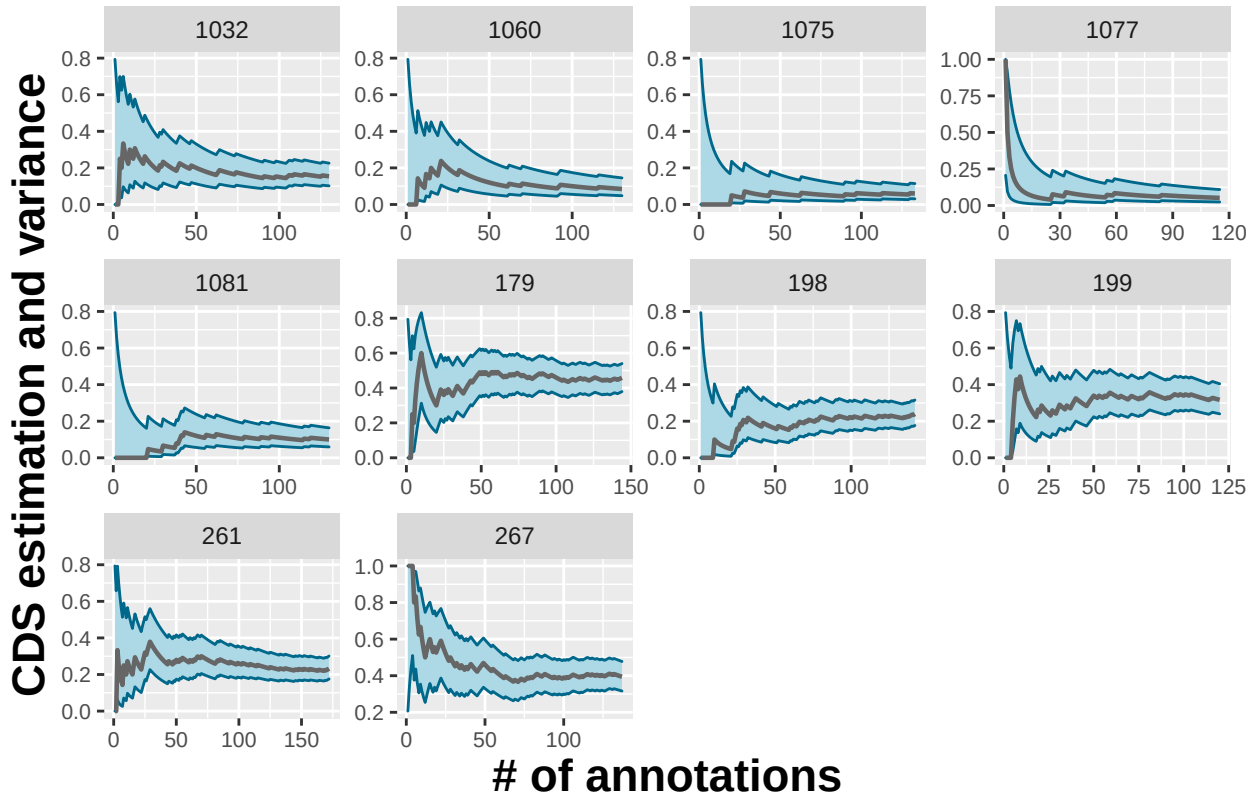
```
## pdf
##   2
```

0.0.4 Part I: Running variance

```
random$id <- plyr::mapvalues(random$id,
                from=c("198-9mo", "261-8mo", "267-12mo"),
                to=c("198", "261", "267"))

# only doing for CDS first - filter for other languages for language
cds_var <- random %>%
  group_by(id) %>%
  mutate(total=n()) %>% # total clips drawn & listened to
  filter(researcher_present!='1' & sleeping!='1' & percents_voc>0) %>% # criteria for draw, but don't l
  distinct(file_name, .keep_all = T) %>%
  mutate(annotation_num = as.numeric(1:n())) %>% # total clips annotated for lang/reg/childvoc/media, n
  select(-Otherchild2OtherChild, -Otherchild2adults, -Otherchild2unsure, -Adult2OtherChild, -Adult2Othe
  gather("addressee", "language", Adult2TargetChild, Otherchild2TargetChild) %>%
  distinct_at(., vars(file_name, timestamp_HHMMSS), .keep_all = T) %>% # CDS only gets counted 1x/clip;
  select(-addressee)


cds_var$cds_cts <- plyr::mapvalues(cds_var$language,
                from=c("Categorize language to target child", "English/Quechua", "Mixed", "Spanish", "U
                to=c("0", "1", "1", "1", "1")) # where 'cat lang...' are ADS or OCDS
cds_var$cds_cts <- as.numeric(cds_var$cds_cts)
cds_var$total <- as.numeric(cds_var$total)

cds_rolling <- cds_var %>%
  group_by(id) %>%
  mutate(cds_running_cts = as.numeric(cumsum(cds_cts))) %>%
  mutate(roll_prop_cds = cds_running_cts / annotation_num,
         roll_mean_cds = rollmean(roll_prop_cds, k=10, fill = NA),
         roll_sd_cds = rollapply(roll_prop_cds, width=10, FUN=sd, fill=NA))

# running binomial confidence interval (wilson)
cds_rolling2 <- cds_rolling %>%
  group_by(id, annotation_num) %>% # group by id and sample size
  summarize(cis = binom.confint(cds_running_cts, annotation_num, methods = 'wilson', conf.level = .95))
  merge(., cds_rolling, by = c('id', 'annotation_num'))

# for models, compute binomial confidence interval in 5-clip batches
#cds_batches <- cds_rolling %>%
#  group_by(id) %>%
#  mutate(five_clip_batch = as.integer(gl(n(), 5, n())) * 5,
#         five_clip_batch = replace(five_clip_batch,  ave(five_clip_batch, five_clip_batch, FUN = lengt
#  ungroup %>%
#  fill(five_clip_batch) #%>%

#cds_batches2 <- cds_batches %>%
#  group_by(id, five_clip_batch) %>%
#  summarize(five_cis = binom.confint(cds_running_cts, 5, methods = 'wilson', conf.level = .95)) %>%
#  merge(., cds_batches, by = c('id', 'five_clip_batch'))
```

```
cds_var_plot <- cds_rolling2 %>%
#filter(roll_sd_cds!='NA') %>% # remove rows where variance wasn't estimated
```

```
mutate(mean_ci = cis$mean,
       upper_ci = cis$upper,
       lower_ci = cis$lower) %>%
ggplot(., aes(annotation_num, roll_prop_cds)) +
  #geom_line(aes(y=rollapply(roll_prop_cds, 10, FUN=sd, fill=NA))) +
  geom_ribbon(aes(ymax=upper_ci, ymin=lower_ci), fill='lightblue', color='deepskyblue4') +
    geom_line(aes(y=mean_ci), color='gray40', size=.8) +
  xlab("# of annotations") +
  ylab("CDS estimation and variance") +
  facet_wrap(~id, scales = "free") +
  #title = 'Variance in child-directed estimation as a function of clips annotated') +
 theme(title = element_text(size=12),
   axis.text=element_text(size=8),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=15)) +
  labs(caption = "Number of clips annotated refers to those annotated for language, speech register, ch
cds_var_plot
```



clips annotated refers to those annotated for language, speech register, child vocalizations, and/or media.

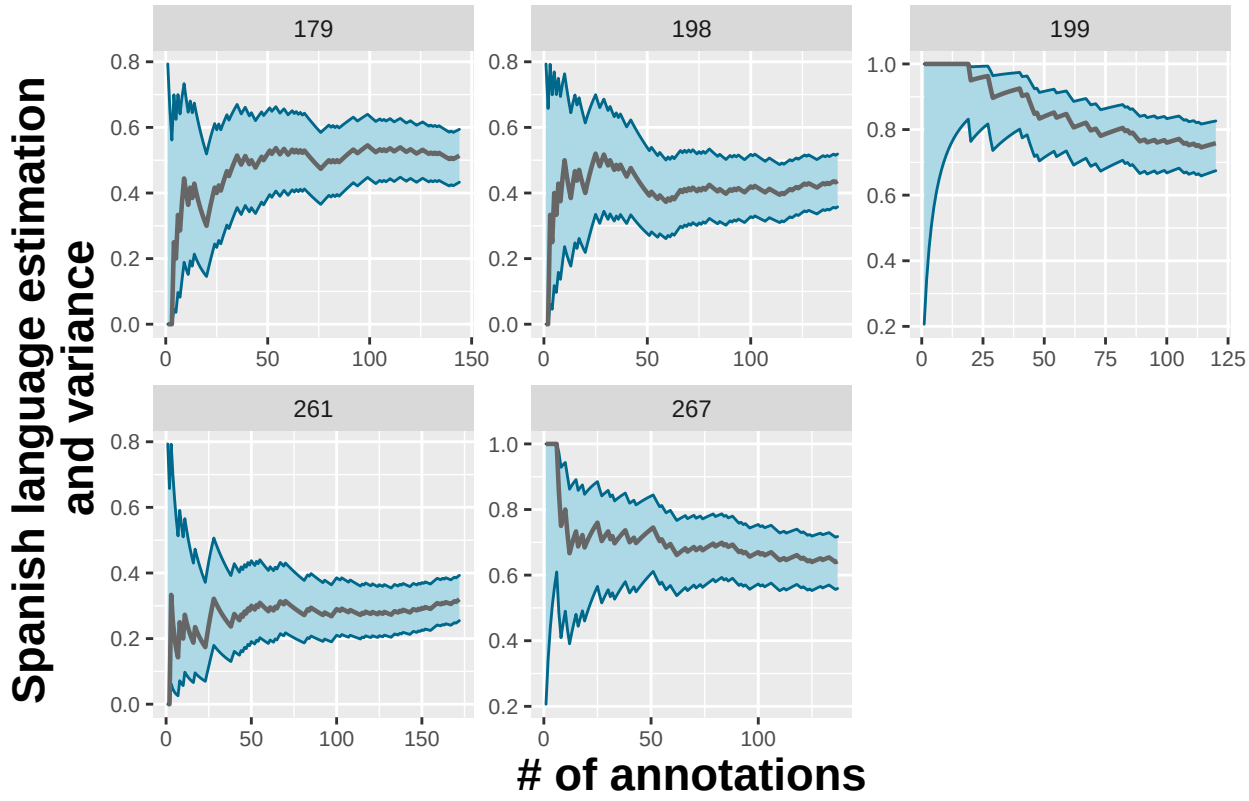
```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/cds_CI_var_plot.jpeg", height = 450, wi
cds_var_plot
dev.off()
```

```
## pdf
##   2
```

```
# now calculate rolling variances for US (Spanish)
span_var <- random %>%
  group_by(id) %>%
  mutate(total=n()) %>% # total clips drawn
  filter(researcher_present!='1' & sleeping!='1' & percents_voc>0) %>% # criteria for draw, but don't l
  distinct(file_name, .keep_all = T) %>%
  mutate(annotation_num = as.numeric(1:n())) %>% # total clips annotated for lang/reg/childvoc/media, n
  gather("addressee", "language", Adult2TargetChild, Otherchild2TargetChild, Otherchild2OtherChild, Othe
         Otherchild2unsure, Adult2OtherChild, Adult2Others, Adult2unsure) %>%
  distinct_at(., vars(file_name, timestamp_HHMMSS, language), .keep_all = T) %>% # each unique 'languag
  select(-addressee)

span_var$span_cts <- plyr::mapvalues(span_var$language,
                from=c("Categorize language to adults", "Categorize language to other adults",
                       "Categorize language to other child(ren)",
                       "Categorize language to someone unknown",
                       "Categorize language to target child",
                       "Unsure",
                       "None", "English/Quechua", "Mixed", "Spanish"),
                to=c("0","0","0","0","0","0","0","0", "0", "1"))

span_var2 <- span_var %>%
  distinct_at(., vars(file_name, span_cts), .keep_all = T) %>%
  mutate(span_cts = as.numeric(span_cts),
         total = as.numeric(total)) %>%
  group_by(file_name, timestamp_HHMMSS) %>%
  add_count() %>%
  filter(!(n==2 & span_cts==0)) %>% # when spanish and another category are marked, only count spanish
  group_by(file_name) %>%
  distinct_at(., vars(annotation_num, language), .keep_all = T) %>% # remove 1 count of spanish (it get
  select(-n)

span_rolling <- span_var2 %>%
  filter(location=='US') %>%
  group_by(id) %>%
  arrange(annotation_num) %>%
  mutate(span_running_cts = as.numeric(cumsum(span_cts))) %>%
  mutate(roll_prop_span = span_running_cts / annotation_num,
         roll_mean_span = rollmean(roll_prop_span, k=10, fill = NA),
         roll_sd_span = rollapply(roll_prop_span, width=10, FUN=sd, fill=NA))

# running binomial confidence interval (wilson)
span_rolling2 <- span_rolling %>%
  group_by(id, annotation_num) %>% # group by id and sample size
  arrange(annotation_num) %>%
  summarize(cis = binom.confint(span_running_cts, annotation_num, methods = 'wilson', conf.level = .95)
  merge(., span_rolling, by = c('id', 'annotation_num'))
```

```
span_var_plot <- span_rolling2 %>%
#filter(roll_sd_span!='NA') %>% # remove rows where variance wasn't estimated
    mutate(mean_ci = cis$mean,
         upper_ci = cis$upper,
         lower_ci = cis$lower) %>%
```

```
ggplot(., aes(annotation_num, roll_prop_span)) +
  geom_ribbon(aes(ymax=upper_ci, ymin=lower_ci), fill='lightblue', color='deepskyblue4') +
  geom_line(aes(y=mean_ci), color='gray40', size=.8) +
  xlab("# of annotations") +
  ylab("Spanish language estimation \n and variance") +
  facet_wrap(~id, scales = "free") +
  #title = 'Variance in Spanish language estimation as a function of clips drawn: US corpus') +
 theme(title = element_text(size=12),
   axis.text=element_text(size=8),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=15))  +
  labs(caption = "Number of clips annotated refers to those annotated for language, speech register, ch
span_var_plot
```



clips annotated refers to those annotated for language, speech register, child vocalizations, and/or media.

```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/span_CI_var_plot.jpeg", height = 450, w
span_var_plot
dev.off()
```

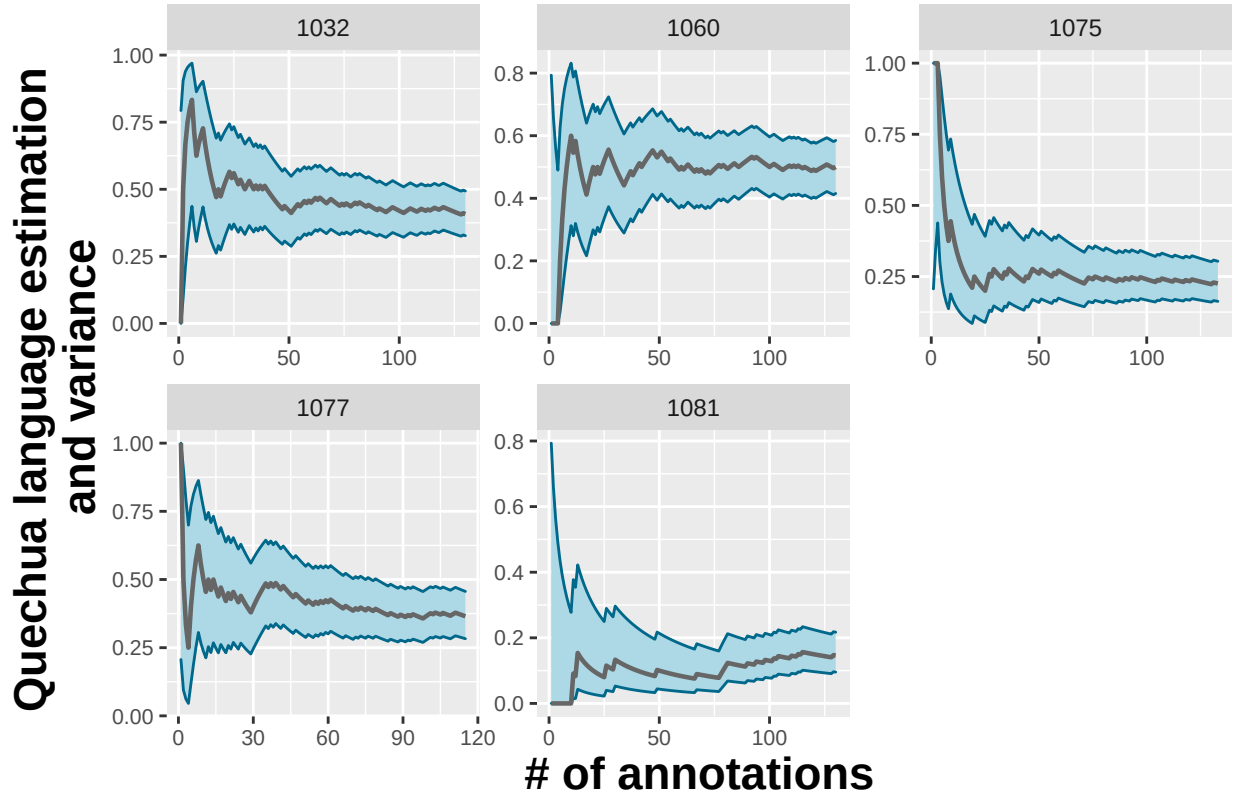
```
## pdf
##   2
```

```
que_var <- random %>%
  group_by(id) %>%
  mutate(total=n()) %>% # total clips drawn
  filter(researcher_present!='1' & sleeping!='1' & percents_voc>0) %>% # criteria for draw, but don't l
  distinct(file_name, .keep_all = T) %>%
```

```
  mutate(annotation_num = as.numeric(1:n())) %>% # total clips annotated for lang/reg/childvoc/media, n
  gather("addressee", "language", Adult2TargetChild, Otherchild2TargetChild, Otherchild2OtherChild, Othe
         Otherchild2unsure, Adult2OtherChild, Adult2Others, Adult2unsure) %>%
  distinct_at(., vars(file_name, timestamp_HHMMSS, language), .keep_all = T) %>% # each unique 'languag
  select(-addressee)

que_var$que_cts <- plyr::mapvalues(que_var$language,
                                   from=c("Categorize language to adults", "Categorize language to otl
                                          "Categorize language to other child(ren)",
                                          "Categorize language to someone unknown",
                                          "Categorize language to target child",
                                          "Unsure",
                                          "None", "English/Quechua", "Mixed", "Spanish"),
                                   to=c("0","0","0","0","0","0","0","1", "0", "0"))

que_var2 <- que_var %>%
  distinct_at(., vars(file_name, que_cts), .keep_all = T) %>%
  mutate(que_cts = as.numeric(que_cts),
         total = as.numeric(total)) %>%
  group_by(file_name, timestamp_HHMMSS) %>%
  add_count() %>%
  filter(!(n==2 & que_cts==0)) %>% # when quechua and another category are marked, only count quechua
  group_by(file_name) %>%
  distinct_at(., vars(annotation_num, language), .keep_all = T) %>% # remove 1 count of quechua (it get

que_rolling <- que_var2 %>%
  filter(location=='Bolivia') %>%
  group_by(id) %>%
  arrange(annotation_num) %>%
  mutate(que_running_cts = as.numeric(cumsum(que_cts))) %>%
  mutate(roll_prop_que = que_running_cts / annotation_num,
         roll_mean_que = rollmean(roll_prop_que, k=10, fill = NA),
         roll_sd_que = rollapply(roll_prop_que, width=10, FUN=sd, fill=NA))

# running binomial confidence interval (wilson)
que_rolling2 <- que_rolling %>%
  group_by(id, annotation_num) %>% # group by id and sample size
  arrange(annotation_num) %>%
  summarize(cis = binom.confint(que_running_cts, annotation_num, methods = 'wilson', conf.level = .95))
  merge(., que_rolling, by = c('id', 'annotation_num'))
```

```
que_var_plot <- que_rolling2 %>%
#filter(roll_sd_que!='NA') %>% # remove rows where variance wasn't estimated
    mutate(mean_ci = cis$mean,
         upper_ci = cis$upper,
         lower_ci = cis$lower) %>%
ggplot(., aes(annotation_num, roll_prop_que)) +
  geom_ribbon(aes(ymax=upper_ci, ymin=lower_ci), fill='lightblue', color='deepskyblue4') +
  geom_line(aes(y=mean_ci), color='gray40', size=.8) +
  xlab("# of annotations") +
  ylab("Quechua language estimation \n and variance") +
  facet_wrap(~id, scales = "free") +
```

```
  #title = 'Variance in Quechua language estimation as a function of clips drawn: Bolivia corpus') +
 theme(title = element_text(size=12),
   axis.text=element_text(size=8),
      axis.title=element_text(size=17,face="bold"),
      legend.title = element_text(size=15)) +
  labs(caption = "Number of clips annotated refers to those annotated for language, speech register, chi
que_var_plot
```



clips annotated refers to those annotated for language, speech register, child vocalizations, and/or media.

```
jpeg("/Users/megcychosz/Google Drive/biling_CDS/results/figures/que_CI_var_plot.jpeg", height = 450, wi
que_var_plot
dev.off()
```

```
## pdf
##   2
```

```
# report CI ranges at 80-clip mark and when annotation stopped, by child
que_cis_table <- que_rolling2 %>%
  group_by(id) %>%
  filter(annotation_num==80 | annotation_num==NROW(id)) %>% # get values at 80-clip mark and cut-off
  mutate(ci_range = cis$upper - cis$lower)

lang_cis_table <- span_rolling2 %>%
  group_by(id) %>%
  filter(annotation_num==80 | annotation_num==NROW(id)) %>% # get values at 80-clip mark and cut-off
  mutate(ci_range = cis$upper - cis$lower) %>%
  rbind(., que_cis_table) %>%
```

```
  select(id, annotation_num, ci_range) %>%
  mutate(ci_range = round(ci_range,2)) %>%
  mutate(timept = if_else(annotation_num==80, '80-clip_lang', 'Cut-off_lang')) %>%
  select(-annotation_num) %>%
  spread("timept", "ci_range")


final_cis_table <- cds_rolling2 %>%
  group_by(id) %>%
  filter(annotation_num==80 | annotation_num==NROW(id)) %>% # get values at 80-clip mark and cut-off
  mutate(ci_range = cis$upper - cis$lower) %>%
  select(id, annotation_num, ci_range) %>%
  mutate(ci_range = round(ci_range,2)) %>%
  mutate(timept = if_else(annotation_num==80, '80-clip', 'Cut-off')) %>%
  select(-annotation_num) %>%
  spread("timept", "ci_range") %>%
  merge(., lang_cis_table, by='id')

knitr::kable(final_cis_table, caption = 'Confidence interval range for Spanish/Quechua and child-directe
             booktabs=T,
             row.names = FALSE,
             col.names = c("Child ID", "80-clip", "Cut-off", "80-clip", "Cut-off")) %>% # "
  kable_styling() %>%
  add_header_above(c(" " = 1, "Language" = 2, "Child-directed speech" = 2)) %>%
  kableExtra::kable_styling(latex_options = "hold_position")
```

Table 6: (#tab:report CI ranges)Confidence interval range for Spanish/Quechua and child-directed speech estimation, by child, after annotating 80 clips and at annotation cut-off.

	Language		Child-directed speech	
Child ID	80-clip	Cut-off	80-clip	Cut-off
1032	0.16	0.12	0.21	0.17
1060	0.13	0.10	0.21	0.17
1075	0.10	0.08	0.18	0.14
1077	0.11	0.09	0.21	0.17
1081	0.14	0.10	0.14	0.12
179	0.21	0.16	0.21	0.16
198	0.18	0.14	0.21	0.16
199	0.20	0.16	0.17	0.15
261	0.19	0.13	0.19	0.14
267	0.21	0.16	0.20	0.16

```
# cds model
cds_model_data <- cds_rolling2 %>%
  group_by(id) %>%
  arrange(annotation_num) %>%
  mutate(halfrow = as.numeric(n()/2)) %>% # for a sanity check
  filter(row_number() > n()*.50) # get the top 10% of rows from each group

cds_model <- cds_model_data %>%
```

```
  #filter(roll_sd_cds!='NA') %>%
  filter(location=='US') %>%
  mutate(ci_range = cis$upper - cis$lower) %>%
  lmer(ci_range~annotation_num + (1|id), data = .) %>%
  summary()

# spanish model
# redo data to get the Bolivia corpus at the same time (more power for stats)
span_rolling_all <- span_var2 %>%
  group_by(id) %>%
  arrange(annotation_num) %>%
  mutate(span_running_cts = as.numeric(cumsum(span_cts))) %>%
  mutate(roll_prop_span = span_running_cts / annotation_num,
         roll_mean_span = rollmean(roll_prop_span, k=10, fill = NA),
         roll_sd_span = rollapply(roll_prop_span, width=10, FUN=sd, fill=NA))

# running binomial confidence interval (wilson)
span_rolling_all2 <- span_rolling_all %>%
  group_by(id, annotation_num) %>% # group by id and sample size
  arrange(annotation_num) %>%
  summarize(cis = binom.confint(span_running_cts, annotation_num, methods = 'wilson', conf.level = .95)
  merge(., span_rolling_all, by = c('id', 'annotation_num'))

# fit the spanish models
span_model_data <- span_rolling_all2 %>%
  group_by(id) %>%
  arrange(annotation_num) %>%
  mutate(halfrow = as.numeric(n()/2)) %>% # for a sanity check
  filter(row_number() > n()*.50)

span_model <- span_model_data %>%
  #filter(roll_sd_span!='NA') %>%
  mutate(ci_range = cis$upper - cis$lower) %>% # get the variance
  lmer(ci_range~annotation_num + (1|id), data = .) %>%
  summary()
```