Projection operators data analysis summary

2024-01-17

Contents

The dataset

The dataset consists of 57160 observations from 2682 participants (recruited on Amazon MTurk and Prolific). We are interested in how projection ratings (`projection`) are affected by `predicate` and `operator` .

```
str(data)
```

```
## 'data.frame':    57160 obs. of  5 variables:
##  $ projection : num  0.3 0.98 0.01 0.99 0.98 0.99 0.01 0.01 0.27 0.01 ...
##  $ predicate  : Factor w/ 20 levels "acknowledge",..: 1 11 16 9 18 13 17 7 14 8 ...
##  $ operator   : Factor w/ 4 levels "conditional",..: 4 4 4 4 4 4 4 4 4 4 ...
##  $ participant: Factor w/ 2682 levels "1","3","4","5",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ item       : Factor w/ 20 levels "charley","danny",..: 1 2 3 4 5 6 7 8 9 10 ...
```

The levels of the independent variables are:

```
levels(data$operator)
```

```
## [1] "conditional" "modal"       "negation"    "question"
```

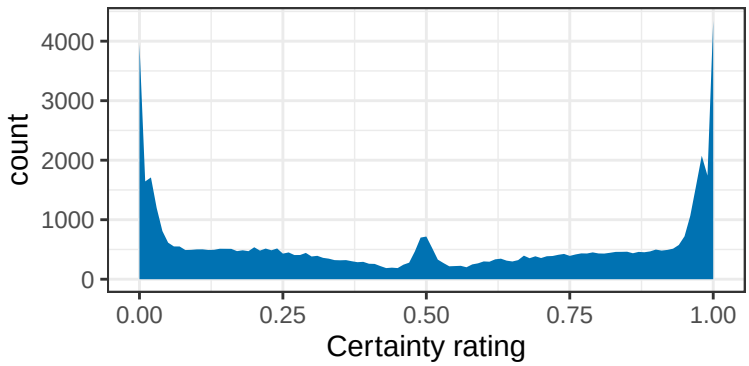
```
levels(data$predicate)
```

```
##  [1] "acknowledge" "admit"       "announce"    "be_annoyed"  "be_right"
##  [6] "confess"     "confirm"     "demonstrate" "discover"    "establish"
## [11] "hear"        "inform"      "know"        "pretend"     "prove"
## [16] "reveal"      "say"         "see"         "suggest"     "think"
```

Graphs and summaries

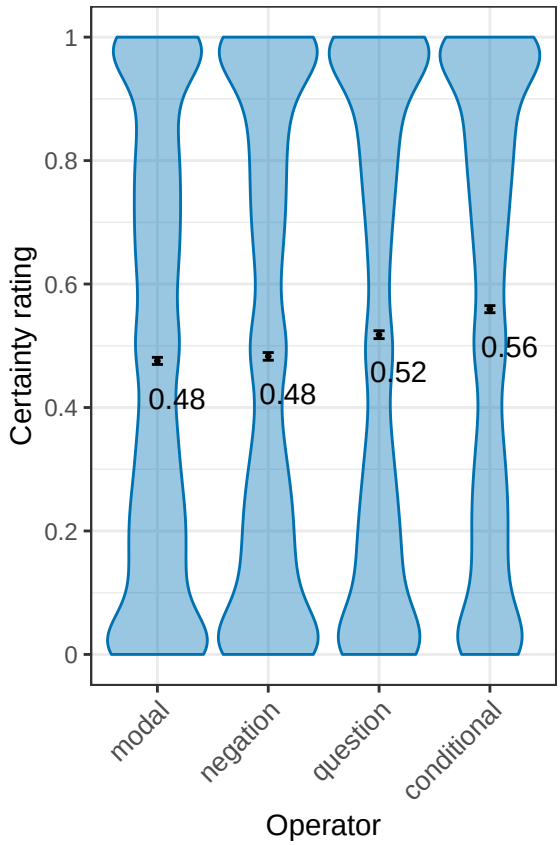
Summary for overall projection ratings

Mean	CILow	CIHigh	YMin	YMax
0.508693	0.0031489	0.0030795	0.5055441	0.5117724



Projection by operator

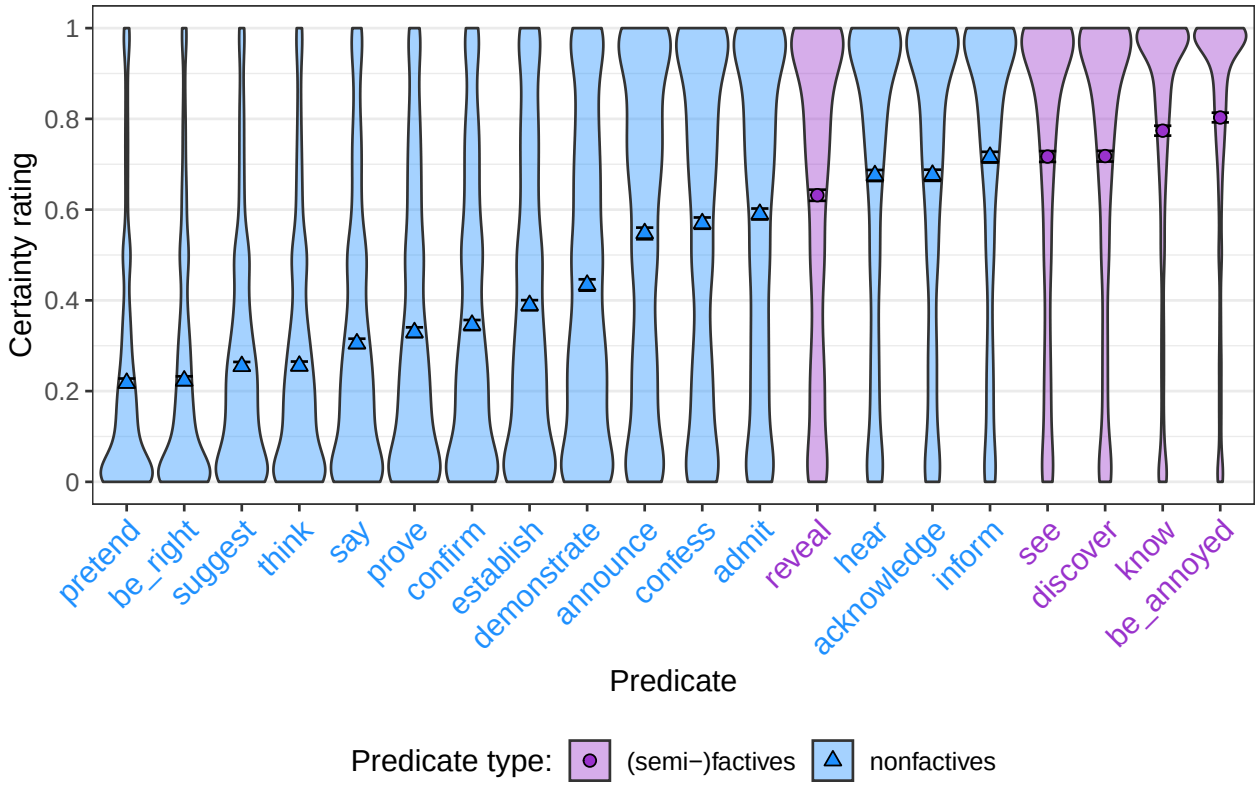
operator	Mean	CILow	CIHigh	YMin	YMax
conditional	0.5593722	0.0057953	0.0056968	0.5535769	0.5650690
modal	0.4754401	0.0056983	0.0057654	0.4697417	0.4812055
negation	0.4829568	0.0063651	0.0060648	0.4765916	0.4890216
question	0.5179672	0.0063692	0.0063521	0.5115980	0.5243193



Projection by predicate

predicate	Mean	CILow	CIHigh	YMin	YMax
acknowledge	0.6762806	0.0128816	0.0116805	0.6633991	0.6879612
admit	0.5902274	0.0119504	0.0121892	0.5782770	0.6024166
announce	0.5477992	0.0131599	0.0125702	0.5346393	0.5603693
be_annoyed	0.8029951	0.0105817	0.0105889	0.7924134	0.8135840
be_right	0.2229391	0.0097774	0.0096468	0.2131617	0.2325859
confess	0.5697411	0.0118622	0.0129652	0.5578788	0.5827063
confirm	0.3458642	0.0114101	0.0108089	0.3344542	0.3566731
demonstrate	0.4340413	0.0126163	0.0123740	0.4214249	0.4464152
discover	0.7179811	0.0120963	0.0115265	0.7058848	0.7295076
establish	0.3893842	0.0113059	0.0110613	0.3780783	0.4004455
hear	0.6755003	0.0124408	0.0118830	0.6630596	0.6873833
inform	0.7159342	0.0122528	0.0114843	0.7036814	0.7274186
know	0.7739713	0.0108867	0.0109109	0.7630846	0.7848822
pretend	0.2178411	0.0094489	0.0099094	0.2083922	0.2277505
prove	0.3294892	0.0106664	0.0110762	0.3188228	0.3405653
reveal	0.6317460	0.0123383	0.0121660	0.6194076	0.6439120
say	0.3048006	0.0100182	0.0107015	0.2947824	0.3155020
see	0.7168824	0.0117396	0.0120687	0.7051428	0.7289511
suggest	0.2548460	0.0090190	0.0094018	0.2458271	0.2642478
think	0.2555948	0.0094266	0.0095611	0.2461682	0.2651560

```
## Warning: Vectorized input to `element_text()` is not officially supported.
## i Results may be unexpected or may change in future versions of ggplot2.
```

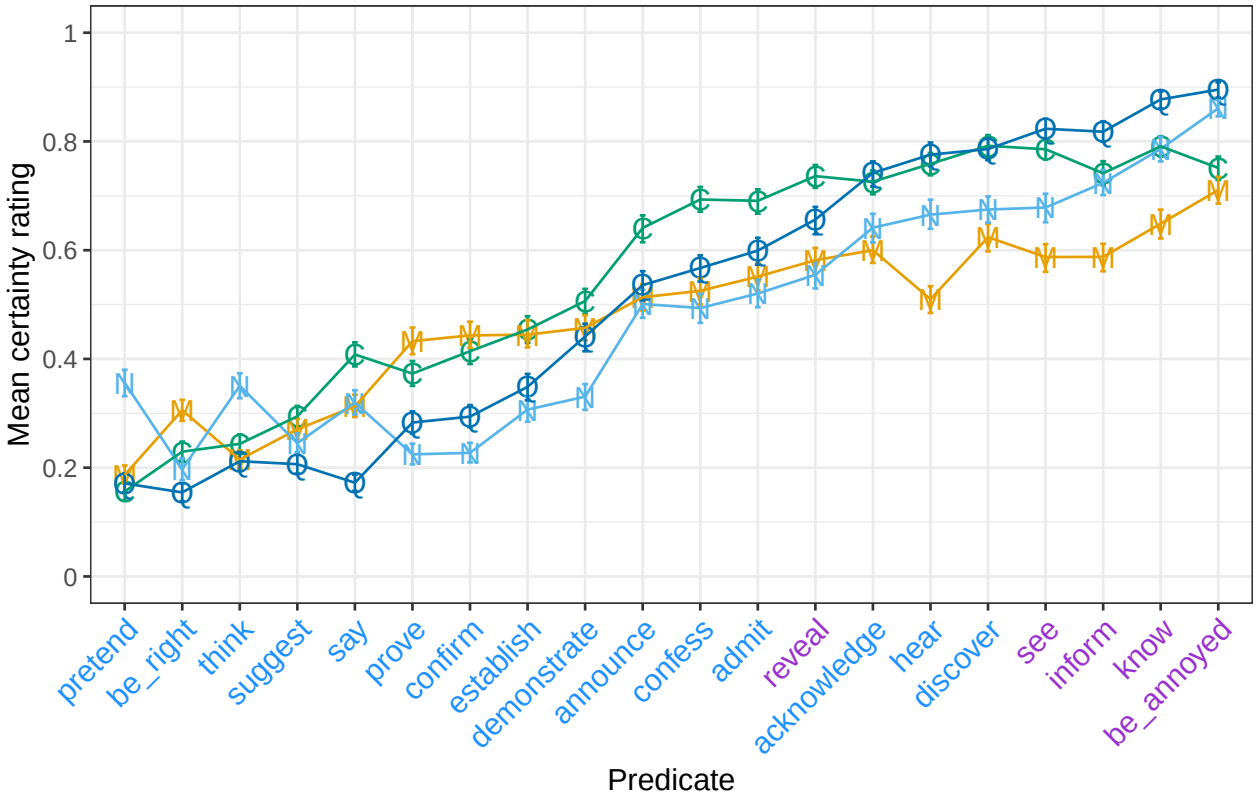


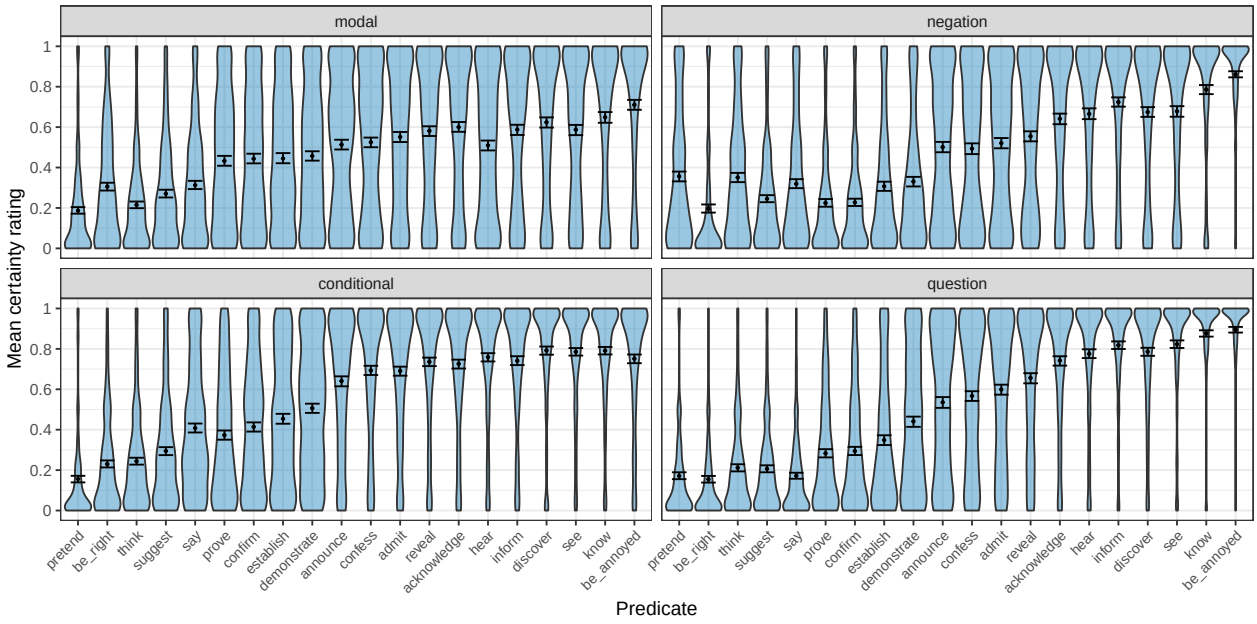
Projection by predicate and operator

predicate	operator	Mean	CILow	CIHigh	YMin	YMax
acknowledge	conditional	0.7259583	0.0232125	0.0208094	0.7027458	0.7467677
acknowledge	modal	0.6000954	0.0232718	0.0251638	0.5768236	0.6252592
acknowledge	negation	0.6413808	0.0270216	0.0255572	0.6143591	0.6669379
acknowledge	question	0.7420378	0.0248916	0.0212842	0.7171463	0.7633221
admit	conditional	0.6907917	0.0234201	0.0211392	0.6673715	0.7119309
admit	modal	0.5514305	0.0252340	0.0245824	0.5261965	0.5760129
admit	negation	0.5203626	0.0250680	0.0256510	0.4952946	0.5460136
admit	question	0.5991994	0.0258279	0.0235881	0.5733715	0.6227875
announce	conditional	0.6409028	0.0263146	0.0230837	0.6145882	0.6639865
announce	modal	0.5134196	0.0241567	0.0241056	0.4892629	0.5375252
announce	negation	0.5010460	0.0253312	0.0258612	0.4757148	0.5269073
announce	question	0.5357496	0.0277045	0.0256099	0.5080451	0.5613595
be_annoyed	conditional	0.7513611	0.0222146	0.0208247	0.7291465	0.7721858
be_annoyed	modal	0.7105586	0.0247980	0.0243277	0.6857606	0.7348862
be_annoyed	negation	0.8609902	0.0146628	0.0155373	0.8463274	0.8765275
be_annoyed	question	0.8953421	0.0146237	0.0133981	0.8807183	0.9087402
be_right	conditional	0.2295139	0.0162111	0.0184236	0.2133028	0.2479375
be_right	modal	0.3057357	0.0195504	0.0190739	0.2861853	0.3248096
be_right	negation	0.1970711	0.0200565	0.0202535	0.1770146	0.2173246
be_right	question	0.1545852	0.0162038	0.0166379	0.1383814	0.1712231
confess	conditional	0.6932361	0.0224510	0.0230420	0.6707851	0.7162781
confess	modal	0.5253406	0.0249414	0.0229588	0.5003992	0.5482994
confess	negation	0.4935844	0.0271043	0.0260798	0.4664801	0.5196642

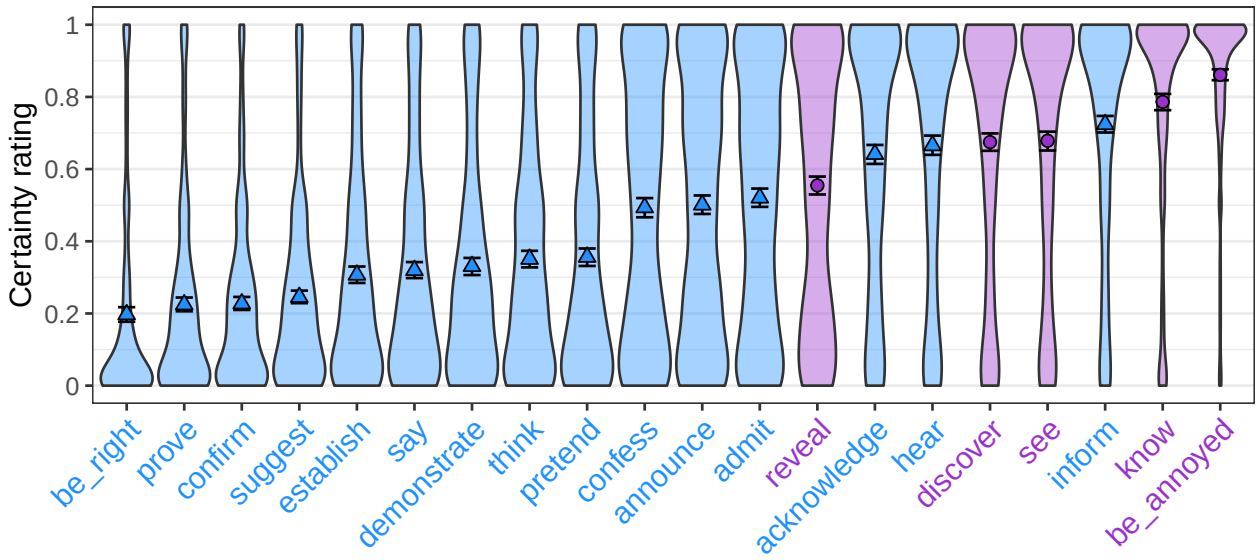
predicate	operator	Mean	CILow	CIHigh	YMin	YMax
confess	question	0.5672344	0.0248115	0.0231638	0.5424229	0.5903981
confirm	conditional	0.4141250	0.0233698	0.0220465	0.3907552	0.4361715
confirm	modal	0.4432834	0.0227568	0.0252180	0.4205266	0.4685014
confirm	negation	0.2273082	0.0174899	0.0185108	0.2098183	0.2458190
confirm	question	0.2939738	0.0194356	0.0211412	0.2745382	0.3151150
demonstrate	conditional	0.5064722	0.0233149	0.0223264	0.4831573	0.5287986
demonstrate	modal	0.4571798	0.0230385	0.0233273	0.4341413	0.4805072
demonstrate	negation	0.3307113	0.0242626	0.0231245	0.3064487	0.3538358
demonstrate	question	0.4412518	0.0271037	0.0235247	0.4141481	0.4647766
discover	conditional	0.7920139	0.0207097	0.0195972	0.7713042	0.8116111
discover	modal	0.6238965	0.0259384	0.0243525	0.5979581	0.6482490
discover	negation	0.6747699	0.0240596	0.0241081	0.6507103	0.6988780
discover	question	0.7860116	0.0204232	0.0194039	0.7655884	0.8054156
establish	conditional	0.4541250	0.0245740	0.0244333	0.4295510	0.4785583
establish	modal	0.4446458	0.0233546	0.0268270	0.4212912	0.4714728
establish	negation	0.3068201	0.0222632	0.0232388	0.2845568	0.3300589
establish	question	0.3486608	0.0246900	0.0237853	0.3239709	0.3724461
hear	conditional	0.7587500	0.0209535	0.0200281	0.7377965	0.7787781
hear	modal	0.5099591	0.0253014	0.0236826	0.4846577	0.5336417
hear	negation	0.6653696	0.0259296	0.0274840	0.6394400	0.6928536
hear	question	0.7756914	0.0212238	0.0223301	0.7544676	0.7980215
inform	conditional	0.7414306	0.0217378	0.0221545	0.7196927	0.7635851
inform	modal	0.5877520	0.0265313	0.0239625	0.5612207	0.6117146
inform	negation	0.7238494	0.0224603	0.0233909	0.7013891	0.7472402
inform	question	0.8179039	0.0185335	0.0191481	0.7993705	0.8370520
know	conditional	0.7909722	0.0185681	0.0185972	0.7724042	0.8095694
know	modal	0.6487057	0.0271308	0.0257997	0.6215749	0.6745054
know	negation	0.7861785	0.0229344	0.0222765	0.7632441	0.8084550
know	question	0.8772489	0.0165673	0.0146448	0.8606816	0.8918937
pretend	conditional	0.1563056	0.0170851	0.0154729	0.1392205	0.1717785
pretend	modal	0.1866213	0.0149053	0.0175095	0.1717159	0.2041308
pretend	negation	0.3564296	0.0248602	0.0236036	0.3315694	0.3800331
pretend	question	0.1710480	0.0158850	0.0181976	0.1551630	0.1892456
prove	conditional	0.3730833	0.0225437	0.0229882	0.3505396	0.3960715
prove	modal	0.4327248	0.0239138	0.0250133	0.4088110	0.4577381
prove	negation	0.2245467	0.0184965	0.0196423	0.2060502	0.2441890
prove	question	0.2830277	0.0201175	0.0206361	0.2629101	0.3036638
reveal	conditional	0.7361944	0.0215323	0.0204722	0.7146622	0.7566667
reveal	modal	0.5815259	0.0254370	0.0226376	0.5560889	0.6041635
reveal	negation	0.5547141	0.0250349	0.0246032	0.5296792	0.5793173
reveal	question	0.6563319	0.0269592	0.0232442	0.6293726	0.6795761
say	conditional	0.4082083	0.0218906	0.0223389	0.3863177	0.4305472
say	modal	0.3128065	0.0194966	0.0213375	0.2933099	0.3341441
say	negation	0.3196792	0.0217179	0.0227507	0.2979613	0.3424299
say	question	0.1723435	0.0150371	0.0147536	0.1573064	0.1870972
see	conditional	0.7856250	0.0188788	0.0184035	0.7667462	0.8040285
see	modal	0.5873433	0.0270037	0.0236580	0.5603396	0.6110014
see	negation	0.6784658	0.0270303	0.0253068	0.6514355	0.7037727
see	question	0.8233333	0.0189087	0.0185808	0.8044247	0.8419141
suggest	conditional	0.2945139	0.0203076	0.0190708	0.2742063	0.3135847
suggest	modal	0.2706948	0.0188621	0.0194966	0.2518328	0.2901914
suggest	negation	0.2451464	0.0166140	0.0181395	0.2285324	0.2632859

predicate	operator	Mean	CILow	CIHigh	YMin	YMax
suggest	question	0.2064629	0.0171769	0.0173100	0.1892860	0.2237729
think	conditional	0.2438611	0.0166826	0.0174309	0.2271785	0.2612920
think	modal	0.2150817	0.0162401	0.0167623	0.1988416	0.2318440
think	negation	0.3507113	0.0229582	0.0228473	0.3277531	0.3735586
think	question	0.2119068	0.0180793	0.0171055	0.1938275	0.2290124

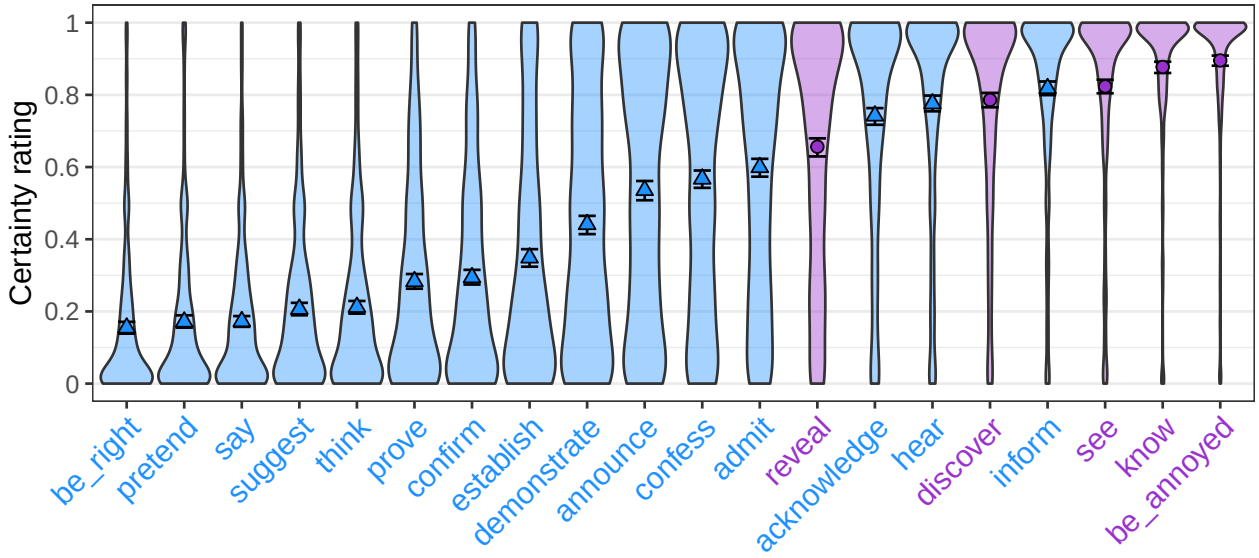




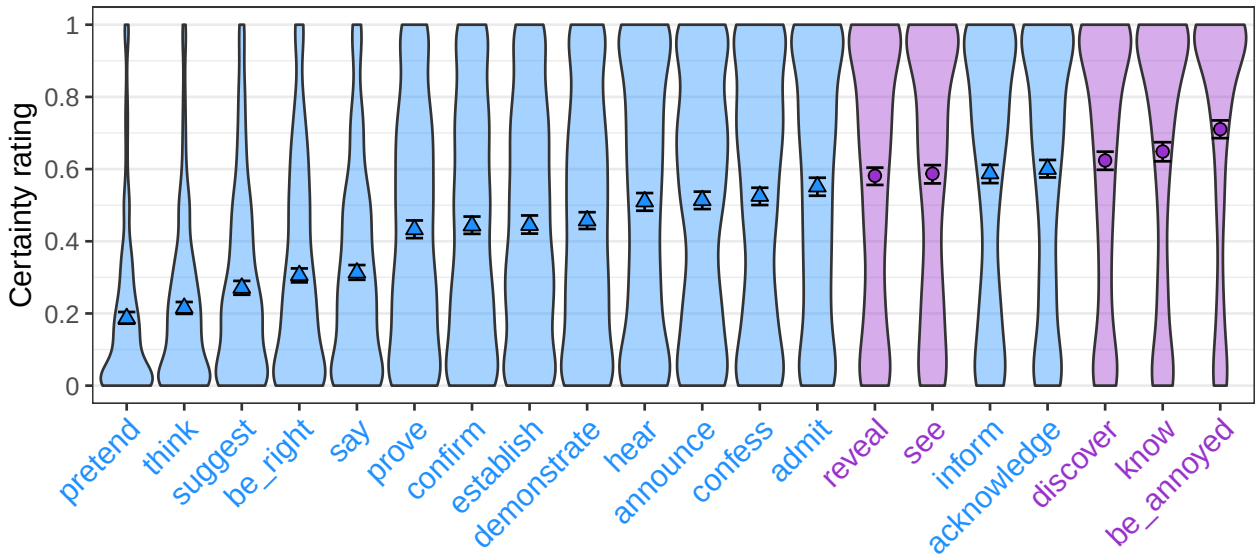
Projection by predicate, negation only



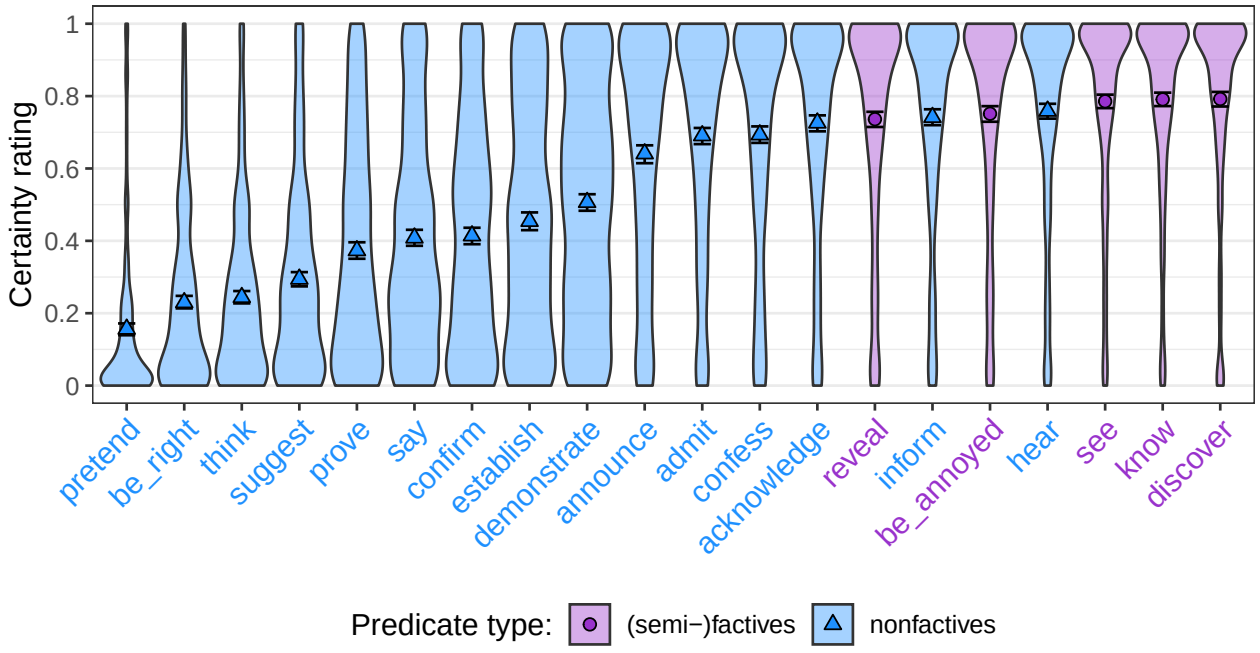
Projection by predicate, question only



Projection by predicate, modal only



Projection by predicate, conditional only



Analysis

Response: projection ratings (rescale for beta regression). Scaling to transform from closed unit interval $[0, 1]$ to open unit interval $(0, 1)$, excluding boundaries using method used in Degen & Tonhauser (2022), from Smithson & Verkuilen (2006), for proportional data.

$$y' = \frac{y \cdot (n - 1) + 0.5}{n}$$

```
data$betaresponse <- (data$projection*(nrow(data)-1) + .5)/nrow(data)
data$betaresponse <- as.numeric(data$betaresponse)
summary(data$betaresponse)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
## 0.0000087 0.1400063 0.5000000 0.5086928 0.8899932 0.9999913
```

```
str(data)
```

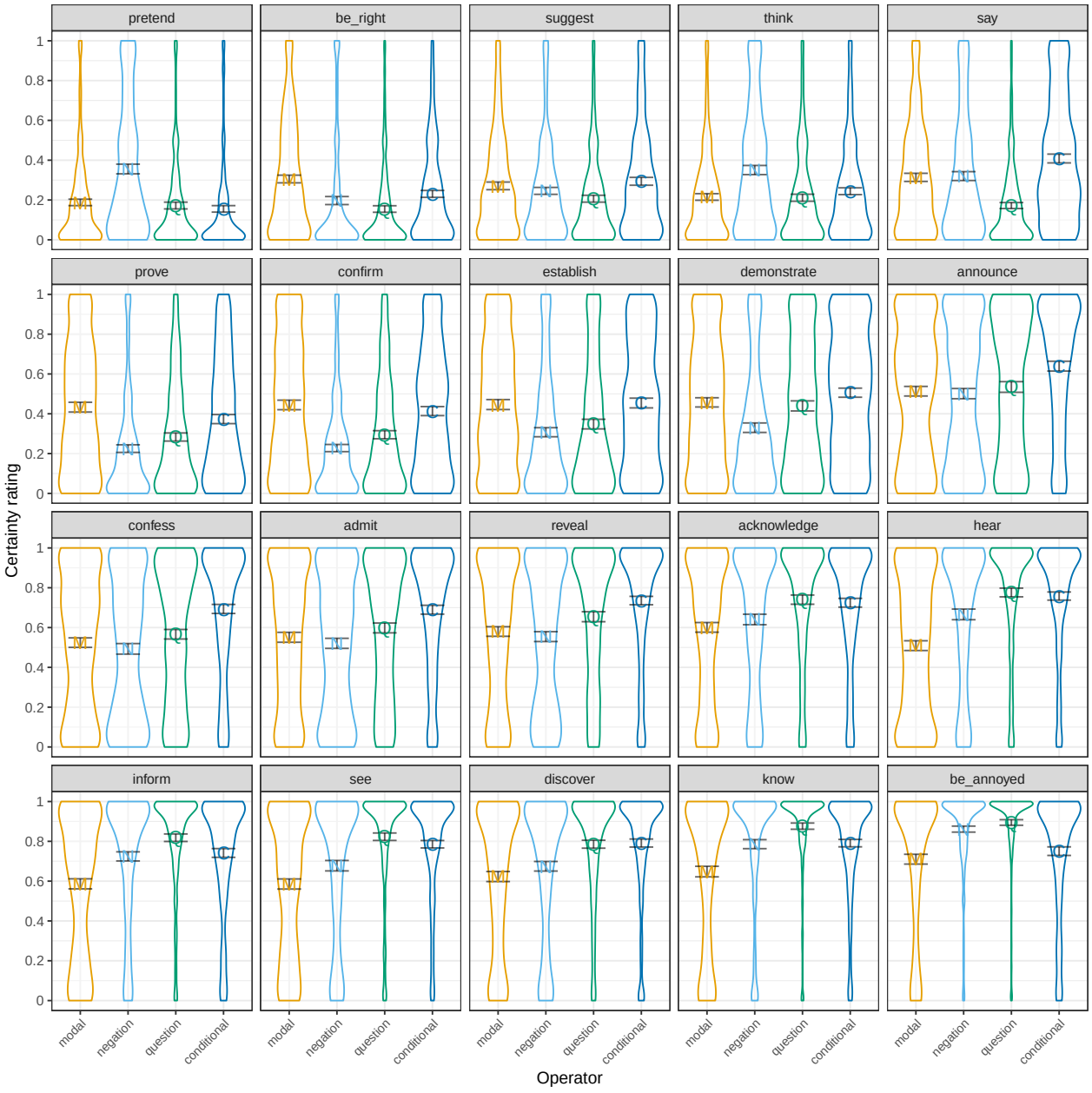
```
## 'data.frame':    57160 obs. of  6 variables:
##  $ projection  : num  0.3 0.98 0.01 0.99 0.98 0.99 0.01 0.01 0.27 0.01 ...
##  $ predicate   : Factor w/ 20 levels "acknowledge",..: 1 11 16 9 18 13 17 7 14 8 ...
##  $ operator    : Factor w/ 4 levels "conditional",..: 4 4 4 4 4 4 4 4 4 4 ...
##  $ participant : Factor w/ 2682 levels "1","3","4","5",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ item        : Factor w/ 20 levels "charley","danny",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ betaresponse: num  0.3 0.98 0.01 0.99 0.98 ...
```

Fixed effect: operator. Using deviation coding to compare each level of operator to the overall mean.

```
data <- data %>% mutate(operator = fct_reorder(operator, projection, .fun = "mean"))
contrasts(data$operator) <- contr.sum(4)
colnames(contrasts(data$operator)) <- c("modal", "negation", "question")
contrasts(data$operator)
```

```
##             modal negation question
## modal           1        0        0
## negation        0        1        0
## question        0        0        1
## conditional    -1       -1       -1
```

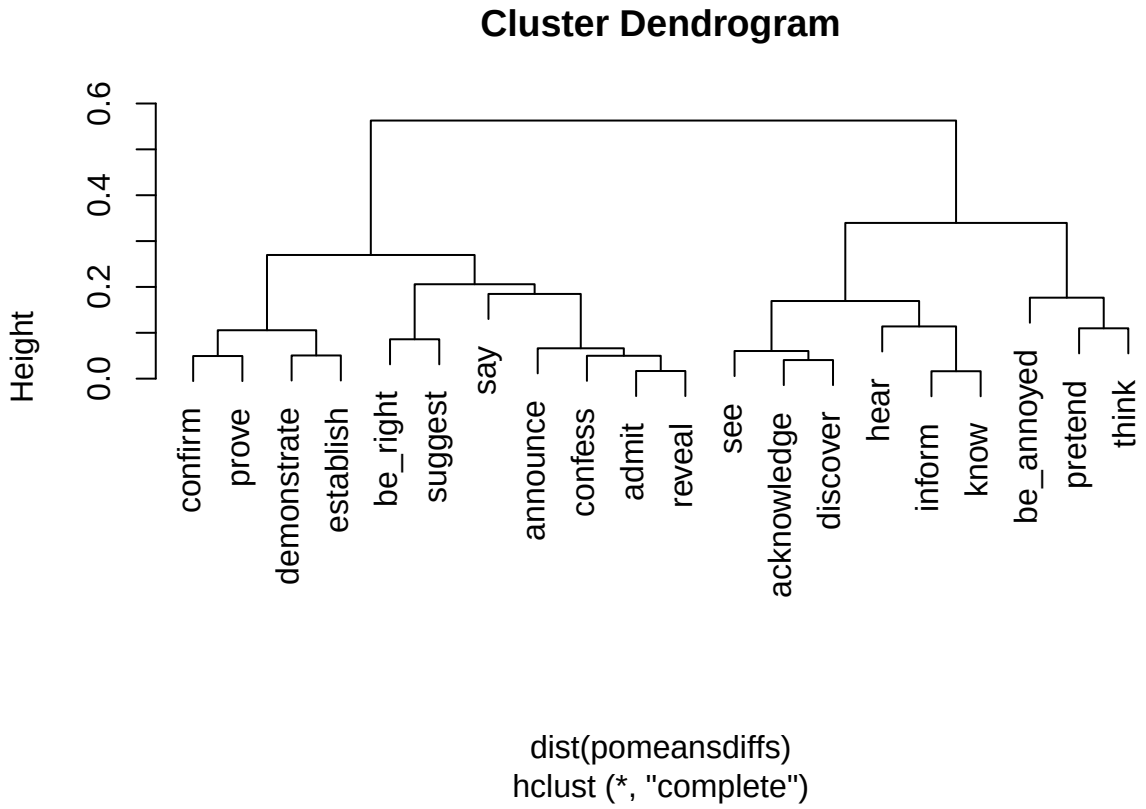
Predicate profiles



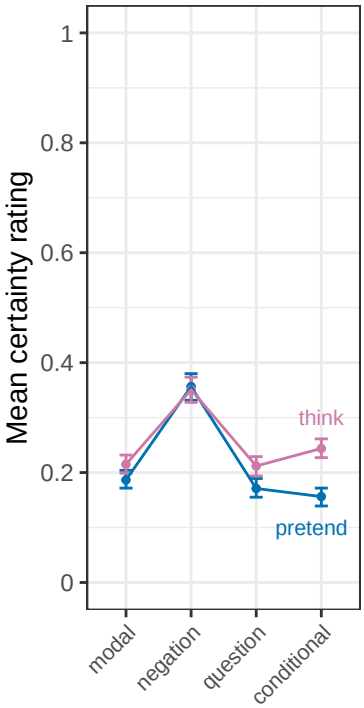
Clustering predicates based on the differences between means for the operators.

```
# cross-tabulate means for predicate / operator
pomeans <- data.frame(matrix(nrow = length(levels(predicate_operator_means$predicate)),
                             ncol = length(levels(predicate_operator_means$operator))),
                      row.names = levels(predicate_operator_means$predicate))

colnames(pomeans) <- levels(predicate_operator_means$operator)

for (i in 1:length(levels(predicate_operator_means$predicate))) {
  current_pred = levels(predicate_operator_means$predicate)[i]
  for(j in 1:length(levels(predicate_operator_means$operator))) {
    current_op = levels(predicate_operator_means$operator)[j]
```

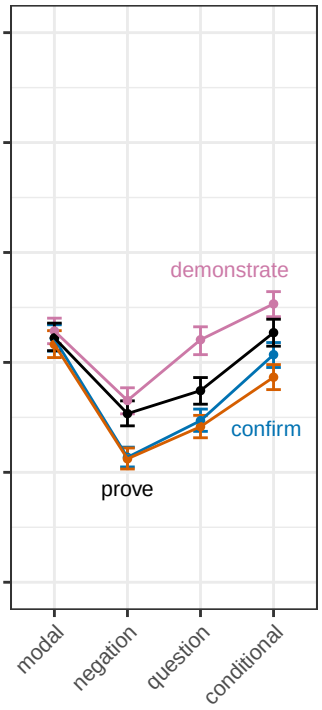
```
    pomeans[current_pred, current_op] <- subset(predicate_operator_means,
                                                predicate == current_pred &
                                                  operator == current_op)$projection[1]
  }
}

# get differences between operator means for each predicate
pomeansdiffs <- pomeans %>% mutate(mn = modal - negation, nc = negation - conditional,
                                   cq = conditional - question, .keep = "none")

# plot hierarchical clusters based on differences
plot(hclust(dist(pomeansdiffs), method = "complete"))
```



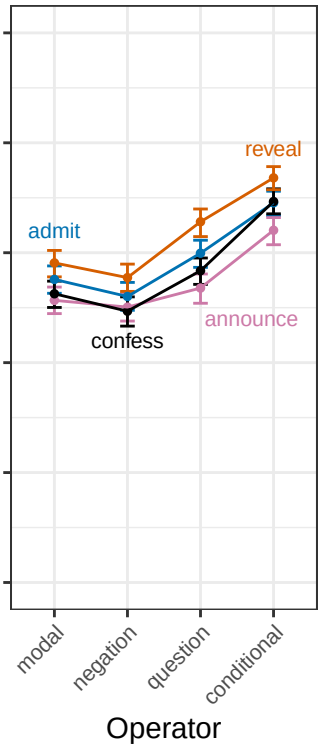
Negation high



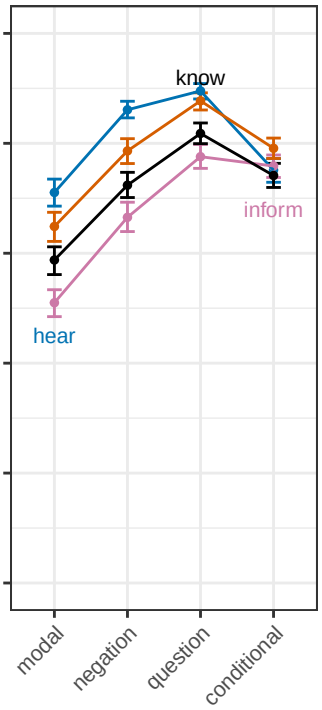
Negation low



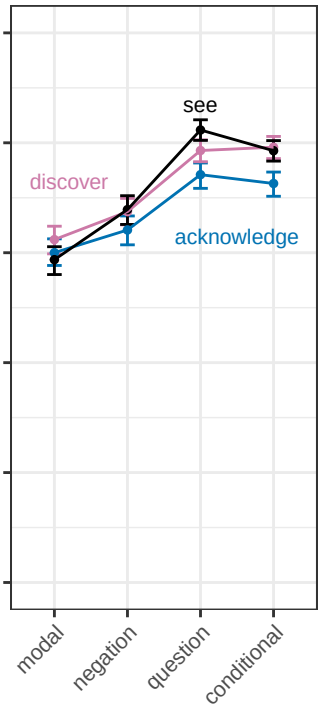
Conditional high



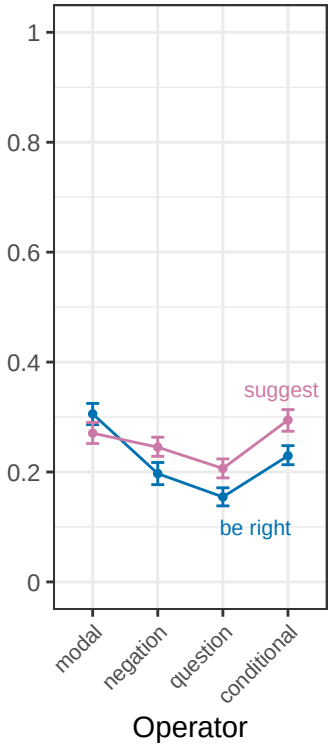
Modal low



Question high



Suggest



R session info

```
## R version 4.3.2 (2023-10-31)
```

```
## Platform: aarch64-apple-darwin20 (64-bit)
## Running under: macOS Sonoma 14.1.2
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/lib/libRlapack.dylib;  LAPACK v
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: Europe/Berlin
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] bootstrap_2019.6 lubridate_1.9.3  forcats_1.0.0    stringr_1.5.1
##  [5] dplyr_1.1.4      purrr_1.0.2      readr_2.1.5      tidyr_1.3.0
##  [9] tibble_3.2.1     ggplot2_3.4.4    tidyverse_2.0.0
##
## loaded via a namespace (and not attached):
##  [1] gtable_0.3.4      compiler_4.3.2    tidyselect_1.2.0  scales_1.3.0
##  [5] yaml_2.3.8        fastmap_1.1.1     R6_2.5.1          labeling_0.4.3
##  [9] generics_0.1.3    knitr_1.45        munsell_0.5.0     pillar_1.9.0
## [13] tzdb_0.4.0        rlang_1.1.3       utf8_1.2.4        stringi_1.8.3
## [17] xfun_0.41         timechange_0.2.0  cli_3.6.2         withr_3.0.0
## [21] magrittr_2.0.3    digest_0.6.34     grid_4.3.2        rstudioapi_0.15.0
## [25] hms_1.1.3         lifecycle_1.0.4   vctrs_0.6.5       evaluate_0.23
## [29] glue_1.7.0        farver_2.1.1      codetools_0.2-19  fansi_1.0.6
## [33] colorspace_2.1-0  rmarkdown_2.25    tools_4.3.2       pkgconfig_2.0.3
## [37] htmltools_0.5.7
```