STATS 205: Homework Assignment 5

Brian Liu

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Solution to Problem 1

> We say that two observations X_1 and X_2 are *independent* of one another with respect to a collection of events $\mathcal{A}$ if
>
> $$Pr\{X_1 \in A \text{ and } X_2 \in B\} = Pr\{X_1 \in A\}\, Pr\{X_2 \in B\}$$
>
> where A and B are any two not necessarily distinct sets of outcomes belonging to $\mathcal{A}^3$.

– 2.2.1 Independent Observations; Permutation, Parametric, and Bootstrap Tests of Hypotheses; Good, Phillip I

> In deciding whether your own observations are exchangeable and a permutation test applicable, the key question is the one we posed in the very first chapter: Under the null hypothesis of no differences among the various experimental or survey groups, can we exchange the labels on the observations without significantly affecting the results?

– 2.2.2 Exchangeable Observations; Permutation, Parametric, and Bootstrap Tests of Hypotheses; Good, Phillip I

Solution to Problem 2

```r
cysticerci <- c(28.9, 32.8, 12.0, 9.9, 15.0, 38.0, 12.5, 36.5, 8.6, 26.8);cysticerci
```

```
##  [1] 28.9 32.8 12.0  9.9 15.0 38.0 12.5 36.5  8.6 26.8
```

```r
worms_reco <- c(1.0, 7.7, 7.3, 7.9, 1.1, 3.5, 18.9, 33.9, 28.6, 25.0); worms_reco
```

```
##  [1]  1.0  7.7  7.3  7.9  1.1  3.5 18.9 33.9 28.6 25.0
```

The null hypothesis is that the mean weight of introduced cysticerci *has no correlation with* the mean weight of worms recovered. That is,

$$H_0 : \tau = 0$$

The alternative hypothesis is that the mean weight of introduced cysticerci is *positively correlated with* the mean weight of worms recovered. That is,

$$H_A : \tau > 0$$

To test the null hypothesis against the alternative hypothesis, we will use the Kendall test, a distribution-free test for independence based on signs.

```r
cor.test(x = cysticerci, y = worms_reco, method = "kendall", alt = "greater")
```

```
##
##  Kendall's rank correlation tau
##
```

```
## data:  cysticerci and worms_reco
## T = 19, p-value = 0.7578
## alternative hypothesis: true tau is greater than 0
## sample estimates:
##        tau
## -0.1555556
```

The p-value is 0.7578, which is *not* significant at the $\alpha = 0.05$ level. There is *not enough* evidence that the mean weight of introduced cysticerci is *positively correlated with* the mean weight of worms recovered.

Solution to Problem 3

```
cysticerci <- c(28.9, 32.8, 12.0, 9.9, 15.0, 38.0, 12.5, 36.5, 8.6, 26.8)
worms_reco <- c(1.0, 7.7, 7.3, 7.9, 1.1, 3.5, 18.9, 33.9, 28.6, 25.0)
cor.test(x = cysticerci, y = worms_reco, method = "kendall", alt = "greater")
```

```
##
##  Kendall's rank correlation tau
##
## data:  cysticerci and worms_reco
## T = 19, p-value = 0.7578
## alternative hypothesis: true tau is greater than 0
## sample estimates:
##        tau
## -0.1555556
```

The estimate for $\tau = -0.1555556$.

Solution to Problem 4

```
brain_weight = c(515, 286, 469, 410, 461, 436, 479, 198, 389, 262, 536); length(brain_weight)
```

```
## [1] 11
```

```
fiber_count  = c(32500, 26800, 11410, 14850, 23640, 23820, 29840, 21830, 24650, 22500, 26000); length(fi
```

```
## [1] 11
```

```
library(bootstrap)
theta.hat = cor(brain_weight, fiber_count); theta.hat
```

```
## [1] 0.1604644
```

```
library(partitions)
n = length(brain_weight)
allCompositions = compositions(n, n);allCompositions[,1:length(brain_weight)]
```

```
##       [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
##  [1,]   11   10    9    8    7    6    5    4    3     2     1
##  [2,]    0    1    2    3    4    5    6    7    8     9    10
##  [3,]    0    0    0    0    0    0    0    0    0     0     0
##  [4,]    0    0    0    0    0    0    0    0    0     0     0
##  [5,]    0    0    0    0    0    0    0    0    0     0     0
##  [6,]    0    0    0    0    0    0    0    0    0     0     0
##  [7,]    0    0    0    0    0    0    0    0    0     0     0
```

```
##  [8,]    0    0    0    0    0    0    0    0    0     0     0
##  [9,]    0    0    0    0    0    0    0    0    0     0     0
## [10,]    0    0    0    0    0    0    0    0    0     0     0
## [11,]    0    0    0    0    0    0    0    0    0     0     0
```

```
allCompositions.sub = allCompositions[, sample(1:dim(allCompositions)[2], size=1000, replace=FALSE)]

draw.bootstrap.samples = function(df){
  n = dim(df)[1]
  ind = sample(n, replace = TRUE)
  cor.bootstrap.replicate = cor(df[ind, "LSAT"], df[ind, "GPA"])
  return(cor.bootstrap.replicate)
}
R = 1000
theta.hat.star = replicate(R, draw.bootstrap.samples(law))
# make a ggplot
library(ggplot2)
```

```
## Registered S3 methods overwritten by 'ggplot2':
##   method         from
##   [.quosures     rlang
##   c.quosures     rlang
##   print.quosures rlang
```

```
theta.hat.star.df = data.frame(theta.hat.star = theta.hat.star)
theta.hat.star
```

```
##    [1] 0.8484063 0.6316826 0.9825900 0.8255229 0.8495999 0.8261002
##    [7] 0.8661347 0.8834630 0.9006001 0.5907339 0.7830618 0.8956721
##   [13] 0.8390269 0.6767403 0.6655151 0.7880434 0.7669794 0.8333284
##   [19] 0.4788920 0.7714328 0.6888578 0.6085110 0.8870055 0.8891343
##   [25] 0.9293760 0.8941580 0.7842890 0.9759656 0.6580838 0.8803008
##   [31] 0.7278119 0.9764674 0.6583863 0.6168595 0.6598359 0.8303769
##   [37] 0.7441387 0.9125698 0.7720787 0.8052933 0.7456710 0.9079140
##   [43] 0.7810588 0.7018577 0.7022426 0.9012286 0.9088847 0.9309482
##   [49] 0.3903147 0.9605292 0.8423109 0.9381429 0.7806078 0.9464569
##   [55] 0.7778007 0.6670899 0.8605475 0.7628063 0.8569390 0.6204809
##   [61] 0.7548218 0.4333586 0.9514910 0.2215294 0.9487501 0.8885582
##   [67] 0.6819842 0.6990087 0.8783708 0.6023873 0.8013960 0.3813482
##   [73] 0.7119660 0.8667703 0.7203806 0.6057199 0.8547396 0.9245165
##   [79] 0.8545298 0.6373720 0.7845749 0.9768518 0.8438509 0.9895442
##   [85] 0.8665138 0.9117396 0.7704158 0.8589641 0.7834545 0.8452853
##   [91] 0.9354389 0.7198367 0.8875415 0.9335897 0.7231350 0.8398740
##   [97] 0.8276306 0.8507689 0.8705201 0.6667573 0.6629954 0.7455497
##  [103] 0.8135639 0.7826830 0.9558701 0.8636942 0.6215780 0.5386313
##  [109] 0.7424817 0.6646911 0.8607529 0.9353608 0.7096247 0.3969845
##  [115] 0.8585453 0.8808895 0.8671265 0.9466575 0.7951984 0.8093433
##  [121] 0.6461451 0.7237113 0.6086657 0.6420466 0.8083532 0.8101672
##  [127] 0.7055363 0.8455851 0.8672329 0.9316990 0.8591594 0.7003659
##  [133] 0.8052631 0.7597974 0.8761399 0.7878997 0.9123433 0.6228996
##  [139] 0.5804809 0.7679912 0.9705725 0.7407414 0.8154191 0.8546031
##  [145] 0.9173857 0.8029028 0.8388353 0.6528412 0.5988332 0.7513465
##  [151] 0.8022712 0.7863913 0.6940034 0.7627176 0.8931142 0.8630833
##  [157] 0.7928282 0.6684376 0.9324184 0.6394841 0.8584064 0.9252122
##  [163] 0.8969546 0.8636759 0.6429309 0.7967141 0.8145145 0.8791452
##  [169] 0.8398039 0.9399158 0.9410929 0.9412756 0.6638791 0.8583365
```

```
## [175] 0.6737819 0.7699293 0.8347644 0.7492324 0.5921786 0.8119755
## [181] 0.6229308 0.4989414 0.8746569 0.7255861 0.8609801 0.8166173
## [187] 0.5334794 0.9104799 0.7811890 0.7510102 0.7829000 0.8339260
## [193] 0.8063302 0.8625832 0.7044331 0.9388681 0.9334327 0.7058491
## [199] 0.7693600 0.9093276 0.9033053 0.7995914 0.7252945 0.8471418
## [205] 0.6337806 0.7837673 0.9531264 0.8907437 0.8434617 0.7711600
## [211] 0.8188653 0.7063732 0.8508669 0.7798309 0.8505594 0.5847226
## [217] 0.7568213 0.9045626 0.9496660 0.6024775 0.8918807 0.7941885
## [223] 0.8873180 0.9107763 0.7447879 0.7336387 0.7119080 0.7073913
## [229] 0.7109964 0.8043846 0.5885016 0.4996746 0.7431657 0.4651076
## [235] 0.8195815 0.8087968 0.7689289 0.8219518 0.8281651 0.8376250
## [241] 0.8574205 0.7711048 0.8520056 0.8012227 0.6669427 0.6382964
## [247] 0.8190446 0.7861443 0.8600243 0.9412712 0.8640642 0.8747762
## [253] 0.8222612 0.6205937 0.6600079 0.7727376 0.7299584 0.9640808
## [259] 0.9863439 0.8388737 0.9288310 0.8073237 0.6721381 0.7015188
## [265] 0.5752959 0.6181041 0.7243230 0.7778983 0.7793896 0.9727994
## [271] 0.8436386 0.8879080 0.7565744 0.8116215 0.6835844 0.7701193
## [277] 0.7333859 0.5970968 0.8611212 0.6305111 0.8013348 0.4775221
## [283] 0.9328511 0.7057912 0.7118070 0.7650197 0.7758004 0.8572204
## [289] 0.8284686 0.7688830 0.7862307 0.9823026 0.8135034 0.9262331
## [295] 0.2935749 0.5046892 0.7306630 0.8373255 0.8605431 0.8600511
## [301] 0.5796348 0.8811059 0.8190785 0.8212030 0.8756490 0.8010216
## [307] 0.9301198 0.7029825 0.8037159 0.8432400 0.5073820 0.7282265
## [313] 0.8187329 0.7305424 0.7428246 0.9248807 0.6800046 0.7205126
## [319] 0.8390958 0.6623474 0.9082076 0.9042436 0.7754951 0.4234463
## [325] 0.4791721 0.5839406 0.6449879 0.8360886 0.8220325 0.8682514
## [331] 0.9462763 0.4927805 0.8702052 0.8297424 0.5743866 0.8638268
## [337] 0.6200188 0.8575615 0.8827770 0.8560487 0.7048624 0.8223029
## [343] 0.8107322 0.8474215 0.6446622 0.7949617 0.8398069 0.8037369
## [349] 0.5738176 0.9621100 0.9510679 0.8073415 0.9045813 0.8311709
## [355] 0.7908642 0.7723811 0.8965577 0.9379014 0.9125163 0.7155668
## [361] 0.9177321 0.9032003 0.7453182 0.8475961 0.6763958 0.9111765
## [367] 0.7215191 0.8975345 0.7182437 0.9327780 0.7749827 0.4613007
## [373] 0.7699416 0.6244720 0.9435499 0.7912792 0.9179509 0.9120472
## [379] 0.6592434 0.7020889 0.7949157 0.7660971 0.7632987 0.8142261
## [385] 0.6814763 0.7778572 0.8305780 0.8733795 0.8894003 0.4779211
## [391] 0.9264889 0.7010274 0.7922144 0.7724571 0.4337690 0.3142486
## [397] 0.8134615 0.7991898 0.3445492 0.7112154 0.8405469 0.8301388
## [403] 0.7269186 0.6638092 0.9012427 0.7914690 0.6230790 0.8195173
## [409] 0.8708369 0.6038329 0.8005954 0.9309686 0.8932810 0.9338088
## [415] 0.6814781 0.9188700 0.6429278 0.9313080 0.6516503 0.8313922
## [421] 0.7807945 0.8019565 0.6132260 0.6138717 0.8568591 0.6699759
## [427] 0.8126850 0.5933424 0.8600165 0.4065893 0.6663190 0.3710635
## [433] 0.7437318 0.7935980 0.4528464 0.8801452 0.9175498 0.6685032
## [439] 0.7230661 0.7272831 0.5718904 0.8832916 0.7332020 0.6743675
## [445] 0.3444414 0.8628954 0.8689840 0.9057621 0.9358893 0.6345076
## [451] 0.9175508 0.7385811 0.9232594 0.9593707 0.7216116 0.6891631
## [457] 0.6704509 0.4139246 0.9242060 0.9311526 0.7402539 0.6674717
## [463] 0.8841071 0.9151263 0.8195928 0.9084508 0.8873319 0.9204116
## [469] 0.8544382 0.7491610 0.9467864 0.6285715 0.6559344 0.6606244
## [475] 0.7933110 0.6867611 0.7557185 0.7935863 0.8332683 0.8130354
## [481] 0.6002205 0.7569397 0.7491856 0.9443432 0.7715007 0.8711288
## [487] 0.9059689 0.6856878 0.7493826 0.7578152 0.9789478 0.7794192
## [493] 0.8706300 0.9263026 0.8759279 0.4862369 0.6639006 0.5864141
```

```
## [499] 0.9066888 0.7381651 0.7182064 0.9228661 0.6913695 0.6998998
## [505] 0.7258716 0.9704164 0.8368530 0.8511458 0.6464158 0.4453887
## [511] 0.8752147 0.7443561 0.7616496 0.9006988 0.8803353 0.4960341
## [517] 0.9145048 0.6525035 0.8582500 0.9303695 0.9000041 0.6161071
## [523] 0.7345535 0.4711859 0.8747066 0.5995823 0.4896198 0.9320428
## [529] 0.8153481 0.6573873 0.8389320 0.7346586 0.8140948 0.7203778
## [535] 0.5798306 0.8660962 0.7715967 0.8515778 0.6739306 0.6711454
## [541] 0.7647722 0.6650198 0.9511903 0.9523745 0.6669188 0.8709629
## [547] 0.7654281 0.9348194 0.8651852 0.6298582 0.9241811 0.8866581
## [553] 0.8212606 0.9073364 0.8106002 0.4884523 0.8923018 0.8773432
## [559] 0.7272449 0.7785269 0.8209021 0.8376321 0.7624946 0.9607840
## [565] 0.9524087 0.8614988 0.6729730 0.8311742 0.7773052 0.5794988
## [571] 0.7323972 0.7686293 0.8580465 0.8619659 0.9010520 0.4769893
## [577] 0.7942936 0.5379205 0.9109302 0.5860928 0.7317986 0.9508078
## [583] 0.9096985 0.8032535 0.9052325 0.7539075 0.8297247 0.7278393
## [589] 0.8649035 0.5617298 0.7068490 0.6855866 0.6978611 0.7283221
## [595] 0.8676930 0.9195045 0.5448878 0.8920227 0.7750389 0.8268857
## [601] 0.7780530 0.9850521 0.8686554 0.7108613 0.6853134 0.5752779
## [607] 0.9046527 0.7171031 0.7826220 0.5600183 0.7368691 0.8900705
## [613] 0.8676643 0.4286164 0.6754064 0.5110668 0.9446405 0.9151668
## [619] 0.9158021 0.6438445 0.6674373 0.7676561 0.7805144 0.5157234
## [625] 0.7919814 0.8960291 0.7346113 0.7220085 0.8223600 0.6798229
## [631] 0.5823128 0.6697052 0.5936597 0.6532075 0.7010886 0.8505122
## [637] 0.6500789 0.6746217 0.8164387 0.8812137 0.5917140 0.8547538
## [643] 0.6146122 0.9554979 0.9550466 0.7423891 0.8707321 0.7445611
## [649] 0.7862246 0.7411131 0.7561633 0.5966908 0.8857497 0.7916467
## [655] 0.8607571 0.8229016 0.6133203 0.6422552 0.8299774 0.6258596
## [661] 0.9783156 0.8823634 0.9052889 0.9465145 0.8553889 0.9196763
## [667] 0.7281712 0.8185132 0.7976887 0.8373100 0.9329585 0.9085770
## [673] 0.7151374 0.5774354 0.8594549 0.9422850 0.8124203 0.7304725
## [679] 0.9195452 0.5686190 0.7741607 0.8244837 0.5209978 0.9634176
## [685] 0.6711526 0.6299782 0.9918361 0.7240248 0.9125133 0.9153378
## [691] 0.6313603 0.7279531 0.8245974 0.7958124 0.6075838 0.5402864
## [697] 0.5136750 0.9184433 0.6808469 0.8992837 0.7501455 0.8097748
## [703] 0.8573210 0.6143540 0.8232470 0.8872820 0.8845771 0.8229001
## [709] 0.7578870 0.9253479 0.5711217 0.8990287 0.4580262 0.8207627
## [715] 0.8425417 0.7745900 0.7072784 0.7937883 0.8725666 0.7029809
## [721] 0.6661814 0.7327877 0.6924548 0.9177936 0.3552199 0.7875509
## [727] 0.8985668 0.7727130 0.9532091 0.6890796 0.5399657 0.6172611
## [733] 0.7321934 0.8123198 0.8731853 0.5422638 0.8813413 0.5839453
## [739] 0.7234418 0.8506626 0.8863809 0.4429041 0.9468900 0.9132313
## [745] 0.7793572 0.8386513 0.7363930 0.9224509 0.8211493 0.8318534
## [751] 0.9054196 0.8238898 0.6307103 0.7839515 0.8506296 0.8085137
## [757] 0.7629900 0.8463466 0.8196959 0.7299904 0.7350514 0.8615653
## [763] 0.8864065 0.9231701 0.6505283 0.9351291 0.6261416 0.9401788
## [769] 0.9548218 0.5200688 0.9386668 0.5103738 0.7594599 0.5858365
## [775] 0.7973548 0.5150957 0.7861382 0.8141736 0.5875679 0.9021349
## [781] 0.6972597 0.9148199 0.7459760 0.8521829 0.9274202 0.7274581
## [787] 0.6557685 0.9848333 0.5815401 0.7764410 0.7728602 0.9132548
## [793] 0.5109258 0.7214993 0.7728011 0.5422207 0.7738965 0.6099208
## [799] 0.6224529 0.6362466 0.7730588 0.7149808 0.6859459 0.8378129
## [805] 0.8085028 0.8538206 0.9799279 0.6191026 0.9292810 0.6483710
## [811] 0.9150360 0.8773784 0.9632035 0.9179394 0.9416594 0.6888332
## [817] 0.9194930 0.7937190 0.7557179 0.9382845 0.7731015 0.7591713
```

```
##  [823] 0.7718074 0.7982163 0.5895211 0.8682406 0.8105870 0.7836722
##  [829] 0.8130234 0.6664242 0.9094402 0.9076426 0.7567746 0.5517168
##  [835] 0.7234137 0.8803638 0.5812526 0.8841997 0.7971025 0.9285724
##  [841] 0.6777402 0.4820797 0.8526137 0.9656699 0.8018406 0.9133694
##  [847] 0.8066360 0.6796558 0.2821170 0.5500308 0.9659223 0.8080355
##  [853] 0.7529393 0.9305615 0.8468762 0.7848164 0.6876661 0.9172720
##  [859] 0.8940477 0.9411414 0.7188100 0.8267012 0.4774145 0.4832236
##  [865] 0.5790943 0.7640526 0.7148584 0.4473728 0.6422627 0.7748095
##  [871] 0.8609262 0.6587911 0.5590200 0.7680032 0.7388040 0.7033241
##  [877] 0.4765397 0.9485446 0.9076330 0.7955476 0.9030230 0.8491559
##  [883] 0.9028816 0.9570602 0.8388348 0.4999516 0.9084215 0.7718385
##  [889] 0.9452761 0.7729639 0.4825567 0.8914957 0.8902164 0.6285405
##  [895] 0.8772998 0.7694990 0.8855217 0.7115879 0.9256531 0.7271115
##  [901] 0.6332688 0.8980526 0.7597185 0.9587484 0.3277952 0.6957912
##  [907] 0.9436030 0.5329854 0.8547113 0.7705394 0.5850841 0.9441016
##  [913] 0.9380508 0.9312880 0.9250382 0.8290341 0.4513537 0.8027011
##  [919] 0.8796030 0.8941213 0.7429799 0.7718867 0.7303820 0.8976351
##  [925] 0.7518645 0.9142553 0.9741537 0.7224712 0.8102082 0.8440600
##  [931] 0.8740437 0.8203747 0.7776758 0.6225317 0.6047948 0.9554754
##  [937] 0.6744197 0.8601355 0.8238910 0.6497458 0.7407098 0.7217674
##  [943] 0.9189859 0.8172124 0.7787066 0.7413331 0.6520937 0.9774700
##  [949] 0.8218603 0.7213974 0.7551289 0.8642981 0.8278792 0.7640785
##  [955] 0.8054259 0.8014907 0.7326306 0.8021894 0.9288738 0.8657932
##  [961] 0.8309316 0.8215137 0.8636100 0.7018080 0.6164522 0.7789584
##  [967] 0.7206287 0.7261358 0.8920904 0.7588431 0.7755221 0.8870612
##  [973] 0.8663629 0.7928683 0.6318836 0.7115789 0.6551894 0.9253604
##  [979] 0.7122619 0.6910876 0.5971311 0.5430247 0.5675155 0.7052825
##  [985] 0.8187125 0.6553523 0.5903269 0.9336316 0.6538122 0.8342932
##  [991] 0.5852040 0.6441082 0.8765090 0.7962291 0.9175517 0.5701648
##  [997] 0.9694874 0.8415724 0.8928194 0.5996846
```

```r
theta.hat.star.df
```

```
##      theta.hat.star
## 1         0.8484063
## 2         0.6316826
## 3         0.9825900
## 4         0.8255229
## 5         0.8495999
## 6         0.8261002
## 7         0.8661347
## 8         0.8834630
## 9         0.9006001
## 10        0.5907339
## 11        0.7830618
## 12        0.8956721
## 13        0.8390269
## 14        0.6767403
## 15        0.6655151
## 16        0.7880434
## 17        0.7669794
## 18        0.8333284
## 19        0.4788920
## 20        0.7714328
## 21        0.6888578
```

```
## 22          0.6085110
## 23          0.8870055
## 24          0.8891343
## 25          0.9293760
## 26          0.8941580
## 27          0.7842890
## 28          0.9759656
## 29          0.6580838
## 30          0.8803008
## 31          0.7278119
## 32          0.9764674
## 33          0.6583863
## 34          0.6168595
## 35          0.6598359
## 36          0.8303769
## 37          0.7441387
## 38          0.9125698
## 39          0.7720787
## 40          0.8052933
## 41          0.7456710
## 42          0.9079140
## 43          0.7810588
## 44          0.7018577
## 45          0.7022426
## 46          0.9012286
## 47          0.9088847
## 48          0.9309482
## 49          0.3903147
## 50          0.9605292
## 51          0.8423109
## 52          0.9381429
## 53          0.7806078
## 54          0.9464569
## 55          0.7778007
## 56          0.6670899
## 57          0.8605475
## 58          0.7628063
## 59          0.8569390
## 60          0.6204809
## 61          0.7548218
## 62          0.4333586
## 63          0.9514910
## 64          0.2215294
## 65          0.9487501
## 66          0.8885582
## 67          0.6819842
## 68          0.6990087
## 69          0.8783708
## 70          0.6023873
## 71          0.8013960
## 72          0.3813482
## 73          0.7119660
## 74          0.8667703
## 75          0.7203806
```

```
## 76          0.6057199
## 77          0.8547396
## 78          0.9245165
## 79          0.8545298
## 80          0.6373720
## 81          0.7845749
## 82          0.9768518
## 83          0.8438509
## 84          0.9895442
## 85          0.8665138
## 86          0.9117396
## 87          0.7704158
## 88          0.8589641
## 89          0.7834545
## 90          0.8452853
## 91          0.9354389
## 92          0.7198367
## 93          0.8875415
## 94          0.9335897
## 95          0.7231350
## 96          0.8398740
## 97          0.8276306
## 98          0.8507689
## 99          0.8705201
## 100         0.6667573
## 101         0.6629954
## 102         0.7455497
## 103         0.8135639
## 104         0.7826830
## 105         0.9558701
## 106         0.8636942
## 107         0.6215780
## 108         0.5386313
## 109         0.7424817
## 110         0.6646911
## 111         0.8607529
## 112         0.9353608
## 113         0.7096247
## 114         0.3969845
## 115         0.8585453
## 116         0.8808895
## 117         0.8671265
## 118         0.9466575
## 119         0.7951984
## 120         0.8093433
## 121         0.6461451
## 122         0.7237113
## 123         0.6086657
## 124         0.6420466
## 125         0.8083532
## 126         0.8101672
## 127         0.7055363
## 128         0.8455851
## 129         0.8672329
```

```
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## 131        0.8591594
## 132        0.7003659
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## 134        0.7597974
## 135        0.8761399
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## 137        0.9123433
## 138        0.6228996
## 139        0.5804809
## 140        0.7679912
## 141        0.9705725
## 142        0.7407414
## 143        0.8154191
## 144        0.8546031
## 145        0.9173857
## 146        0.8029028
## 147        0.8388353
## 148        0.6528412
## 149        0.5988332
## 150        0.7513465
## 151        0.8022712
## 152        0.7863913
## 153        0.6940034
## 154        0.7627176
## 155        0.8931142
## 156        0.8630833
## 157        0.7928282
## 158        0.6684376
## 159        0.9324184
## 160        0.6394841
## 161        0.8584064
## 162        0.9252122
## 163        0.8969546
## 164        0.8636759
## 165        0.6429309
## 166        0.7967141
## 167        0.8145145
## 168        0.8791452
## 169        0.8398039
## 170        0.9399158
## 171        0.9410929
## 172        0.9412756
## 173        0.6638791
## 174        0.8583365
## 175        0.6737819
## 176        0.7699293
## 177        0.8347644
## 178        0.7492324
## 179        0.5921786
## 180        0.8119755
## 181        0.6229308
## 182        0.4989414
## 183        0.8746569
```

```
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## 185        0.8609801
## 186        0.8166173
## 187        0.5334794
## 188        0.9104799
## 189        0.7811890
## 190        0.7510102
## 191        0.7829000
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## 193        0.8063302
## 194        0.8625832
## 195        0.7044331
## 196        0.9388681
## 197        0.9334327
## 198        0.7058491
## 199        0.7693600
## 200        0.9093276
## 201        0.9033053
## 202        0.7995914
## 203        0.7252945
## 204        0.8471418
## 205        0.6337806
## 206        0.7837673
## 207        0.9531264
## 208        0.8907437
## 209        0.8434617
## 210        0.7711600
## 211        0.8188653
## 212        0.7063732
## 213        0.8508669
## 214        0.7798309
## 215        0.8505594
## 216        0.5847226
## 217        0.7568213
## 218        0.9045626
## 219        0.9496660
## 220        0.6024775
## 221        0.8918807
## 222        0.7941885
## 223        0.8873180
## 224        0.9107763
## 225        0.7447879
## 226        0.7336387
## 227        0.7119080
## 228        0.7073913
## 229        0.7109964
## 230        0.8043846
## 231        0.5885016
## 232        0.4996746
## 233        0.7431657
## 234        0.4651076
## 235        0.8195815
## 236        0.8087968
## 237        0.7689289
```

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## 238        0.8219518
## 239        0.8281651
## 240        0.8376250
## 241        0.8574205
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## 243        0.8520056
## 244        0.8012227
## 245        0.6669427
## 246        0.6382964
## 247        0.8190446
## 248        0.7861443
## 249        0.8600243
## 250        0.9412712
## 251        0.8640642
## 252        0.8747762
## 253        0.8222612
## 254        0.6205937
## 255        0.6600079
## 256        0.7727376
## 257        0.7299584
## 258        0.9640808
## 259        0.9863439
## 260        0.8388737
## 261        0.9288310
## 262        0.8073237
## 263        0.6721381
## 264        0.7015188
## 265        0.5752959
## 266        0.6181041
## 267        0.7243230
## 268        0.7778983
## 269        0.7793896
## 270        0.9727994
## 271        0.8436386
## 272        0.8879080
## 273        0.7565744
## 274        0.8116215
## 275        0.6835844
## 276        0.7701193
## 277        0.7333859
## 278        0.5970968
## 279        0.8611212
## 280        0.6305111
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## 283        0.9328511
## 284        0.7057912
## 285        0.7118070
## 286        0.7650197
## 287        0.7758004
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## 289        0.8284686
## 290        0.7688830
## 291        0.7862307
```

```
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## 293          0.8135034
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## 295          0.2935749
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## 303          0.8190785
## 304          0.8212030
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## 315          0.7428246
## 316          0.9248807
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## 323          0.7754951
## 324          0.4234463
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## 328          0.8360886
## 329          0.8220325
## 330          0.8682514
## 331          0.9462763
## 332          0.4927805
## 333          0.8702052
## 334          0.8297424
## 335          0.5743866
## 336          0.8638268
## 337          0.6200188
## 338          0.8575615
## 339          0.8827770
## 340          0.8560487
## 341          0.7048624
## 342          0.8223029
## 343          0.8107322
## 344          0.8474215
## 345          0.6446622
```

```
## 346        0.7949617
## 347        0.8398069
## 348        0.8037369
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## 351        0.9510679
## 352        0.8073415
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## 356        0.7723811
## 357        0.8965577
## 358        0.9379014
## 359        0.9125163
## 360        0.7155668
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## 365        0.6763958
## 366        0.9111765
## 367        0.7215191
## 368        0.8975345
## 369        0.7182437
## 370        0.9327780
## 371        0.7749827
## 372        0.4613007
## 373        0.7699416
## 374        0.6244720
## 375        0.9435499
## 376        0.7912792
## 377        0.9179509
## 378        0.9120472
## 379        0.6592434
## 380        0.7020889
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## 382        0.7660971
## 383        0.7632987
## 384        0.8142261
## 385        0.6814763
## 386        0.7778572
## 387        0.8305780
## 388        0.8733795
## 389        0.8894003
## 390        0.4779211
## 391        0.9264889
## 392        0.7010274
## 393        0.7922144
## 394        0.7724571
## 395        0.4337690
## 396        0.3142486
## 397        0.8134615
## 398        0.7991898
## 399        0.3445492
```

```
## 400          0.7112154
## 401          0.8405469
## 402          0.8301388
## 403          0.7269186
## 404          0.6638092
## 405          0.9012427
## 406          0.7914690
## 407          0.6230790
## 408          0.8195173
## 409          0.8708369
## 410          0.6038329
## 411          0.8005954
## 412          0.9309686
## 413          0.8932810
## 414          0.9338088
## 415          0.6814781
## 416          0.9188700
## 417          0.6429278
## 418          0.9313080
## 419          0.6516503
## 420          0.8313922
## 421          0.7807945
## 422          0.8019565
## 423          0.6132260
## 424          0.6138717
## 425          0.8568591
## 426          0.6699759
## 427          0.8126850
## 428          0.5933424
## 429          0.8600165
## 430          0.4065893
## 431          0.6663190
## 432          0.3710635
## 433          0.7437318
## 434          0.7935980
## 435          0.4528464
## 436          0.8801452
## 437          0.9175498
## 438          0.6685032
## 439          0.7230661
## 440          0.7272831
## 441          0.5718904
## 442          0.8832916
## 443          0.7332020
## 444          0.6743675
## 445          0.3444414
## 446          0.8628954
## 447          0.8689840
## 448          0.9057621
## 449          0.9358893
## 450          0.6345076
## 451          0.9175508
## 452          0.7385811
## 453          0.9232594
```

```
## 454        0.9593707
## 455        0.7216116
## 456        0.6891631
## 457        0.6704509
## 458        0.4139246
## 459        0.9242060
## 460        0.9311526
## 461        0.7402539
## 462        0.6674717
## 463        0.8841071
## 464        0.9151263
## 465        0.8195928
## 466        0.9084508
## 467        0.8873319
## 468        0.9204116
## 469        0.8544382
## 470        0.7491610
## 471        0.9467864
## 472        0.6285715
## 473        0.6559344
## 474        0.6606244
## 475        0.7933110
## 476        0.6867611
## 477        0.7557185
## 478        0.7935863
## 479        0.8332683
## 480        0.8130354
## 481        0.6002205
## 482        0.7569397
## 483        0.7491856
## 484        0.9443432
## 485        0.7715007
## 486        0.8711288
## 487        0.9059689
## 488        0.6856878
## 489        0.7493826
## 490        0.7578152
## 491        0.9789478
## 492        0.7794192
## 493        0.8706300
## 494        0.9263026
## 495        0.8759279
## 496        0.4862369
## 497        0.6639006
## 498        0.5864141
## 499        0.9066888
## 500        0.7381651
## 501        0.7182064
## 502        0.9228661
## 503        0.6913695
## 504        0.6998998
## 505        0.7258716
## 506        0.9704164
## 507        0.8368530
```

```
## 508         0.8511458
## 509         0.6464158
## 510         0.4453887
## 511         0.8752147
## 512         0.7443561
## 513         0.7616496
## 514         0.9006988
## 515         0.8803353
## 516         0.4960341
## 517         0.9145048
## 518         0.6525035
## 519         0.8582500
## 520         0.9303695
## 521         0.9000041
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## 524         0.4711859
## 525         0.8747066
## 526         0.5995823
## 527         0.4896198
## 528         0.9320428
## 529         0.8153481
## 530         0.6573873
## 531         0.8389320
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## 533         0.8140948
## 534         0.7203778
## 535         0.5798306
## 536         0.8660962
## 537         0.7715967
## 538         0.8515778
## 539         0.6739306
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## 545         0.6669188
## 546         0.8709629
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## 550         0.6298582
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## 552         0.8866581
## 553         0.8212606
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## 556         0.4884523
## 557         0.8923018
## 558         0.8773432
## 559         0.7272449
## 560         0.7785269
## 561         0.8209021
```

```
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## 563        0.7624946
## 564        0.9607840
## 565        0.9524087
## 566        0.8614988
## 567        0.6729730
## 568        0.8311742
## 569        0.7773052
## 570        0.5794988
## 571        0.7323972
## 572        0.7686293
## 573        0.8580465
## 574        0.8619659
## 575        0.9010520
## 576        0.4769893
## 577        0.7942936
## 578        0.5379205
## 579        0.9109302
## 580        0.5860928
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## 582        0.9508078
## 583        0.9096985
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## 586        0.7539075
## 587        0.8297247
## 588        0.7278393
## 589        0.8649035
## 590        0.5617298
## 591        0.7068490
## 592        0.6855866
## 593        0.6978611
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## 597        0.5448878
## 598        0.8920227
## 599        0.7750389
## 600        0.8268857
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## 603        0.8686554
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## 607        0.9046527
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## 609        0.7826220
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## 611        0.7368691
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## 613        0.8676643
## 614        0.4286164
## 615        0.6754064
```

```
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## 622         0.7676561
## 623         0.7805144
## 624         0.5157234
## 625         0.7919814
## 626         0.8960291
## 627         0.7346113
## 628         0.7220085
## 629         0.8223600
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## 631         0.5823128
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## 633         0.5936597
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## 639         0.8164387
## 640         0.8812137
## 641         0.5917140
## 642         0.8547538
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## 645         0.9550466
## 646         0.7423891
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## 648         0.7445611
## 649         0.7862246
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## 651         0.7561633
## 652         0.5966908
## 653         0.8857497
## 654         0.7916467
## 655         0.8607571
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## 659         0.8299774
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## 661         0.9783156
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## 663         0.9052889
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## 665         0.8553889
## 666         0.9196763
## 667         0.7281712
## 668         0.8185132
## 669         0.7976887
```

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## 670         0.8373100
## 671         0.9329585
## 672         0.9085770
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## 674         0.5774354
## 675         0.8594549
## 676         0.9422850
## 677         0.8124203
## 678         0.7304725
## 679         0.9195452
## 680         0.5686190
## 681         0.7741607
## 682         0.8244837
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## 684         0.9634176
## 685         0.6711526
## 686         0.6299782
## 687         0.9918361
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## 689         0.9125133
## 690         0.9153378
## 691         0.6313603
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## 693         0.8245974
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## 696         0.5402864
## 697         0.5136750
## 698         0.9184433
## 699         0.6808469
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## 701         0.7501455
## 702         0.8097748
## 703         0.8573210
## 704         0.6143540
## 705         0.8232470
## 706         0.8872820
## 707         0.8845771
## 708         0.8229001
## 709         0.7578870
## 710         0.9253479
## 711         0.5711217
## 712         0.8990287
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## 715         0.8425417
## 716         0.7745900
## 717         0.7072784
## 718         0.7937883
## 719         0.8725666
## 720         0.7029809
## 721         0.6661814
## 722         0.7327877
## 723         0.6924548
```

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## 724         0.9177936
## 725         0.3552199
## 726         0.7875509
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## 728         0.7727130
## 729         0.9532091
## 730         0.6890796
## 731         0.5399657
## 732         0.6172611
## 733         0.7321934
## 734         0.8123198
## 735         0.8731853
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## 739         0.7234418
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## 744         0.9132313
## 745         0.7793572
## 746         0.8386513
## 747         0.7363930
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## 749         0.8211493
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## 751         0.9054196
## 752         0.8238898
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## 754         0.7839515
## 755         0.8506296
## 756         0.8085137
## 757         0.7629900
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## 759         0.8196959
## 760         0.7299904
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## 774         0.5858365
## 775         0.7973548
## 776         0.5150957
## 777         0.7861382
```

```
## 778        0.8141736
## 779        0.5875679
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## 781        0.6972597
## 782        0.9148199
## 783        0.7459760
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## 785        0.9274202
## 786        0.7274581
## 787        0.6557685
## 788        0.9848333
## 789        0.5815401
## 790        0.7764410
## 791        0.7728602
## 792        0.9132548
## 793        0.5109258
## 794        0.7214993
## 795        0.7728011
## 796        0.5422207
## 797        0.7738965
## 798        0.6099208
## 799        0.6224529
## 800        0.6362466
## 801        0.7730588
## 802        0.7149808
## 803        0.6859459
## 804        0.8378129
## 805        0.8085028
## 806        0.8538206
## 807        0.9799279
## 808        0.6191026
## 809        0.9292810
## 810        0.6483710
## 811        0.9150360
## 812        0.8773784
## 813        0.9632035
## 814        0.9179394
## 815        0.9416594
## 816        0.6888332
## 817        0.9194930
## 818        0.7937190
## 819        0.7557179
## 820        0.9382845
## 821        0.7731015
## 822        0.7591713
## 823        0.7718074
## 824        0.7982163
## 825        0.5895211
## 826        0.8682406
## 827        0.8105870
## 828        0.7836722
## 829        0.8130234
## 830        0.6664242
## 831        0.9094402
```

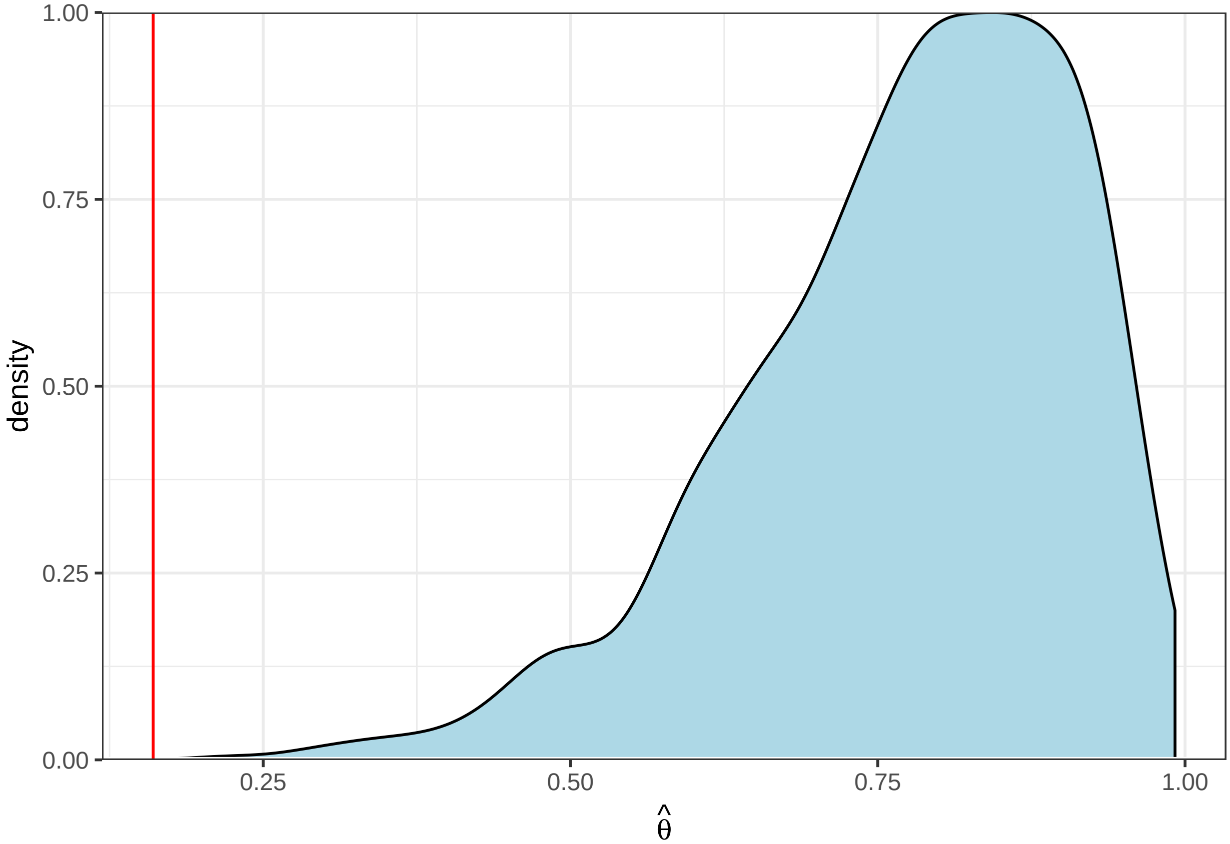
```
## 832          0.9076426
## 833          0.7567746
## 834          0.5517168
## 835          0.7234137
## 836          0.8803638
## 837          0.5812526
## 838          0.8841997
## 839          0.7971025
## 840          0.9285724
## 841          0.6777402
## 842          0.4820797
## 843          0.8526137
## 844          0.9656699
## 845          0.8018406
## 846          0.9133694
## 847          0.8066360
## 848          0.6796558
## 849          0.2821170
## 850          0.5500308
## 851          0.9659223
## 852          0.8080355
## 853          0.7529393
## 854          0.9305615
## 855          0.8468762
## 856          0.7848164
## 857          0.6876661
## 858          0.9172720
## 859          0.8940477
## 860          0.9411414
## 861          0.7188100
## 862          0.8267012
## 863          0.4774145
## 864          0.4832236
## 865          0.5790943
## 866          0.7640526
## 867          0.7148584
## 868          0.4473728
## 869          0.6422627
## 870          0.7748095
## 871          0.8609262
## 872          0.6587911
## 873          0.5590200
## 874          0.7680032
## 875          0.7388040
## 876          0.7033241
## 877          0.4765397
## 878          0.9485446
## 879          0.9076330
## 880          0.7955476
## 881          0.9030230
## 882          0.8491559
## 883          0.9028816
## 884          0.9570602
## 885          0.8388348
```

```
## 886        0.4999516
## 887        0.9084215
## 888        0.7718385
## 889        0.9452761
## 890        0.7729639
## 891        0.4825567
## 892        0.8914957
## 893        0.8902164
## 894        0.6285405
## 895        0.8772998
## 896        0.7694990
## 897        0.8855217
## 898        0.7115879
## 899        0.9256531
## 900        0.7271115
## 901        0.6332688
## 902        0.8980526
## 903        0.7597185
## 904        0.9587484
## 905        0.3277952
## 906        0.6957912
## 907        0.9436030
## 908        0.5329854
## 909        0.8547113
## 910        0.7705394
## 911        0.5850841
## 912        0.9441016
## 913        0.9380508
## 914        0.9312880
## 915        0.9250382
## 916        0.8290341
## 917        0.4513537
## 918        0.8027011
## 919        0.8796030
## 920        0.8941213
## 921        0.7429799
## 922        0.7718867
## 923        0.7303820
## 924        0.8976351
## 925        0.7518645
## 926        0.9142553
## 927        0.9741537
## 928        0.7224712
## 929        0.8102082
## 930        0.8440600
## 931        0.8740437
## 932        0.8203747
## 933        0.7776758
## 934        0.6225317
## 935        0.6047948
## 936        0.9554754
## 937        0.6744197
## 938        0.8601355
## 939        0.8238910
```

```
## 940         0.6497458
## 941         0.7407098
## 942         0.7217674
## 943         0.9189859
## 944         0.8172124
## 945         0.7787066
## 946         0.7413331
## 947         0.6520937
## 948         0.9774700
## 949         0.8218603
## 950         0.7213974
## 951         0.7551289
## 952         0.8642981
## 953         0.8278792
## 954         0.7640785
## 955         0.8054259
## 956         0.8014907
## 957         0.7326306
## 958         0.8021894
## 959         0.9288738
## 960         0.8657932
## 961         0.8309316
## 962         0.8215137
## 963         0.8636100
## 964         0.7018080
## 965         0.6164522
## 966         0.7789584
## 967         0.7206287
## 968         0.7261358
## 969         0.8920904
## 970         0.7588431
## 971         0.7755221
## 972         0.8870612
## 973         0.8663629
## 974         0.7928683
## 975         0.6318836
## 976         0.7115789
## 977         0.6551894
## 978         0.9253604
## 979         0.7122619
## 980         0.6910876
## 981         0.5971311
## 982         0.5430247
## 983         0.5675155
## 984         0.7052825
## 985         0.8187125
## 986         0.6553523
## 987         0.5903269
## 988         0.9336316
## 989         0.6538122
## 990         0.8342932
## 991         0.5852040
## 992         0.6441082
## 993         0.8765090
```

```
## 994       0.7962291
## 995       0.9175517
## 996       0.5701648
## 997       0.9694874
## 998       0.8415724
## 999       0.8928194
## 1000      0.5996846
```

```
ggplot(theta.hat.star.df) +
  geom_density(aes(x = theta.hat.star, y = ..scaled..),
    fill = "lightblue") +
  geom_hline(yintercept=0, colour="white", size=1) +
  theme_bw() +
  ylab("density") +
  xlab(bquote(hat(theta))) +
  geom_vline(xintercept = theta.hat, col = "red")+
  scale_y_continuous(expand = c(0,0))
```



Solution to Problem 5

```
cysticerci <- c(28.9, 32.8, 12.0, 9.9, 15.0, 38.0, 12.5, 36.5, 8.6, 26.8)
worms_reco <- c(1.0, 7.7, 7.3, 7.9, 1.1, 3.5, 18.9, 33.9, 28.6, 25.0)
```

The null hypothesis is that the mean weight of introduced cysticerci *has no correlation with* the mean weight of worms recovered. That is,

$$H_0 : r_s < r_{s,\alpha}$$

The alternative hypothesis is that the mean weight of introduced cysticerci is *positively correlated with* the mean weight of worms recovered. That is,

$$H_A : r_s \geq r_{s,\alpha}$$

Otherwise, do not reject.

To test the null hypothesis against the alternative hypothesis, we will use the Spearman test, a distribution-free test for independence based on ranks.

```
# this method of performing the test was given in the textbook
library(SuppDists)
qSpearman(p = 0.05, r = 10)
```

```
## [1] -0.5393939
```

~~Since $r_{s,\alpha} = -0.5393939$, we will reject the null hypothesis only if $r_s \geq -0.5393939$.~~

~~Calculating r_s,~~

```
cor(x = cysticerci, y = worms_reco, method = "spearman")
```

```
## [1] -0.2
```

~~Since $r_s = -0.2$ and $r_{s,\alpha} = -0.5393939$, the statement $r_s \geq r_{s,\alpha}$ is *true*. Thus, we *reject* the null hypothesis. There is *sufficient* evidence that the mean weight of introduced cysticerci is *positively correlated with* the mean weight of worms recovered.~~

NOTE: ~~At this point, I tried to use `cor.test()` with `method` = "spearman" but I got a different result than I expected, and I'm not sure why. Maybe I'm interpreting the output incorrectly?~~

```
cor.test(x = cysticerci, y = worms_reco, method = "spearman", alternative = "greater")
```

```
##
##  Spearman's rank correlation rho
##
## data:  cysticerci and worms_reco
## S = 198, p-value = 0.72
## alternative hypothesis: true rho is greater than 0
## sample estimates:
##  rho
## -0.2
```

The p-value is 0.72, which is *not* significant at the $\alpha = 0.05$ level. There is *not enough* evidence that the mean weight of introduced cysticerci is *positively correlated with* the mean weight of worms recovered.

Solution to Problem 6

```
x = c(0, 5000, 10000, 15000, 20000, 25000, 30000, 100000)
y = c(0.924, 0.988, 0.992, 1.118, 1.133, 1.145, 1.157, 1.357)
```

The null hypothesis is that the mean weight of introduced cysticerci *has no correlation with* the mean weight of worms recovered. That is,

$$H_0 : \beta = \beta_0$$
$$H_0 : \beta = 0$$

The alternative hypothesis is that the mean weight of introduced cysticerci is *positively correlated with* the mean weight of worms recovered. That is,

$$H_A : \beta > \beta_0$$
$$H_A : \beta > 0$$

To test the null hypothesis against the alternative hypothesis, we will use the Theil test, a distribution-free test for the slope of the regression line.

```r
library(NSM3)
```

```
## Loading required package: combinat
```

```
##
## Attaching package: 'combinat'
```

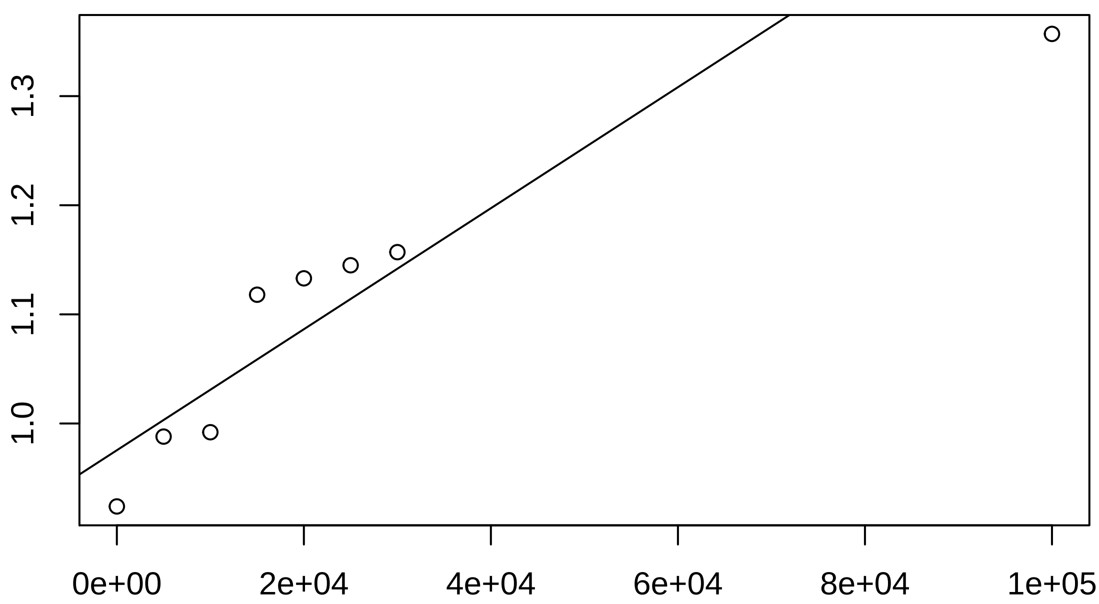
```
## The following object is masked from 'package:utils':
##
##     combn
```

```
## Loading required package: MASS
```

```
## Loading required package: survival
```

```
## fANCOVA 0.5-1 loaded
```

```r
theil(x, y, alpha=0.05, beta.0=0, type = "u")
```




```
## Alternative: beta greater than 0
## C = 28, C.bar = 1, P = 0
## beta.hat = 0
```

```
## alpha.hat = 0.975
##
## 1 - alpha = 0.95 upper bound for beta:
## -Inf, 0
```

```r
theil.fit = theil (x,
  y,
  beta.0 = 0 ,
  slopes=TRUE,
  type = "u",
  doplot = FALSE)
theil.fit
```

```
## Alternative: beta greater than 0
## C = 28, C.bar = 1, P = 0
## beta.hat = 0
## alpha.hat = 0.975
##
## All slopes:
##   i j         S.ij
##   1 2 1.280000e-05
##   1 3 6.800000e-06
##   1 4 1.293333e-05
##   1 5 1.045000e-05
##   1 6 8.840000e-06
##   1 7 7.766667e-06
##   1 8 4.330000e-06
##   2 3 8.000000e-07
##   2 4 1.300000e-05
##   2 5 9.666667e-06
##   2 6 7.850000e-06
##   2 7 6.760000e-06
##   2 8 3.884211e-06
##   3 4 2.520000e-05
##   3 5 1.410000e-05
##   3 6 1.020000e-05
##   3 7 8.250000e-06
##   3 8 4.055556e-06
##   4 5 3.000000e-06
##   4 6 2.700000e-06
##   4 7 2.600000e-06
##   4 8 2.811765e-06
##   5 6 2.400000e-06
##   5 7 2.400000e-06
##   5 8 2.800000e-06
##   6 7 2.400000e-06
##   6 8 2.826667e-06
##   7 8 2.857143e-06
##
##
## 1 - alpha = 0.95 upper bound for beta:
## -Inf, 0
```

```r
theil.output = theil(x,
  y,
```

```r
  beta.0 = 0,
  slopes=TRUE,
  type = "u", doplot = FALSE, alpha = .05)
c(theil.output$L, theil.output$U)
```

```
## [1] -Inf    0
```

TODO: Interpret these results correctly.

Solution to Problem 7

```r
height = c(42.8, 63.5, 37.5, 39.5, 45.5, 38.5, 43.0, 22.5, 37.0, 23.5, 33.0, 58.0)
weight = c(40.0, 93.5, 35.5, 30.0, 52.0, 17.0, 38.5, 8.5, 33.0, 9.5, 21.0, 79.0)
heart_catheter_length = c(37.0, 49.5, 34.5, 36.0, 43.0, 28.0, 37.0, 20.0, 33.5, 30.5, 38.5, 47.0)

cor.test(x = height, y = heart_catheter_length, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  height and heart_catheter_length
## t = 5.8936, df = 10, p-value = 0.0001524
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6216270 0.9663721
## sample estimates:
##       cor
## 0.8811691
```

```r
cor.test(x = weight, y = heart_catheter_length, method = "pearson")
```

```
##
##  Pearson's product-moment correlation
##
## data:  weight and heart_catheter_length
## t = 6.3033, df = 10, p-value = 8.871e-05
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.6568763 0.9700971
## sample estimates:
##       cor
## 0.8938226
```

From the Pearson correlation tests, there is *strong evidence* that, individually, height and weight contribute to the determination of heart catheter length.

```r
library(Rfit)

r.01 <- rfit(heart_catheter_length ~ height)
f.01 <- rfit(heart_catheter_length ~ height + weight)
first_drop_test <- drop.test(f.01, r.01)
first_drop_test
```

```
##
## Drop in Dispersion Test
```

```
## F-Statistic     p-value
##     1.55202     0.24429
```

```r
r.02 <- rfit(heart_catheter_length ~ weight)
second_drop_test <- drop.test(f.01, r.02)
second_drop_test
```

```
##
## Drop in Dispersion Test
## F-Statistic     p-value
##    0.014435    0.907007
```

However, based on the large p-values from the Drop in Dispersion tests, there is *not enough evidence* to suggest that height or weight contribute significantly over each other to the determination of heart catheter length.

Note

> Treating length of heart catheter as the *independent* variable, test for the importance of height and weight in *determining* the required catheter length.

If height and weight are the *determiners* of length of heart catheter, length of heart catheter must be the *dependent* variable.