# Problem Set 1: animal\_maze\_learning.csv

A scientist is interested in how chemotherapy affects spatial memory. The first phase of the experiment is to train a large group of rats (N=25) to learn a complex maze. After training for 30 days, the researcher wants to show that during the last 5 days of training all rats have hit their steady state performance in terms of completion time (in seconds). The collected data are in animal\_maze\_learning.csv. These data are the completion times for each rat over the last five days of training.

Use Repeated-measures ANOVA

1. Provide a compelling graph of the data.
2. What is the statistical hypothesis, and which statistical test is most appropriate? Are follow-up comparisons needed?

The statistical hypothesis is Dunnett’s multiple comparisons test is most appropriate. No follow-up comparisons are needed.

1. Provide the appropriate descriptive statistics.
2. Provide a *numeric* description of the statistical hypothesis test result and follow-up comparisons (if needed).
3. Provide a *verbal* description of the scientific result (not just reject/fail to reject the null hypothesis). Should the second phase of the experiment be started?

# Problem Set 2: compare\_three\_drugs.csv

Use one-way (non-repeated) ANOVA

A scientist is examining whether three current drugs for nausea are equally effective at reducing self-reported nausea. The collected data are in compare\_three\_drugs.csv. These data show symptom severity (on a scale of 0 through 10, 10 being the most severe) for 60 adults taking one of three common over-the-counter nausea medications.

1. Provide a compelling graph of the data.
2. What is the statistical hypothesis, and which statistical test is most appropriate? Are follow-up comparisons needed?
3. Provide descriptive statistics.
4. Provide a numeric and verbal description of the output of the statistical test and follow-up comparisons (if needed).
5. Is *one* drug demonstrably the best? Why or why not?

# Problem Set 3: seizures.csv

A group of researchers are testing a new drug that should reduce seizures by suppressing activity of a particular class of neurotransmitter receptors. The dataset seizures.csv contains the results of a pilot study. Assume the pilot study is accurate.

Use power analysis and effect size

1. What is the expected effect size (Cohen's *d*)?
2. How many animals (in each group) are needed to have a 90% chance of detecting a statistically significant (*p* < 0.05) effect of the drug?
3. The researchers are considering a pre/post design where the same animals are observed for a period with and without the drug. Assuming the effect size stays the same, how many total animals would be needed for this kind of research design?
4. The company rep sends out an email that a new version of the drug is available. This version has a stronger binding affinity and blocks receptors at a higher rate. The claim is that this should increase the effect of the drug by 20%. Unfortunately, the drug costs 50% more than the original drug. Discuss how you could use power analysis to determine the relevant ethical and financial trade-offs in using this new drug (for the purposes of this question, let's assume the company rep is telling the truth about the effectiveness of the new drug).

# Problem Set 4: age\_at\_onset\_and\_severity.csv

A scientist is trying to understand how age of onset impacts the severity of chicken pox (varicella). The collected data are in age\_at\_onset\_and\_severity.csv. These data show age of onset of chicken pox and a self-reported measure of severity (on a scale of 1 through 10; 10 being the most severe) for 800 children.

Use Linear Regression

1. Provide an appropriate graph showing the raw data.
2. What is the statistical hypothesis, and which statistical test is most appropriate?
3. Provide a numeric and verbal description of the output of the statistical test. Is *all* the output interpretable in the context of the question? (if not, specify which and why)
4. What is the predicted severity, with 95% confidence interval, of a child that contracts the virus at age 5? Do you think the prediction is good?
5. Should the scientist use these results to predict symptom severity for an individual in their 20s? Why or why not?

# Problem Set 5: blood\_sugar\_cereals.csv

A scientist is interested in how breakfast foods affect short-term blood sugar levels. Two groups of human volunteers (*n* = 35 in each) are given either a standard cereal or Special J, a cereal designed to sustain higher blood sugar levels for 4 hours. After eating, each subject’s blood sugar level is monitored (testing every 20 minutes) until it drops below 100, or until 5 hours has elapsed. The collected data are in blood\_sugar\_cereals.csv. These data are the elapsed time from eating until blood sugar dropped below 100. If blood sugar did not drop below 100 after 5 hours, the subjects were given the special value: -99. (Hint: you’ll need to fix both the format of the file and the special values to get these data analyzed).

Use survival analysis

1. Provide the most appropriate graph of the data.
2. What two kind of censoring are present in these data?
3. Which statistical test is most appropriate? What is the *statistical* null hypothesis?
4. Provide appropriate descriptive statistics.
5. Provide a numeric and verbal description of the results of the scientific hypothesis test. Provide follow-up comparisons only if needed.

Data:

Dataset 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Day** | **s1** | **s2** | **s3** | **s4** | **s5** | **s6** | **s7** | **s8** | **s9** | **s10** | **s11** | **s12** | **s13** | **s14** | **s15** | **s16** | **s17** | **s18** | **s19** | **s20** | **s21** | **s22** | **s23** | **s24** | **s25** |
| **1** | 446.279561163956 | 529.16656975878 | 567.479918412089 | 484.60169010742 | 517.230901014159 | 376.985787543751 | 614.760268429906 | 489.718910724759 | 460.515049554184 | 471.310054406814 | 483.899157207581 | 431.614425622732 | 365.416250041737 | 594.084440770339 | 502.452047580918 | 349.825488180542 | 470.17851825333 | 476.492768012134 | 432.79359015891 | 576.27233474357 | 502.056715632886 | 760.902521506751 | 500.11015213911 | 376.131864079893 | 557.15580929958 |
| **2** | 487.781043181414 | 550.800348737257 | 518.164433801925 | 405.223163424116 | 542.120302635824 | 459.13458866851 | 703.316578851462 | 533.869376519322 | 434.033291137632 | 451.237863061741 | 487.896098274561 | 458.234123725858 | 361.76124718313 | 578.325227374066 | 488.269639657458 | 453.624991918642 | 429.956481292307 | 458.482385991653 | 416.414400412131 | 534.278962213594 | 469.732512062957 | 682.756841051051 | 528.811119421707 | 408.225844280196 | 563.324721686598 |
| **3** | 505.185366126873 | 569.810191446646 | 566.899229877926 | 417.128250734989 | 527.91488083882 | 514.786997037247 | 631.407401708627 | 471.904897098184 | 388.376898164889 | 420.20367600568 | 483.723095806815 | 437.271613716297 | 370.357655117275 | 624.123374892916 | 510.130452554433 | 360.723288334016 | 448.03641614183 | 440.316287255118 | 437.662397556633 | 625.789695260674 | 483.505469818912 | 679.228618666157 | 472.286458815863 | 466.64038219433 | 574.238819868204 |
| **4** | 464.906027034137 | 539.443565179162 | 516.284461018676 | 414.380280497085 | 556.087655311015 | 454.672159477346 | 656.453129327479 | 508.322636020541 | 516.963284915233 | 495.662469397504 | 521.649908467721 | 440.943004052035 | 395.31932636704 | 629.064672859229 | 500.54108475898 | 382.99354778249 | 440.669762921721 | 474.369066118594 | 428.959940278318 | 541.440750723035 | 501.711466413019 | 680.747397577247 | 552.520030438446 | 454.136927172565 | 549.987421077094 |
| **5** | 535.389524048438 | 527.270265677096 | 490.70025813832 | 436.799011945054 | 539.804149355249 | 457.813526856124 | 682.302375973512 | 530.055562984943 | 424.200353627492 | 489.766624267686 | 503.941638202905 | 441.439227407307 | 373.532663064653 | 564.648891073644 | 529.267053692503 | 388.899506824225 | 556.537087555785 | 433.338382016361 | 446.657702810604 | 590.319863030224 | 492.098507979604 | 660.429759080697 | 516.619837415753 | 409.756534415199 | 585.233305543182 |

Dataset 2:

|  |  |
| --- | --- |
| **drug** | **severity** |
| **Benadryl** | 5.06081196842715 |
| **Benadryl** | 7.04634155407548 |
| **Benadryl** | 4.91459011463448 |
| **Benadryl** | 4.1883358172141 |
| **Benadryl** | 5.95528945708647 |
| **Benadryl** | 5.01403548372909 |
| **Benadryl** | 7.97678403360769 |
| **Benadryl** | 6.18639686424285 |
| **Benadryl** | 4.10869135269895 |
| **Benadryl** | 3.86340879257768 |
| **Benadryl** | 4.96690994240344 |
| **Benadryl** | 4.11632731817663 |
| **Benadryl** | 3.18802103521302 |
| **Benadryl** | 8.03796827057377 |
| **Benadryl** | 5.80169717278332 |
| **Benadryl** | 2.81517395796254 |
| **Benadryl** | 5.08886295743287 |
| **Benadryl** | 4.14879041295499 |
| **Benadryl** | 4.19627921972424 |
| **Benadryl** | 6.00747862756252 |
| **Benadryl** | 4.83003057576716 |
| **Benadryl** | 8.86676772926003 |
| **Benadryl** | 5.99100207975134 |
| **Benadryl** | 4.17467718943954 |
| **Benadryl** | 7.10694420253858 |
| **Dramamine** | 0.853588390629739 |
| **Dramamine** | 1.95826479364187 |
| **Dramamine** | 2.81784597942606 |
| **Dramamine** | -0.0109074145555496 |
| **Dramamine** | 4.82133078919724 |
| **Dramamine** | 0.0937465768307447 |
| **Dramamine** | 0.835642910562456 |
| **Dramamine** | 1.91072759274393 |
| **Dramamine** | -0.0912297428585589 |
| **Dramamine** | 0.977131700702012 |
| **Dramamine** | 6.11251195101067 |
| **Dramamine** | 3.13330345386639 |
| **Dramamine** | 5.96969858687371 |
| **Dramamine** | 1.93175750598311 |
| **Dramamine** | 1.15510042002425 |
| **Dramamine** | 5.98597834492102 |
| **Dramamine** | 0.934882952272892 |
| **Dramamine** | 1.90351139651611 |
| **Dramamine** | 1.05068685570732 |
| **Dramamine** | 2.96147028170526 |
| **Dramamine** | -0.0900626423768699 |
| **Dramamine** | 2.15733653018251 |
| **Dramamine** | 1.07071668524295 |
| **Dramamine** | 2.95435428731143 |
| **Dramamine** | 1.86289691887796 |
| **Emetrol** | 1.09668608186767 |
| **Emetrol** | 3.1953010385856 |
| **Emetrol** | 7.11147683979943 |
| **Emetrol** | 3.14127543373033 |
| **Emetrol** | 3.03839558511972 |
| **Emetrol** | 0.0694152229465544 |
| **Emetrol** | 6.0468984939158 |
| **Emetrol** | 0.864248820208013 |
| **Emetrol** | 3.12787332693115 |
| **Emetrol** | 3.80558388736099 |
| **Emetrol** | 1.18860505698249 |
| **Emetrol** | 4.18540538335219 |
| **Emetrol** | 0.100536755193025 |
| **Emetrol** | 1.97441978277639 |
| **Emetrol** | 2.81587919639423 |
| **Emetrol** | 4.91323518529534 |
| **Emetrol** | 2.98548722527921 |
| **Emetrol** | -0.0883359179832041 |
| **Emetrol** | 7.93413138873875 |
| **Emetrol** | 2.13070957167074 |
| **Emetrol** | 4.92230115393177 |
| **Emetrol** | 3.95092201661319 |
| **Emetrol** | 0.809152176696807 |
| **Emetrol** | 5.89685875540599 |
| **Emetrol** | 6.00170557713136 |

Dataset 3:

|  |  |
| --- | --- |
| **group** | **seizures** |
| **Control** | 8.15652150288224 |
| **Control** | 7.07787518147379 |
| **Control** | 8.92790527781472 |
| **Control** | 6.06902567083016 |
| **Treated** | 7.88984792986885 |
| **Treated** | 1.85786624001339 |
| **Treated** | 4.8461499848403 |
| **Treated** | 7.04938332336023 |

Data 4:

|  |  |
| --- | --- |
| **ParticipantAge** | **SymptomSeverity** |
| **7.80905627589673** | 2.84980877703056 |
| **9.10693358760327** | 1.02875215178356 |
| **12.0347715052776** | 1.00531873246655 |
| **9.81584954159334** | 6.94250235343352 |
| **2.99217323390767** | 10.046569794789 |
| **9.93009122442454** | 5.87441016659141 |
| **7.14040180286393** | 6.86291631674394 |
| **2.80439473548904** | 6.08137422828004 |
| **2.84434255603701** | 5.12964672651142 |
| **3.94917612047866** | 2.91388829043135 |
| **5.97529460769147** | 9.8325554355979 |
| **3.1285299083218** | 7.80387554448098 |
| **6.95934407999739** | 5.1639231402427 |
| **4.94686519736424** | 2.8043825013563 |
| **9.81336602782831** | 2.16375407334417 |
| **10.0352590682916** | 7.0360972485505 |
| **9.9523521088995** | 2.051710877195 |
| **10.9868568227626** | 0.91196602107957 |
| **6.90297168418765** | 7.1249866255559 |
| **4.16133761135861** | 5.18330448977649 |
| **4.93023018287495** | 1.10075612040237 |
| **4.17046374594793** | 6.84797194479033 |
| **9.95459129838273** | 3.8351799480617 |
| **4.18218701118603** | 3.02268321281299 |
| **4.1865523006767** | 5.18993902886286 |
| **8.17432364411652** | 1.09696510257199 |
| **5.99474350763485** | 7.06729051657021 |
| **3.1077805319801** | 5.03518684506416 |
| **6.94044851874933** | 2.08651907164603 |
| **9.89311789497733** | 8.10916695222259 |
| **8.11157681085169** | 5.96746500823647 |
| **7.15807004347444** | 6.1339363148436 |
| **5.16726580541581** | 4.06742793470621 |
| **11.9491664553992** | 2.94595958413556 |
| **3.05067707598209** | 10.0069301198237 |
| **5.17184309037402** | 6.84006203291938 |
| **6.99675167538226** | 6.87454354120418 |
| **7.84398759156466** | 4.03247017273679 |
| **11.9507324431092** | 4.88659743620083 |
| **8.05101829059422** | 4.06545514753088 |
| **8.92500310661271** | 3.96899862075225 |
| **4.81004630997777** | 5.99138520490378 |
| **5.92502238610759** | 5.99612304549664 |
| **7.98721373844892** | 7.17064001513645 |
| **8.17720847129822** | 2.8066520050168 |
| **5.81028585201129** | 7.94365852121264 |
| **5.18148602833971** | 8.16408887226135 |
| **5.14513749657199** | 5.16223726794124 |
| **9.97250060392544** | 5.07206636723131 |
| **3.15397208584473** | 10.0623508194461 |
| **6.14124394739047** | 5.94457475580275 |
| **4.89817131087184** | 4.08594122352079 |
| **6.05438536806032** | 4.07681115260348 |
| **7.89902913877741** | 4.98249231334776 |
| **11.1696232877672** | 1.19186931923032 |
| **11.9814425602555** | 5.09853220209479 |
| **4.81258445158601** | 5.96799379494041 |
| **7.95981816602871** | 1.86714594131336 |
| **4.9597947312519** | 5.17029689531773 |
| **12.1211211445741** | 4.9437812756747 |
| **12.024331713561** | 5.07617996120825 |
| **2.84040394918993** | 8.8002731458284 |
| **10.8937255315483** | 3.03460685489699 |
| **11.9766850710846** | 2.85639042714611 |
| **7.02224720017985** | 6.9044717149809 |
| **5.1300732252188** | 8.09980940157548 |
| **8.09994992166758** | 6.05011612754315 |
| **3.9027988945134** | 5.83798522790894 |
| **7.86186382034793** | 4.07192843900993 |
| **6.98360922131687** | 8.11555656949058 |
| **10.0596505997702** | 1.02091040778905 |
| **7.04028416071087** | 5.81736475303769 |
| **5.12537527102977** | 4.0610322272405 |
| **6.00036213770509** | 1.01502540120855 |
| **8.88531465474516** | 5.85394557062537 |
| **7.07451726235449** | 7.89180458914489 |
| **6.03773045791313** | 1.87360325576738 |
| **3.05944754900411** | 7.10710840206593 |
| **7.88452870044857** | 3.84517478095368 |
| **4.17420322215185** | 0.80987586537376 |
| **2.83207378992811** | 7.91347209019586 |
| **11.8350966542959** | 4.00052447943017 |
| **6.8822874690406** | 9.04267007522285 |
| **9.8764451735653** | 5.07833941532299 |
| **11.9539542997256** | 5.04159733271226 |
| **5.13650807151571** | 9.906228826195 |
| **11.8429566810839** | 7.01696395687759 |
| **6.91009253468364** | 7.06774067338556 |
| **6.98096573194489** | 3.0391078485176 |
| **11.1372207329609** | 0.927110429573804 |
| **6.87060848651454** | 5.97393367178738 |
| **10.0958996453322** | 3.0797166544944 |
| **9.11935851629823** | 8.17523603858426 |
| **11.8756149733439** | 1.98028590800241 |
| **10.8168546711095** | 7.91972709437832 |
| **2.87538853390142** | 8.08193389317021 |
| **6.08035416025668** | 4.9346379247494 |
| **3.93166960896924** | 5.97047118935734 |
| **4.15336890835315** | 4.95957073792815 |
| **6.95973843308166** | 0.889045337494463 |
| **10.9465599399991** | 1.14607245968655 |
| **7.16557201296091** | 4.8052196059376 |
| **8.8471646586433** | 1.17660047868267 |
| **6.16618570415303** | 9.90987373990938 |
| **4.85817469088361** | 7.92527850763872 |
| **4.10325251854956** | 4.17767400024459 |
| **10.1955767165869** | 0.966327624674886 |
| **9.83537425352261** | 1.11760699171573 |
| **8.91778321638703** | 4.94790074788034 |
| **9.80690784314647** | 3.07126296013594 |
| **11.0094630542211** | 4.15538993161172 |
| **2.89409244060516** | 3.12047553937882 |
| **2.90413994845003** | 7.85135893234983 |
| **11.1859285434708** | 4.92657655924559 |
| **2.94319930635393** | 8.91754839615896 |
| **3.09356519831344** | 4.8858478535898 |
| **9.00294498568401** | 0.859806319139898 |
| **8.11766256028786** | 4.18130007181317 |
| **4.06141044124961** | 9.96143495179713 |
| **4.09551607873291** | 6.0099950584583 |
| **12.1135715331882** | 1.95444259978831 |
| **3.84373673396185** | 7.1960724292323 |
| **6.02072242833674** | 7.89782218607143 |
| **2.97774470280856** | 8.86836869781837 |
| **11.932128511928** | 6.02390307318419 |
| **6.94470800049603** | 4.15678310934454 |
| **8.19437188077718** | 6.19354233909398 |
| **6.10817326689139** | 1.9054276291281 |
| **10.0233846836723** | 4.82788150366396 |
| **8.90815314883366** | 1.84464994976297 |
| **2.82352810176089** | 5.97336035612971 |
| **11.0653167348355** | 0.994135226495564 |
| **8.92665450107306** | 0.977400274202228 |
| **10.971637377236** | 2.14120783125982 |
| **2.89570925282314** | 8.13122043590993 |
| **10.8678113019094** | 10.0908934928477 |
| **7.15837448211387** | 3.18921726131812 |
| **3.94645851571113** | 6.15466736909002 |
| **8.06757145477459** | 7.17223842013627 |
| **11.9535212579183** | 3.99975829133764 |
| **2.82227965267375** | 9.99126213593408 |
| **6.07977253003046** | 3.83461715588346 |
| **5.84343024380505** | 6.05143292034045 |
| **7.98268437031656** | 5.01908626845106 |
| **8.96696696775034** | 5.11573336543515 |
| **8.89673251165077** | 1.12487962059677 |
| **2.85719032362103** | 5.87580781774595 |
| **8.04442629721016** | 1.0979452278465 |
| **6.98212310401723** | 4.89292877959087 |
| **10.1699724596925** | 6.18740624655038 |
| **11.9887930146419** | 1.1016305455938 |
| **2.88601571032777** | 9.09958143588156 |
| **9.03113765604794** | 4.02359472466633 |
| **11.8209197532386** | 4.08545316886157 |
| **5.09827018808573** | 1.86084387907758 |
| **5.01611896725371** | 5.04655870106071 |
| **3.88262187885121** | 7.89193511968479 |
| **4.16591385509819** | 4.97514383234084 |
| **11.0642447547056** | 1.04120299145579 |
| **5.17846976565197** | 2.06583060137928 |
| **12.1656441917643** | 3.8171825430356 |
| **11.8847180639394** | 0.862847960740328 |
| **3.90389786018059** | 5.83272749045864 |
| **8.88453084472567** | 5.97752901744097 |
| **9.89292663317174** | 8.94902718923986 |
| **3.92499537272379** | 7.93214862039313 |
| **9.02922382038087** | 4.15239632520825 |
| **9.04375472785905** | 4.06105088768527 |
| **11.9740506709553** | 5.10189975854009 |
| **2.97942191874608** | 7.124764025677 |
| **9.82485280046239** | 2.87913663452491 |
| **5.86891785953194** | 5.095974262245 |
| **9.91097206873819** | 5.06039650989696 |
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