Chapter 6: Non-parametric models

Labcoat Leni's Real Research

Having a Quail of a Time?

Problem

Matthews, R. C. et al. (2007). *Psychological Science*, 18(9), 758-762.

We encountered some research in Chapter 2 in which we discovered that you can influence aspects of male quail's sperm production through 'conditioning'. The basic idea is that the male is granted access to a female for copulation in a certain chamber (e.g. one that is coloured green) but gains no access to a female in a different context (e.g. a chamber with a tilted floor). The male, therefore, learns that when he is in the green chamber his luck is in, but if the floor is tilted then frustration awaits. For other males the chambers will be reversed (i.e. they get sex only when in the chamber with the tilted floor). The human equivalent (well, sort of) would be if you always managed to pull in the Pussycat Club but never in the Honey Club. During the test phase, males get to mate in both chambers; the question is: after the males have learnt that they will get a mating opportunity in a certain context, do they produce more sperm or better-quality sperm when mating in that context compared to the control context? (That is, are you more of a stud in the Pussycat club? OK, I'm going to stop this anaology now.)
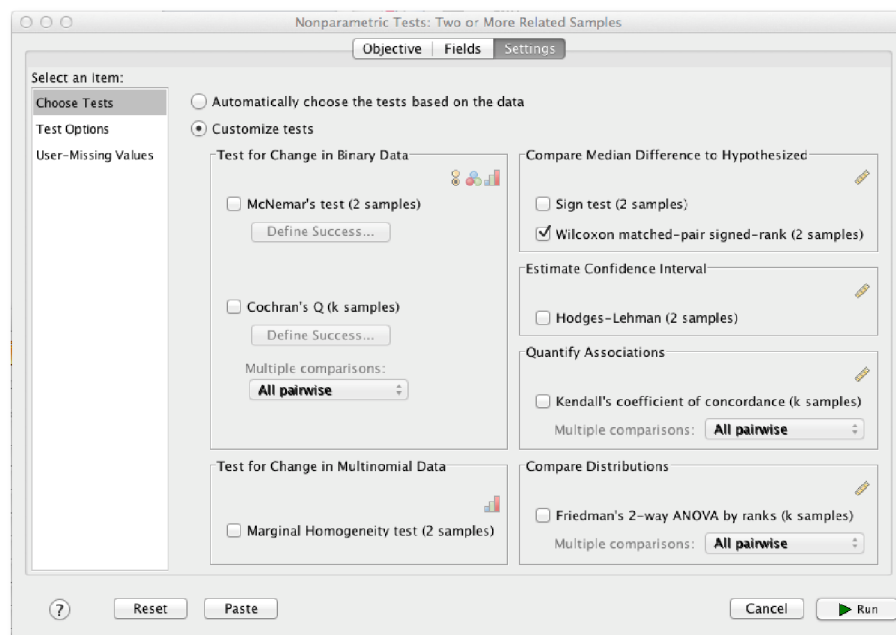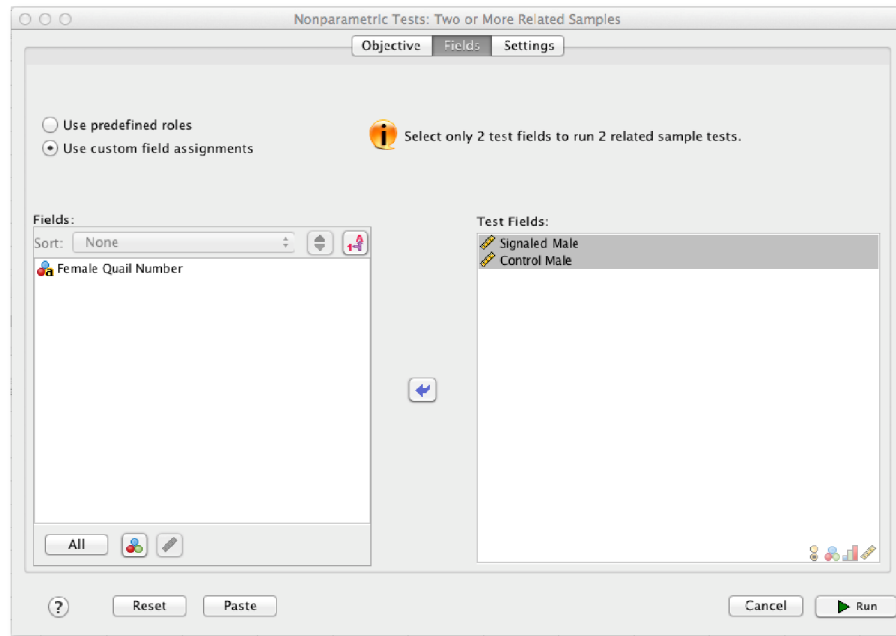
Mike Domjan and his colleagues predicted that if conditioning evolved because it increases reproductive fitness then males who mated in the context that had previously signalled a mating opportunity would fertilize a significantly greater number of eggs than quails that mated in their control context (Matthews, Domjan, Ramsey, & Crews, 2007). They put this hypothesis to the test in an experiment that is utter genius. After training, they allowed 14 females to copulate with two males (counterbalanced): one male copulated with the female in the chamber that had previously signalled a reproductive opportunity (**Signalled**), whereas the second male copulated with the same female but in the chamber that had not previously signalled a mating opportunity (**Control**). Eggs were collected from the females for 10 days after the mating and a genetic analysis was used to determine the father of any fertilized eggs.

The data from this study are in the file **Matthews et al. (2007).sav**. Labcoat Leni wants you to carry out a Wilcoxon signed-rank test to see whether more eggs were fertilized by males mating in their signalled context compared to males in their control context.

Solution

To run a Wilcoxon test you need to follow the general procedure outlined in the book chapter. First of all you need to select   . When you reach the

tab you will see all of the variables in the data editor listed in the box labelled *Fields*. If you assigned roles for the variables in the data editor ⊙ Use predefined roles will be selected and SPSS will have automatically assigned your variables. If you haven't assigned roles then ⊙ Use custom field assignments will be selected and you'll need to assign variables yourself. Select both dependent variables from the list (click on **Signaled Male** then, holding down *Ctrl* (*Cmd* on a Mac), click on **Control Male** and drag them to the box labelled *Test Fields* (or click on 🔸). The completed dialog box is shown below. Next, select the [Objective | Fields | Settings] tab to activate the test options. You can let SPSS pick a test for you (⊙ Automatically choose the tests based on the data), but you have more options available if you select ⊙ Customize tests. To do a Wilcoxon test check ☑ Wilcoxon matched-pair signed-rank (2 samples) and then click on [▶ Run] to run the analysis.

Nonparametric Tests: Two or More Related Samples

All

Reset Paste   Cancel   ▶ Run

Nonparametric Tests: Two or More Related Samples

Test for Change in Multinomial Data   Compare Distributions

☐ Marginal Homogeneity test (2 samples)   ☐ Friedman's 2-way ANOVA by ranks (k samples)

                                                  Multiple comparisons: All pairwise

Reset Paste   Cancel   ▶ Run

The completed dialog boxes for running a Wilcoxon signed-rank test. (NB: These dialog boxes look strange because I was working on a Mac rather than a PC for this question. Don't worry though: apart from being grey scale rather than blue, they are basically the same.)
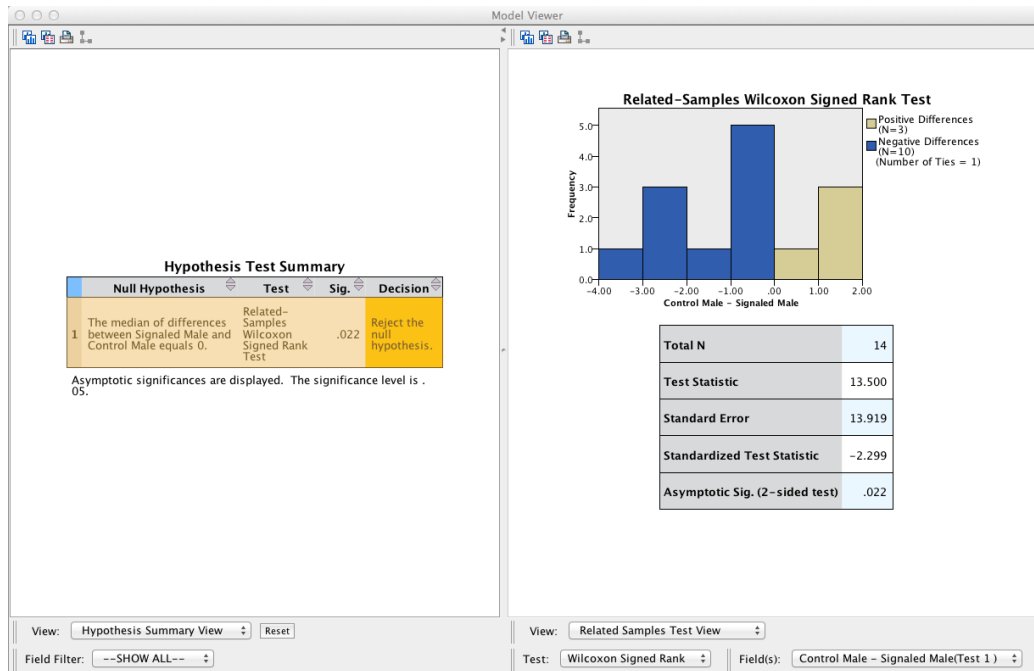
The summary table in the output above tells you that the significance of the test was .022 and suggests that we reject the null hypothesis. Double click on this table to enter the *model viewer*. Notice that we have different coloured bars: the brown bars represent positive differences (these are females that produced fewer eggs fertilized by the male in his signalled chamber than the male in his control chamber) and the blue bars negative differences (these are females that produced more eggs fertilized by the male in his signalled chamber than the male in his control chamber). We can see that the bars are predominantly blue. The legend of the graph confirms that there were 3 positive differences, 10 negative differences and 1 tie. This means that for 10 of the 14 quails, the number of eggs fertilized by the male in his signalled chamber was greater than for the male in his control chamber, indicating an adaptive benefit to learning that a chamber signalled reproductive opportunity. The one tied rank tells us that there was one female who produced an equal number of fertilized eggs for both males.

There is a table below the histogram that tells us the test statistic (13.50), its standard error (13.92), and the corresponding *z*-score (−2.30). The *p*-value associated with the *z*-score is .022, which means that there's a probability of .022 that we would get a value of *z* as large as the one we have if there were no effect in the population; because this value is less than the critical value of .05 we should conclude that there were a greater number of fertilized eggs from males mating in their signalled context, $z = -2.30$, $p < .05$. In other words, conditioning (as a learning mechanism) provides some adaptive benefit in that it makes it more likely that you will pass on your genes.

The authors concluded as follows:

Of the 78 eggs laid by the test females, 39 eggs were fertilized. Genetic analysis indicated that 28 of these (72%) were fertilized by the signalled males, and 11 were fertilized by the control males. Ten of the 14 females in the experiment produced more eggs fertilized by the signalled male than by the control male (see Fig. 1; Wilcoxon signed-ranks test, *T* = 13.5, p < .05). These effects were independent of the order in which the 2 males copulated with the female. Of the 39 fertilized eggs, 20 were sired by the 1st male and 19 were sired by the 2nd male.

The present findings show that when 2 males copulated with the same female in succession, the male that received a Pavlovian CS signalling copulatory opportunity fertilized more of the female's eggs. Thus, Pavlovian conditioning increased reproductive fitness in the context of sperm competition.' (p. 760)

Labcoat Leni's Real Research

Eggs-traordinary

Problem

Çetinkaya, H., & Domjan, M. (2006). *Journal of Comparative Psychology*, *120*(4), 427-432.

There seems to be a lot of sperm in this book (not literally I hope) – it's possible that I have a mild obsession. We saw that male quail fertilized more eggs if they had been trained to be able to predict when a mating opportunity would arise. However, some quail develop fetishes. Really. In the previous example the type of compartment acted as a predictor of an opportunity to mate, but in studies where a terrycloth object acts as a sign that a mate will shortly become available, some quail start to direct their sexuial behaviour towards the terrycloth object. (I may regret this anology, but in human terms if you imagine that every time you were going to have sex with your boyfriend you gave him a green towel a few moments before seducing him, then after enough seductions he would start rubbing his crotch against any green towel he saw. If you've ever wondered why you boyfriend rubs his crotch on green towels, then I hope this explanation has been enlightening.) In evolutionary terms, this fetishistic behaviour seems counterproductive because sexual behaviour becomes directed towards something that cannot provide reproductive success. However, perhaps this behaviour serves to prepare the organism for the 'real' mating behaviour.

Hakan Çetinkaya and Mike Domjan conducted a brilliant study in which they sexually conditioned male quail (Çetinkaya & Domjan, 2006). All quail experienced the terrycloth stimulus and an opportunity to mate, but for some the terrycloth stimulus immediately preceded the mating opportunity (paired group) whereas for others they experienced it 2 hours after the mating opportunity (this was the control group because the terrycloth stimulus did not predict a mating opportuinity). In the paired group, quail were classified as fetishistic or not depending on whether they engaged in sexual behaviour with the terrycloth object.

During a test trial the quail mated with a female and the researchers measured the percentage of eggs fertilized, the time spent near the terrycloth object, the latency to initiate copulation, and copulatory efficiency. If this fetishistic behaviour provides an evolutionary advantage then we would expect the fetishistic quail to fertilize more eggs, initiate copulation faster and be more efficient in their copulations.

The data from this study are in the file **Çetinkaya & Domjan (2006).sav**. Labcoat Leni wants you to carry out a Kruskal–Wallis test to see whether fetishist quail produced a higher percentage of fertilized eggs and initiated sex more quickly.

Solution

To run a Kruskal–Wallis test, follow the general procedure outlined in the book chapter. First of all select [Objective] [Fields] [Settings] . When you reach the [Objective] [Fields] [Settings] tab you should see all of the variables in the data editor listed in the box labelled *Fields*. If you assigned roles for the variables in the data editor ⊙ Use predefined roles will be selected and SPSS will have automatically assigned your variables. If you haven't assigned roles then ⊙ Use custom field assignments will be selected and you'll need to assign variables yourself. Select the two dependent variables from the list (click on **Percentage of Eggs Fertilised** and, while holding down the *Ctrl* key, **Time taken to initiate copulation**) and drag them to the box labelled *Test Fields* (or click on [↦]). Next, select the independent variable (the grouping variable), in this case **Group**, and drag it to the box labelled *Groups*.

   Next, select the [Objective] [Fields] [Settings] tab to activate the test options. You can let SPSS pick a test for you (⊙ Automatically choose the tests based on the data), but you have more options available if you select ⊙ Customize tests. To do a Kruskal–Wallis test check ☑ Kruskal-Wallis 1-way ANOVA (k samples). Next to this option there is a drop down list labelled *Multiple comparisons*. This option allows us to look at differences between individual groups. Within this list there are two options: to compare every group against every other group (*All pairwise*) or to use a step-down method (*Stepwise step-down*), I have selected *All pairwise.* To run the analysis click on [▶ Run]. The completed dialog boxes are shown below.
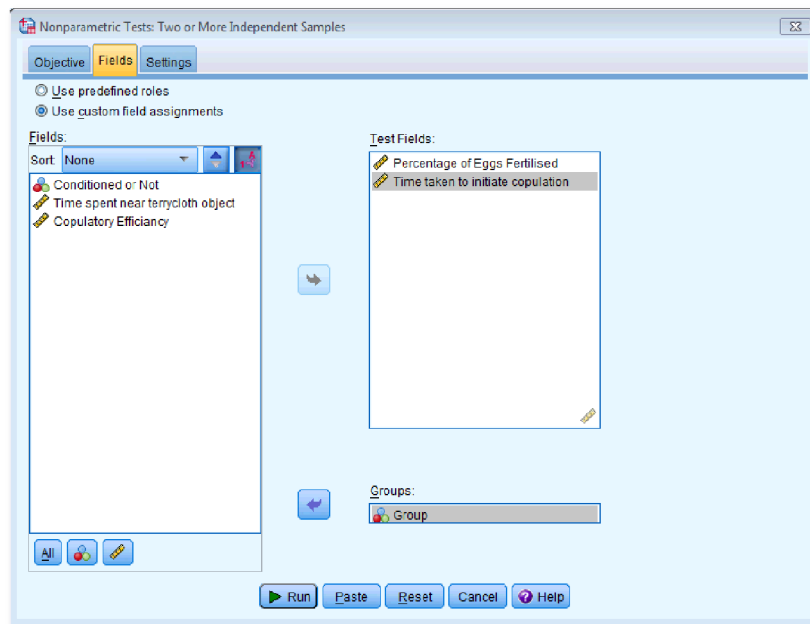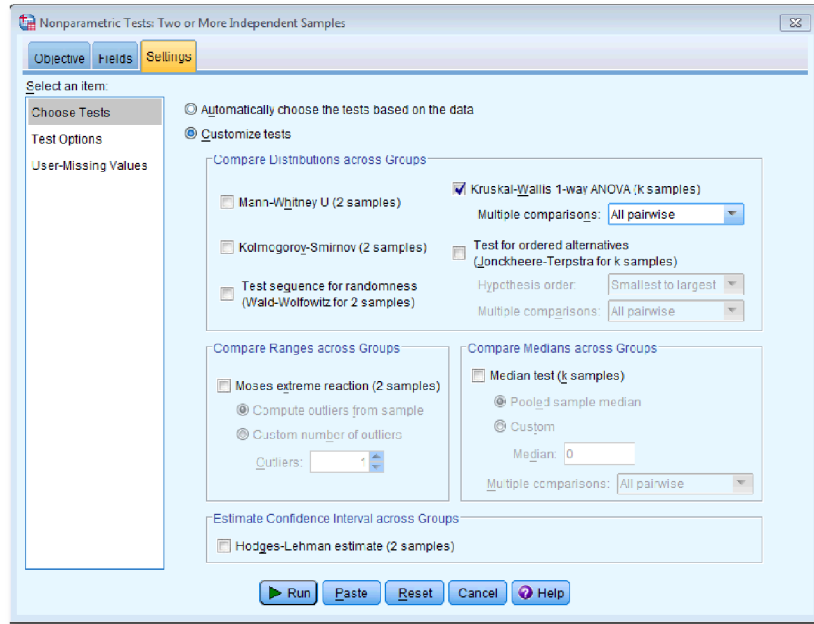
The summary table below tells us that for both variables there is a significant effect, and gives us a little message of advice telling us to reject both of the null hypotheses.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Percentage of Eggs Fertilised is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	.003	Reject the null hypothesis.
2	The distribution of Time taken to initiate copulation is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Double-click on the first row of the summary table to open up the model viewer window, which shows the results of whether the percentage of eggs fertilized was different across groups in more detail (see below). Here we can see the test statistic, H, for the Kruskal–Wallis (11.955), its associated degrees of freedom (2) and the significance. The crucial thing to look at is the significance value, which is .003; because this value is less than .05 we could conclude that the percentage of eggs fertilized was significantly different across the two groups.
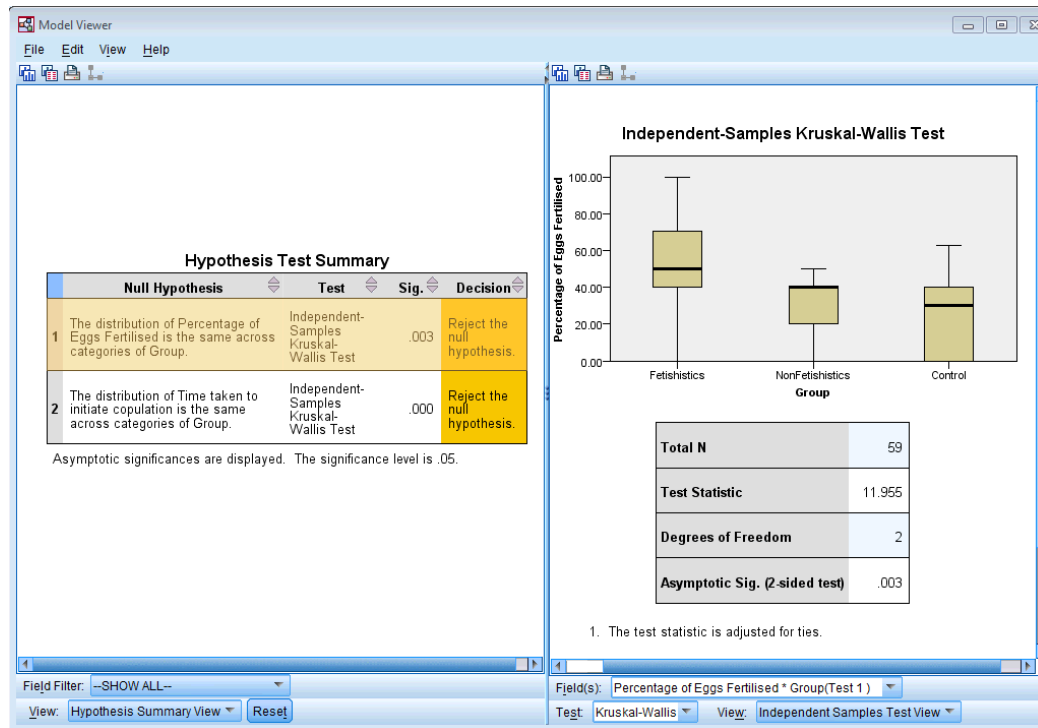
Next, double-click on the second row of the summary table to open up the model viewer window, which displays the results of the test of whether the time taken to initiate copulation was different across groups in more detail. In this window we can see the test statistic, *H*, for the Kruskal–Wallis (32.244) its associated degrees of freedom (2) and the significance. The crucial thing to look at is the significance value, which is .000; because this value is less than .05 we could conclude that the time taken to initiate copulation differed significantly across the two groups.
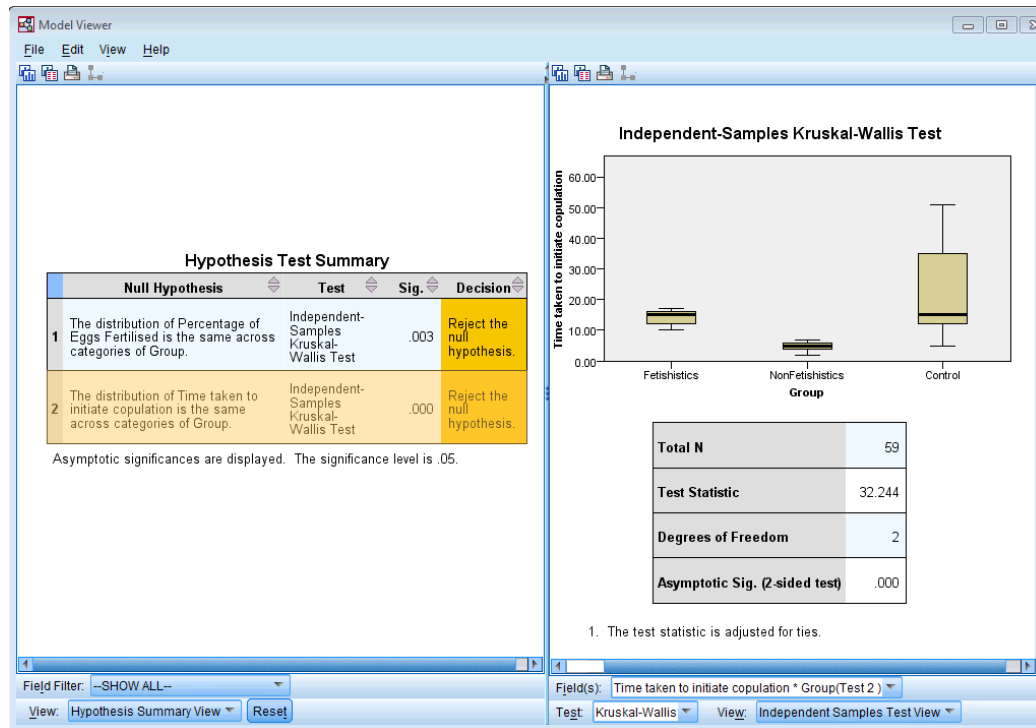
So we now know that there are differences between the groups but we don't know where these differences lie. One way to see which groups differ is to look at boxplots. SPSS produces boxplots for us (see the outputs above). If we look at the boxplot in the first output (percentage of eggs fertilized), using the control as our baseline, the medians for the non-fetishistic male quail and the control group were similar, indicating that the non-fetishistic males yielded similar rates of fertilization to the control group. However, the median of the fetishistic males is higher than the other two groups, suggesting that the fetishistic male quail yielded higher rates of fertilization than both the non-fetishistic male quail and the control male quail.

If we now look at the boxplot for the time taken to initiate copulation, the medians suggest that non-fetishistic males had shorter copulatory latencies than both the fetishistic male quail and the control male. However, these conclusions are subjective. What we really need are some follow-up analyses.

The output of the follow-up tests won't be immediately visible in the model viewer window. The right-hand side of the model viewer window shows the main output by default (labelled the *Independent Samples Test View*), but we can change what is visible in the right-hand panel by using the drop-down list at the bottom of the window labelled *View*. By clicking on this drop-down list you'll see several options including *Pairwise Comparisons* (because we selected *All pairwise* when we ran the analysis). Selecting this option displays the output for the follow-up analysis in the right-hand panel of the model viewer, and to switch back to the main output you would use the same drop-down list but select *Independent Samples Test View*.

Let's look at the pairwise comparisons first for the percentage of eggs fertilized first (see output below). The diagram at the top shows the average rank within each group: so, for example, the average rank in the fetishistic group was 41.82, and in the non-fetishistic group it was 26.97. This diagram will also highlight differences between groups by using a different coloured line to connect them. In the current example, there are significant differences between the fetishistic group and the

control group, and also between the fetishistic group and the non-fetishistic group, which is why these connecting lines are in yellow. There was no significant difference between the control group and the non-fetishistic group, which is why its connecting line is black). The table underneath shows all of the possible comparisons. The column labelled *Adj.Sig.* contains the adjusted *p*-values and it is this column that we need to interpret (no matter how tempted we are to interpret the one labelled *Sig.*). Looking at this column, we can see that significant differences were found between the control group and the fetishistic group, *p* = .002, and between the fetishistic group and the non-fetishistic group, *p* = .039. However, the non-fetishistic group and the control group did not differ significantly, *p* = 1. We know by looking at the boxplot and the ranks that the fetishistic males yielded significantly higher rates of fertilization than both the non-fetishistic male quail and the control male quail.

Pairwise Comparisons of Group
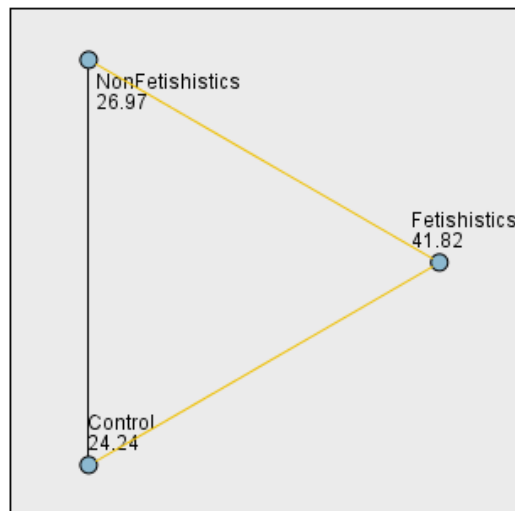
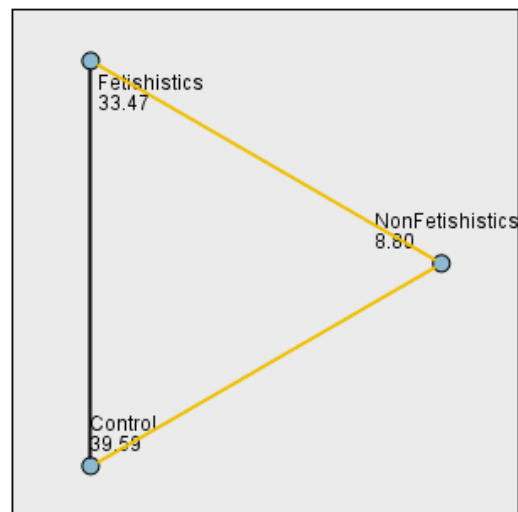Each node shows the sample average rank of Group.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Control-NonFetishistics	2.726	5.439	.501	.616	1.000
Control-Fetishistics	17.583	5.229	3.362	.001	.002
NonFetishistics-Fetishistics	14.857	5.983	2.483	.013	.039

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Let's now look at the pairwise comparisons for the time taken to initiate copulation (see output below). The diagram highlights differences between groups by using a different coloured line to connect them. In the current example, there was not a significant difference between the fetishistic group and the control group, as indicated by the black connecting line. However, there were

significant differences between the fetishistic group and the non-fetishistic group, and between the non-fetishistic group and the control, which is why these connecting lines are in yellow. The table underneath shows all of the possible comparisons. The column labelled *Adj.Sig.* contains the adjusted *p*-values, and it is this column that we need to interpret. Looking at this column, we can see that significant differences were found between the control group and the non-fetishistic group, *p* = .000, and between the fetishistic group and the non-fetishistic group, *p* = .000. However, the fetishistic group and the control group did not differ significantly, *p* = .743. We know by looking at the boxplot and the ranks that the non-fetishistic males yielded significantly shorter latencies to initiate copulation than the fetishistic males and the controls.

Pairwise Comparisons of Group

Each node shows the sample average rank of Group.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
NonFetishistics-Fetishistics	24.671	6.058	4.072	.000	.000
NonFetishistics-Control	-30.793	5.507	-5.591	.000	.000
Fetishistics-Control	-6.122	5.295	-1.156	.248	.743

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

The authors reported as follows:

Kruskal–Wallis analysis of variance (ANOVA) confirmed that female quail partnered with the different types of male quail produced different percentages of fertilized eggs,   (2, *N* = 59) =11.95, *p* < .05, = 0.20. Subsequent pairwise comparisons with the Mann–Whitney *U* test (with the Bonferroni correction) indicated that fetishistic male quail yielded higher rates of fertilization than both the nonfetishistic male quail (*U* = 56.00, N_1 = 17, N_2 = 15, effect size = 8.98, *p* < .05) and the control male

quail (U = 100.00, N_1 = 17, N_2 = 27, effect size = 12.42, $p < .05$). However, the nonfetishistic group was not significantly different from the control group (U = 176.50, N_1 = 15, N_2 = 27, effect size = 2.69, $p > .05$). (p. 429)

For the latency data they reported as follows:

A Kruskal–Wallis analysis indicated significant group differences, (2, N = 59) = 32.24, $p < .05$, = 0.56. Pairwise comparisons with the Mann–Whitney U test (with the Bonferroni correction) showed that the nonfetishistic males had significantly shorter copulatory latencies than both the fetishistic male quail (U = 0.00, N_1 = 17, N_2 = 15, effect size = 16.00, $p < .05$) and the control male quail (U = 12.00, N_1 = 15, N_2 = 27, effect size = 19.76, $p < .05$). However, the fetishistic group was not significantly different from the control group (U = 161.00, N_1 = 17, N_2 = 27, effect size = 6.57, $p > .05$). (p. 430)

These results support the authors' theory that fetishist behaviour may have evolved because it offers some adaptive function (such as preparing for the real thing).