Chapter 16: Answers

Task 1

Certain editors at Sage publications like to think there a bit of a whiz at football (soccer if you prefer). To see whether they are better than Sussex lecturers and postgraduates we invited various employees of sage to join in our football matches (oh, sorry, I mean we invited down for important meetings about books). Every player was only allowed to play in one match. Over many matches, we counted the number of players that scored goals. The data are in the file **SageEditorsCan'tPlayFootball.sav**, do a chi-square test to see whether more publishers or academics scored goals. We predict that Sussex people will score more than Sage people.

SPSS Output

The crosstabulation table produced by SPSS contains the number of cases that falls into each combination of categories. We can see that in total 28 people scored goals (36.47% of the total) and of these 5 were from Sage publications (17.9% of the total that scored) and only 23 were from Sussex (82.1% of the total that scored). Forty-nine people didn't score at all (63.6% of the total) and of those, 19 worked for sage (38.8% of the total that didn't score) and 30 were from Sussex (61.2% of the total that didn't score).

Job * Did they score a goal? Crosstabulation

			Did they score a goal?		
			Yes	No	Total
Job	Sage Publications	Count	5	19	24
		Expected Count	8.7	15.3	24.0
		% within Job	20.8%	79.2%	100.0%
		% within Did they score a goal?	17.9%	38.8%	31.2%
		% of Total	6.5%	24.7%	31.2%
	University of Sussex	Count	23	30	53
		Expected Count	19.3	33.7	53.0
		% within Job	43.4%	56.6%	100.0%
		% within Did they score a goal?	82.1%	61.2%	68.8%
		% of Total	29.9%	39.0%	68.8%
Total		Count	28	49	77
		Expected Count	28.0	49.0	77.0
		% within Job	36.4%	63.6%	100.0%
		% within Did they score a goal?	100.0%	100.0%	100.0%
		% of Total	36.4%	63.6%	100.0%

Before moving on to look at the test statistics itself it is vital that we check that the assumption for chi-square has been met. The assumption is that in 2 $\times$ 2 tables (which is what we have here), all expected frequencies should be greater than 5. If you look at the expected counts in the crosstabulation table, it should be clear that the smallest expected count is 8.7 (for sage editors who scored). This value exceeds 5 and so the assumption has been met.

Pearson's chi-square test examines whether there is an association between two categorical variables (in this case the job and whether the person scored or not). As part of the crosstabs procedure SPSS produces a table that includes the chi-square statistic and its significance value. The Pearson chi-square statistic tests whether the two variables are independent. If the significance value is small enough (conventionally Sig. must be less than 0.05) then we reject the hypothesis that the variables are independent and accept the hypothesis that they are in some way related. The value of the chi-square statistic is given in the table (and the degrees of freedom) as is the significance value. The value of the chi-square statistic is 3.63. This value has a two-tailed significance of 0.057, which is bigger than 0.05 (hence non-significant).

However, we made a specific prediction (that Sussex people would score more than sage people) hence we can halve this value. Therefore, the chi-square is significant (one-tailed) because p = 0.0285, which is less than 0.05. The one-tailed significance values of the other statistics are also less than 0.05 so we have consistent results.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.634[b]	1	.057		
Continuity Correction[a]	2.725	1	.099		
Likelihood Ratio	3.834	1	.050		
Fisher's Exact Test				.075	.047
Linear-by-Linear Association	3.587	1	.058		
N of Valid Cases	77				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.73.

The highly significant result indicates that there is an association between the type of job someone does and whether they score goals. This significant finding reflects the fact that for Sussex employees there is about a 50% split of those that scored and those that didn't, but for Sage employees there is about a 20-80 split with only 20% scoring and 80% not scoring. This supports our hypothesis that people from Sage, despite their delusions, are crap at football!

Calculating an Effect Size

The odds of someone scoring given that they were employed by Sage is 5/19 = 0.26, and the odds of someone scoring given that they were employed by Sussex university is 23/30 = 0.77. Therefore, the odds ratio is 0.26/0.77 = 0.34. In other words, the odds of scoring if you work for sage are 0.34 times higher than if you work for Sussex, a better way to express this is that if you work for sage, the odds of scoring are 1/0.34 = 2.95 lower than if you work for Sussex!

Reporting the Results of Chi-Square

We could report:

- ✓ There was a significant association between the type of job and whether or not a person scored a goal, χ^2 (1) = 3.63, p < .05 (one-tailed). This represents the fact that, based on the odds ratio, Sage employees were 2.95 times less likely to score than Sussex employees.

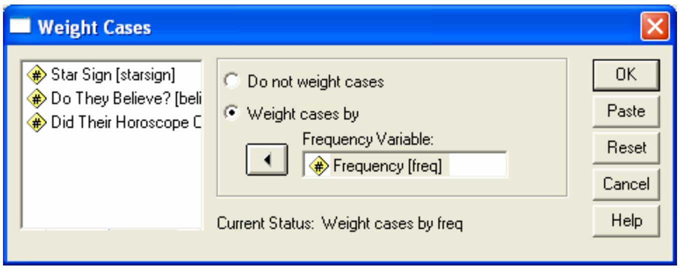
Task 2

I was interested in whether Horoscopes are just a figment of people's minds. Therefore, I got 2201 people, made a note of their star sign (this variable, obviously has 12 categories: Capricorn, Aquarius, Pisces, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio and Sagittarius) and whether they believed in Horoscopes (this variable has two categories: believer or unbeliever). I then sent them a horoscope in the post of what would happen over the next month: everybody, regardless of their star sign, received the same horoscope which read 'August is an exciting month for you. You will make friends with a tramp in the first week of the month and cook him a cheese omelette. Curiosity is your greatest virtue, and in the second week you'll discover knowledge of a subject that you previously thought was boring, statistics perhaps. You might purchase a book around this time that guides you towards this knowledge. Your new wisdom leads to a change in career around the third week, when you ditch your current job and become an accountant. By the final week you find yourself free from the constraints of having friends, your boy/girlfriend has left you for a Russian ballet dancer with a glass eye, and you now spend your weekends doing loglinear analysis by hand with a pigeon called Hephzibah for company'. At the end of August I interviewed all of these people a depending on how closely their lives matched the fictitious horoscope I classified the horoscope as having come true, or not. The data are in the file **Horoscope.sav**. Conduct a loglinear analysis to see whether there is a relationship between the person's star sign, whether they believe in horoscopes, and whether the horoscope came true.

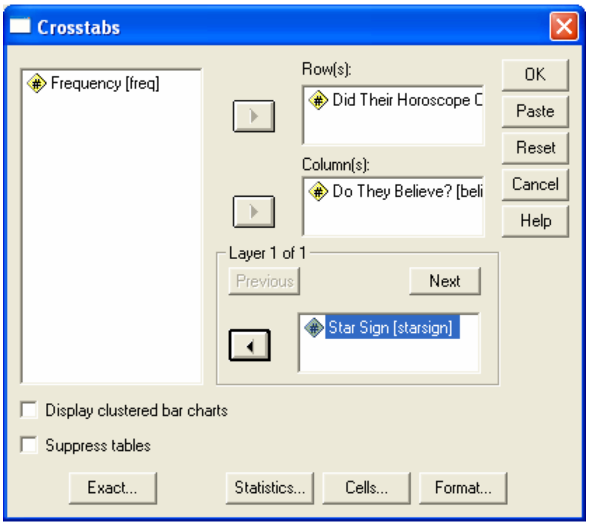
Running the Analysis

Initial Considerations

Data are entered for this example as frequency values for each combination of categories so before you begin you must weight the cases by the variable **frequent**. If you don't do this the entire output will be wrong!



To begin with we should use the *crosstabs* command to produce a contingency table of the data.



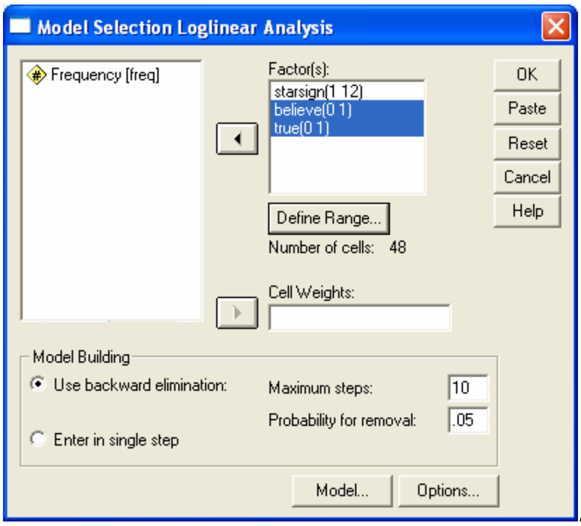
The crosstabulation table produced by SPSS contains the number of cases that falls into each combination of categories. Although this table is quite complicated you should be able to see that there roughly the same number of believers and non-believers and similar numbers of those whose horoscopes came true or didn't. These proportions are fairly consistent also across the different star signs! Also there are no expected counts less than 5, so our assumptions are met.

Did Their Horoscope Come True? * Do They Believe? * Star Sign Crosstabulation

				Do They Believe?		
Star Sign				Unbeliever	Believer	Total
Capricorn	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	56	50	106
			Expected Count	51.0	55.0	106.0
			% of Total	26.4%	23.6%	50.0%
		Horoscope Came True	Count	46	60	106
			Expected Count	51.0	55.0	106.0
			% of Total	21.7%	28.3%	50.0%
	Total		Count	102	110	212
			Expected Count	102.0	110.0	212.0
			% of Total	48.1%	51.9%	100.0%
Aquarius	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	26	22	48
			Expected Count	22.8	25.2	48.0
			% of Total	26.8%	22.7%	49.5%
		Horoscope Came True	Count	20	29	49
			Expected Count	23.2	25.8	49.0
			% of Total	20.6%	29.9%	50.5%
	Total		Count	46	51	97
			Expected Count	46.0	51.0	97.0
			% of Total	47.4%	52.6%	100.0%
Pisces	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	55	64	119
			Expected Count	52.6	66.4	119.0
			% of Total	22.9%	26.7%	49.6%
		Horoscope Came True	Count	51	70	121
			Expected Count	53.4	67.6	121.0
			% of Total	21.3%	29.2%	50.4%
	Total		Count	106	134	240
			Expected Count	106.0	134.0	240.0
			% of Total	44.2%	55.8%	100.0%
Aries	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	42	70	112
			Expected Count	43.2	68.8	112.0
			% of Total	20.8%	34.7%	55.4%
		Horoscope Came True	Count	36	54	90
			Expected Count	34.8	55.2	90.0
			% of Total	17.8%	26.7%	44.6%
	Total		Count	78	124	202
			Expected Count	78.0	124.0	202.0
			% of Total	38.6%	61.4%	100.0%
Taurus	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	56	41	97
			Expected Count	50.3	46.7	97.0
			% of Total	29.6%	21.7%	51.3%
		Horoscope Came True	Count	42	50	92
			Expected Count	47.7	44.3	92.0
			% of Total	22.2%	26.5%	48.7%
	Total		Count	98	91	189
			Expected Count	98.0	91.0	189.0
			% of Total	51.9%	48.1%	100.0%
Gemini	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	65	40	105
			Expected Count	60.1	44.9	105.0
			% of Total	31.6%	19.4%	51.0%
		Horoscope Came True	Count	53	48	101
			Expected Count	57.9	43.1	101.0
			% of Total	25.7%	23.3%	49.0%
	Total		Count	118	88	206
			Expected Count	118.0	88.0	206.0
			% of Total	57.3%	42.7%	100.0%
Cancer	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	84	96	180
			Expected Count	85.0	95.0	180.0
			% of Total	24.8%	28.3%	53.1%
		Horoscope Came True	Count	76	83	159
			Expected Count	75.0	84.0	159.0
			% of Total	22.4%	24.5%	46.9%
	Total		Count	160	179	339
			Expected Count	160.0	179.0	339.0
			% of Total	47.2%	52.8%	100.0%
Leo	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	14	12	26
			Expected Count	13.9	12.1	26.0
			% of Total	20.3%	17.4%	37.7%
		Horoscope Came True	Count	23	20	43
			Expected Count	23.1	19.9	43.0
			% of Total	33.3%	29.0%	62.3%
	Total		Count	37	32	69
			Expected Count	37.0	32.0	69.0
			% of Total	53.6%	46.4%	100.0%
Virgo	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	69	49	118
			Expected Count	61.2	56.8	118.0
			% of Total	28.9%	20.5%	49.4%
		Horoscope Came True	Count	55	66	121
			Expected Count	62.8	58.2	121.0
			% of Total	23.0%	27.6%	50.6%
	Total		Count	124	115	239
			Expected Count	124.0	115.0	239.0
			% of Total	51.9%	48.1%	100.0%
Libra	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	27	22	49
			Expected Count	23.4	25.6	49.0
			% of Total	24.3%	19.8%	44.1%
		Horoscope Came True	Count	26	36	62
			Expected Count	29.6	32.4	62.0
			% of Total	23.4%	32.4%	55.9%
	Total		Count	53	58	111
			Expected Count	53.0	58.0	111.0
			% of Total	47.7%	52.3%	100.0%
Scorpio	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	32	24	56
			Expected Count	27.0	29.0	56.0
			% of Total	29.6%	22.2%	51.9%
		Horoscope Came True	Count	20	32	52
			Expected Count	25.0	27.0	52.0
			% of Total	18.5%	29.6%	48.1%
	Total		Count	52	56	108
			Expected Count	52.0	56.0	108.0
			% of Total	48.1%	51.9%	100.0%
Sagittarius	Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	56	42	98
			Expected Count	50.3	47.7	98.0
			% of Total	29.6%	22.2%	51.9%
		Horoscope Came True	Count	41	50	91
			Expected Count	46.7	44.3	91.0
			% of Total	21.7%	26.5%	48.1%
	Total		Count	97	92	189

The Loglinear Analysis

Having established that the assumptions have been met we can move onto the main analysis. Use the **Analyze⇒Loglinear Statistics⇒Model Selection…** menu to access the main dialog box. This should look like the picture below when completed.



Output from Loglinear Analysis

The initial output from the loglinear analysis tells us that we have 2201 cases. SPSS then lists all of the factors in the model and the number of levels they have. To begin with SPSS fits the saturated model (all terms are in the model including the highest order interaction, in this case the star sign × believer × true interaction). SPSS then gives us the observed and expected counts for each of the combinations of categories in our model. These values should be the same as the original contingency table except that each cell has 0.5 added to it. The final bit of this initial output gives us two goodness of fit statistics (Pearson's chi-square and the likelihood-ratio statistic, both of which we came across at the beginning of this chapter). In this context these tests are testing the hypothesis that the frequencies predicted by the model (the expected frequencies) are significantly different from the actual frequencies in our data (the observed frequencies). Now, obviously, if our model is a good fit of the data then the observed and expected frequencies should be very similar (i.e. not significantly different). Therefore, we want these statistics to be non-significant. A significant result would mean that our model was significantly different from our data (i.e. the model is a bad fit of the data). In large samples these statistics should give the same results but the likelihood ratio statistic is preferred in small samples. In this example, both statistics are 0 and yield a probability value, *p*, of –INF, which is a rather confusing way of saying that the probability is very high. Put another way, at this stage the model perfectly predicts the data. If you read the theory section this shouldn't surprise you as I showed there that the saturated model is a perfect fit of the data. What's interesting in loglinear analysis is what bits of the model we can then remove without significantly affecting the fit of the model.

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* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

DATA   Information

         48 unweighted cases accepted.
          0 cases rejected because of out-of-range factor values.
          0 cases rejected because of missing data.
       2201 weighted cases will be used in the analysis.


FACTOR Information

   Factor  Level  Label
   STARSIGN   12  Star Sign
   BELIEVE     2  Do They Believe?
   TRUE        2  Did Their Horoscope Come True?

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* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

DESIGN 1 has generating class

    STARSIGN*BELIEVE*TRUE

 Note: For saturated models   .500 has been added to all observed cells.
 This value may be changed by using the CRITERIA = DELTA subcommand.


The Iterative Proportional Fit algorithm converged at iteration 1.
The maximum difference between observed and fitted marginal totals is     .000
and the convergence criterion is     .250

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 Observed, Expected Frequencies and Residuals.

       Factor          Code            OBS count  EXP count  Residual  Std Resid


  STARSIGN        Capricor
   BELIEVE         Unbeliev
    TRUE            Horoscop                56.5       56.5       .00        .00
    TRUE            Horoscop                46.5       46.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                50.5       50.5       .00        .00
    TRUE            Horoscop                60.5       60.5       .00        .00

  STARSIGN        Aquarius
   BELIEVE         Unbeliev
    TRUE            Horoscop                26.5       26.5       .00        .00
    TRUE            Horoscop                20.5       20.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                22.5       22.5       .00        .00
    TRUE            Horoscop                29.5       29.5       .00        .00

  STARSIGN        Pisces
   BELIEVE         Unbeliev
    TRUE            Horoscop                55.5       55.5       .00        .00
    TRUE            Horoscop                51.5       51.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                64.5       64.5       .00        .00
    TRUE            Horoscop                70.5       70.5       .00        .00

  STARSIGN        Aries
   BELIEVE         Unbeliev
    TRUE            Horoscop                42.5       42.5       .00        .00
    TRUE            Horoscop                36.5       36.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                70.5       70.5       .00        .00
    TRUE            Horoscop                54.5       54.5       .00        .00

  STARSIGN        Taurus
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   BELIEVE         Unbeliev
    TRUE            Horoscop                    56.5       56.5       .00        .00
    TRUE            Horoscop                    42.5       42.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    41.5       41.5       .00        .00
    TRUE            Horoscop                    50.5       50.5       .00        .00

  STARSIGN        Gemini
   BELIEVE         Unbeliev
    TRUE            Horoscop                    65.5       65.5       .00        .00
    TRUE            Horoscop                    53.5       53.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    40.5       40.5       .00        .00
    TRUE            Horoscop                    48.5       48.5       .00        .00

  STARSIGN        Cancer
   BELIEVE         Unbeliev
    TRUE            Horoscop                    84.5       84.5       .00        .00
    TRUE            Horoscop                    76.5       76.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    96.5       96.5       .00        .00
    TRUE            Horoscop                    83.5       83.5       .00        .00

  STARSIGN        Leo
   BELIEVE         Unbeliev
    TRUE            Horoscop                    14.5       14.5       .00        .00
    TRUE            Horoscop                    23.5       23.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    12.5       12.5       .00        .00
    TRUE            Horoscop                    20.5       20.5       .00        .00

  STARSIGN        Virgo
   BELIEVE         Unbeliev
    TRUE            Horoscop                    69.5       69.5       .00        .00
    TRUE            Horoscop                    55.5       55.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    49.5       49.5       .00        .00
    TRUE            Horoscop                    66.5       66.5       .00        .00

  STARSIGN        Libra
   BELIEVE         Unbeliev
    TRUE            Horoscop                    27.5       27.5       .00        .00
    TRUE            Horoscop                    26.5       26.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    22.5       22.5       .00        .00
    TRUE            Horoscop                    36.5       36.5       .00        .00

  STARSIGN        Scorpio
    BELIEVE         Unbeliev
    TRUE            Horoscop                    32.5       32.5       .00        .00
    TRUE            Horoscop                    20.5       20.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    24.5       24.5       .00        .00
    TRUE            Horoscop                    32.5       32.5       .00        .00

  STARSIGN        Sagittar
   BELIEVE         Unbeliev
    TRUE            Horoscop                    56.5       56.5       .00        .00
    TRUE            Horoscop                    41.5       41.5       .00        .00
   BELIEVE         Believer
    TRUE            Horoscop                    42.5       42.5       .00        .00
    TRUE            Horoscop                    50.5       50.5       .00        .00

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 Goodness-of-fit test statistics

    Likelihood ratio chi square =      .00000    DF = 0  P =  -INF
             Pearson chi square =      .00000    DF = 0  P =  -INF

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The next part of the output tells us something about which components of the model can be removed. The first bit of the output is labelled *Tests that K-way and higher order effects are zero* and underneath there is a table showing likelihood-ratio and chi-square statistics when K = 3, 2 and 1 (as we go down the rows of the table). The first row (K = 3) is testing whether removing the 3-way effect *and* higher order effects will significantly affect the fit of the model. Now of course, the 3-way interaction is the highest order effect that we have so this is simply testing whether removal of 3-way interaction (i.e. the star sign × believer × true interaction) will significantly affect the fit of the model. If you look at the two columns labelled *Prob* then you can see that both chi-square and likelihood ratio tests agree that removing this interaction will not significantly affect the fit of the model (because the probability value is greater than 0.05). The next row of the table (K = 2) tells us whether removing the 2-way interactions (i.e. the star sign × believer, star sign × true and believer × true interactions) and any higher order effects will affect the model. In this case there is a higher-order effect (the 3-way interaction) so this is testing whether removing the 2-way interactions **and** the 3-way interaction would affect the fit of the model. This is significant (the probability is 0.03, which is less than 0.05) indicating that if we removed the 2-way interactions and the 3-way interaction then this would have a significant detrimental effect on the model. The final row (K = 1) tells us whether removing the 1-way effects (i.e. the main effects of star sign, believer and true) and any higher order effects will significantly affect the fit of the model. There are lots of higher order effects here—there are the two way interactions and the three-way interaction—and so this is basically testing whether if we remove everything from the model there will be a significant effect on the fit of the model. This is highly significant because the probability value is 0.000, which is less than 0.05 (which we would expect because as we've already seen the 2-way interactions are highly significant and this test includes these interactions).

The next part of the table expresses the same thing but without including the higher order effects. It's labelled *Tests that K-way effects are zero* and then lists tests for when K = 1, 2 and 3. The first row (K = 1), therefore, tests whether removing the main effects (the 1-way effects) has a significant detrimental effect on the model. The probability values are less than 0.05 indicating that if we removed the main effects of star sign, believer and true from our model it would significantly affect the fit of the model (in other words one or more of these effects are significant predictors of the data). The second row (K = 2) tests whether removing the 2-way interactions has a significant detrimental effect on the model. The probability values are less than 0.05 indicating that if we removed the star sign × believer, star sign × true and believer × true interactions then this would significantly reduce how well the model fits the data. In other words one or more of these two-way interactions is a significant predictor of the data. The final row (K = 3) tests whether removing the 3-way interaction has a significant detrimental effect on the model. The probability values are greater than 0.05 indicating that if we removed the star sign × believer × true interaction then this would significantly reduce how well the model fits the data. In other words this three-way interaction is not a significant predictor of the data. This row should be identical to the first row of the previous table (the *Tests of K-way and higher order effects are zero*) because it is the highest order effect and so in the previous table there were no higher order effects to include in the test (look at the output and you'll see the results are identical).

What this is actually telling us is that the three-way interaction is not significant: removing it from the model does not have a significant effect on how well the model fits the data. We also know that removing all two-way interactions does have a significant effect on the model, as does removing the main effects, but you have to remember that loglinear analysis should be done hierarchically and so these two-way interactions are more important than the main effects.

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* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

Tests that K-way and higher order effects are zero.

         K     DF   L.R. Chisq    Prob  Pearson Chisq    Prob   Iteration

         3     11        8.841   .6365          8.850   .6357           3
         2     34       50.930   .0311         51.094   .0301           2
         1     47      411.393   .0000        400.923   .0000           0

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Tests that K-way effects are zero.

         K     DF   L.R. Chisq    Prob  Pearson Chisq    Prob   Iteration

         1     13      360.463   .0000        349.829   .0000           0
         2     23       42.088   .0089         42.244   .0085           0
         3     11        8.841   .6365          8.850   .6357           0
```

SPSS Output Error! No text of specified style in document.**.1**

If you selected an *Association table* then you'll get the output below. This simply breaks down the table that we've just looked at into its component parts. So, for example, although we know from the previous output that removing all of the two-way interactions significantly affects the model, we don't know which of the two-way interactions is having the effect. This table tells us. We get a Pearson chi-square test for each of the two-way interactions and the main effects and the column labelled *Prob* tells us which of these effects is significant (values less than 0.05 are significant). We can tell from this that the star sign × believe and believe × true interactions are significant but the star sign × true interaction is not. Likewise, we saw in the previous output that removing the 1-way effects also significantly affect the fit of the model, and these findings are confirmed here because the main effect of star sign is highly significant (although this just means that we collected different amounts of data for each of the star signs!).

```
* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

 Tests of PARTIAL associations.

  Effect Name                                   DF  Partial Chisq    Prob  Iter


  STARSIGN*BELIEVE                              11         20.666   .0370     2
  STARSIGN*TRUE                                 11         10.740   .4653     2
  BELIEVE*TRUE                                   1         12.541   .0004     2
  STARSIGN                                      11        358.551   .0000     2
  BELIEVE                                        1          1.582   .2085     2
  TRUE                                           1           .331   .5648     2

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

```
* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

Backward Elimination (p = .050) for DESIGN 1 with generating class

  STARSIGN*BELIEVE*TRUE

 Likelihood ratio chi square =      .00000    DF = 0  P =  -INF

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

If Deleted Simple Effect is                DF   L.R. Chisq Change    Prob  Iter

 STARSIGN*BELIEVE*TRUE                     11               8.841   .6365     3
```

```
Step 1

  The best model has generating class

      STARSIGN*BELIEVE
      STARSIGN*TRUE
      BELIEVE*TRUE

  Likelihood ratio chi square =     8.84125    DF = 11  P =  .637

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

If Deleted Simple Effect is                 DF   L.R. Chisq Change    Prob  Iter

 STARSIGN*BELIEVE                           11              20.666   .0370     2
 STARSIGN*TRUE                              11              10.740   .4653     2
 BELIEVE*TRUE                                1              12.541   .0004     2

Step 2

  The best model has generating class

      STARSIGN*BELIEVE
      BELIEVE*TRUE

  Likelihood ratio chi square =    19.58173    DF = 22  P =  .609

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

If Deleted Simple Effect is                 DF   L.R. Chisq Change    Prob  Iter

 STARSIGN*BELIEVE                           11              19.737   .0491     2
 BELIEVE*TRUE                                1              11.612   .0007     2


* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

Step 3

  The best model has generating class

      STARSIGN*BELIEVE
      BELIEVE*TRUE

  Likelihood ratio chi square =    19.58173    DF = 22  P =  .609

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

* * * * * * * *  H I E R A R C H I C A L   L O G   L I N E A R  * * * * * * * *

The final model has generating class

    STARSIGN*BELIEVE
    BELIEVE*TRUE

The Iterative Proportional Fit algorithm converged at iteration 0.
The maximum difference between observed and fitted marginal totals is     .000
and the convergence criterion is     .250

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

The final bit of output deals with the backward elimination. SPSS will begin with the highest order effect (in this case the star sign × believe × true interaction), it removes it from the model, sees what effect this has, and if it doesn't have a significant effect then it moves onto the next highest effects (in this case the two-way interactions). As we've already seen, removing the three way interaction does not have a significant effect and this is confirmed at this stage by the table labelled *If Deleted Simple Effect is*, which confirms that removing the three way interaction has a non-significant effect on the model. Therefore, the *The best model has generated class* tells us that the two-way interactions are retained at step 1. These three two-way interactions are then assessed in the bit of the table labelled *If Deleted Simple Effect* *is*. From the values of *Prob* it's clear that the star sign × believe (p = 0.037) and believe × true (p = 0.0004) interactions are significant but the star sign × true interaction (p = 0. 465) is not. Therefore, at step two the non-significant star sign × true interaction is deleted leaving the remaining two-way interactions in the model. These two interactions are then re-evaluated and both the star sign × believe (p = 0.049) and believe × true (p = 0.0007) interactions are still significant and so are still retained. Therefore, the final model is the one that retains all main effects and these two interactions. As neither of these interactions can be removed without affecting the model, and these interactions involve all three of the main effects (the variables star sign, true and believe are all involved in at least one of the remaining interactions), the main effects are not examined (because their effect is confounded with the interactions that have been retained. Finally, SPSS evaluates this final model with the likelihood ratio statistic and we're looking for a non-significant test statistic which indicates that the expected values generated by the model are not significantly different from the observed data (put another way the model is a good fit of the data). In this case the result is very non-significant indicating that the model is a good fit of the data.

The believe × true Interaction

The next step is to try to interpret these interactions. The first useful thing we can do is to collapse the data. Remember from the chapter that there are the following rules for collapsing data: (1) The highest order interaction should be nonsignificant, and (2) At least one of the lower order interaction terms involving the variable to be deleted should be nonsignificant. We need to look at star sign × believe and believe × true interaction. Let's take the believe × true interaction first. Ideally we want to collapse the data across the star sign variable. To do this the three-way interaction must be non-significant (it was) and at least one lower order interaction involving star sign must be also (the star sign × true interaction was). So, we can look at this interaction by doing a chi-square on believe and true, ignoring star sign. The results are below:

Did Their Horoscope Come True? * Do They Believe? Crosstabulation

			Do They Believe?		
			Unbeliever	Believer	Total
Did Their Horoscope Come True?	Horoscope Didn't Come True	Count	582	532	1114
		Expected Count	542.1	571.9	1114.0
		% of Total	26.4%	24.2%	50.6%
	Horoscope Came True	Count	489	598	1087
		Expected Count	528.9	558.1	1087.0
		% of Total	22.2%	27.2%	49.4%
Total		Count	1071	1130	2201
		Expected Count	1071.0	1130.0	2201.0
		% of Total	48.7%	51.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.601[b]	1	.001		
Continuity Correction[a]	11.312	1	.001		
Likelihood Ratio	11.612	1	.001		
Fisher's Exact Test				.001	.000
Linear-by-Linear Association	11.596	1	.001		
N of Valid Cases	2201				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 528.93.

This chi-square is highly significant. To interpret this we could consider calculating some odds ratios. First, the odds of the horoscope coming true given that the person was a believer was 598/532 = 1.12. However, the odds of the horoscope coming true given that the person was an unbeliever was 489/582 = 0.84. Therefore, the odds ratio is 1.12/0.84 = 1.33. We can interpret this by saying that believers were 1.33 times more likely to have the horoscope come true than non-believers. Given that the horoscopes were made up twaddle this might be evidence that believers behave in ways to make their horoscopes come true!

The star sign × believe interaction

Next, we can look at the star sign × believe interaction. For this interaction we'd like to collapse across the true variable, To do this (1) The highest order interaction should be nonsignificant (which it is), and (2) At least one of the lower order interaction terms involving the variable to be deleted should be nonsignificant (the star sign × true interaction was). So, we can look at this interaction by doing a chi-square on star sign and believe, ignoring true. The results are below:

Star Sign * Do They Believe? Crosstabulation

			Do They Believe?		
			Unbeliever	Believer	Total
Star Sign	Capricorn	Count	102	110	212
		Expected Count	103.2	108.8	212.0
		% within Star Sign	48.1%	51.9%	100.0%
	Aquarius	Count	46	51	97
		Expected Count	47.2	49.8	97.0
		% within Star Sign	47.4%	52.6%	100.0%
	Pisces	Count	106	134	240
		Expected Count	116.8	123.2	240.0
		% within Star Sign	44.2%	55.8%	100.0%
	Aries	Count	78	124	202
		Expected Count	98.3	103.7	202.0
		% within Star Sign	38.6%	61.4%	100.0%
	Taurus	Count	98	91	189
		Expected Count	92.0	97.0	189.0
		% within Star Sign	51.9%	48.1%	100.0%
	Gemini	Count	118	88	206
		Expected Count	100.2	105.8	206.0
		% within Star Sign	57.3%	42.7%	100.0%
	Cancer	Count	160	179	339
		Expected Count	165.0	174.0	339.0
		% within Star Sign	47.2%	52.8%	100.0%
	Leo	Count	37	32	69
		Expected Count	33.6	35.4	69.0
		% within Star Sign	53.6%	46.4%	100.0%
	Virgo	Count	124	115	239
		Expected Count	116.3	122.7	239.0
		% within Star Sign	51.9%	48.1%	100.0%
	Libra	Count	53	58	111
		Expected Count	54.0	57.0	111.0
		% within Star Sign	47.7%	52.3%	100.0%
	Scorpio	Count	52	56	108
		Expected Count	52.6	55.4	108.0
		% within Star Sign	48.1%	51.9%	100.0%
	Sagittarius	Count	97	92	189
		Expected Count	92.0	97.0	189.0
		% within Star Sign	51.3%	48.7%	100.0%
Total		Count	1071	1130	2201
		Expected Count	1071.0	1130.0	2201.0
		% within Star Sign	48.7%	51.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.634[a]	11	.051
Likelihood Ratio	19.737	11	.049
Linear-by-Linear Association	2.651	1	.103
N of Valid Cases	2201		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 33.58.

This chi-square is borderline significant (two-tailed, but then again we had no prediction so we need to look at the two-tailed significance). It doesn't make a lot of sense to compute odds ratios because there are so many star signs (although we could use one star sign as a base category and compute odds ratios for all other signs compared to this category). However, the obvious general interpretation of this effect is that the ratio of believers to unbelievers in certain star signs is different. For example, in most star signs there is a roughly 50:50 split of believers and unbelievers, but for Aries there is a 40:60 split and it is probably this difference that is most contributing to the effect. However, it's important to keep this effect in perspective. It may not be that interesting that we happened to sample a different ratio of believers and unbelievers in certain star signs (unless you believe that certain star signs should have more cynical views of horoscopes than others!). We actually set out to find out something about whether the horoscopes would come true and it's worth remembering that this interaction ignores the crucial variable that measured whether or not the horoscope came true!

Reporting the Results

For this example we could report:

- The three-way loglinear analysis produced a final model that retained the star sign × believe and believe × true interactions. The likelihood ratio of this model was, χ^2 (22) = 19.58, p = 0.61. The star sign × believe interaction was significant, χ^2 (11) = 19.74, p < 0.05. This interaction indicates that the ratio of believers and unbelievers was different across the 12 star signs. In particular the ratio in Aries (38.6:62.4 ratio of unbelievers to believers was quite different to the other groups, which consistently had a roughly 50:50 split). The believe × true interaction was also significant, χ^2 (1) = 11.61, p < .001. The odds ratio indicated that believers were 1.33 times more likely to have the horoscope come true than non-believers. Given that the horoscopes were made up twaddle this might be evidence that believers behave in ways to make their horoscopes come true.