12.2: Coding for Carry-Over Covariates

The late Dr. Steve Arnold (Penn State), came up with a satisfactory solution to account for carry-over effects in the data analysis. The following example will illustrate how the procedure works. The data can be found in the textbook *Design of Experiments*, by Kuehl, as Example 16.1. Investigators want to evaluate the effect of 3 diets on Neutral Detergent Fiber (NDF) levels in steer. The three diets are administered to each steer in a sequence over 3 periods. A total of 6 sequences were used and two steers were assigned to each sequence of treatments.

The cross-over design can be summarized as:

	Period		
Sequence	1	2	3
1	A	B	C
2	B	C	A
3	C	A	B
4	A	C	B
5	B	A	C
6	C	B	A

If we look at the first part of the dataset (Steer Data) for this example in Excel, we can see the following:

	A	B	C	D	E
1	PER	SEQ	DIET	STEER	NDF
2	1	1	A	1	50
3	1	1	A	2	55
4	1	2	B	1	44
5	1	2	B	2	51
6	1	3	C	1	35
7	1	3	C	2	41
8	1	4	A	1	54
9	1	4	A	2	58
10	1	5	B	1	50
11	1	5	B	2	55
12	1	6	C	1	41
13	1	6	C	2	46
14	2	1	B	1	61
15	2	1	B	2	63
16	2	2	C	1	42
17	2	2	C	2	45
18	2	3	A	1	55
19	2	3	A	2	56
20	2	4	C	1	48
21	2	4	C	2	51
22	2	5	A	1	57
23	2	5	A	2	59

Figure 12.2.1: First five columns of steer dataset in Excel.

We need now to add two columns to use an effect-type coding for the 3 treatment levels. We can use:

	x_1	x_2
A	1	0
B	0	1
C	-1	-1

Where x_1 and x_2 will be columns we create in the data to input for all of the rows of data. The coding values depend on which treatment level is administered during the ***previous period***. For example, if treatment A was administered in the previous period, then coding values would be $x_1 = 1, x_2 = 0$.

There will be no entries for the first period because on the first application of each treatment there are no treatments that have preceded it. Therefore a 0 is used as the coding value for both x_1 and x_2.

	A	B	C	D	E	F	G
1	PER	SEQ	DIET	STEER	NDF	x1	x2
2	1	1	A	1	50	0	0
3	1	1	A	2	55	0	0
4	1	2	B	1	44	0	0
5	1	2	B	2	51	0	0
6	1	3	C	1	35	0	0
7	1	3	C	2	41	0	0
8	1	4	A	1	54	0	0
9	1	4	A	2	58	0	0
10	1	5	B	1	50	0	0
11	1	5	B	2	55	0	0
12	1	6	C	1	41	0	0
13	1	6	C	2	46	0	0
14	2	1	B	1	61	1	0
15	2	1	B	2	63	1	0
16	2	2	C	1	42	0	1
17	2	2	C	2	45	0	1
18	2	3	A	1	55	-1	-1
19	2	3	A	2	56	-1	-1
20	2	4	C	1	48	1	0
21	2	4	C	2	51	1	0
22	2	5	A	1	57	0	1
23	2	5	A	2	59	0	1

Figure 12.2.2: Steer dataset, including x_1 and x_2, in Excel.

Looking at Period 2, sequence 1, treatment B we can refer back to the Sequence chart and see that it was preceded by treatment level A, so we assign $x_1 = 1$, and $x_2 = 0$, indicating that it was treatment A that could produce a carry-over effect here.

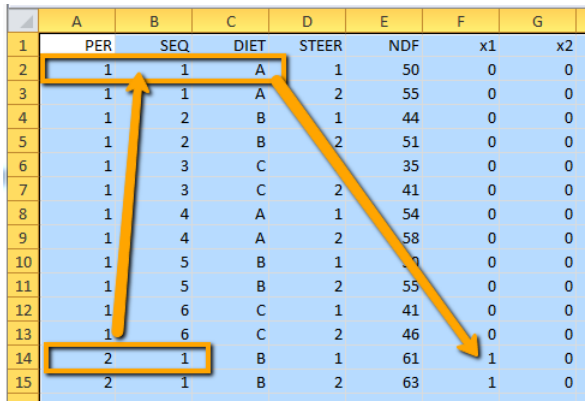

Figure 12.2.3: Identifying the carry-over effects using the spreadsheet.

The process can be repeated to define the coding variables to each entry in the dataset. The coded variables x_1 and x_2 are then entered into the general linear model as continuous covariates and LSmeans for treatments are adjusted for carry-over effects.
