APPLYING THE TOOLS

Example Two

1. Problem Statement

2. Analyst Statement

3. Solution

Example Two

I am a student in a required MBA statistics course. For the statistical inference part of the course, each student has been assigned to gather data in a real setting that can be used to find a suitably narrow confidence interval for population parameter. Although the instructor, G. Harel, certainly knows statistics well, he has asked us to include explanations of relevant statistical concepts in our reports, just to confirm that we know what we are talking about. Professor Harel has made it clear that he does not want a lot of "padding". He wants reports that are short and to the point.

Example 2

The Stevens Honda-Olds automobile dealership often sells to husband/wife pairs. The manager would like to check whether the sales presentation is viewed any more or less favorable by the husband than the wife. If it is, then some new training might be recommended for its salespeople. To check for differences, a random sample of husbands and wives are asked (separately) to rate the sales presentation on a 1 to 10 scale, 10 being the most favorable rating. The results appear in Figure 1. What can the manager conclude from this data?

Sales presentation ratings		
Pair	*Husband*	*Wife*
1	6	3
2	7	8
3	8	5
4	6	4
5	8	5
6	7	6
7	8	5
8	6	7
9	7	8
30	7	3
31	7	5
32	5	1
33	7	5
34	7	4
35	10	5

PAIRED SAMPLES

When the samples we want to compare are paid in some natural way, such as a pretest/ posttest for each person or husband/wife pairs, there is a more appropriate form of analysis than the two-sample procedure. Consider the example where each new employee takes test. Then receives a 3 month training course, and finally takes another similar test. There is likely to be a fairly strong correlation between the protest and posttest scores. Employees who score relatively low on the first test are likely to score relatively low on the second test, and employees who score relatively high on the first test are likely to score relatively high in the second test. The two-sample procedure does not take this correlation into account and essentially ignores important information.

The procedure itself is very straightforward. We do not directly analyze two separate variables (protest scores and posttest scores, say); we analyze their *differences*. For each pair in the sample, we calculate the difference between the two scores for the pair. Then we perform a *one*-sample analysis on these differences. Actually, Stat-Pro's Paid-Sample procedure does the difference and the ensuing one-sample analysis automatically, as described in the example above.

Solution

We illustrate two ways to perform the analysis. Normally, we would only use the second of these, but the first sheds some light on the procedure. For the first method, make a copy of the Data sheet and call it OneSample. Then manually form a new variable in column D called Difference by entering the formula

$$= B4 - C4$$

in cell D4 and copying it down column D. (See Figure 2.) Next, with the cursor anywhere in the resulting data set, select the StatPro/Statistical Inference/One-Sample Analysis menu item, select the variable Difference for analysis, and accept all the defaults in the other dialog boxes. This produces the output shown in Figure 2. We see that the sample mean Husband minus Wife difference is 1.629 and that a 95% confidence interval for this difference extends from 1.057 to 2.200. The standard error in cell H13, 0.281, refers to the standard error of the sample mean *difference.*

To perform this analysis more efficiently, again make a copy of the Data sheet and called it Paired. Then use the StatPro/Statistical Inference/ Paired-Sample Analysis menu item, select the Husband and Wife variables for analysis, and accept the defaults in the other dialog boxes. We obtain the output in Figure 3. Obviously, the results are exactly the same as before. This is because StatPro's Paired-Sample procedure performs a one-sample analysis on the differences—and it saves you the work of creating the differences.

Figure 2 One-Sample Analysis of Differences for Automobile Data

	A	B	C	D	E	F	G	H
1	Sales presentation ratings							
2								
3	Pair	Husband	Wife	Difference	for one-sample analysis for Difference			
4	1	6	3	3				
5	2	7	8	-1		Summary measures		
6	3	8	5	3			Sample size	35
7	4	6	4	2			Sample mean	1.629
8	5	8	5	3			Sample standard deviation	1.664
9	6	7	6	1				
10	7	8	5	3		Confidence interval for mean		
11	8	6	7	-1			Confidence level	95.0%
12	9	7	8	-1			Sample mean	1.629
13	10	7	5	2			Std error of mean	0.281
14	11	6	3	3			Degrees of freedom	34
15	12	5	4	1			Lower limit	1.057
16	13	8	5	3			Upper limit	2.200
17	14	7	8	-1				
37	34	·7	4	3			.	
38	35	10	5	5				

Figure 3 Paired-Sample Analysis of Automobile Data

	A	B	C	D	E	F	G	H
1	Sales presentation ratings							
2								
3	Pair	Husband	Wife	Husband-Wife		Paired-sample analysis for Husband minus Wife		
4	1	6	3	3				
5	2	7	8	-1		Summary measures for Husband-Wife		
6	3	8	5	3			Sample size	35
7	4	6	4	2			Sample mean	1.629
8	5	8	5	3			Sample standard deviation	1.664
9	6	7	6	1				
10	7	8	5	3		Confidence interval for mean		
11	8	6	7	-1			Confidence level	95.0%
12	9	7	8	-1			Sample mean	1.629
13	10	7	5	2			Std error of mean	0.281
14	11	6	3	3			Degrees of freedom	34
15	12	5	4	1			Lower limit	1.057
16	13	8	5	3			Upper limit	2.200
36	33	7	5	2				
37	34	7	4	3				
38	35	10	5	5				

Figure 6 Two-Sample Analysis of Automobile Data

	A	B	C	D	E	F	G	H
1	Sales presentation ratings							
2								
3	Pair	Husband	Wife		*Two-sample analysis for Husband minus Wife*			
4	1	6	3					
5	2	7	8		*Summary stats for two samples*			
6	3	8	5				Husband	Wife
7	4	6	4			Sample sizes	35	35
8	5	8	5			Sample means	6.914	5.286
9	6	7	6			Sample standard deviations	1.222	1.792
10	7	8	5					
11	8	6	7		*Confidence interval for difference between means*			
12	9	7	8			Confidence level	95.0%	
13	10	7	5			Sample mean difference	1.629	
14	11	6	3			Pooled standard deviation	1.533	NA
15	12	5	4			Std error of difference	0.367	0.367
16	13	8	5			Degrees of freedom	68	60
17	14	7	8			Lower limit	0.897	0.895
18	15	7	5			Upper limit	2.360	2.362
19	16	7	6					
20	17	6	5		*Test of equality of variances*			
21	18	5	4			Ratio of sample variances	2.151	
22	19	6	5			p-value	0.014	
23	20	9	10					
37	34	7	4					
38	35	10	5					

In general, the paired-sample procedure is appropriate when the samples are naturally paired in some way and there is a reasonably large positive correlation between the pairs. In this case the paired-sample procedure makes more efficient use of the data and generally results in narrower confidence intervals.

Before leaving this example, we check what would have happened if we had used the two-sample procedure on the Husband and Wife variables. The results appear in Figure 6. Because there is a considerable difference between the sample standard deviations, we should probably use the confidence interval output in column H, not column G, although there is not much difference between the two. The important point is that the resulting confidence interval for the mean difference extends from 0.895 to 2.362, which is somewhat *wider* than the confidence interval from the paired-sample procedure. This is typical. When we use the two-sample procedure in a situation where the paired-sample procedure is more appropriate, we do not use the data as efficiently. The effect is that the standard error of the difference tends to be larger, and the resulting confidence interval tends to be wider.

Why is the paired-sample procedure appropriate here? It is *not* just because husbands and wives naturally come in pairs. It is because they tend to react similarly to one another. You can check that the correlation between the husbands' scores and their wives scores is 0.442. (Use Excel's CORREL function on the Husband and Wife variables.) This is far from perfect correlation, but it is large enough to warrant using the paired-sample procedure.

Figure 4 shows side-by-side boxplots of the husband and wife scores. These boxplots are not as useful here as in the two-sample procedure because we lose sight of which husbands are paired with which wives. A more useful boxplot is of the differences, shown in Figure 5. Here we see that the sample mean difference is positive, but even more importantly, we see that the vast majority of husband scores are greater than the corresponding wife scores. There is little doubt that most husbands ten to react more favorably to the sales presentations than their wives. Perhaps the salespeople need to be somewhat more sensitive to their female customers!
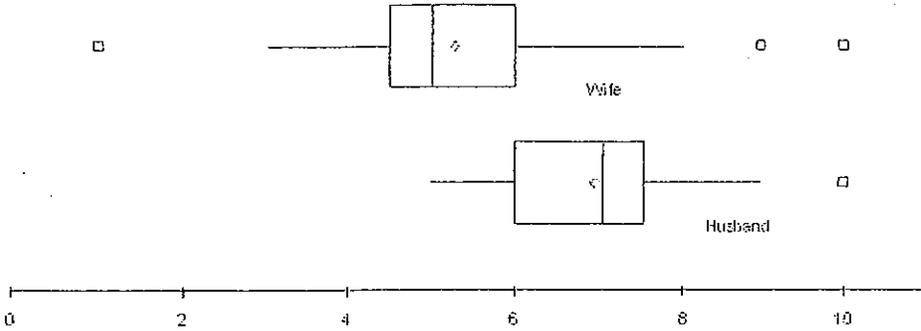
Figure 4 Side-by-side Boxplots for automobile Data

Figure 5 Single Boxslot of Differences for Automobile Data