Blind Analysis for Design of Experiments and Response Surface Methodology Preview

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Thank you,

Bill Kappele

Chapter 2: Blind Analysis

This chapter introduces the idea of Blind Analysis. The next two chapters will develop the techniques for Blind Design Creation and Blind Response Surface Analysis.

What is Blind Analysis?

The most basic idea of blind analysis is to hide the result from the analyst. The answer can be hidden in different ways. However the result is hidden, you don't want the analyst to know what the result is while performing the analysis. This was originally done to prevent the analyst from inadvertently changing the result with his own personal bias. It can also be used to protect proprietary information.

The Difficulty of Bias

Every model will have some bias. Bias is an average difference between what you measure in the lab and what your model predicts. A useful model will have minimal bias.

Bias can come from many sources, among them are:

1. Mathematical artifacts of data analysis.
2. Mistakes
3. Skewing of the data by the people participating in the experiments (participants).
4. Skewing of the data by the people running the experiment (the experimenters).
5. Skewing of the result by the people analyzing the data (the analysts).

Noise and Mathematical Artifacts

Mathematical artifacts come from the nature of data. What makes a piece of datum different from a number is that the datum is uncertain. Eight is always 8, but a measured 8 inches may be 8.1 inches one time and 7.9 inches another time. Data come from measurements. All measurements are uncertain. Everything that comes from data, including predictions, is uncertain because the measurements upon which all calculations from data are based are uncertain.

The uncertainty in measurements is often referred to as noise. Noise tends to be random and symmetrical – it just as often makes a measurement look larger than its average as it makes it look smaller, and it is impossible to predict the direction or the magnitude. If we could repeat a measurement an infinite number of times the average would be the true measurement free of noise. All of the high noise would exactly cancel the low noise.

Unfortunately we cannot repeat a measurement an infinite number of times even if we want to! We can only repeat a measurement a finite number of times. When we do this, it is almost certain that the high noise and the low noise will not exactly cancel each other. This leads to bias – either the average will be a little too high or a little too low. Predictions from models are predictions of averages, so the predictions will tend to be either a little too high or a little too low.

As long as this bias isn't too large it will not prevent our models from being useful.

Mistakes

Good experimenters take every precaution they can to avoid mistakes. Unfortunately, mistakes sometimes happen anyway. When they do, they lead to bias. The Peer Review process is one way to catch these mistakes.

Single Blind, Double Blind, and Triple Blind Studies

In any experiment the participants, the experimenters, and the analysts could introduce bias. This happens when the data are skewed in some way, either intentionally or unintentionally. Three approaches have been developed to address these sources of bias: Single Blind, Double Blind, and Triple Blind studies are the result.

In a Single Blind study, information that could bias the participants is withheld from them. The experimenters and the analysts have all the information. The “Pepsi challenge” is an example of a

Single Blind study. The experimenter pours Pepsi into one cup and Coke into another cup. The participant does not know which cup is which. The participant tastes each drink and states which he prefers.

In a Double Blind study, information that might lead to bias is withheld from both the participants and the experimenters. The "Pepsi challenge" could be modified to a Double Blind study if the experimenter did not know which drink was which. Two bottles labeled "A" and "B" could be provided to the experimenter. He would have no way to know which contained Pepsi and which Coke, so he could not subtly influence the decision of the participant. Another experimenter, who would not be present, would hold the key to which was which.

In a Triple Blind study, information that might lead to bias is withheld from the participants, the experimenters, and the analysts. The analyst would be provided data without knowing the identities of the participants and only knowing if a participant preferred A or B. When his analysis was completed, he would know if either A or B was Statistically Significantly preferred, and if one were preferred whether it was A or B. Once again, another experimenter who did not interact with the others would hold the key to the true identities.

The Triple Blind study is the only study that incorporated Blind Analysis – hiding information that could bias the analysts. Blind Analysis can be performed without blinding the participants and/or the experimenter. This is convenient because not all experiments lend themselves to the full Triple Blind protocol.

Disguising the Data

In order for an analysis to be blind, the data must be disguised in some way. It is not necessary that every aspect of the experiment be disguised – only those features that could lead to bias. For example, in the "Pepsi challenge" it would not be necessary to prevent the analysts from knowing they were analyzing taste test data.

Revealing the Results

When the analysis is complete and the analysts have agreed that all anomalies have been accounted for and they are confident that the analysis is correct, the experimenter holding the key can now reveal the actual results.

Further Analysis of Revealed Data

It is not necessary that analysis should stop once the results are revealed. If the result is clearly wrong it would be foolish to accept it just because it was produced by a blind analysis. For instance, you might run the experiment predicted by your model. If it doesn't predict well, the model isn't useful.

If the analysts are still blind to the results (it is best not to let them know everything until you are satisfied with the result) you could ask them to review the analysis in light of new information – the experiment that did not agree with the prediction. Of course the new information must also be disguised.

In some situations it would make sense to perform a limited additional analysis without blinding. For example, calculating the Statistical Tolerance Limits on results at a Sweet Spot generally need no blinding.

No Guarantees

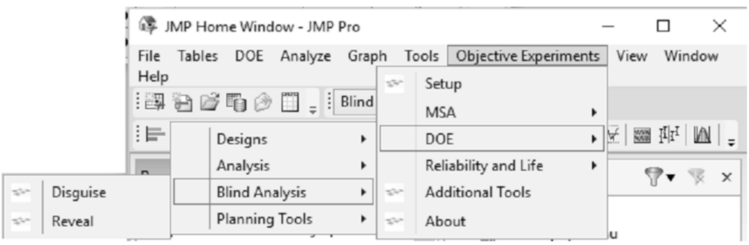
It is important to realize that blind studies do not guarantee that no bias has been introduced. They always rely on the integrity of everyone involved. The purpose of blind studies, and Blind Analysis specifically, is to prevent *accidental* bias.

Chapter 5: Blind Design of Experiments and Response Surface Methodology: Examples using JMP®

This chapter has 3 examples using JMP. These examples should cover most tasks you will encounter.

Sidekick™

A JMP Add-In adds features to your software. Sidekick is a customized Add-In for Objective Experiments' students. Sidekick streamlines the design and analysis process. Blind Analysis is included in Sidekick 12.3.1 and later. Please see Appendix 4 for installation instructions.



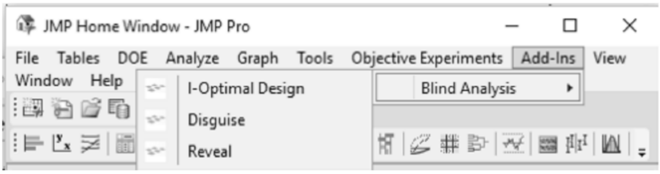
I will use Sidekick in the examples because it simplifies many of the analysis tasks.

You will find a copy of Sidekick in a zipped folder with the examples, available from ObjectiveExperiments.com/BlindAnalysis.

JMP Add-In

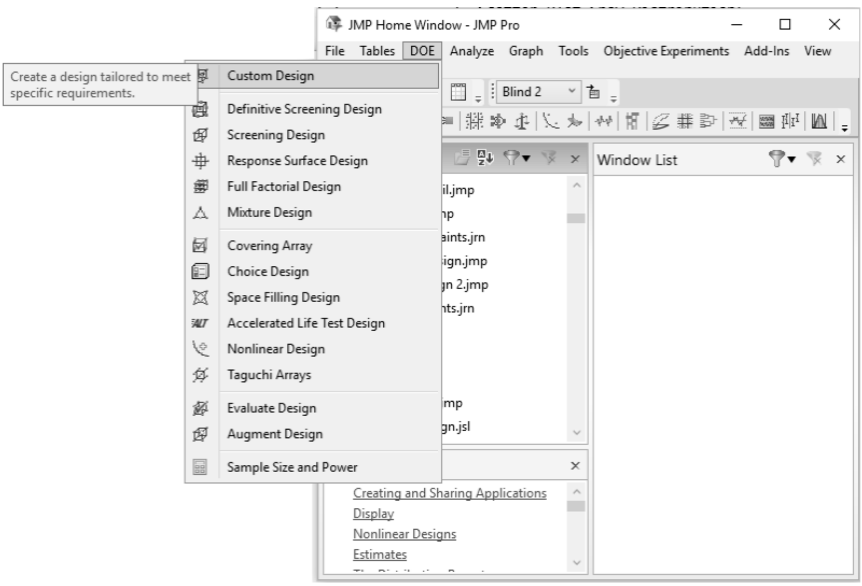
If you prefer to analyze your data without Sidekick, you can get an Add-In to assist you in Blind Analysis for Design of Experiments from ObjectiveExperiments.com/BlindAnalysis or from the JMP User Community.

Once you have downloaded the Add-In, simply double click its icon to install it. After installation you will see Blind Analysis listed under "Add-Ins" on the menu bar:

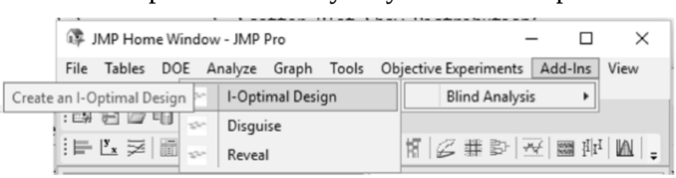


Creating the Design

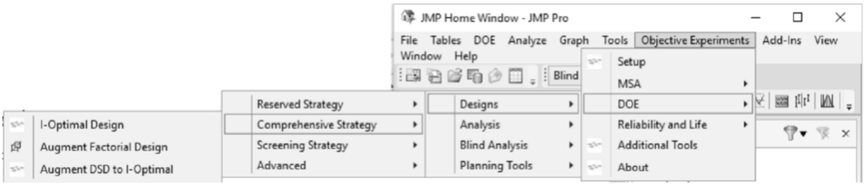
JMP provides a custom design generator. You can use this to create your experiment designs.



The Add-In provides an easy way to create I-Optimal Designs:

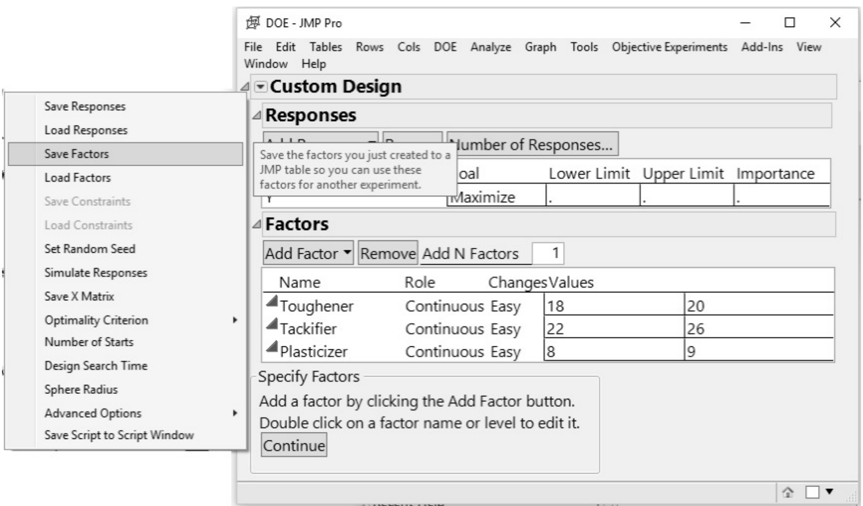


Sidekick provides a variety of design options organized by Strategy (Appendix 3 has a list of common strategies):

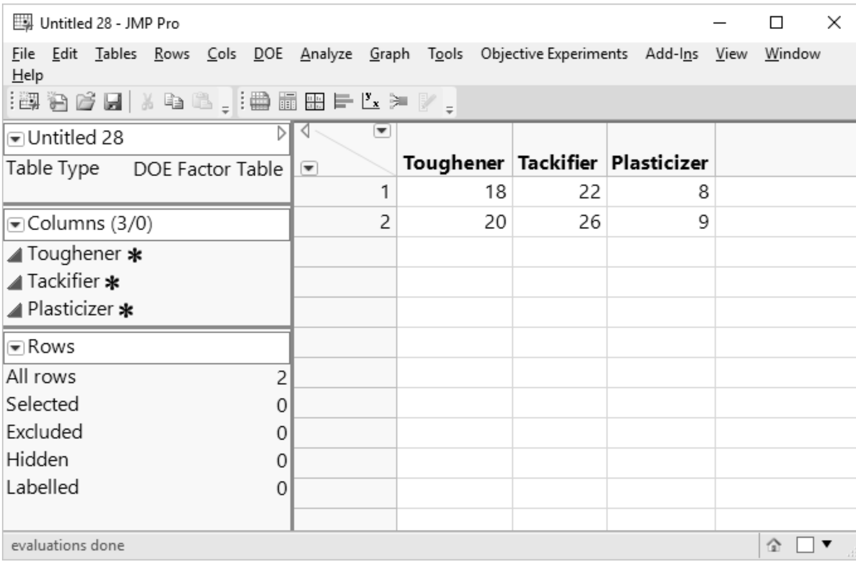


I-Optimal Designs are found under the Comprehensive Strategy.

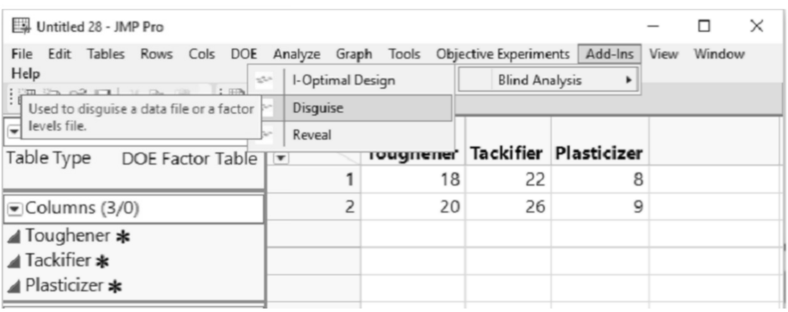
However you choose to create your design, JMP has a simple way to send the design criteria to your analyst. First, enter your factors and levels without disguising anything:

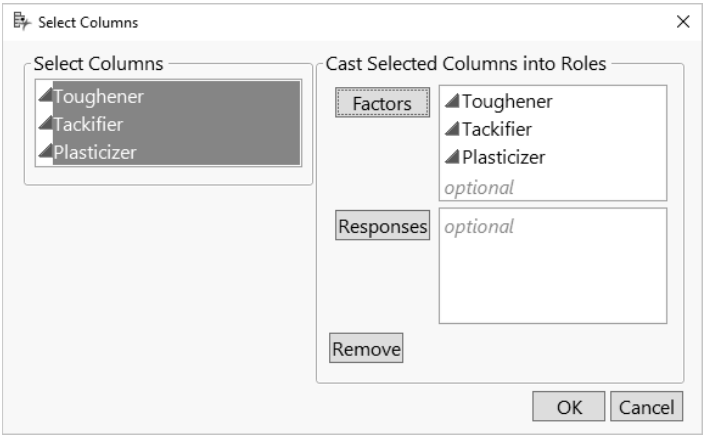


Use the menu revealed by clicking the red triangle by "Custom Design" to select "Save Factors."

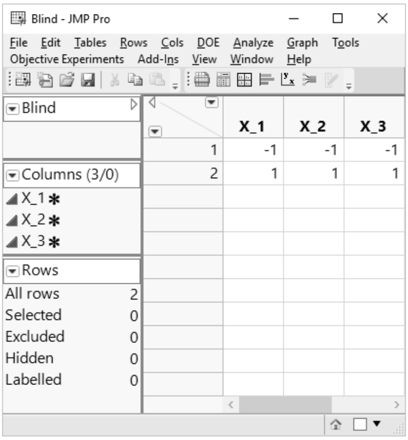


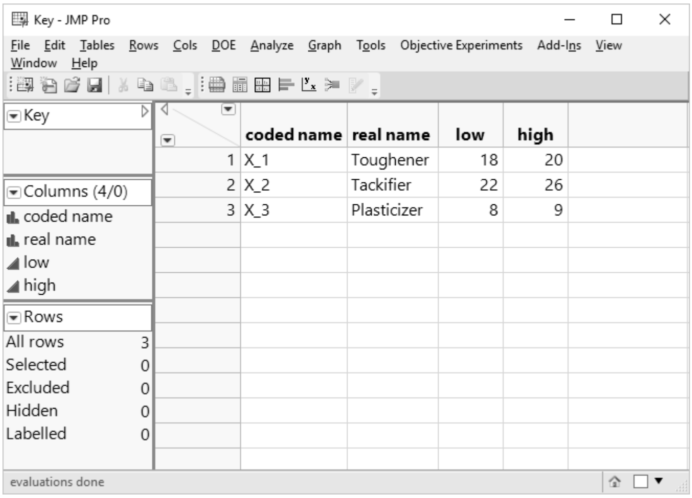
Now disguise this worksheet:





You will get both a file to send to your designer and a design key to reveal the design:

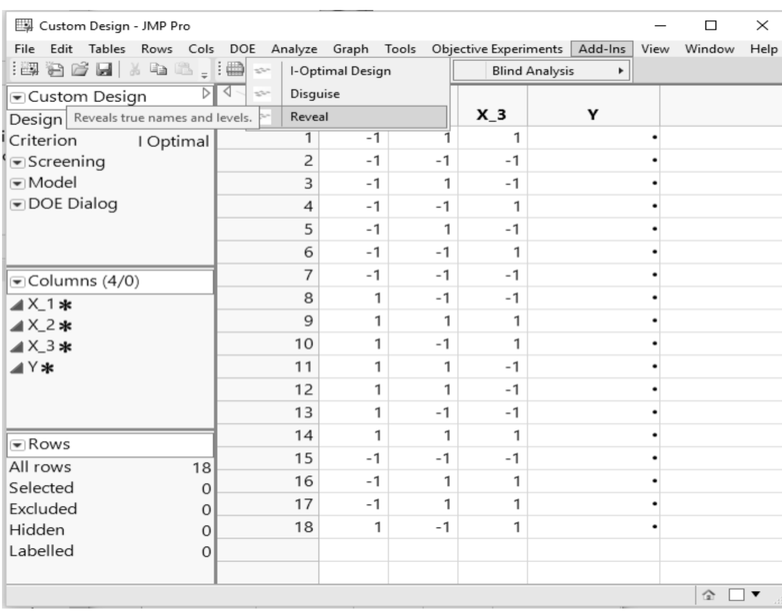


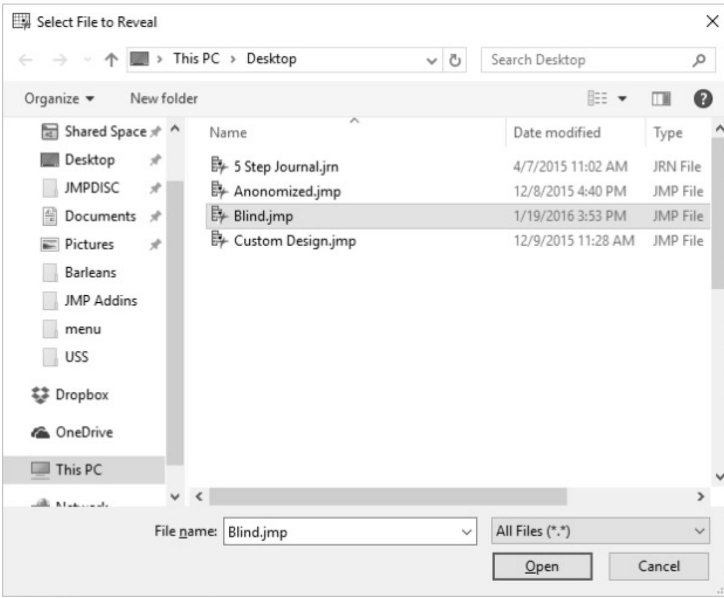


Be sure to keep the design key secret and save it in a safe place.

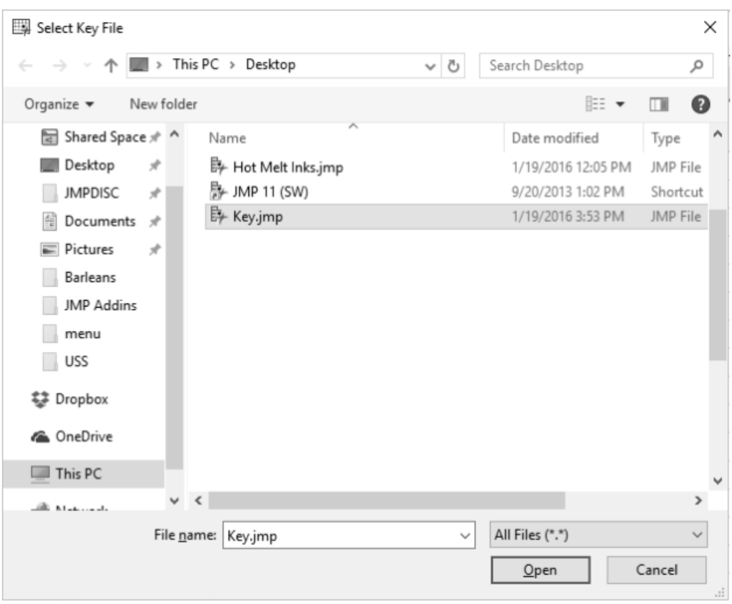
Revealing the Design

Once you receive the design from your analyst you can use the design key to reveal it:

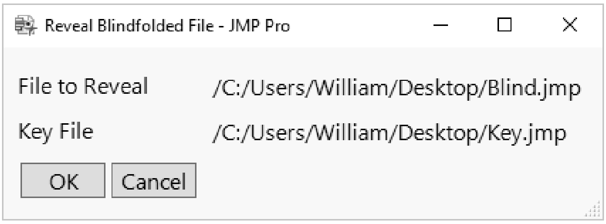




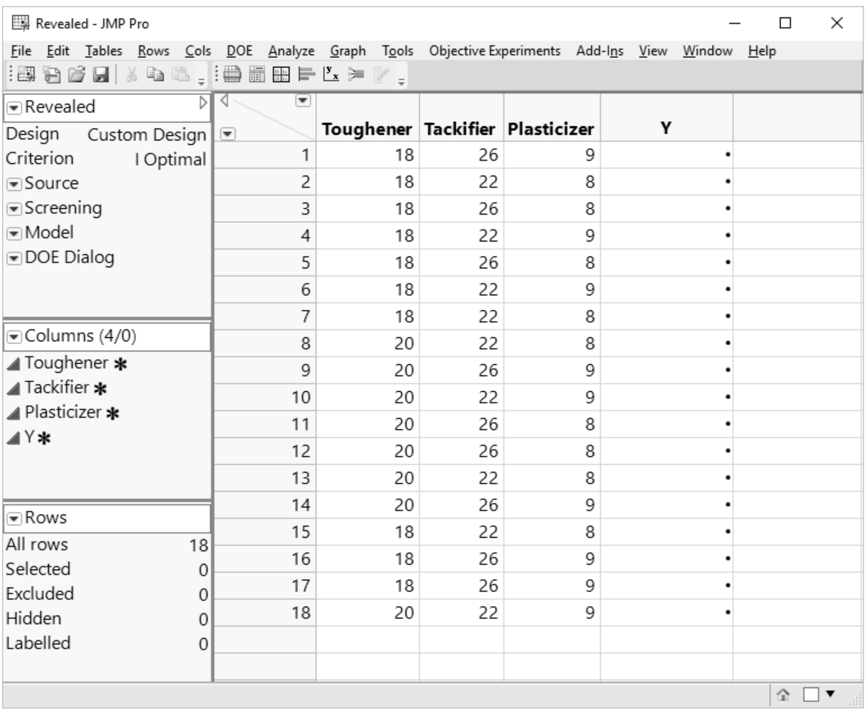
First select the design to reveal.



Next select the design key.



Confirm your choices by clicking OK.

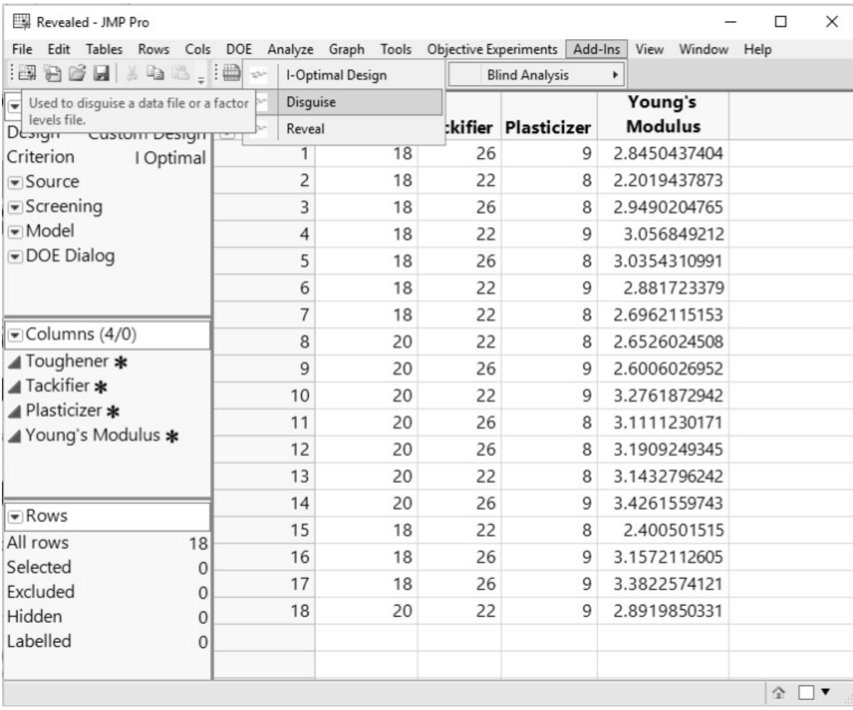


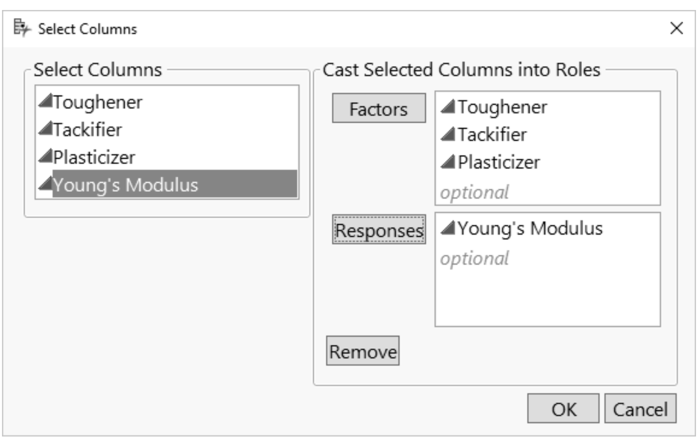
	Toughener	Tackifier	Plasticizer	Y
1	18	26	9	•
2	18	22	8	•
3	18	26	8	•
4	18	22	9	•
5	18	26	8	•
6	18	22	9	•
7	18	22	8	•
8	20	22	8	•
9	20	26	9	•
10	20	22	9	•
11	20	26	8	•
12	20	26	8	•
13	20	22	8	•
14	20	26	9	•
15	18	22	8	•
16	18	26	9	•
17	18	26	9	•
18	20	22	9	•

Now you are ready to collect your data.

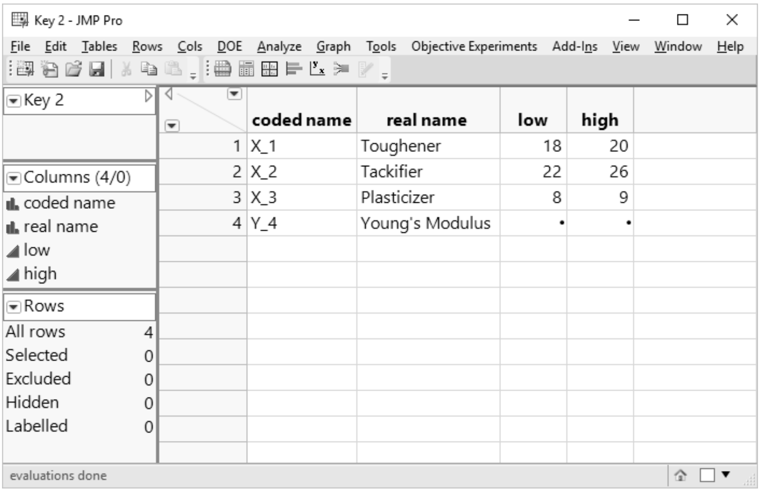
Disguising the Design

Once data have been collected you will need to disguise your design. Simply use the “Disguise” command as before:


Revealed - JMP Pro
File Edit Tables Rows Cols DOE Analyze Graph Tools Objective Experiments Add-Ins View Window Help
I-Optimal Design
Blind Analysis
Disguise
Reveal
Used to disguise a data file or a factor levels file.
Criterion I Optimal
Source
Screening
Model
DOE Dialog
Columns (4/0)
Toughener
Tackifier
Plasticizer
Young's Modulus
Rows
All rows 18
Selected 0
Excluded 0
Hidden 0
Labelled 0
ckifier Plasticizer Young's Modulus
1 18 26 9 2.8450437404
2 18 22 8 2.2019437873
3 18 26 8 2.9490204765
4 18 22 9 3.056849212
5 18 26 8 3.0354310991
6 18 22 9 2.881723379
7 18 22 8 2.6962115153
8 20 22 8 2.6526024508
9 20 26 9 2.6006026952
10 20 22 9 3.2761872942
11 20 26 8 3.1111230171
12 20 26 8 3.1909249345
13 20 22 8 3.1432796242
14 20 26 9 3.4261559743
15 18 22 8 2.400501515
16 18 26 9 3.1572112605
17 18 26 9 3.3822574121
18 20 22 9 2.8919850331


Select Columns
Select Columns
Toughener
Tackifier
Plasticizer
Young's Modulus
Cast Selected Columns into Roles
Factors
Toughener
Tackifier
Plasticizer
optional
Responses
Young's Modulus
optional
Remove
OK
Cancel

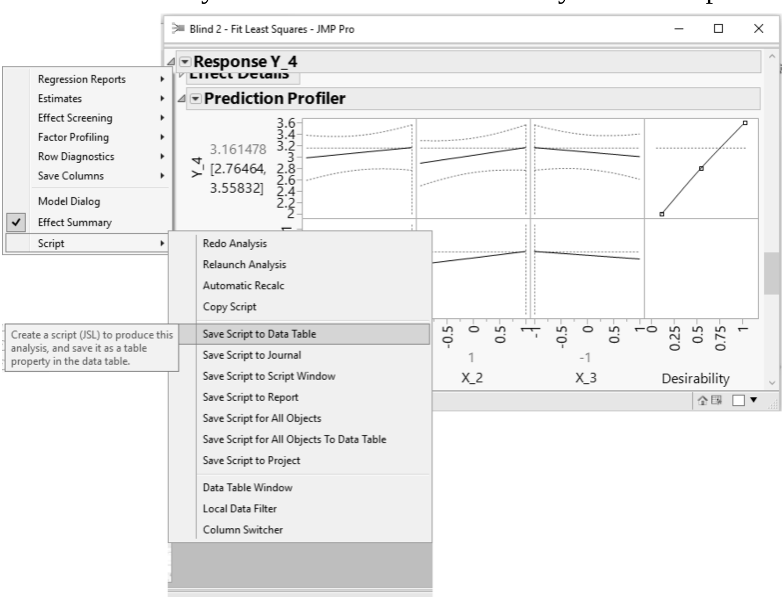
IMPORTANT: ***Don't confuse the design key with the analysis key. Be sure to keep this analysis key secret and safe.***



	coded name	real name	low	high
1	X_1	Toughener	18	20
2	X_2	Tackifier	22	26
3	X_3	Plasticizer	8	9
4	Y_4	Young's Modulus	•	•

Analyzing the Design

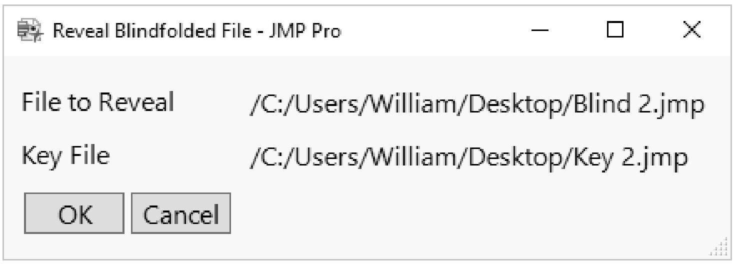
The analyst needs to save his final analysis as a script:



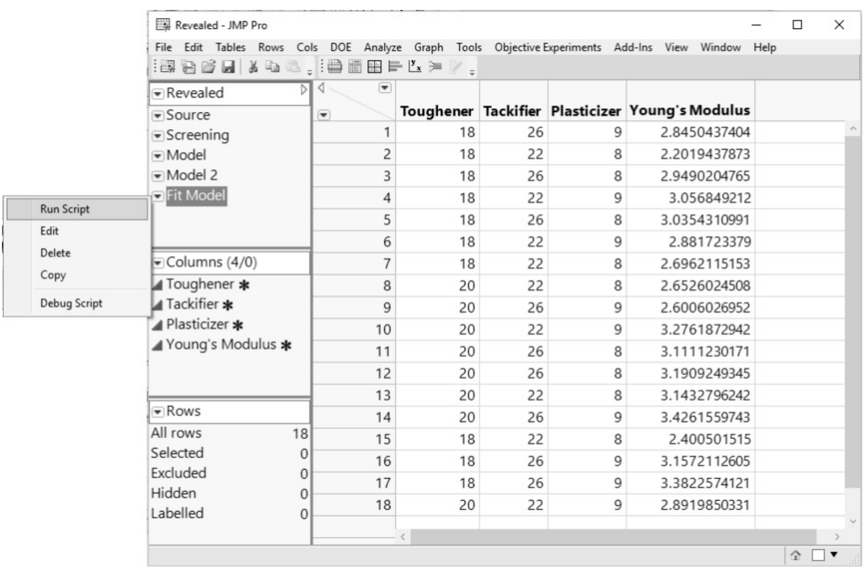
The analyst will save the data table and send it on to you.

Revealing the Results

When you receive the file from your analyst, you can reveal it.

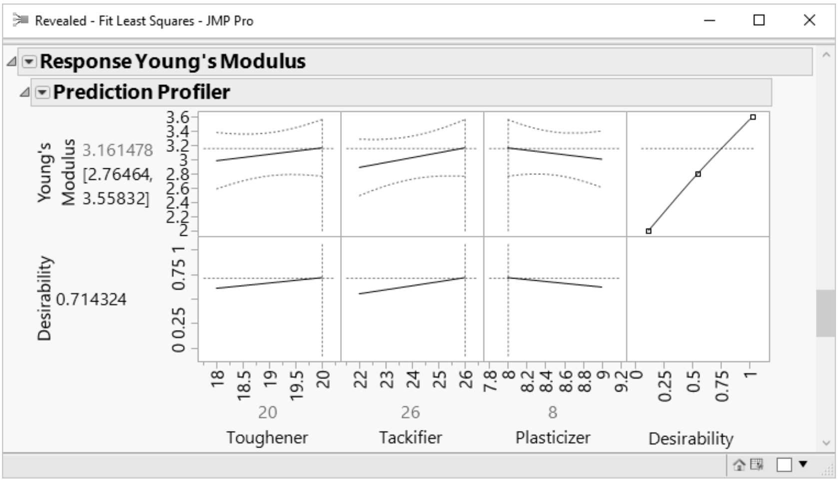


Be sure to confirm that you are using the analysis key for this file.



	Toughener	Tackifier	Plasticizer	Young's Modulus
1	18	26	9	2.8450437404
2	18	22	8	2.2019437873
3	18	26	8	2.9490204765
4	18	22	9	3.056849212
5	18	26	8	3.0354310991
6	18	22	9	2.881723379
7	18	22	8	2.6962115153
8	20	22	8	2.6526024508
9	20	26	9	2.6006026952
10	20	22	9	3.2761872942
11	20	26	8	3.1111230171
12	20	26	8	3.1909249345
13	20	22	8	3.1432796242
14	20	26	9	3.4261559743
15	18	22	8	2.400501515
16	18	26	9	3.1572112605
17	18	26	9	3.3822574121
18	20	22	9	2.8919850331

Run the “Fit Model” script to see your revealed results.



Example 1: Continuous Factors

ACME has decided to improve the reliability of their printheads. The printer jets ink by applying power to a small heating element under the liquid ink. A thin layer of tantalum protects this heating element from the ink. ACME scientists believe that superior performance can be achieved if the resistivity of the tantalum layer can be increased. Your boss tells you that the company wants a tantalum thin film with the same thickness as the current printhead, about 850 nm, but with a Resistivity of 0.25 to 22 micro-ohm-centimeters.

After speaking with Acme's scientists, you learn that the tantalum is sputter coated in a Hot Shot 2000 sputter deposition instrument. You determine that the following factors are important within the specified limits:

Factor	**Factor Limits**
Sputtering time	1 to 10 seconds
Sputtering Power	1 to 5 kWatts
Pre-sputter etch time	1 to 10 seconds
Preheat time at 250 °C	15 to 30 seconds
Sputtering temperature	250 to 500 ºC

End of Preview

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Bill Kappele.