stat teaser

ABOUT STAT-EASE SOFTWARE, TRAINING, AND CONSULTING FOR DOE
Phone 612.378.9449 Toll-Free 800.801.7191 E-mail info@statease.com Website www.statease.com

Workshop Schedule

Experiment Design Made Easy
May 16-18: Seattle, WA - **New Site!**
June 20-22: Minneapolis, MN
August 1-3: Detroit, MI
Study the practical aspects of Design of Experiments (DOE). Learn about simple but powerful two-level factorial designs.

Response Surface Methods for Process Optimization
June 6-8: Minneapolis, MN
November 7-9: Atlanta, GA
Find the optimum settings for your process. Generate 3D maps to identify the peak area and overlay plots to find your sweet spot.

Mixture Design for Optimal Formulations
April 4-6: Minneapolis, MN
June 6-8: Cambridge, UK
July 11-13: Minneapolis, MN
Standard factorial designs don't work well for formulations. Learn all the skills you need for mixture design in this course.

Robust Design: DOE Tools for Reducing Variation
April 25-27: Minneapolis, MN
Use DOE to create products and processes that are robust to varying conditions. Factorial and RSM proficiency are required.

Real-Life DOE
August 22-23: Minneapolis, MN
Not your normal textbook data - analyze real data sets and learn how to deal with messy problems! Working knowledge of factorial designs is required.

Attendance limited to 20. Reserve your place by calling Sherry, ext. 18, at **(800) 801-7191.**

Stat-Ease
statistics made easy™

Blocking is Better

NO KIDDING AROUND

The following is excerpted from "DOE Simplified: Practical Tools for Effective Experimentation" by Mark J. Anderson and Patrick J. Whitcomb. Copyright ©2000 Productivity, Inc., PO Box 13390, Portland, OR 97213. 800-394-6868. www.productivityinc.com. The book retails for $39.95 and is available from Stat-Ease, or through the publisher.

Known sources of variation caused by changes in personnel, materials, or machinery can be a real nuisance. Fortunately for us, statisticians such as Fisher developed techniques to "block" out these nuisance variables. Blocking is an especially effective tool for experiments that involve people. Each person will behave differently, but in many cases a consistent pattern will emerge.

A group of preschool children were asked to pick out and stack three dice with 1, 2, 3, 4, 5, or 6 dots. Because young children develop at such differing rates, the time needed to accomplish this task varied widely. However, by repeating the entire exercise for each child, the differences between children were blocked out. The final results were somewhat surprising.

The table below shows the data for four children. You can assume that each result is actually an average from several trials, because individual times would normally vary more than those shown. Each child has two columns of numbers shown. The first column contains the original times recorded and the second column shows the times adjusted for blocking (this process will be described soon!) The last row shows how each

(Continued on page 2)

Child (block)	K1		K2		K3		K4		Within-Dot Mean	Within-Dot Variance	
1 dot	7.2	25.7	13.2	19.9	39.9	14.3	22.2	22.7	20.6	203.3	23.6
2 dots	10.0	28.5	21.6	28.3	45.3	19.7	24.1	24.6	25.3	216.8	17.0
3 dots	25.6	44.1	36.2	42.9	79.7	54.0	44.6	45.1	46.5	548.3	25.7
4 dots	15.2	33.7	30.0	36.7	54.5	28.8	32.9	33.4	33.1	262.5	10.5
5 dots	33.0	51.5	48.1	54.8	90.8	65.2	52.7	53.2	56.1	604.7	38.0
6 dots	19.5	38.0	32.0	38.7	65.0	39.4	42.0	42.5	39.6	370.9	3.9
Mean	18.4	36.9	30.2	36.9	62.5	36.9	36.4	36.9	36.9	367.8	23.7
Diff	-18.47	0	-6.7	0	25.64	0	-0.46	0	0.0		

Time (in seconds) needed for stacking three dice with the same number of dots (original data and data corrected for blocks).

Blocking, continued...

child differs from the overall average of 36.9 seconds. For example, the K1 child completed the tasks 18.47 seconds faster on average than the group as a whole. These differences are substantial relative to the differences due to the various dot patterns. For example, child K3 evidently required some coaxing to do the task at hand, because his/her times far exceed those of the other individuals.

The F-test with no correction for blocks is shown below:

$$F = \frac{n s^2_{\bar{y}}}{S^2_{pooled}} = \frac{4*Var(20.6, 25.3, 46.5, 33.1, 56.1, 39.6)}{367.8}$$

$$= \frac{4*176.9}{367.8} = 1.92$$

This F-value is based on 5 df for the between means comparison (numerator) and 18 df for the within means comparison. The critical F for 5% risk is 2.77, so the actual F-value of 1.92 fails to reject the null hypothesis at the 95% confidence level. In other words, the results are not significant. In figure 1 you can see a pattern, but it's obscured statistically by the variability between children. How can we properly recognize the pattern statistically?

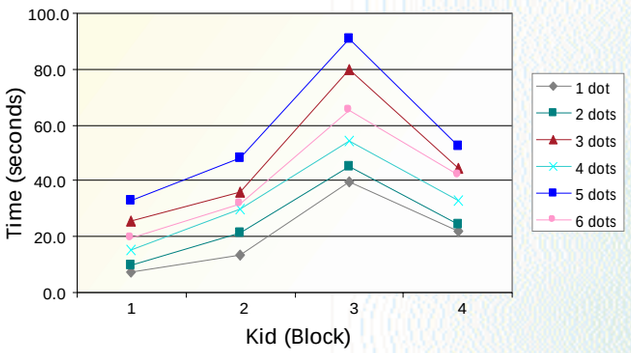

Figure 1 - Scatter plot of times to stack dice

The answer is to remove the variability between children by subtracting the difference shown on the last line of the table from the raw data in the associated columns. This is how you can block out a known source of variation. The results are given in the second column for each child. The means for each dot pattern (1 through 6) remain the same, but notice the huge reduction in within-dot variance after removal of the blocks. It drops more than 10-fold from 367.8 down to 23.7. Obviously this will have a very beneficial impact on the F-ratio. The calculation is:

$$F = \frac{4*176.9}{23.7} = 29.8$$

Notice that the numerator remains unchanged from the unblocked case, because the treatment means are unaffected. The degrees of freedom for the numerator also remain the same as before at 5 df. However, the degrees of freedom for the denominator of F must be reduced because we took the block means into account. Specifically, the calculation of the 4 block means causes a loss of 3 df (n-1 with n = 4) for calculating error, so only 15 df remain. This loss of information for estimating error must be accounted for when looking up the critical value for F. On the 5% table, you will find a value of 2.9 under column 5 and row 15. The actual F value of 29.8 far exceeds this critical F, so the outcome is statistically significant. In this case, blocking proved to be the key to success.

The effects plot (figure 2) shows the times as a function of the number of dots. It does not show the blocks, but they are accounted for when calculating the LSD bars. Aided by this tool of statistics, you can see the unexpected outcome - the children found it most difficult to pick out the 5-spot dice. They were very quick to identify the 1-spot dice, significantly so in relation to all but the 2-spot dice. The 3-spot seemed to cause more trouble than the 4-spot dice.

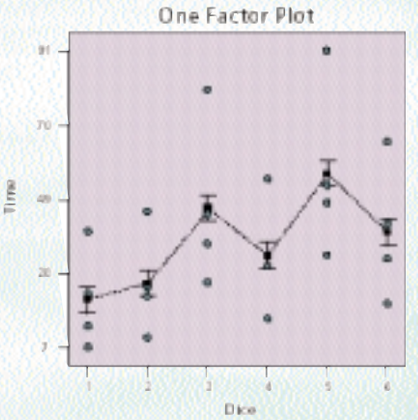

Figure 2 - Effects plot of times to stack dice (corrected for blocks)

Many more children would need to be tested to confirm these findings. The point of this exercise is simply to show the advantage of blocking out known sources of variation. Blocking can be applied to any kind of DOE, not just simple comparisons such as those illustrated in this chapter. It often reveals results that would otherwise be obscured.

- Mark@StatEase.com

Where can you find us?

March 21-23 - American Physical Society, Minneapolis, MN, Booth #239

March 27- ASQ Minnesota Quality Congress, Minneapolis, MN, Booth #15

*Talk - Multi-Level Factorial Designs Offer DOE Flexibility, 1:30-2:30 pm - Shari Kraber, PE, CQE

*Talk - Combining Mixture Components & Process Factors in a Single Design, 1:30-4:00 pm - Pat Whitcomb, PE, CQE

May 8-10 - ASQ 2000, Indianapolis, IN, Booth #701

W A N T E D

Statistical Contract Consultant to represent Stat-Ease in the California area.

We are looking for someone well-versed in DOE who is willing to train and travel. If interested contact Pat at pat@statease.com or 800.801.7191.

Go for the Gold at the 2000 DOE Conference

Join Stat-Ease at its second annual DOE (Design of Experiments) Conference in Minneapolis, Minnesota July 27-28. During this two-day conference you'll discover new experimental design techniques, learn about real-world applications and hear presentations given by experts in the field of DOE.

This year we are offering more sessions in an effort to meet the needs of both beginning and advanced DOE users. Day one, Thursday, will be split into two tracks. Track A topics will be targeted toward the DOE novice. Track B topics will target those of you already familiar with experimentation who want to learn more in-depth skills. On Friday, there will be case studies presented by experimenters like you. **(New for 2000!)**

Get free advice from Stat-Ease consultants and programmers and give us your suggestions for future versions of Design-Ease® and Design-Expert® software. You'll also have plenty of time for networking and sharing DOE ideas with others. Come prepared to learn how to improve your organization's products and processes!

Keynote Dinner Presentation by
Dr. Douglas Montgomery
Thursday, July 27, 6-8 pm

Our Keynote Speaker...

We had the pleasure of hosting Dr. Douglas Montgomery as our keynote speaker at last year's DOE conference. His talk was very well received. We are delighted to have him back again this year.

Dr. Montgomery is Professor of Industrial and Management Systems Engineering at Arizona State University. He holds BSIE, MS and Ph.D. degrees from Virginia Polytechnic Institute.

He is the author of twelve books, including *Response Surface Methodology*, 1995 and *Design and Analysis of Experiments*, 5th edition 2000.

We welcome Dr. Montgomery back to Minneapolis!

Stat-Ease Conference Schedule (Tentative)

Wednesday, July 26

5:00 - 7:00 pm Optional Registration

Conference Location:

Holiday Inn METRODOME

Minneapolis, MN

A block of rooms have been reserved at the discounted Stat-Ease rate of $94 per night (plus tax). To reserve a room, call the hotel toll-free at 800-448-3663 or direct at 612-333-4646. Be sure to mention the Stat-Ease conference when registering and ask for the discount. You must make your reservation by July 7 in order to get this special rate.

Please Note:
Parking is not included in the conference fees. Parking is available in the attached municipal lot.

Thursday, July 27

7:00 - 8:00	Registration and Continental Breakfast
8:00 - 9:30	A: DOE Introduction B: Design Augmentation
9:30 - 10:00	Break
10:00 - 11:30	A: Two-Level Factorials B: Algorithmic Point Selection
11:30 - 1:00	Lunch
1:00 - 2:30	A: RSM/Mixture Designs B: Power Information
2:30 - 3:00	Break
3:00 - 4:30	A: Keys to DOE Success B: "What If" Optimization
4:30 - 6:00	Break
6:00 - 8:00	Dinner with Keynote Presentation by Dr. Douglas Montgomery

Friday, July 28

7:00 - 8:00	Continental Breakfast
8:00 - 9:30	Real-World Presentations
9:30 - 10:00	Break
10:00 - 11:30	Outliers and Aliases
11:30 - 1:00	Lunch
1:00 - 2:30	Real-World Presentations
2:30 - 3:00	Questions, help, etc..

Enjoy the summer weekend in the land of 10,000 lakes!

Stat-Ease statistics made easy™

Stat-Ease DOE Conference Registration Form

3/00

If different from the label below, please print or type your address information.

Name _____ Title _____

Company _____

Mailing Address _____

City _____ State _____ Zip _____

Telephone _____ E-mail _____

DOE Conference Registration Fee

Early Bird Registration (by June 30) $395, Regular Registration (July 1-28) $445, Academic Discount - 50%, (Registration Fee includes the two-day conference, two continental breakfasts, two lunches, dinner Thursday evening, and a time-limited copy of Design-Expert 6.0.)

Which Track (Thursday only) are you more likely to attend?

☐ Track A (Novice) ☐ Track B (Expert)

Keynote Dinner and Presentation

☐ Please confirm that you will be attending the dinner Thursday evening by checking this box. Thank you in advance!

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