Lawn Toss: Producing Data On-the-Fly

Eric Nordmoe
Kalamazoo College, Michigan, USA.
e-mail: enordmoe@kzoo.edu

◆INTRODUCTION ◆

SPRING has sprung! My introductory statistics students petition for a change-of-venue for today's class. "Can we hold class outside today?" They want to move today's lesson outside where the weather has turned warm, the sun is shining and the flowers have begun to blossom. I gaze out the windows of my stuffy classroom to see several clusters of students in the quadrangle below, seated in the grass under shade trees, surrounding their respective professors. "Probably philosophy or literature classes," I mutter to myself as I rue the day I chose a discipline which keeps me chained inside the classroom on such a beautiful day. I pledge to rack my brain that evening so that the next time I'm faced with such a situation, I'll have a productive outdoor activity prepared to implement.

◆THE ACTIVITY: LAWN TOSS ◆

Growing up in the midwestern United States, I recall playing a backyard game named "Lawn Darts" with rules quite similar to those in the game of horseshoes. Players attempt to throw two large darts, each about a foot in length, so that they land inside (or at least near) a plastic ring about 20 inches in diameter placed on the ground about 20 feet away.

These very unsafe metal darts have since been replaced by much safer versions with weighted blunt plastic heads. The low level of skill required and the quantitative nature of measurements of distance from the "dart" to the centre of the circle suggested that this game might serve as an excellent device for data collection especially on a warm spring day after a difficult midterm exam! If this particular game cannot be found, any similar game will be likely to satisfy the objectives, for example horseshoes, flying disc golf, etc. Of course, reasonable safety precautions should be taken.

◆THE DESIGN ◆

I describe here one design for the data collection and suggest some possible applications. Many modifications of the suggested design may be made at the discretion of the instructor in light of the specific curricular objectives to be satisfied.

The dependent variable to be measured is *distance* from the dart to the centre of the circle. The instructor may wish to specify the accuracy required or allow students to determine for themselves how accurately the measurements may reasonably be made.

The factors and levels in the design are:

1. *Distance to the target:* (1) short (15 feet) and (2) long (30 feet).
2. *Hand used for throwing:* (1) dominant or (2) non-dominant.

If a student throws 10 times at each factor-level combination, he or she will have measurements on a total of 40 tosses. Depending on the class size, this may be too time-consuming and the number of repetitions will necessarily be fewer. Alternatively, students could complete the data collection outside class time if the appropriate equipment is available. A completed sample data collection table using 10 replications appears in figure 1. The table entries are the distances, in centimetres, from the dart to the centre of the ring.

Equipment needs for the data collection exercise are modest: darts (or reasonable facsimiles), targets (e.g. rings), tape measures, and recording forms.

Distance	Short (15 ft)		Long (30 ft)	
Hand	Dominant (cm)	Non-dominant (cm)	Dominant (cm)	Non-dominant (cm)
Throw 1	41	73	48	50
Throw 2	58	124	34	39
Throw 3	50	101	23	111
Throw 4	73	60	23	13
Throw 5	58	83	44	137
Throw 6	42	68	48	28
Throw 7	7	17	82	69
Throw 8	60	15	37	32
Throw 9	54	15	22	45
Throw 10	6	49	34	47

Fig 1. Sample data collection form

◆A SAMPLE ANALYSIS ◆

While many analyses could be performed with these data, one simple analysis suitable for introductory statistics students would involve using the measurements for one distance level (short or long) and investigating the presence or absence of a "dominant hand" effect. Students would conduct a significance test to answer the research question:

"Are dominant hand throws more accurate than non-dominant hand throws?"

To answer this question (illustrating for the short throws), first compute the differences between the distances for each of the 10 pairs of dominant and non-dominant hand throws:

Difference = Non-dominant hand distance -Dominant hand distance

The boxplot and dotplot of these differences in figure 2 suggest the possibility of a dominant hand effect. The data appear to be concentrated along the positive portions of the axes of both plots.

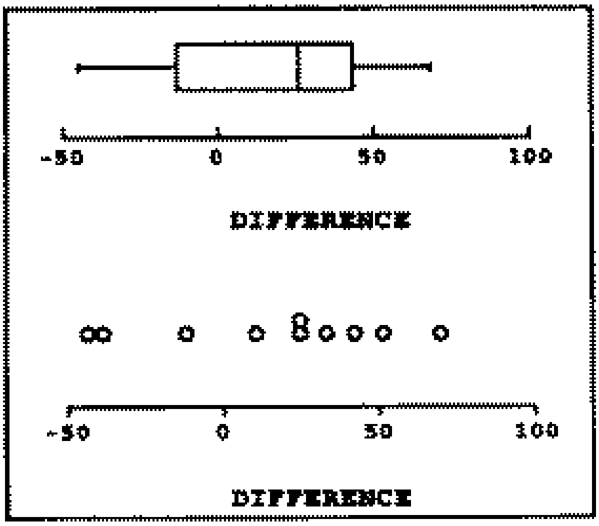

Fig 2 Summary Plots of Differences

We formally test for a dominant hand effect by conducting a standard paired *t* -test. Our null hypothesis is "the average difference is zero," i.e. that there is no dominant hand effect. The mean and median of the differences are 15.6 cm and 25.5 cm respectively and the standard deviation is 37.3 cm. Computation of the paired *t* statistic yields $t = 1.323$ with 9 degrees of freedom. The corresponding one-sided p - value of 0.109 constitutes little or no evidence against the null hypothesis. That is, for the figure 1 data, we have little or no evidence of a dominant hand effect.

Depending on the scope of your course, you may wish to explore whether the assumptions of the paired *t* - test are satisfied. If your students are familiar with the Normal probability plot, you could ask them to display the plot for their data and see whether is any reason to doubt the Normal assumption.

◆DISCUSSION◆

The analysis above suggests a very simple use of these data. Other analyses which may fall within your syllabus:
1. Sensitivity of analysis to outliers: Because of the nature of the data collection exercise, (potentially extreme!) outliers may occur. These offer splendid opportunities for the consideration of the impact of outliers on the analysis. More importantly, the exercise affords the opportunity to discuss the appropriate treatment of outliers in an experiment *where the student knows exactly how the outlier arose.*
2. 2-sample t-test: Compare the 2 independent samples of differences obtained for the short and long distances to see whether the dominant hand effect is consistent for short and long distances. Such an analysis could also include discussion of whether the samples are indeed independent.
3. Experimental design: If your syllabus includes consideration of designed experiments, you may wish to ask your students to think of each pair of throws as a block. All the data could then be analysed together using methods for handling a randomised blocks design. Alternatively, the experiment could be modified to illustrate a *completely randomised design;* portions of the class could be randomly allocated to distinct experimental treatment groups.
4. Non-parametric methods: If your course includes non-parametric methods, your students might appropriately analyse these data using, for example, the sign test or the Wilcoxon signed-rank test. These would be especially appropriate if their checks for Normality showed t-tests to be questionable.

In sum, my students found collecting lawn toss data to be both interesting and enjoyable. Along with friendly competition to be close to the target came also a greater than usual interest in the results. At the outset, most students found the idea of a dominant hand effect to be plausible and likely. The analysis then proceeded just as we always hope it will - with students anxiously looking to see if their original hypothesis is confirmed or refuted by the data.

Happy tossing! One final suggestion: data collection tends to be much more successful if carried out in the Spring or Fall rather than in the dead of Winter. Of course, snowballs could be substituted for lawn darts, but then new dangers would arise!