Bringing Unit 2 Together

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I'm going to present examples of solutions to the "Bringing Unit 2 Together" Design Activity in this document. I must stress that these examples are *just three of the many possible* designs you could generate for these contexts/SRQs. Many more exist. I'll attempt to provide both a bullet list of elements as well as a more narrative format.

Quick Bread Comparison

A quick bread is a bread leavened with a chemical leavener (e.g., baking soda or baking powder) rather than yeast. Example of quick breads would include banana bread, chocolate tea bread, and pumpkin bread. We want to understand the impact of baking temperature (low, medium, high, very high) has on the volume of quick bread prepared from a package mix. I have provided you with enough money to purchase 20 packages of mix plus any additional ingredients (i.e., oil, eggs, etc.).

SRQ

How does the baking temperature (low, medium, high, very high) impact the volume of the loaf?

Study Design (List Format)

- **Measurement Unit**: loaf of bread (20 loaves)
- **Response**: volume (cubic centimeters)
- **Factor**: temperature (4 levels, fixed effect)
- **Treatments**: 300^{o}F (low), 350^{o}F (medium), 375^{o}F (high), 400^{o}F (very high)
- **Treatment Selection Method**: Not applicable as I'm using fixed effect.
- **Experimental Unit**: a batch of five loaves
- **Treatment Assignment Method**: Batches will be done in order. Remove 4 cards of the same suit (Ace—4) from a deck. Shuffle the cards, deal cards face up, in a row. The left-most card will be the low temperature setting; the right-most the very high setting. The values of the card reflect the ordering of temperatures/which batch gets which temperature.
- **Hasse Diagram:** See Figure 1

Study Design (Narrative Format)

To study the impact of baking temperature on the volume of quick bread loaves, I will conduct a simple experiment. To minimize confounding, we will use the same brand and flavor of mix for the quick bread (Betty Crocker Wild Blueberry). We will buy 20 boxes from the same grocery store (selected via lottery); we will pre-arrange with the store for the order. We will also use five identical loaf pans and set up five identical mixing stations.

Using the first four cards (Ace—4) of the same suit from a deck of cards, we will shuffle and then deal the cards in a line from left to right. The left-most position will be the low baking temperature (300^{o}F); the right-most will be the very high temperature (400^{o}F). The face value of the cards will denote which batch and the baking order. We will start with a completely cool oven (room temperature, 68-70^{o}F) for each batch.

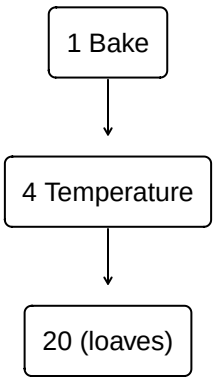

Figure 1: Hasse Diagram for Quick Bread Comparison Study

For each batch and while the oven is heating, five people will each make the batter from one box of mix (selected by draw from a box containing all 20 packages to start), following the directions on the package. A probe thermometer will be inserted into each loaf and the loaves placed into the oven. Loaves will be removed from the oven when they have reached an internal temperature of 190°F.

Once the loaves are completely cooled, we will place each loaf into a calibrated volumeter to record the loaf's volume (cc).

This design results in the Hasse diagram shown in Figure 1. From the layout, we have a one-way ANOVA/completely random design.

Hay Fever Relief

Hay fever is a common name given to a set of symptoms brought on by a minor/mild allergic reaction to pollen and dust, triggering watery eyes and a runny nose. A research laboratory has developed a new compound to provide relief for severe cases of hay fever. The amounts of two active ingredients in the compound are varied at three levels each using the same number of volunteers. The researchers recorded the number of hours each volunteer had relief from hay fever symptoms.

SRQ

How do the amounts of two active ingredients impact the number of hours relief hay fever sufferers experience?

Study Design (List Format)

- **Measurement Unit**: hay fever sufferer (selected via stratified lottery on self-reported gender)
- **Response**: hours of hay fever symptom relief
- **Factor**: amount of active ingredient A (three levels, fixed), active ingredient B (three levels, fixed)
- **Treatments**: A1 × B1, A1 × B2, A1 × B3, A2 × B1, A2 × B2, A2 × B3, A3 × B1, A3 × B2, A3 × B3
- **Treatment Selection Method**: I will reach out to the scientists in the lab for what amounts of the two active ingredients they want to use
- **Block**: self-reported gender; 2 levels (Woman, Not Woman; Preview of things to come)
- **Covariate**: self-report of time spent outside during study period (hours; Preview of things to come)
- **Experimental Unit**: person

- **Treatment Assignment Method**: Each participant will be issued a study ID; IDs starting with 1 belong to the Woman gender group, while those starting with 2 belong to the Not Woman gender group. We will form participant pools of at least 100 people in each gender group. We will first use a lottery (without replacement) to select 90 individuals from each pool. We will then run a second lottery (without replacement) to select 10 individuals at time to assign treatment groups. The first set of 10 from each group will get A1 x B1, next 10 A2 x B1, et cetera, to the last 10 get A3 x B3. The study will be double blind.
- **Hasse Diagram:** See Figure 2

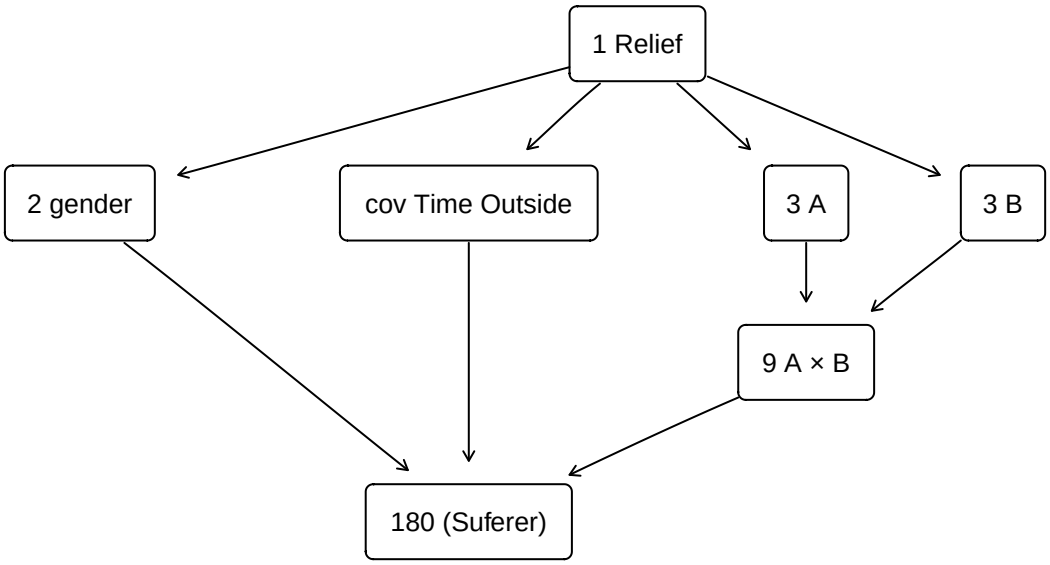

Figure 2: Hasse Diagram for Hay Fever Relief Study

Study Design (Narrative Format)

From Figure 2, we can see that we have two factors of interest (active ingredients A and B) which will have three levels each, a block of self-reported gender (Woman/Not Woman), and a covariate of time spent outside (hours) during the study period. We will put out a call for participants who suffer from hay fever to collect an initial pool of at least 100 individuals in each gender category.

From each gender pool, we will select 90 individuals with a lottery (without replacement) to select the initial research subjects (180 total). Then, from within each set of 90, we will run a second lottery (without replacement) to form nine groups of 10 subjects. The first set of nine will receive treatment A1 x B1, the second A2 x B1, and continue until the ninth group gets A3 x B3. The administration of treatments will be double blind.

Each participant will be given the appropriate number of tablets and instructions on taking them for the duration of the study (30 days). During that time, participants will be asked to record daily their adherence to the treatment play, how many hours of relief the experienced, and how many hours they spent outside.

This study results in a Two-way Analysis of Covariance (ANCOVA) + Block design.

Bounty, "The Quicker Picker Upper"®

Design a way to test Bounty's advertising claim that they are "the quicker picker upper".

SRQ

Is Bounty the quickest at absorbing liquid for paper towels?

Study Design (List Format)

- **Measurement Unit**: piece of paper towel (240 pieces)
- **Response**: Absorption Speed (amount of liquid mL absorbed in 10 seconds)
- **Factor**: Brand (1 fixed, 5 random), Size (two levels, fixed)
- **Treatments**: Bounty × center square, Bounty × Std. piece, Brand A × center square, Brand A × Std. piece, Brand B × center square, Brand B × Std. piece, Brand C × center square, Brand C × Std. piece, Brand D × center square
- **Treatment Selection Method**: I will compile a list of Bounty's competitors, placing each brand onto a ping pong ball. Once finished, I will place all ping pong balls into a bag and then remove five without replacement. These will be the five brands I will compare Bounty against.
- **Experimental Unit**: piece of paper towel
- **Treatment Assignment Method**: Each piece of paper towel will come from a brand of paper towel. The size will either be a 3-inch square cutout from the middle of a standard piece of the towel or a standard size piece (i.e., the size that is set by the brand through perforation/tear locations or pre-cut sizes). Two pieces will paired together; a coin flip (heads-center square, tails-standard) will determine whether the first (left-/top-most) towel of the pair gets which treatment; the other towel will get the other. Repeat for 20 pairs for each of the six brands.
- **Hasse Diagram:** See Figure 3

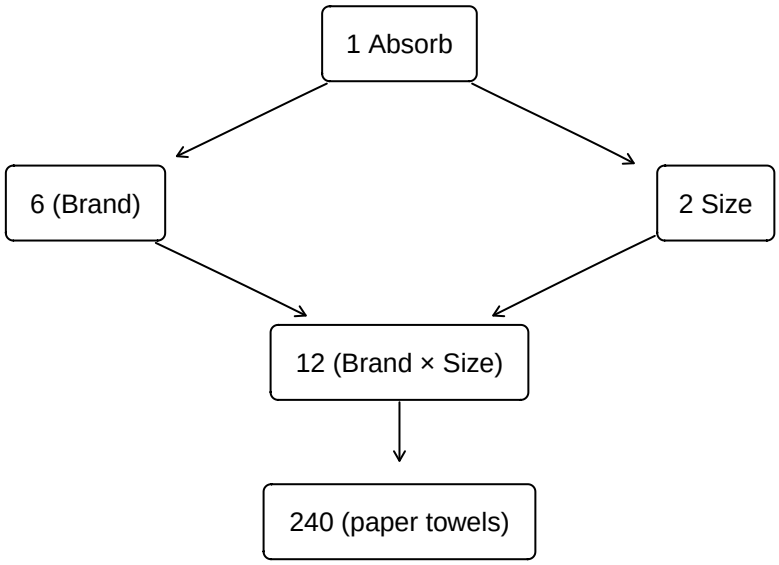

Figure 3: Hasse Diagram for Bounty Paper Towel Study

Study Design (Narrative Format)

To answer the question of whether Bounty is the fastest at absorbing liquid among paper towel brands, we will perform a quasi-experiment. We will compare Bounty to five brands selected via a ping-pong ball lottery. (I will compile a list of Bounty's competitors, placing each brand onto a ping pong ball. Once finished, I will

place all ping pong balls into a bag and then remove five without replacement. These will be the five brands I will compare Bounty against.) We will the purchase a single roll package for each brand.

Since not all paper towel brands create towels of the same dimensions, we will use two sizes of towels. The size of a single towel as denoted by perforation/tear points or pre-cut will be our "standard" size for each brand. Within a standard size piece, we will then find the geometric center of the piece, and center a 3-inch square there. We will cut out the square to serve as the "center square" piece. Twenty pairs of standard sized towels from each brand will be made. A coin flip (heads-center square, tails-standard) will determine whether the first (left-/top-most) towel of the pair gets which treatment; the other towel will get the other.

We will place each experimental unit in a lipped tray and pour 30 mL of colored water over the towel piece. We will then time the towel for 10 seconds. At the end of 10 seconds, we will move the wet towel to an extraction chamber to draw all moisture out of the towel, measuring the volume; this will let us calculate the absorption speed (mL/10 sec)

Figure 3 highlights that our quasi-experiment results in a Two-way ANOVA.

Code Appendix

```
# This template file is based off of a template created by Alex Hayes
# https://github.com/alexpghayes/rmarkdown_homework_template

# Setting Document Options
knitr::opts_chunk$set(
  echo = FALSE,
  warning = FALSE,
  message = FALSE,
  fig.align = "center"
)

# Add additional packages by name to the following list
packages <- c("tidyverse", "knitr", "kableExtra", "hasseDiagram")
lapply(
  X = packages,
  FUN = library,
  character.only = TRUE
)

# Hasse Diagram for Quick Bread Study
modelLabels <- c("1 Bake", "4 Temperature", "20 (loaves)")
modelMatrix <- matrix(
  data = c(FALSE, FALSE, FALSE, TRUE, FALSE, FALSE, TRUE, TRUE, FALSE),
  nrow = 3,
  ncol = 3,
  byrow = FALSE
)
hasseDiagram::hasse(
 data = modelMatrix,
 labels = modelLabels
)

# Create treatment list for Hay Fever Relief Study
hayTrt <- sapply(
    X = 1:9,
    FUN = function(x){
        temp1 <- tidyr::crossing(c("A1","A2","A3"),c("B1","B2","B3"))
        return(paste(temp1[x,], collapse = " \U00D7 "))
    },
    USE.NAMES = FALSE
)

# Hasse Diagram for Hay Fever Relief Study
modelLabels <- c("1 Relief", "2 gender", "cov Time Outside", "3 A", "3 B", "9 A × B",
                 "180 (Suferer)")
modelMatrix <- matrix(
  data = c(FALSE, FALSE, FALSE, FALSE, FALSE, FALSE, FALSE, TRUE, FALSE, FALSE, FALSE,
           FALSE, FALSE, FALSE, FALSE, TRUE, FALSE, FALSE, FALSE, FALSE, FALSE, FALSE, TRUE,
           FALSE, FALSE, FALSE, FALSE, FALSE, FALSE, FALSE, TRUE, FALSE, FALSE, FALSE, FALSE,
           FALSE, FALSE, TRUE, FALSE, FALSE, TRUE, TRUE, FALSE, FALSE, TRUE, TRUE,
           TRUE, TRUE, TRUE, TRUE, FALSE),
  nrow = 7,
```

```
  ncol = 7,
  byrow = FALSE
)
hasseDiagram::hasse(
 data = modelMatrix,
 labels = modelLabels
)

# Treatment listing for Bounty Study
paperTrt <- sapply(
    X = 1:9,
    FUN = function(x){
        temp1 <- tidyr::crossing(c("Bounty","Brand A","Brand B", "Brand C", "Brand D",
                                   "Brand E"), c("center square","Std. piece"))
        return(paste(temp1[x,], collapse = " \U00D7 "))
    },
    USE.NAMES = FALSE
)

# Hasse Diagram for Bounty Study
modelLabels <- c("1 Absorb", "6 (Brand)", "2 Size", "12 (Brand × Size)",
                 "240 (paper towels)")
modelMatrix <- matrix(
  data = c(FALSE, FALSE, FALSE, FALSE, FALSE, TRUE, FALSE, FALSE, FALSE, FALSE, TRUE,
           FALSE, FALSE, FALSE, FALSE, TRUE, TRUE, TRUE, FALSE, FALSE, TRUE, TRUE,
           TRUE, TRUE, FALSE),
  nrow = 5,
  ncol = 5,
  byrow = FALSE
)
hasseDiagram::hasse(
 data = modelMatrix,
 labels = modelLabels
)
```