Can Coffee Grind Size Impact the Brewing Speed and Bitterness?

PLSC 341. The Logic of Randomized Experiments in Political Science

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I. *Introduction*

This experiment aims to test the effect of coffee grind size on coffee's brewing speed and the degree of bitterness. I conduct a complete random assignment by assigning 18 units to coarse grinds and 18 units to fine grinds. I measure the brewing time for making 0.68 oz of coffee and collect 3 participants' ratings of bitterness. My findings suggest that the average dripping time and ratings of bitterness increase significantly when we grind the coffee finer.

II. *Theory*

Brewing coffee is the procedure of extracting flavor compounds from the coffee. When we grind coffee to make it finer, we increase the exposed surface area, which, in turn, increases the contact time and slows down the extraction. Moreover, a finer grind increases the dripping time by

making it easier for the particles to remain on the filter. By contrast, water flows more quickly through the coarse grinds as they are more permeable.

The particle size may also affect the flavor and taste. When ground finely, the coffee usually tastes bitter since it is over-extracted. As the dripping time increases, more caffeine will be extracted from these grinds, resulting in a bitter flavor. On the other hand, the coarse coffee is under-extracted and tastes flat.

III. *Research Design*

This research uses a two-arm design in which the coffee beans are randomly assigned to ground in fine and coarse sizes. Two outcomes are measured in this experiment: the dripping time and people's rating of the bitterness of the coffee.

A. *Grinding and Brewing the Coffee*

The treatment in this experiment is grinding the coffee into different sizes (varying degrees of fineness). Coffee beans are ground into fine powder (18 groups, 7 grams in each group) in the treatment groups, and into coarse powder in the control group (18 groups, 7 grams in each group). I use a manual coffee grinder and control the fineness of the particles by adjusting the grinding groove.

Figure 1. The Coffee Grinder

Figure 2. The Coffee Dripper

The water temperature is kept at around 200 degrees Fahrenheit. The coffee is ground from 252 grams of dark roast coffee beans, and I control the same flow rate and same room temperature while brewing the coffee. Each time after brewing, the cone-shaped coffee filter is disposed and replaced. To make it sufficient enough to detect the treatment effect, the sample size is 36, producing a statistical power greater than 80%.

B. *Pre-experiment Survey*

Three of my friends are invited to rate the coffee's bitterness. Since different people have different preferences for coffee, the ratings of coffee can be influenced. People's attitudes

towards coffee can be considered as a covariate that can be observed but cannot be controlled. Prior to the experiment, a survey is conducted, containing the following question: Do you love coffee? The answers are binary: either yes or no. In my pre-analysis plan, I intended to use them as covariates for precision, but it turns out that all of the participants are coffee lovers. I dropped the covariates for precision analysis since there are no variations in the outcomes.

C. *Outcome Measurement: Measuring Brewing Speed and Bitterness*

127 grams of fine grinds and 127 grams of coarse grinds are divided into 36 cups (7 grams in each cup). The first outcome measurement is the time it takes to make 0.68 oz of coffee, which is measured by a timer.

Figure 3. Coffee Grinds (36 Units)

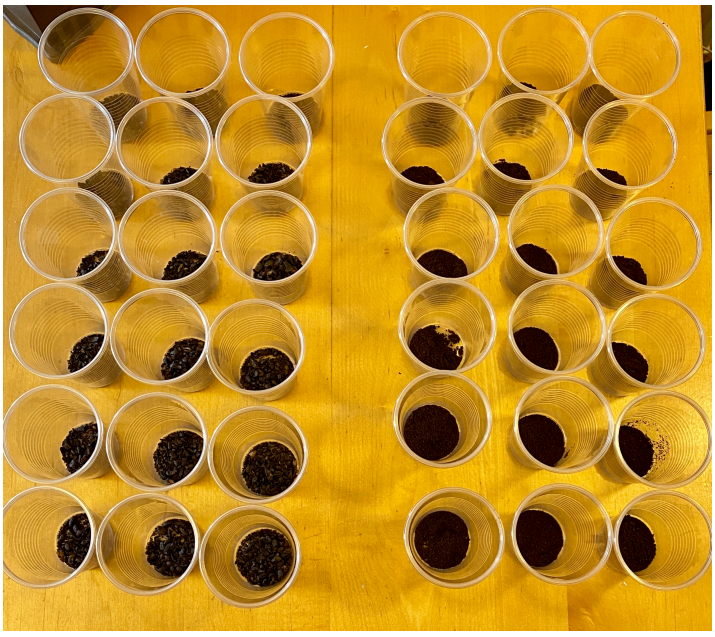
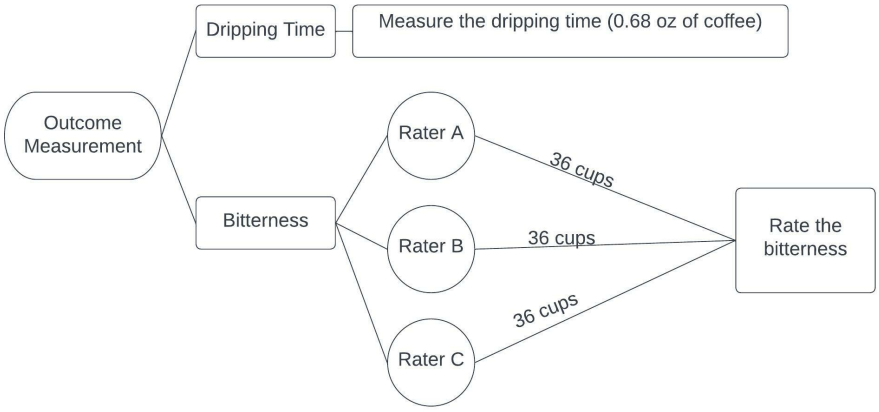


Figure 4. Brewed Coffee (36 Units)

Figure 5. Outcome Measurement



I divide each cup of coffee into 3 cups (108 cups of coffee in total) and invited the same person to taste all the 36 cups of coffee. In order to minimize measurement error, each cup of coffee has been rated more than once. I then shuffle the coffee and randomize the order in which they rate the coffee. While rating the coffee, participants are instructed not to talk to each other. They are also instructed to drink some water to cleanse the palate. One question is asked after participants taste the coffee: On a scale of 1 to 10, how bitter is the coffee?

IV. *Results*

I regressed the brewing time dripping time and bitterness on the fineness of the coffee. The results imply that a finer grind increases the brewing time and bitterness significantly. The average dripping time for making 0.68 oz of coffee with coarse grinds is 52.7 seconds, while that for the fine grinds is 77.88 seconds. The difference-in-means is 25.178 seconds, which is

statistically significant ($p<0.05$). Participants' average rating of bitterness for the treatment group (coarse coffee) is 2.266. As Table 1 shows, when ground finely, the coffee is 4.783 scale points more bitter than the coffee brewed from coarse grinds ($p<0.05$).

Table 1. Effects of Grind Size on Dripping Time and Bitterness

	Dripping Time	Bitterness
(Intercept)	52.706 ***	2.266 ***
	(2.019)	(0.175)
Fine	25.178 ***	4.783 ***
	(6.916)	(0.278)
R^2	0.280	0.686
Adj. R^2	0.259	0.683
Num. obs.	36	137
RMSE	20.749	1.631

*** p < 0.001; ** p < 0.01; * p < 0.05

Figure 6. Model of the Experiment

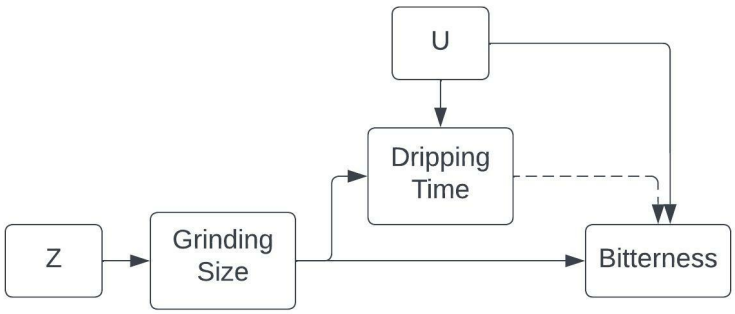


Figure 6 shows the model of this experiment. The dripping time and bitterness are likely to be impacted by other unknown factors (U), such as the room temperature. I test whether the rating

of bitterness for the same cup of coffee is homogenous among different raters. According to table 2, the rating given by rater 3 is significantly different for different cups of coffee ($p < 0.05$). When invited to rate the coffee, rater 3 rated 24 cups of coffee on the first day, went to New York City, and rated the remaining 12 cups the following day. The coffee may have become more bitter overnight and thus result in a variance in rating.

Table 2.Effects of Raters on Bitterness Measurement

	Bitterness by Raters
(Intercept)	2.176 ***
	(0.335)
ZFine	5.212 ***
	(0.550)
ByRater 2	0.224
	(0.484)
ByRater 3	0.157
	(0.578)
ZFine:ByRater 2	0.588
	(0.754)
ZFine:ByRater 3	-1.712 *
	(0.846)
R^2	0.697
Adj. R^2	0.682
Num. obs.	101
RMSE	1.690

*** p < 0.001; ** p < 0.01; * p < 0.05

Figure 7. Effects of Grind Size on Dripping Time

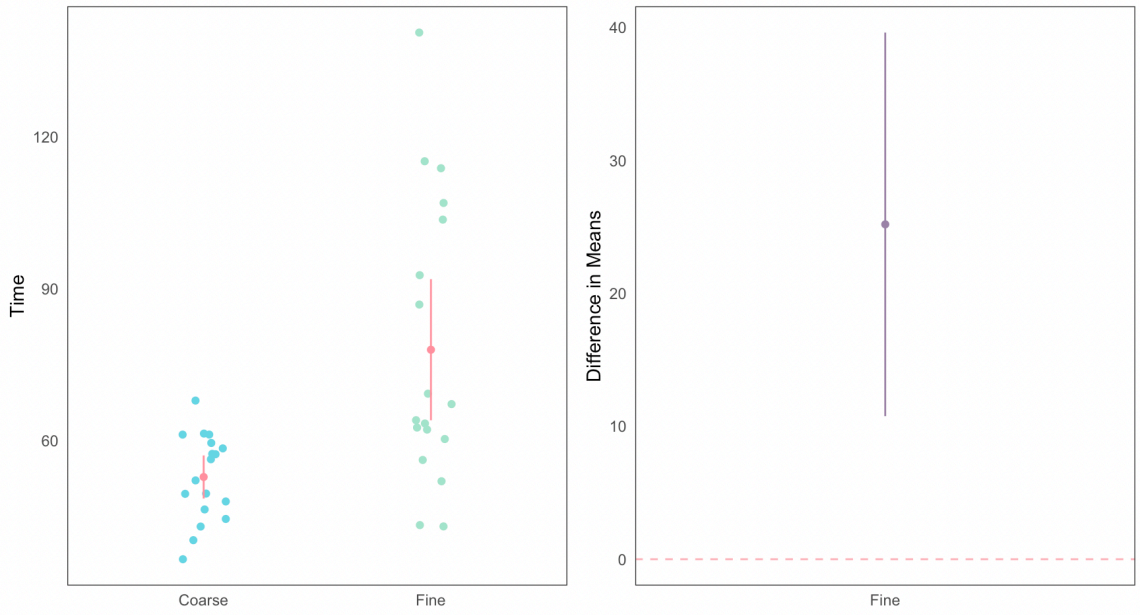
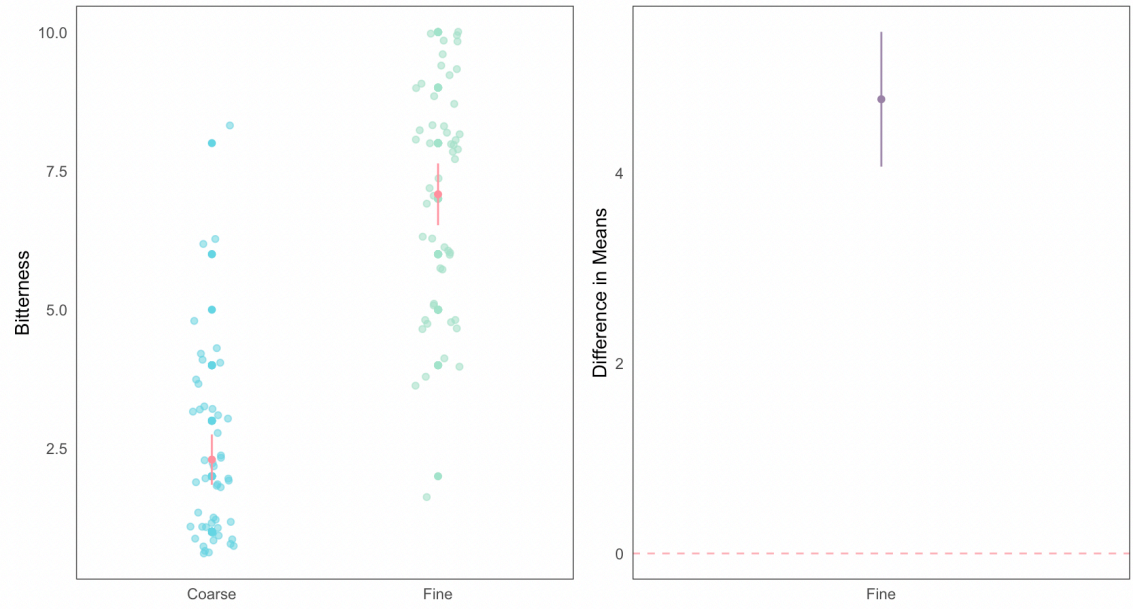


Figure 8. Effects of Grind Size on Bitterness



V. *Discussion*

This experiment tests the effect of sizes of coffee grinds on the brewing speed and bitterness of coffee, which is useful for baristas when deciding on the coffee grind size. Knowing these effects can make it easier for baristas to control the coffee flavor more precisely. A finer grind is preferred when intending to make a more bitter cup of coffee. The potential effect of dripping time on bitterness also requires further study.

VI. *Acknowledgements*

I would like to express my gratitude to Professor Coppock and Shikhar Singh for all of the help, encouragement and support throughout the year. I am also deeply indebted to Chloe Papai (BK' 23), Leo Roberts (BK' 22) and Mehmed Can Olgac (Silliman' 22) for tasting and rating 36 cups of coffee.