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Causality, Statistical Significance, and Substantive Significance

PROBLEM SET

1. Evaluate whether each of these statements correctly conveys statistical significance. If not, rewrite the sentence so that the verbal description about statistical significance matches the numbers; leave the numeric values unchanged.
 - a. There was a statistically significant increase in average salaries over the past three years ($p = .04$).
 - b. The p -value for the t -test for difference in mean ozone levels equals 0.95, so we can be 95% certain that the observed difference is not due to chance.
 - c. The difference in voter participation between men and women was not statistically significant ($p = 0.35$).
 - d. The p -value for the t -test for difference in mean ozone levels equals 0.95. This test shows we can be 95% certain that the difference in ozone levels can be explained by random chance, hence the difference is statistically significant.
 - e. The price of gas increased by \$0.05 over the past three months, meaning that the p -value = 0.05.
 - f. The p -value comparing trends in gas prices = 0.05, hence the price of gas increased by \$0.05.
 - g. Voter participation was 20% higher among Democrats than among Republicans in the recent local election. Statistical tests show $p < .01$, so we can be 99% certain that the observed difference is not due to chance.
 - h. The average processor speed was slightly higher for Brand A than for Brand B; however $p = .09$, so the effect was not statistically significant. If the sample size were increased from 40 to 400, the difference in processor speeds between the two brands would increase, so it might become statistically significant.
 - i. The average processor speed was slightly higher for Brand A than for Brand B; however $p = .09$, so the effect was not statistically significant. If the sample size were increased from 40 to 400, the standard error would decrease, so the difference might become statistically significant.
2. For each of the following findings, identify background facts that could help decide whether the effect is big enough to matter. Look up your suggested facts for one of the research questions. What do you conclude about the substantive significance of the finding?
 - a. Jo's IQ score increased 2 points in one year.

- b. The average response on a political opinion poll for two adjacent counties differed by 2 points. The question was scaled “agree strongly,” “agree,” “neither agree nor disagree,” “disagree,” and “disagree strongly.”
 - c. The Dow Jones Industrial Index dropped 2 points since this morning.
 - d. Bed rest is expected to prolong Mrs. Peterson’s pregnancy to 36 weeks from 34 weeks’ gestation.
3. Discuss whether each of the following research questions involves a causal relationship. If the relationship is causal, describe one or more plausible mechanisms by which one variable could cause the other. If the relationship is not causal, give alternative explanations or mechanisms for the association.
 - a. April showers bring May flowers.
 - b. People with blue eyes are more likely to have blond hair.
 - c. Pollen allergies increase rapidly with longer daylight hours.
 - d. Eating spicy foods is negatively correlated with heartburn.
 - e. Prices and sales volumes are inversely related, so high sales volumes cause prices to drop.
 - f. Fair-skinned people sunburn faster than do those with dark skin.
 - g. Average reading ability increases dramatically with height between 4’ and 5’.
 4. For each of the studies summarized in table 3A
 - a. explain how would you describe the findings in the results section of a scientific paper;
 - b. identify the criteria you used to decide how to discuss the findings for that study.

Table 3A. Hypothetical study results

Topic I: Effect of new math curriculum on test scores*	Effect size	Statistical significance (<i>p</i> -value)	Sample size
Study 1	+1/2 point	$p < .01$	1 million
Study 2	+1/2 point	$p = .45$	1 million
Study 3	+5 points	$p < .01$	1 million
Study 4	+5 points	$p = .07$	1 hundred
Study 5	+5 points	$p = .45$	1 million
Topic II: Effect of white hair on mortality**			
Study 1	+ 5%	$p < .01$	1 million
Study 2	+ 5%	$p = .45$	1 million
Study 3	+50%	$p < .01$	1 million
Study 4	+50%	$p = .07$	1 hundred
Study 5	+50%	$p = .45$	1 million

* Effect size for math curriculum studies = scores under new curriculum – scores under old curriculum.

** Effect size for hair color studies = death rate for white-haired people – death rate for people with other hair colors.

5. For each of the topics in table 3A, indicate whether you would recommend a policy or intervention based on the results, and explain the logic behind your decision.
6. For each of the topics in table 3A, write one or two sentences to describe the conclusions of each study to a lay audience.