things to know

- PS 4's grading is ongoing
- PS 5 is due now
- Next Monday I will do a review and try to generate a useful in-class set of exercises
- We won't meet next Wednesday
- Exam 1 will be available on March 6, due March 11

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multi-factor designs: larger designs

February 26, 2024

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larger two-factor designs

- Factor A: sentence (normal/intact vs scrambled)
- Factor B: presentation rate (300, 450, 600 wpm)
- DV = % correct detection of a word

- this is a 2 (sentence) × 3 (rate) design
- there are six groups
- ultimately, no matter how we create them, we'll need five contrast codes

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the results (cell, marginal, overall means)

	300	450	600	
intact	64	60	44	56
scrambled	54	50	46	50
	59	55	45	53

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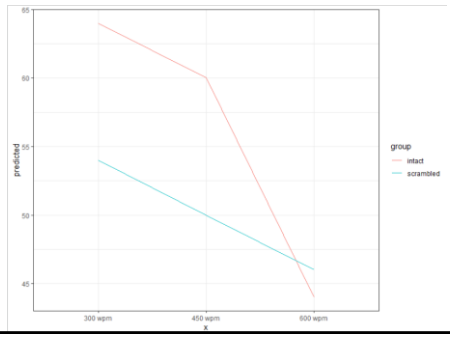
results, plotted



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how to analyze?

- let's generate contrast codes for each factor, ignoring the other factor
- for the sentence factor, there's no decision to be made
- with two levels, we'll use +1/2 and -1/2

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filling in some codes

	intact 300	intact 450	intact 600	scr 300	scr 450	scr 600
T	+1/2	+1/2	+1/2	-1/2	-1/2	-1/2

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how to analyze?

- let's generate contrast codes for each factor, ignoring the other factor
- for the rate factor, the researcher thought something interest would happen at the very-high rate relative to the other two
- R1: 300, 450 vs 600
- the other contrast is the only one leftover
- R2: 300 vs 450

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filling in some codes

	intact 300	intact 450	intact 600	scr 300	scr 450	scr 600
T	+1/2	+1/2	+1/2	-1/2	-1/2	-1/2
R1	1/3	1/3	-2/3	1/3	1/3	-2/3

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filling in some codes

	intact 300	intact 450	intact 600	scr 300	scr 450	scr 600
T	+1/2	+1/2	+1/2	-1/2	-1/2	-1/2
R1	+1/3	+1/3	-2/3	+1/3	+1/3	-2/3
R2	+1/2	-1/2	0	+1/2	-1/2	0

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filling in some codes: multiply to get interactions

	intact 300	intact 450	intact 600	scr 300	scr 450	scr 600
T	+1/2	+1/2	+1/2	-1/2	-1/2	-1/2
R1	+1/3	+1/3	-2/3	+1/3	+1/3	-2/3
R2	+1/2	-1/2	0	+1/2	-1/2	0
T*R1						

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filling in some codes: multiply to get interactions

	intact 300	intact 450	intact 600	scr 300	scr 450	scr 600
T	+1/2	+1/2	+1/2	-1/2	-1/2	-1/2
R1	+1/3	+1/3	-2/3	+1/3	+1/3	-2/3
R2	+1/2	-1/2	0	+1/2	-1/2	0
T*R1	+1/6	+1/6	-2/6	-1/6	-1/6	+2/6

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filling in some codes: multiply to get interactions

	intact 300	intact 450	intact 600	scr 300	scr 450	scr 600
T	+1/2	+1/2	+1/2	-1/2	-1/2	-1/2
R1	+1/3	+1/3	-2/3	+1/3	+1/3	-2/3
R2	+1/2	-1/2	0	+1/2	-1/2	0
T*R1	+1/6	+1/6	-2/6	-1/6	-1/6	+2/6
T*R2	+1/4	-1/4	0	-1/4	+1/4	0

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what do we get?

	Estimate	SE	t	Pr(>|t|)
(Intercept)	53	0.99	53.62	< 2e-16
T	6	1.98	3.03	0.00412
R1	12	2.10	5.72	9.95e-07
R2	4	2.42	1.65	0.10600
TR1	12	4.19	2.86	0.00655
TR2	0	4.84	0.00	1.00000

	300	450	600	
intact	64	60	44	56
scrambled	54	50	46	50
	59	55	45	53

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a write-up of *this* model

- Intact text led to significantly higher performance than scrambled text, $t(42) = 3.04$, $p = .004$.
- Slower presentation rates (300 & 450 wpm) led to significantly higher performance than 600 wpm, $t(42) = 5.72$, $p < .001$, but there was no significant difference between the former two, $t(42) = 1.65$, $p = .11$.
- The advantage for the slower presentation rates over 600 wpm was significantly larger for intact than for scrambled text, $t(42) = 2.86$, $p = .007$.
- There was no significant difference in the 300 vs 450 wpm contrast between intact and scrambled test, $t(42) = 0$, $p = 1$.

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the conventional ANOVA results

```
> summary(aov(dv ~ text*wpm, scrambled))
            Df Sum Sq Mean Sq F value  Pr(>F)
text         1    432   432.0   9.210 0.00412
wpm          2   1664   832.0  17.738 2.6e-06
text:wpm     2    384   192.0   4.093 0.02376
Residuals   42   1970    46.9
```

- Post-tests for significant main effects with >1 *df* (main effect contrasts) are common
- Post-tests for significant interactions (simple effects tests & interaction contrasts) are common

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multiply by common denominators to simplify

	i3	i4	i6	s3	s4	s6
T	+1	+1	+1	-1	-1	-1
R1	+1	+1	-2	+1	+1	-2
R2	+1	-1	0	+1	-1	0
T*R1	+1	+1	-2	-1	-1	+2
T*R2	+1	-1	0	-1	+1	0

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what is Model A/Model C? for variable R1 (300, 450 vs 600)

- Model A

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- Model C

$$Y = \beta_0 + \beta_1 T + 0R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

$$Y = \beta_0 + \beta_1 T \qquad \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

$$H_0\colon \beta_2 = 0$$

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what is Model A/Model C? for variable TR1

- Model A

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- Model C

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + 0TR1 + \beta_5 TR2$$

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \qquad \beta_5 TR2$$

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other versions of Model C

- Model A

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- Model C for the typical ANOVA main effect of text

$$Y = \beta_0 \qquad + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- PRE gives R^2 for text (often reported as η_p^2)

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other versions of Model C

- Model A

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- Model C for the typical ANOVA main effect of rate/wpm

$$Y = \beta_0 + \beta_1 T + \qquad \beta_4 TR1 + \beta_5 TR2$$

- PRE gives R^2 for rate (often reported as η_p^2)

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other versions of Model C

- Model A

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- Model C for the typical ANOVA interaction effect

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2$$

- PRE gives R^2 for the interaction (often reported as η_p^2)

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other versions of Model C

- Model A

$$Y = \beta_0 + \beta_1 T + \beta_2 R1 + \beta_3 R2 + \beta_4 TR1 + \beta_5 TR2$$

- Model C for the whole model

$$Y = \beta_0$$

- PRE gives R^2 for the whole model

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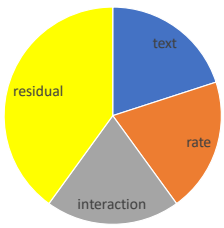
the typical ANOVA



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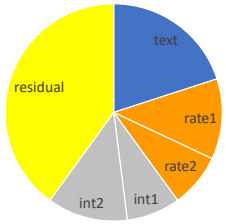
using single-*df* orthogonal contrasts



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dealing with 3+ factors

- for each factor, generate a set of orthogonal contrast codes
- for the two-factor interactions, multiply all pairs of contrasts (across factors, but not within)
- for the three-factor interactions, multiply all triads of contrasts (across factors, but not within)
- etc.
- model as usual
- but be aware that most people can't think very clearly about interactions among three factors (and more than that ... 🤯)

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general advice

- the overall ANOVA will usually leave you needing follow-up tests in many cases
- let your substantive questions dictate the analyses you execute
- be aware of the costs and benefits of using orthogonal contrast codes vs other possibilities (e.g., dummy codes)
- use cell means to help you interpret what your slopes are about
- alternatively, you can interpret slopes as we did with continuous predictors; this may be easier with dummy codes than with orthogonal contrasts

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