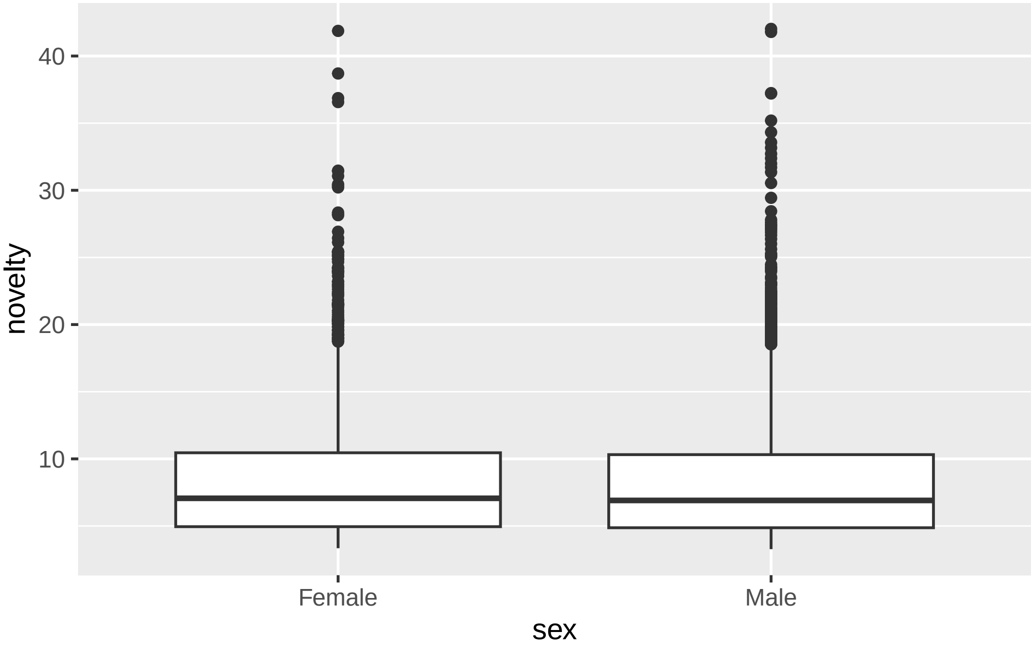
Case Study:Diversity and Innovation

Planning a model: the response would be novelty, and predictors are sex and race ethnicity. I wanted to know if sex and race would have any correlation with innovation level.

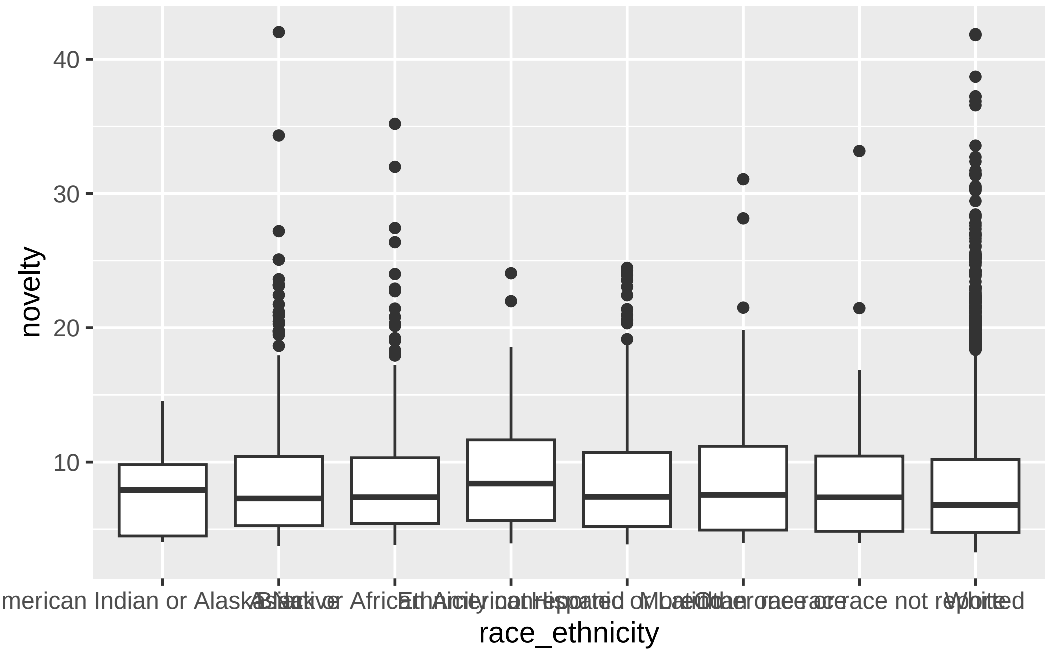
```
innovation <- read_csv('https://sldr.netlify.app/data/phd_innovation.csv', show_col_types
model <- lm(novelty ~ sex + race_ethnicity, data = innovation)
nrow(innovation)
```

```
[1] 4195
```

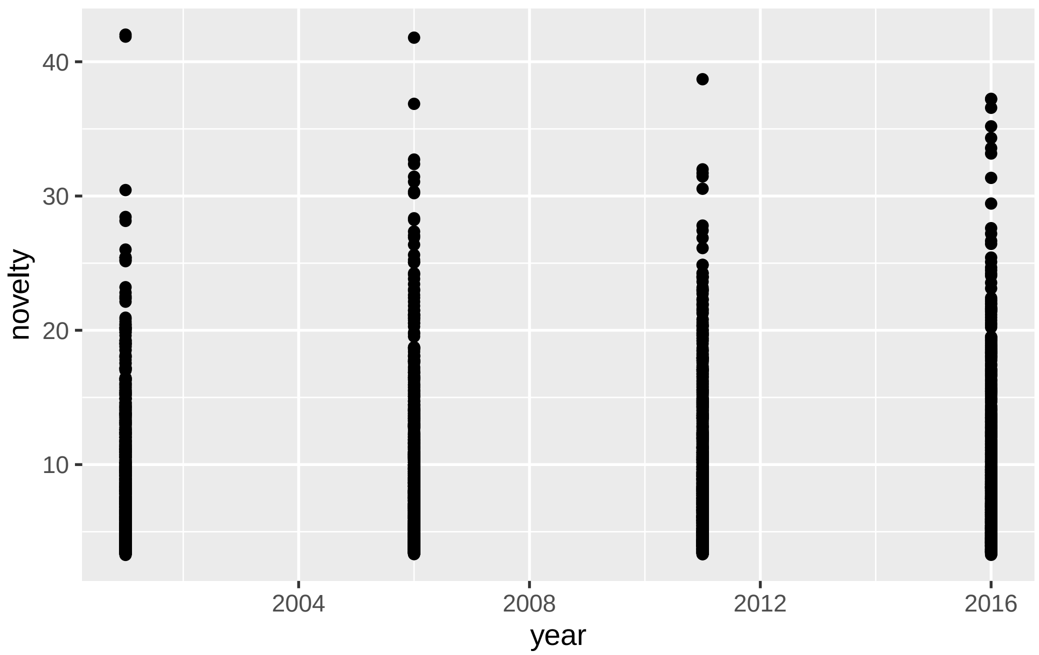
```
gf_boxplot(novelty ~ sex, data = innovation)
```



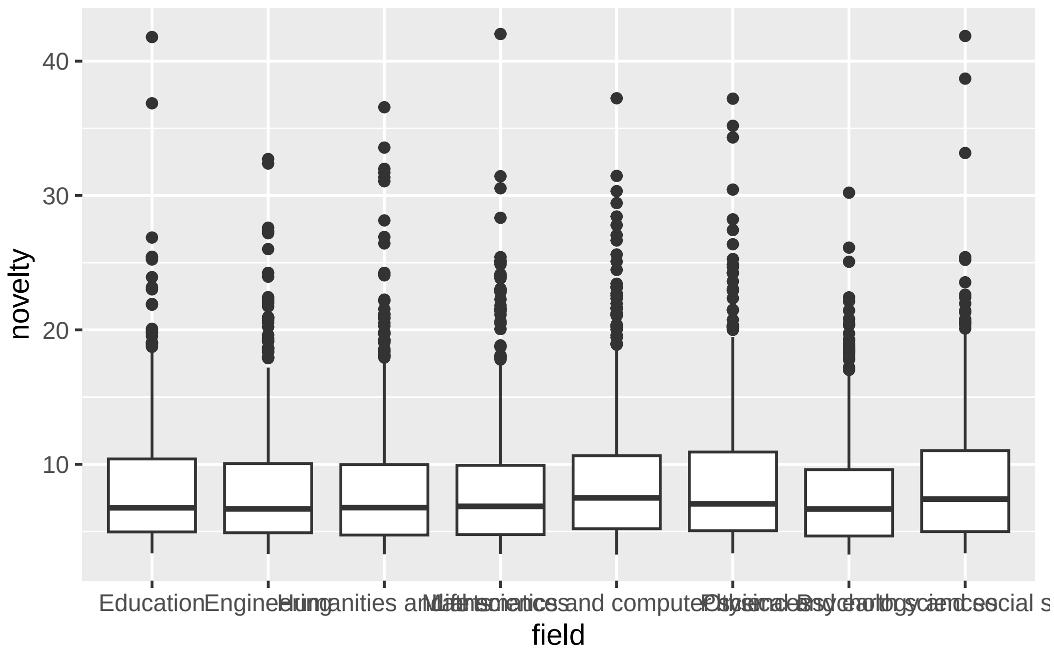
```
gf_boxplot(novelty ~ race_ethnicity, data = innovation)
```



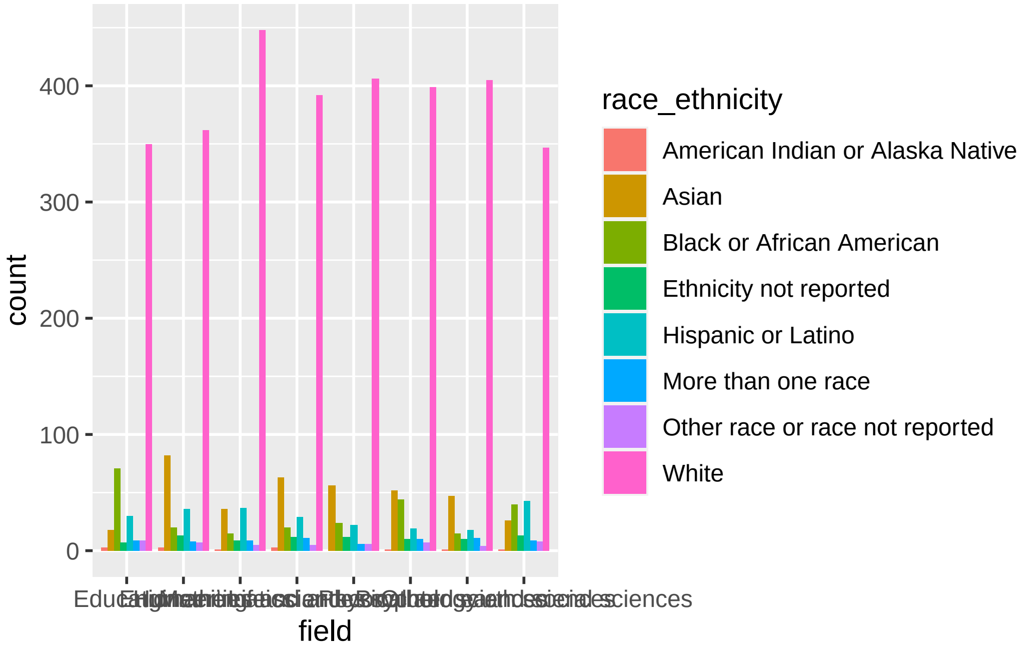
```
gf_point(novelty ~ year, data = innovation)
```



```
gf_boxplot(novelty ~ field, data = innovation)
```



```
gf_bar( ~ field,
        fill = ~ race_ethnicity,
        data = innovation,
        position = 'dodge')
```



The graph between novelty and sex doesn't show much since they have very similar median and IQR. The graph between novelty and race ethnicity shows a dominant lead for White followed by Asians and Black or African American. I can also see a small trend as the year goes on the novelty level tend to be down a little bit. There are some fields are leading the novelty level but I can't really tell since the names are all overlapped.

```
summary(model)
```

```
Call:
lm(formula = novelty ~ sex + race_ethnicity, data = innovation)

Residuals:
   Min      1Q  Median      3Q     Max
-5.313  -3.551 -1.491   1.870  33.519
```

```
Coefficients:
                                              Estimate Std. Error t value
(Intercept)                                    8.03157    1.38423   5.802
sexMale                                       -0.09716    0.15580  -0.624
race_ethnicityAsian                            0.85802    1.40703   0.610
race_ethnicityBlack or African American        0.80241    1.41871   0.566
race_ethnicityEthnicity not reported           1.22550    1.48426   0.826
race_ethnicityHispanic or Latino               0.83296    1.42123   0.586
race_ethnicityMore than one race               1.16157    1.50115   0.774
race_ethnicityOther race or race not reported  0.72359    1.54965   0.467
race_ethnicityWhite                            0.34103    1.38608   0.246
                                              Pr(>|t|)    
(Intercept)                                   7.03e-09 ***
sexMale                                          0.533    
race_ethnicityAsian                              0.542    
race_ethnicityBlack or African American          0.572    
race_ethnicityEthnicity not reported             0.409    
race_ethnicityHispanic or Latino                 0.558    
race_ethnicityMore than one race                 0.439    
race_ethnicityOther race or race not reported    0.641    
race_ethnicityWhite                              0.806    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.986 on 4186 degrees of freedom
Multiple R-squared:  0.002523,	Adjusted R-squared:  0.0006166 
F-statistic: 1.323 on 8 and 4186 DF,  p-value: 0.2265
```

Causal Diagram:

My main predictor is race ethnicity with my response variable novelty. I made sex as a moderator since it doesn't affect novelty level directly. Both field and year showed a reasonable correlation with novelty. I would include race ethnicity, field, and year as my predictors to my new model.

```r
nmodel <- lm(novelty ~ race_ethnicity + field + year, data = innovation)
summary(nmodel)
```

```
Call:
lm(formula = novelty ~ race_ethnicity + field + year, data = innovation)
```

```
Residuals:
   Min     1Q Median     3Q    Max 
-5.656 -3.522 -1.545  1.876 33.635 

Coefficients:
                                               Estimate Std. Error t value
(Intercept)                                   -30.53964   27.54555  -1.109
race_ethnicityAsian                             0.70139    1.40565   0.499
race_ethnicityBlack or African American         0.56545    1.41834   0.399
race_ethnicityEthnicity not reported            1.03825    1.48281   0.700
race_ethnicityHispanic or Latino                0.61522    1.42053   0.433
race_ethnicityMore than one race                0.99800    1.50053   0.665
race_ethnicityOther race or race not reported   0.50596    1.54801   0.327
race_ethnicityWhite                             0.18061    1.38506   0.130
fieldEngineering                               -0.08386    0.31417  -0.267
fieldHumanities and arts                        0.09449    0.30943   0.305
fieldLife sciences                             -0.03971    0.31287  -0.127
fieldMathematics and computer sciences          0.56017    0.31306   1.789
fieldOther                                      0.44429    0.31044   1.431
fieldPhysical and earth sciences               -0.51178    0.31651  -1.617
fieldPsychology and social sciences             0.45058    0.31835   1.415
year                                            0.01920    0.01371   1.400
                                              Pr(>|t|)  
(Intercept)                                     0.2676  
race_ethnicityAsian                             0.6178  
race_ethnicityBlack or African American         0.6902  
race_ethnicityEthnicity not reported            0.4838  
race_ethnicityHispanic or Latino                0.6650  
race_ethnicityMore than one race                0.5060  
race_ethnicityOther race or race not reported   0.7438  
race_ethnicityWhite                             0.8963  
fieldEngineering                                0.7895  
fieldHumanities and arts                        0.7601  
fieldLife sciences                              0.8990  
fieldMathematics and computer sciences          0.0736 .
fieldOther                                      0.1525  
fieldPhysical and earth sciences                0.1060  
fieldPsychology and social sciences             0.1570  
year                                            0.1615  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.978 on 4179 degrees of freedom
```

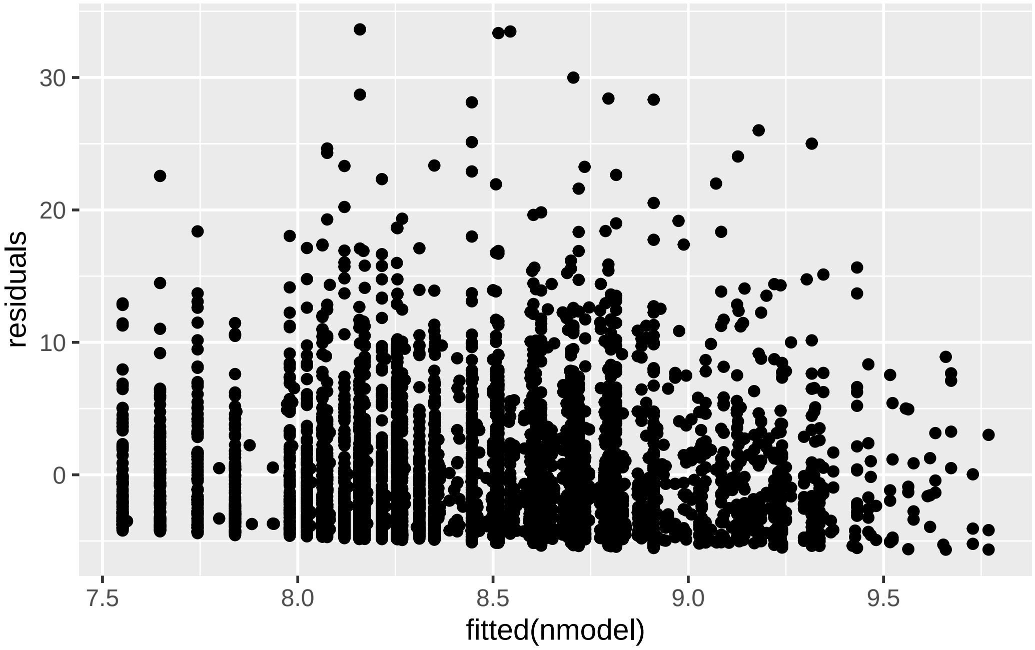
```
Multiple R-squared:  0.007298,  Adjusted R-squared:  0.003735
F-statistic: 2.048 on 15 and 4179 DF,  p-value: 0.009758
```

$$y = -30.54 + 0.7\beta_{raceAsian} + 0.57\beta_{raceAfricanAmerican} + 1.04\beta_{raceNotReported}$$
$$+0.62\beta_{raceLatino} + 1\beta_{raceMorethanone} + 0.51\beta_{raceOther} + 0.18\beta_{raceWhite}$$
$$-0.08\beta_{fieldEngineering} + 0.09\beta_{fieldHumanityandArts} - 0.04\beta_{fieldLifeScience}$$

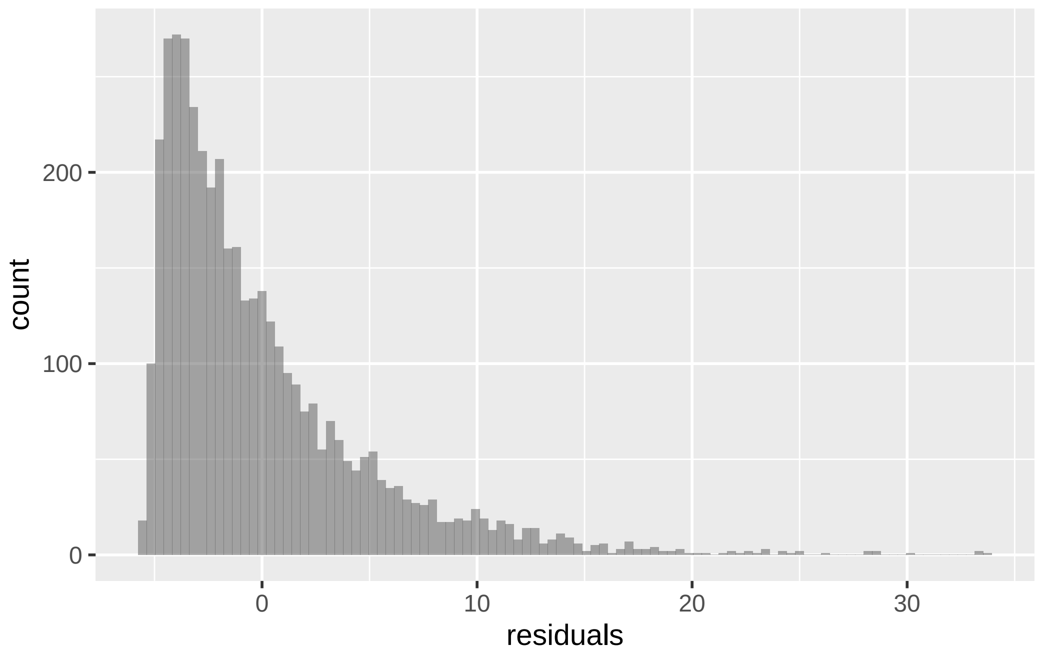
$+$

$$0.56\beta_{fieldMathandCS} + 0.44\beta_{fieldOther} - 0.51\beta_{fieldPhysicalandEarthScience}$$
$$+0.45\beta_{fieldPhychologyandSocialScience} + 0.02\beta_{year} + \epsilon,$$
$$\epsilon \sim N(0, 4.978)$$

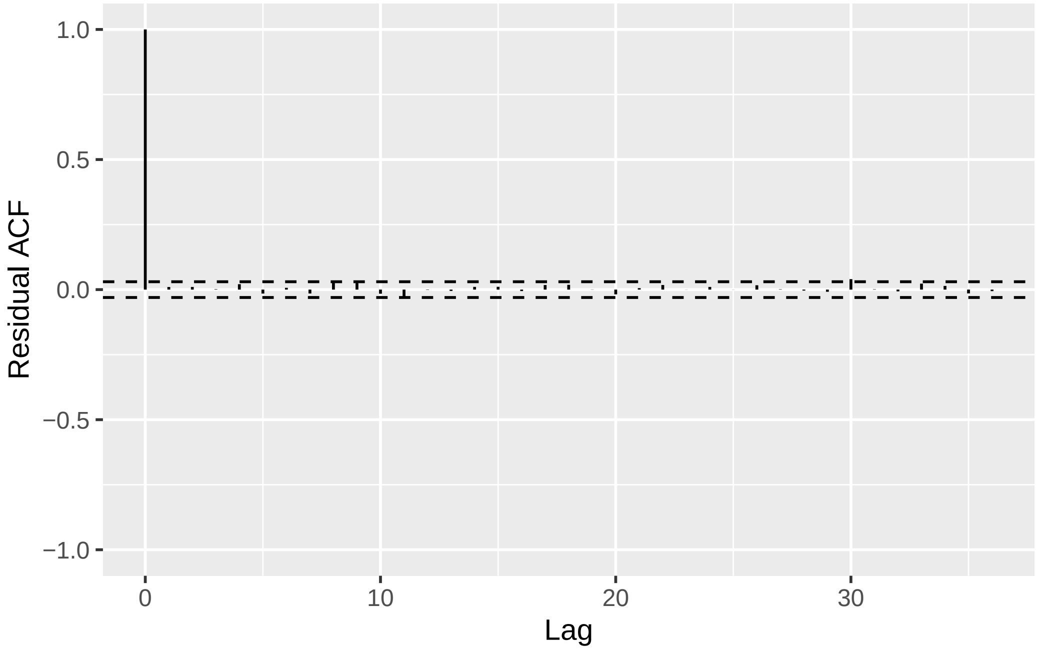
```r
innovation$residuals <- residuals(nmodel)
gf_point(residuals ~ fitted(nmodel), data = innovation)
```



```r
gf_histogram(~residuals,data = innovation, bins=100)
```



```
s245::gf_acf(~nmodel) |> gf_lims(y = c(-1,1))
```



Residuals and fitted model: It doesn't really show linearity from this graph, so I don't think it meets the condition.

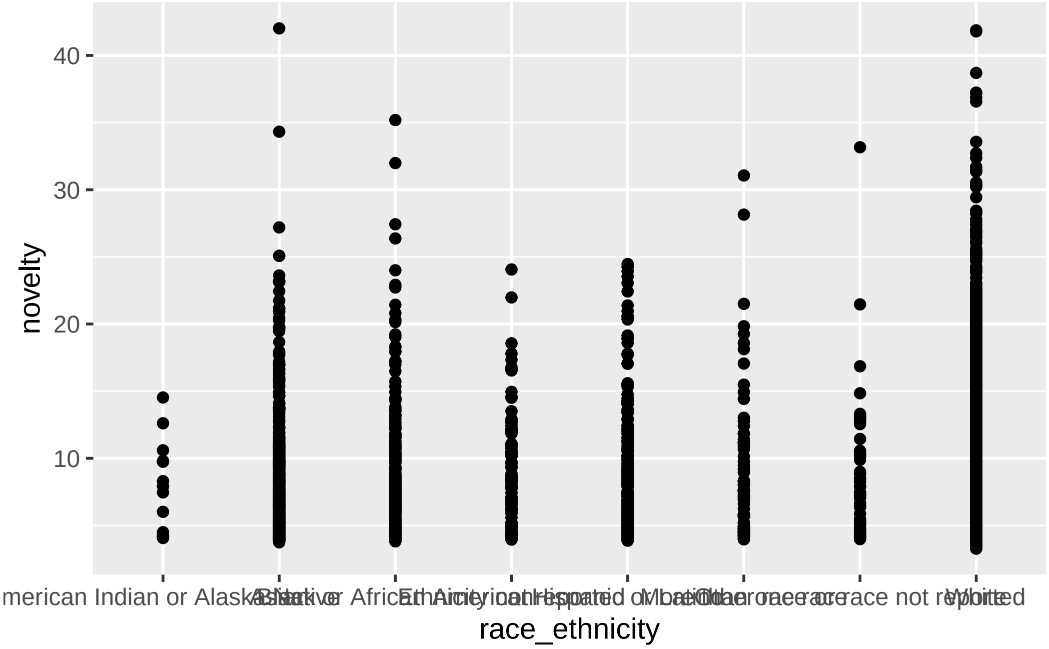
Histogram of residuals: This is not normally distributed. This is a right-skewed graph. It also don't meet the condition.

ACF plot of residuals: There is only one significant spike, so I would say this meets the condition.

Since not all of them met the conditions, I cannot draw a valid conclusion from this model.

```
b2 <- innovation |>
 select(field, race_ethnicity, year, novelty) |>
 na.omit() |>
 mutate(preds = predict(nmodel),
        resids = resid(nmodel))
```

```
gf_point(novelty ~ race_ethnicity,
 data = b2) |>
gf_line(preds ~ race_ethnicity)
```



I don't know why somehow the line doesn't show.