

# comparing more than two means

# vocabulary score and class

from the 2010 GSS

	wordsum	class
1	6	middle class
2	9	working class
3	6	working class
4	5	working class
5	6	working class
6	6	working class
...	...	...
795	9	middle class

10 question  
vocabulary test  
(scores range from  
0 to 10)

self identified  
social class  
(lower, working,  
middle, upper)



# vocabulary score

Choose a word from a list of provided options that comes closest to the meaning of the first word provided in capital letters.

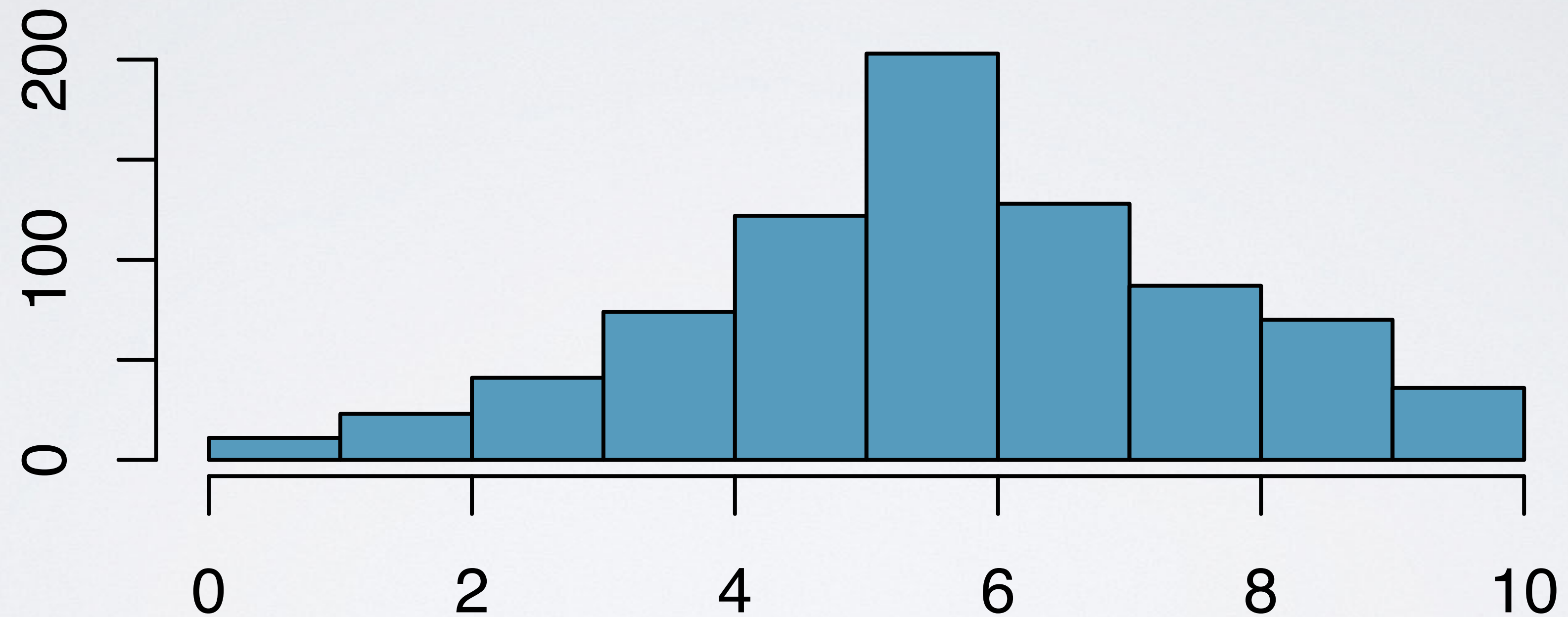
## wordsum

1. SPACE (school, noon, captain, room, board, don't know)
2. BROADEN (efface, make level, elapse, embroider, widen, don't know)
3. EMANATE (populate, free, prominent, rival, come, don't know)
4. EDIBLE (auspicious, eligible, fit to eat, sagacious, able to speak, don't know)
5. ANIMOSITY (hatred, animation, disobedience, diversity, friendship, don't know)
6. PACT (puissance, remonstrance, agreement, skillet, pressure, don't know)
7. CLOISTERED (miniature, bunched, arched, malady, secluded, don't know)
8. CAPRICE (value, a star, grimace, whim, inducement, don't know)
9. ACCUSTOM (disappoint, customary, encounter, get used to, business, don't know)
10. ALLUSION (reference, dream, eulogy, illusion, aria, don't know)

vocabulary  
score

wordsum

## vocabulary scores



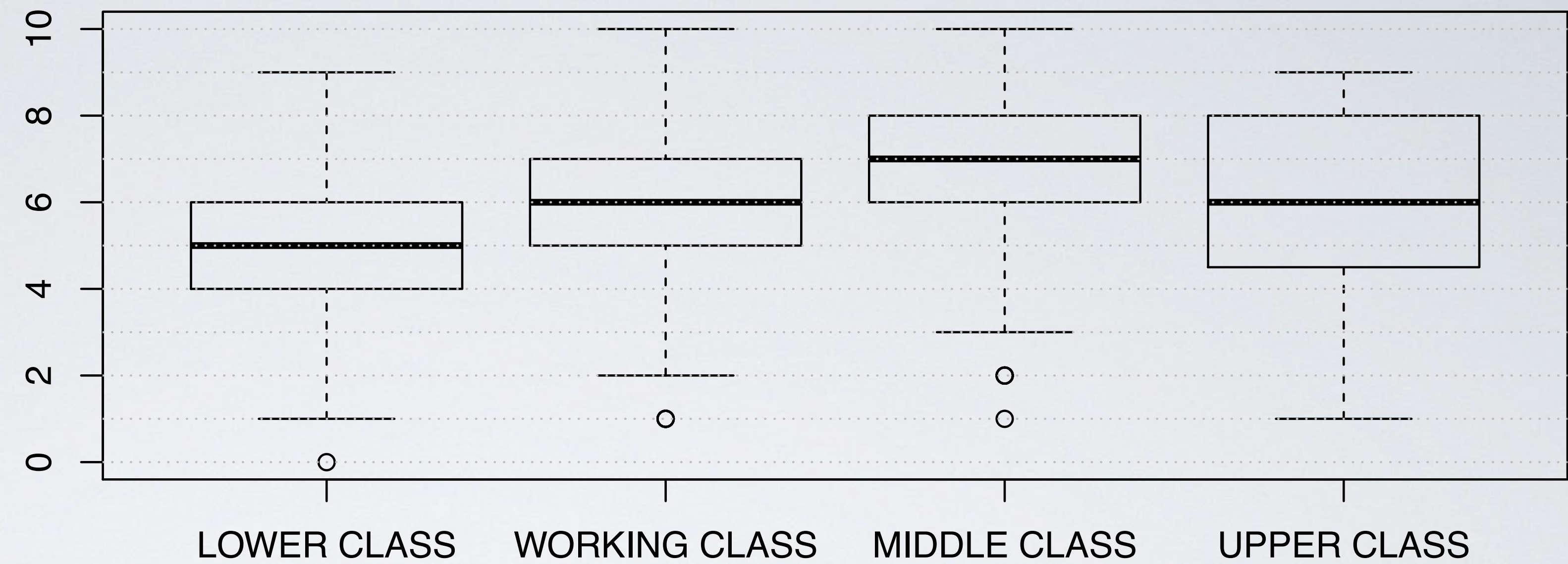


# self identified social class class

If you were asked to use one of four names for your social class, which would you say you belong in: the lower class, the working class, the middle class, or the upper class?



exploratory  
analysis

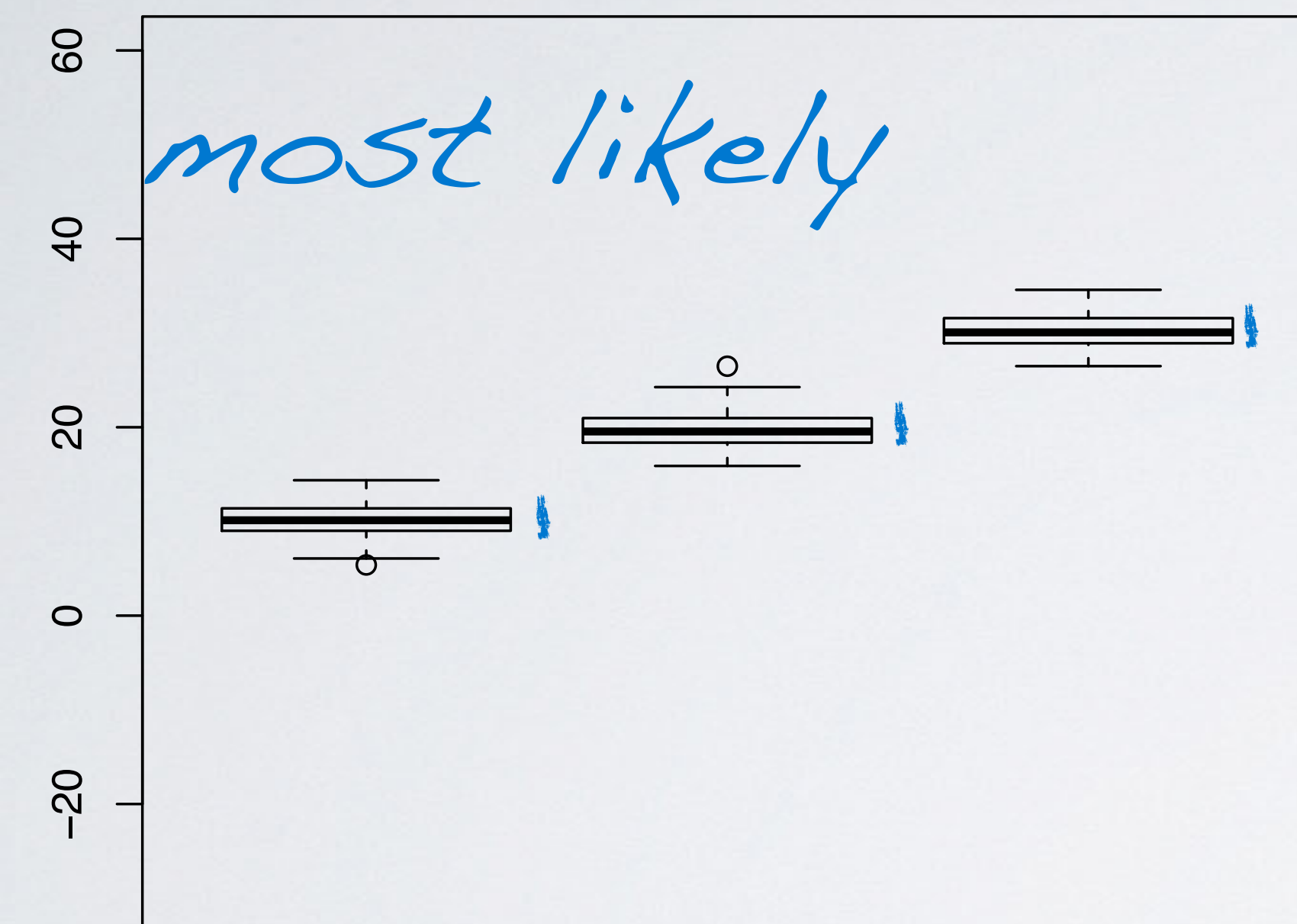


	n	mean	sd
lower class	41	5.07	2.24
working class	407	5.75	1.87
middle class	331	6.76	1.89
upper class	16	6.19	2.34
overall	795	6.14	1.98

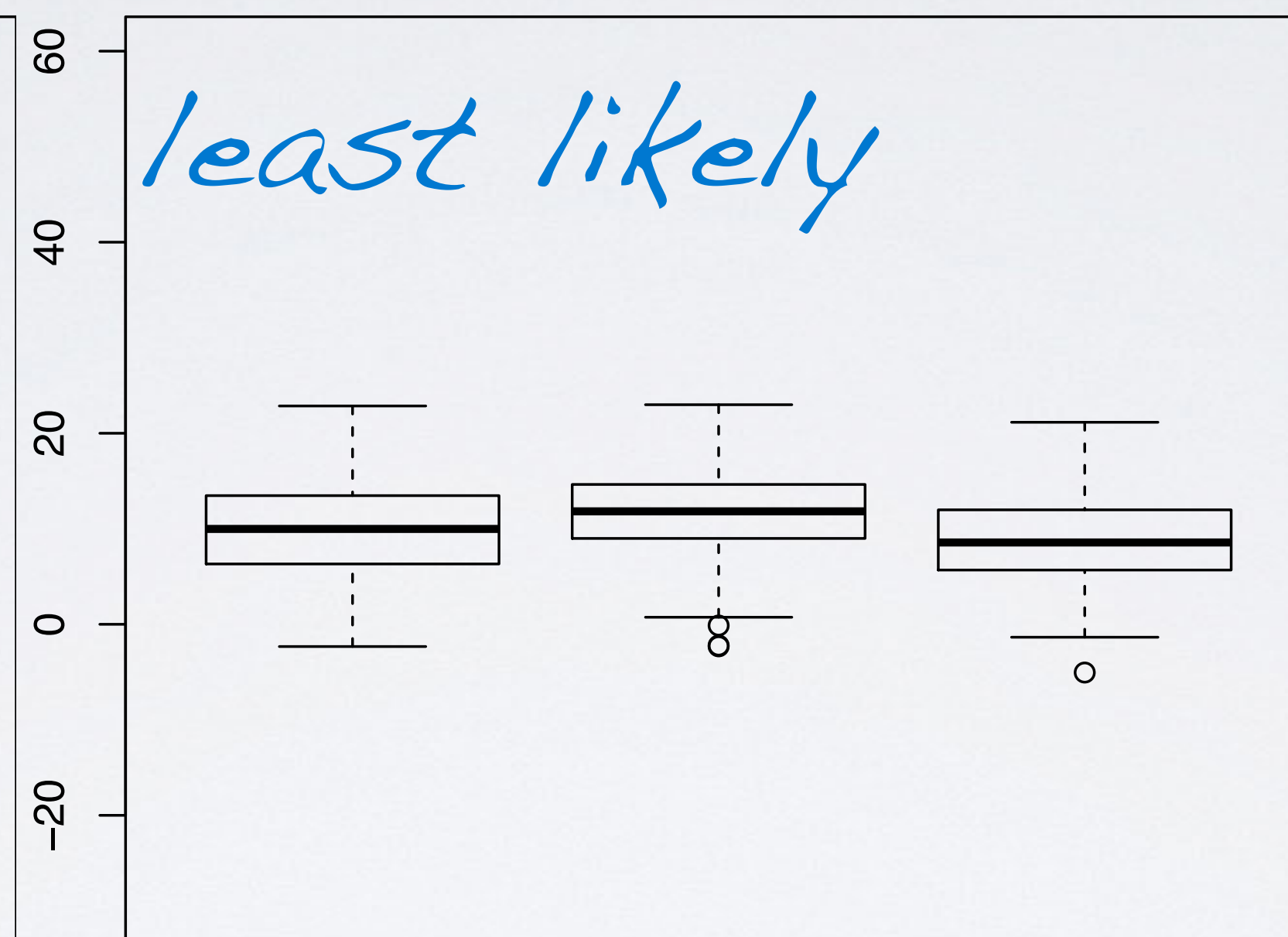


Which of the following plots shows groups with means that are most and least likely to be significantly different from each other?

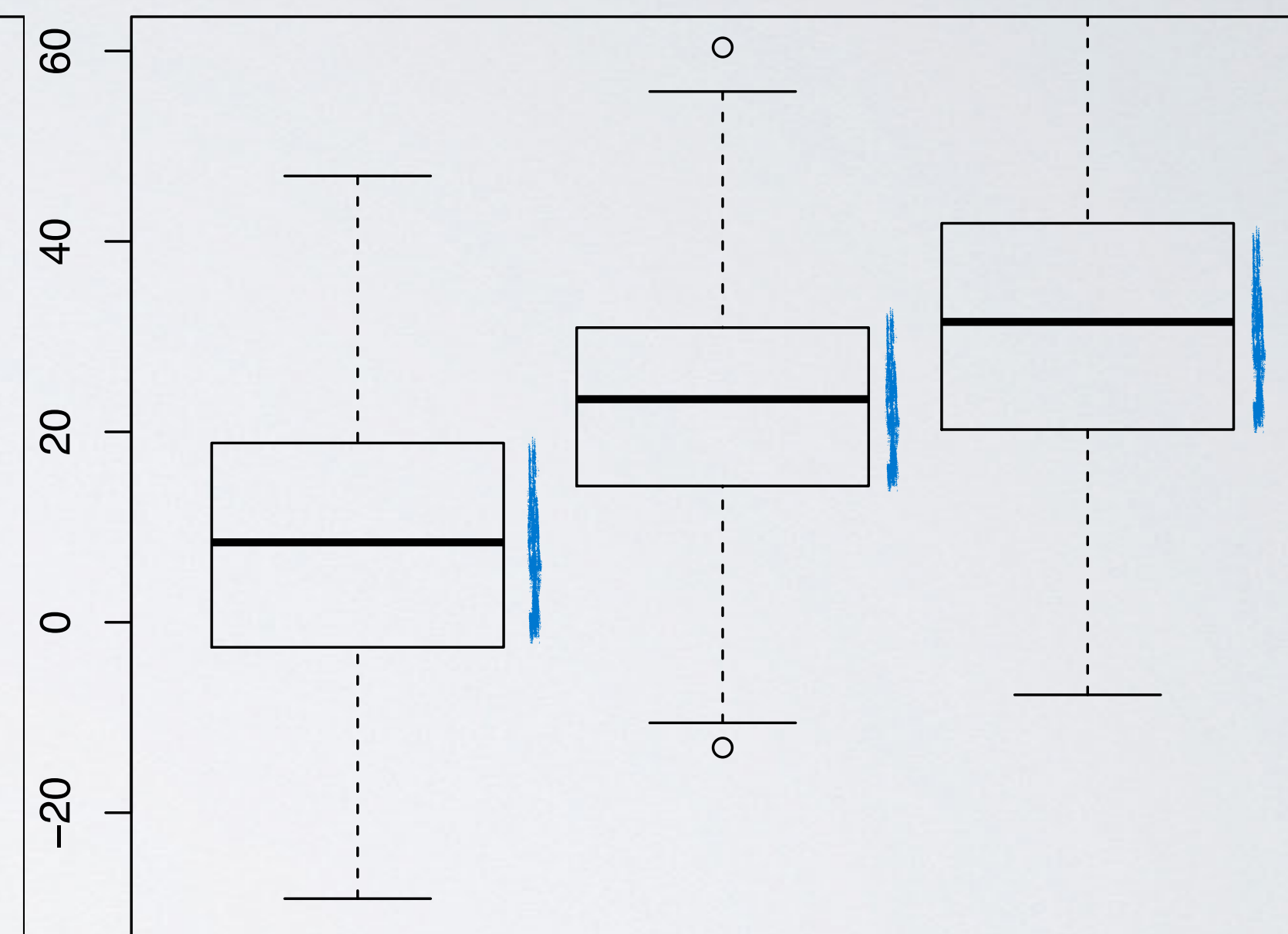
I



II



III



Is there a difference between the average vocabulary scores of Americans from different (self reported) classes?

- ▶ Compare means of 2 groups using a T statistic.
- ▶ Compare means of 3+ groups using a new test called **analysis of variance (ANOVA)** and a new statistic called **F**.



# anova

**H<sub>0</sub>:** The mean outcome is the same across all categories

$$\mu_1 = \mu_2 = \cdots = \mu_k$$

$\mu_i$  : mean of the outcome for observations in category  $i$        $k$  : number of groups

**H<sub>A</sub>:** At least one pair of means are different from each other

## t-test

Compare means from **two** groups: are so far apart that the observed difference cannot reasonably be attributed to sampling variability?

$$H_0 : \mu_1 = \mu_2$$

## anova

Compare means from **more than two** groups: are they so far apart that the observed differences cannot all reasonably be attributed to sampling variability?

$$H_0 : \mu_1 = \mu_2 = \cdots = \mu_k$$



## t-test

Compute a test statistic (a ratio).

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{SE_{(\bar{x}_1 - \bar{x}_2)}}$$

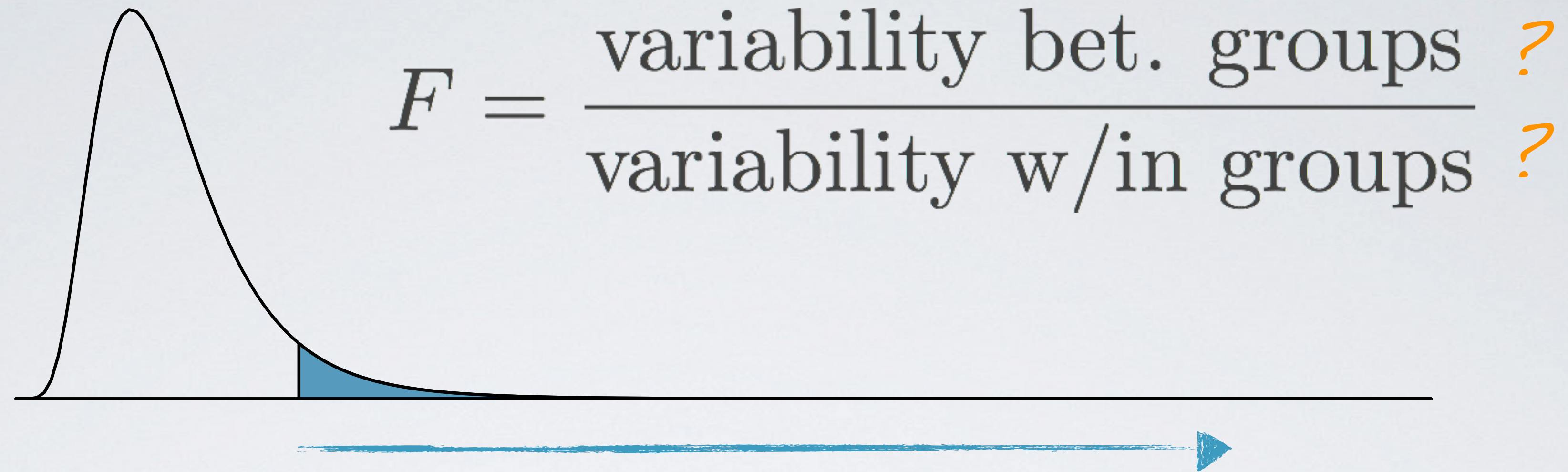
## anova

Compute a test statistic (a ratio).

$$F = \frac{\text{variability bet. groups}}{\text{variability w/in groups}}$$

- ▶ Large test statistics lead to small p-values.
- ▶ If the p-value is small enough  $H_0$  is rejected, and we conclude that the data provide evidence of a difference in the population means.





- ▶ In order to be able to reject  $H_0$ , we need a small p-value, which requires a large F statistic.
- ▶ Obtaining a large F statistic requires that the variability between sample means is greater than the variability within the samples.