



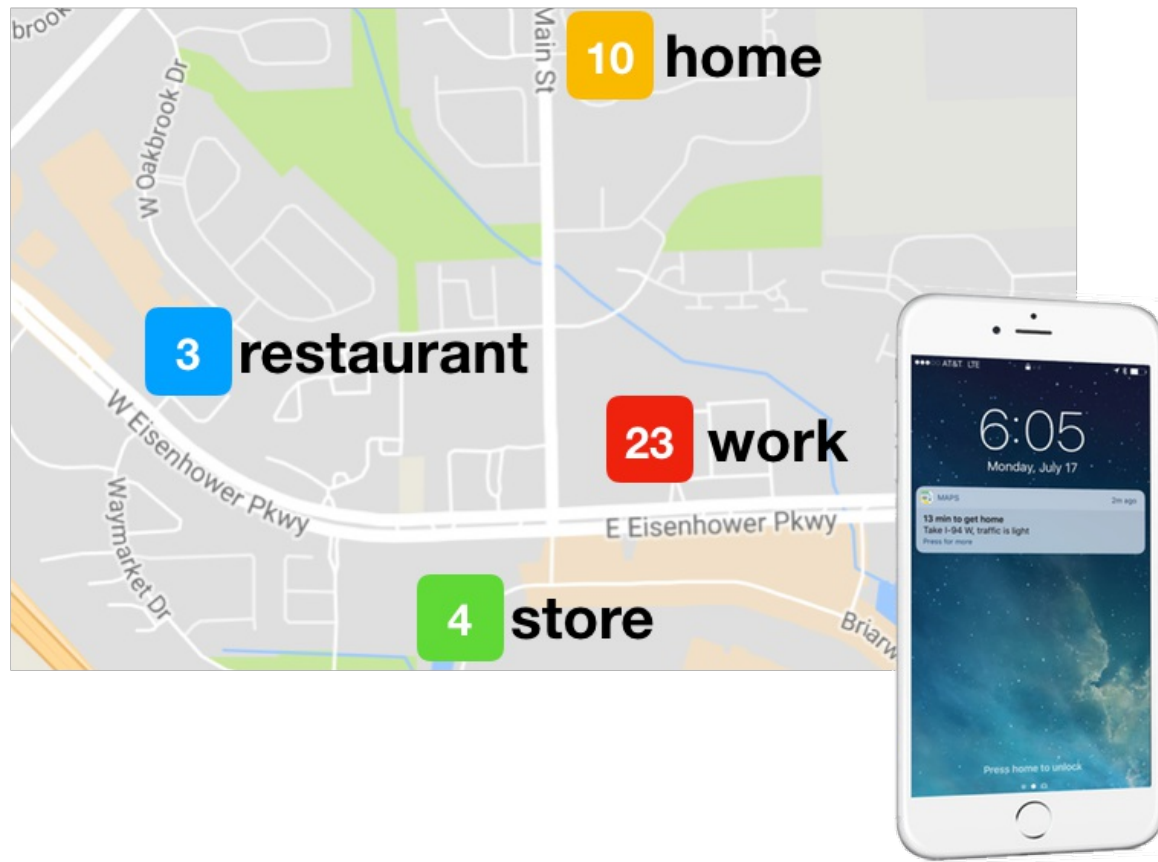
SUPERVISED LEARNING IN R: CLASSIFICATION

Understanding Bayesian methods

Brett Lantz
Instructor



Estimating probability



The **probability** of A is denoted $P(A)$

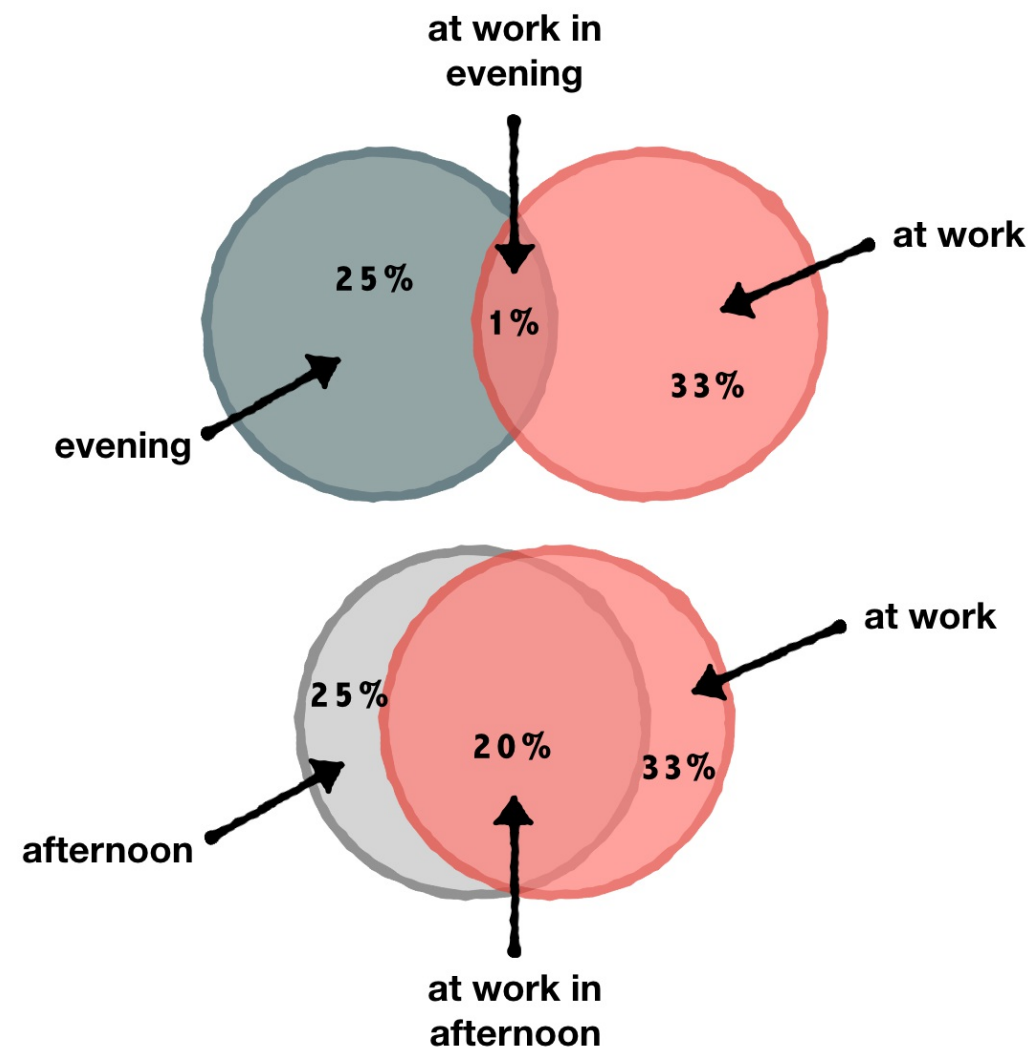
- $P(\text{work}) = 23 / 40 = 57.5\%$
- $P(\text{store}) = 4 / 40 = 10.0\%$



Joint probability and independent events

The **joint probability** of events A and B is denoted $P(A \text{ and } B)$

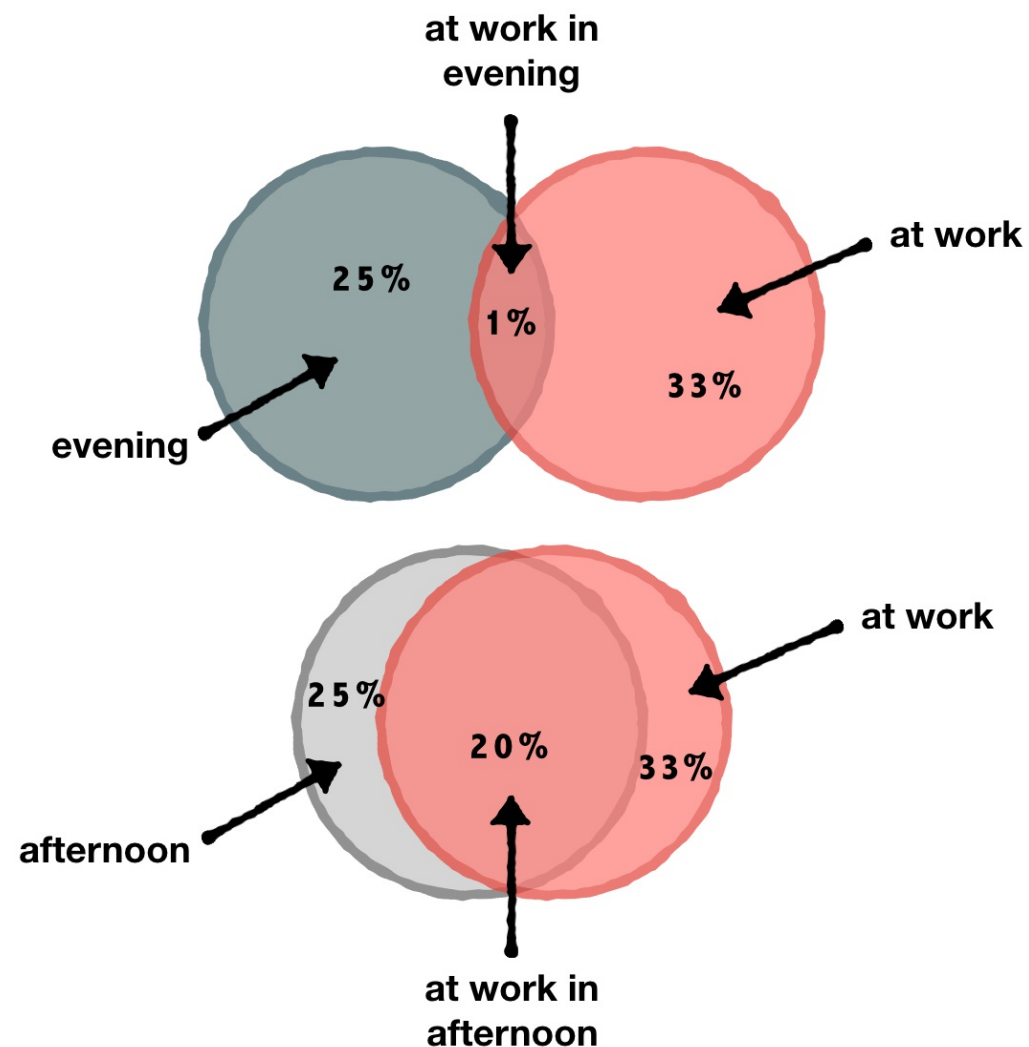
- $P(\text{work and evening}) = 1\%$
- $P(\text{work and afternoon}) = 20\%$



Conditional probability and dependent events

The **conditional probability** of events A and B is denoted $P(A | B)$

- $P(A | B) = P(A \text{ and } B) / P(B)$
- $P(\text{work} | \text{evening}) = 1 / 25 = 4\%$
- $P(\text{work} | \text{afternoon}) = 20 / 25 = 80\%$





Making predictions with Naive Bayes

```
# building a Naive Bayes model  
library(naivebayes)  
m <- naive_bayes(location ~ time_of_day, data = location_history)
```

```
# making predictions with Naive Bayes  
future_location <- predict(m, future_conditions)
```



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Let's practice!



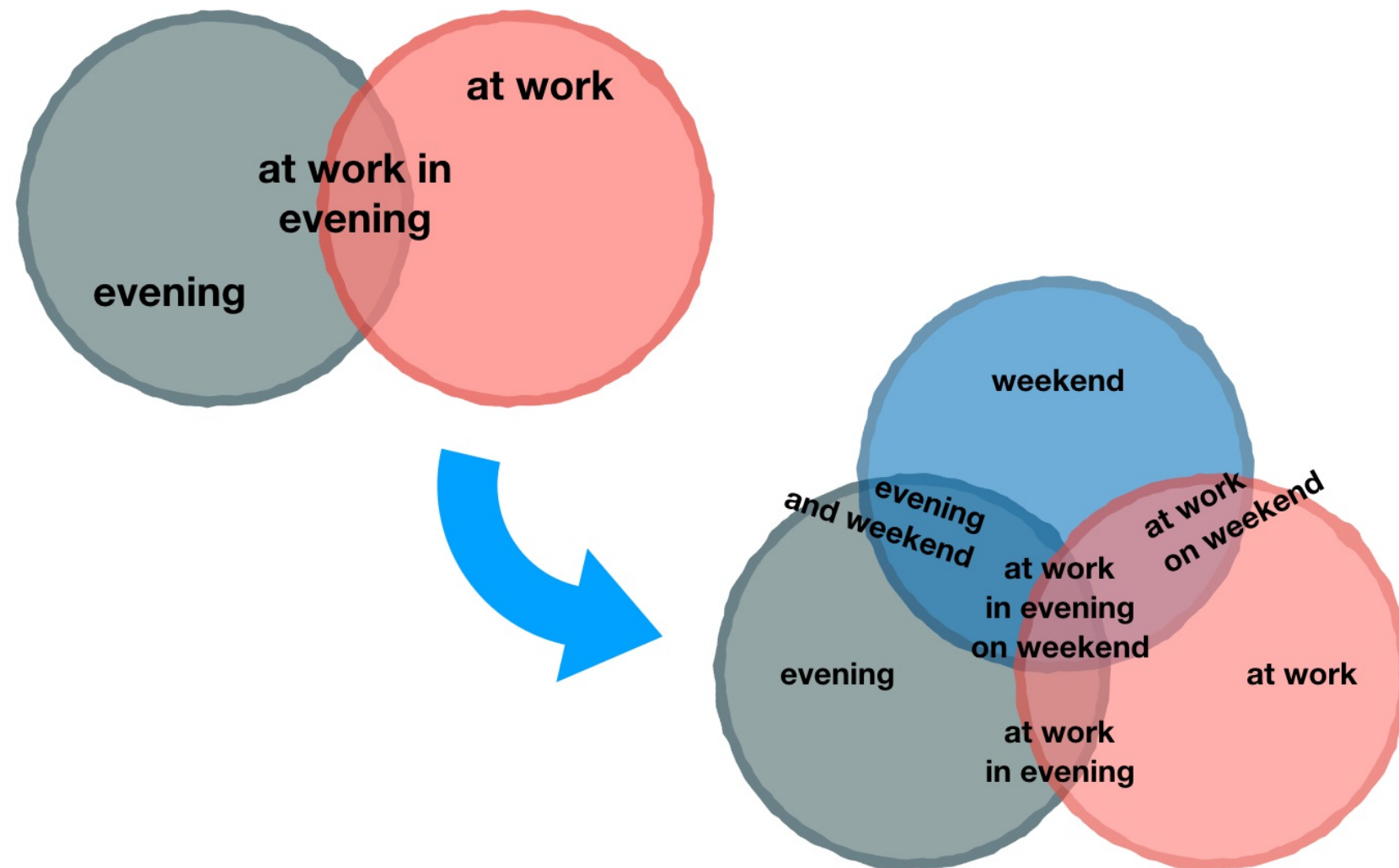
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Understanding NB's "naivety"

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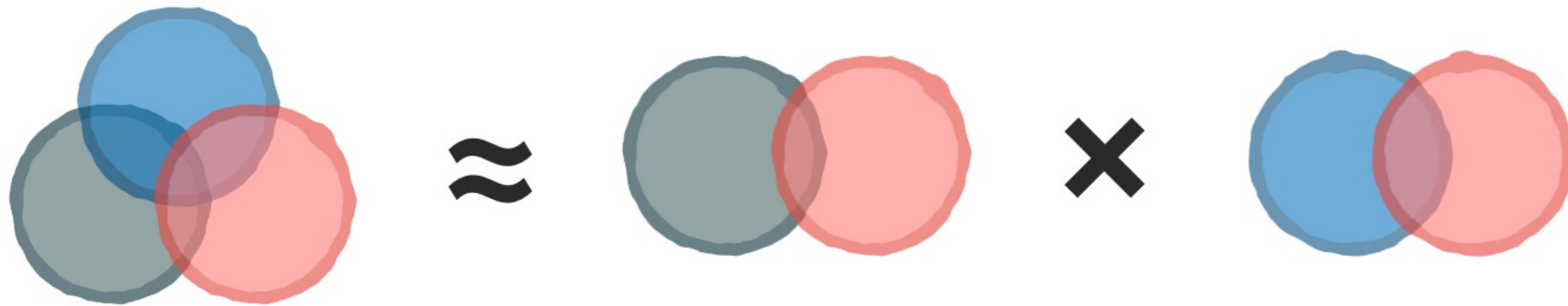


The challenge of multiple predictors



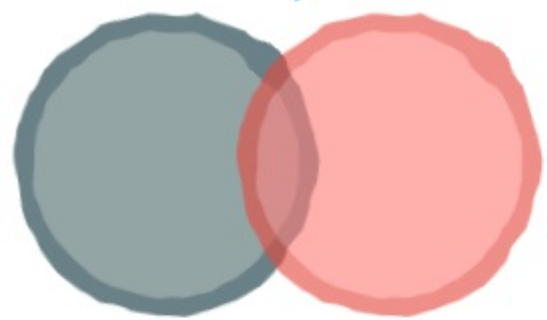


A "naive" simplification



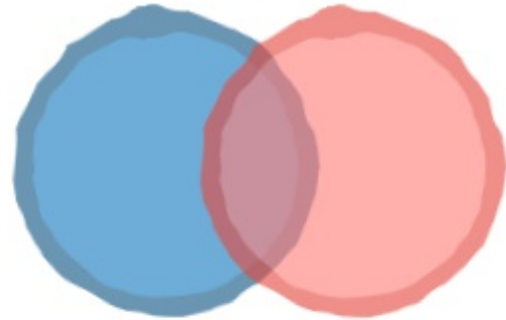


An "infrequent" problem



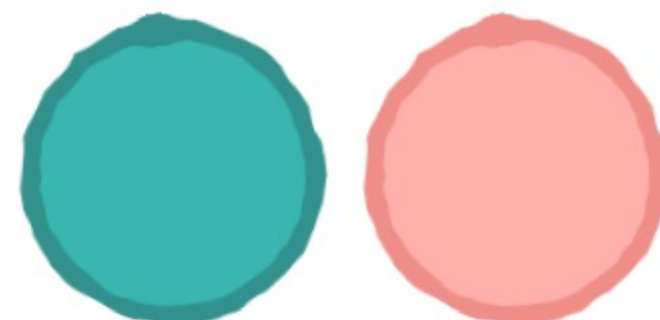
$$P(A \cap B) = 0.10$$

×



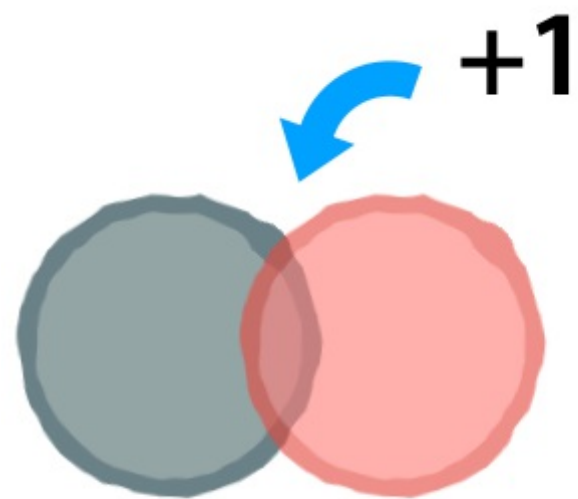
$$P(A \cap B) = 0.30$$

×



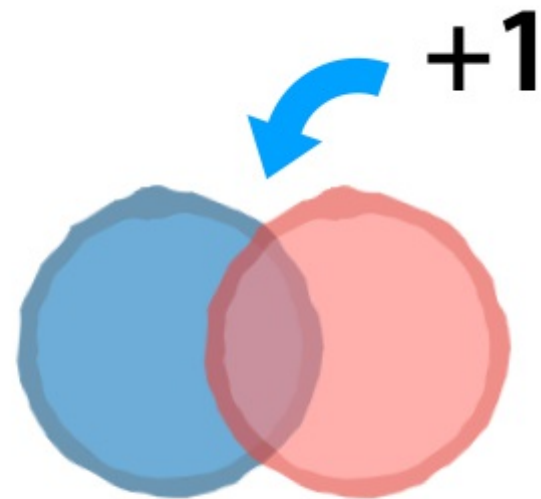
$$P(A \cap B) = 0.00$$

The Laplace correction



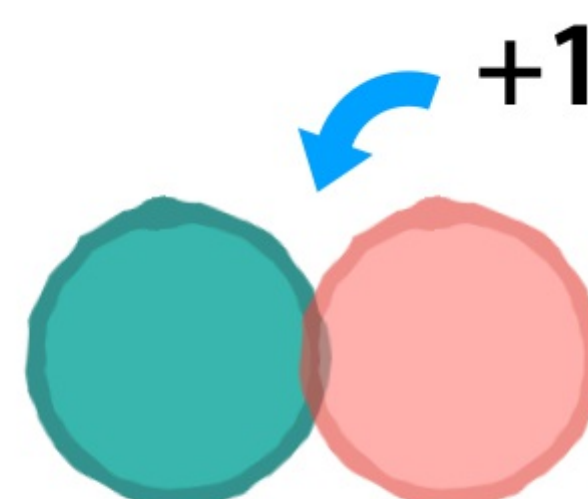
$$P(A \cap B) = 0.11$$

×



$$P(A \cap B) = 0.30$$

×



$$P(A \cap B) = 0.01$$



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Let's practice!



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Applying Naive Bayes to other problems

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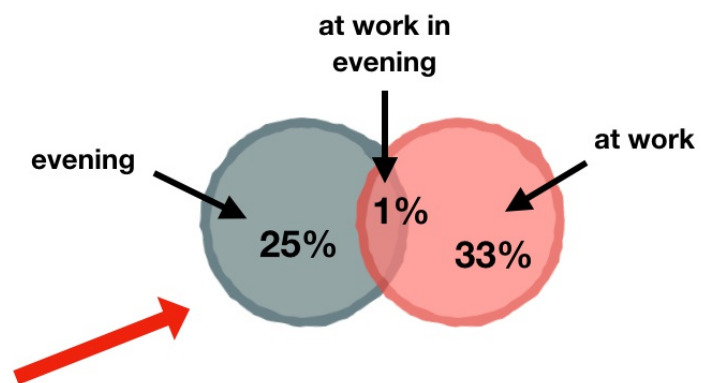


How Naive Bayes uses data

locations								
	month	day	weekday	daytype	hour	hourtype	location	
1	1	4	wednesday	weekday	0	night	home	
2	1	4	wednesday	weekday	1	night	home	
3	1	4	wednesday	weekday	2	night	home	
4	1	4	wednesday	weekday	3	night	home	
5	1	4	wednesday	weekday	4	night	home	
6	1	4	wednesday	weekday	5	night	home	
7	1	4	wednesday	weekday	6	morning	home	
8	1	4	wednesday	weekday	7	morning	home	
9	1	4	wednesday	weekday	8	morning	home	
10	1	4	wednesday	weekday	9	morning	office	
11	1	4	wednesday	weekday	10	morning	office	
12	1	4	wednesday	weekday	11	morning	office	
13	1	4	wednesday	weekday	12	afternoon	office	

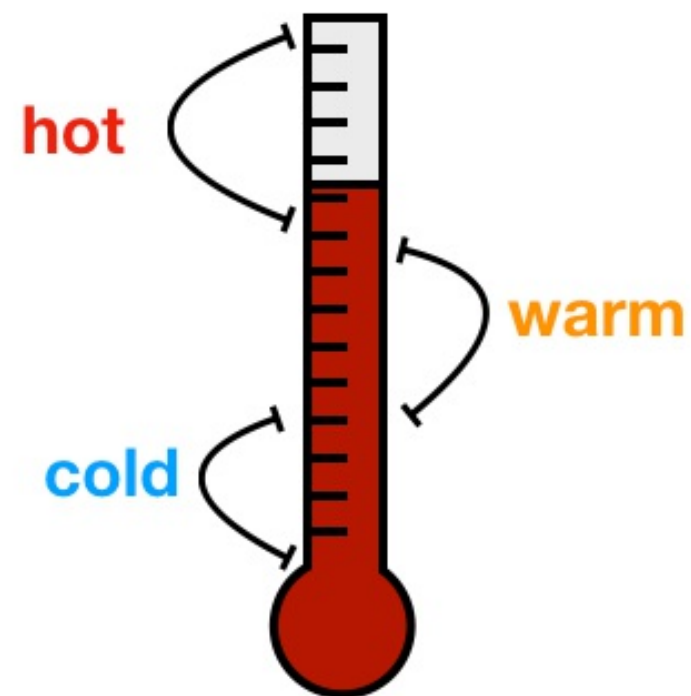
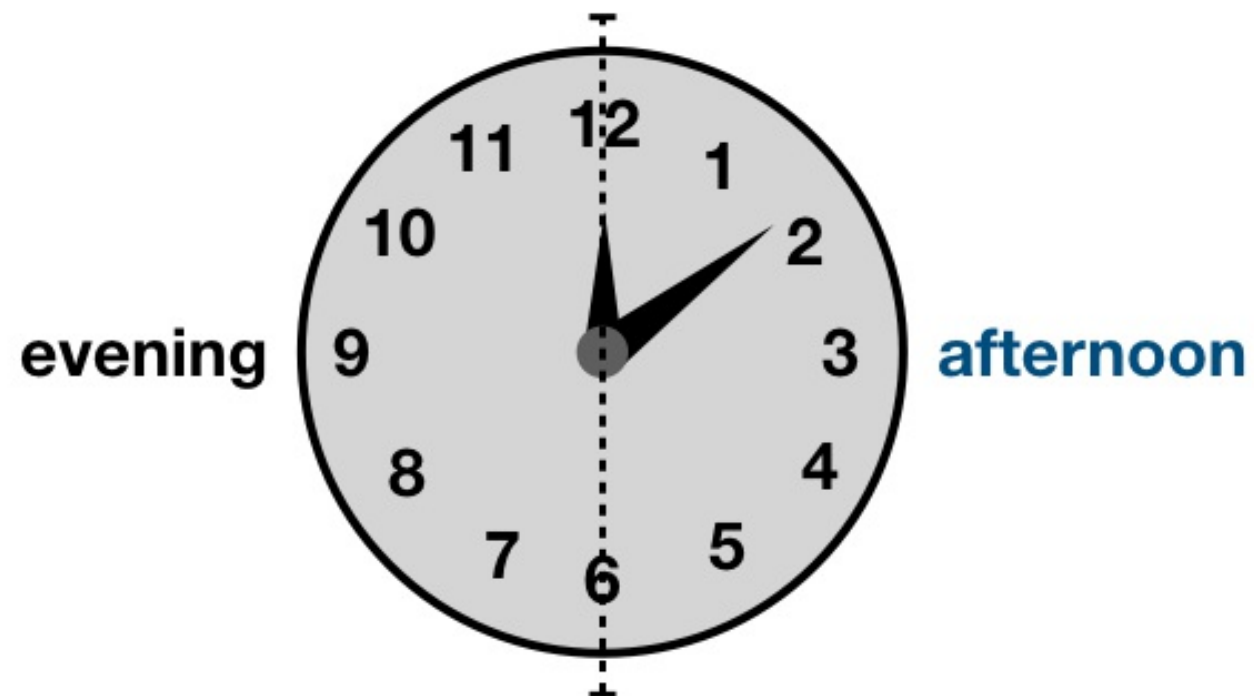
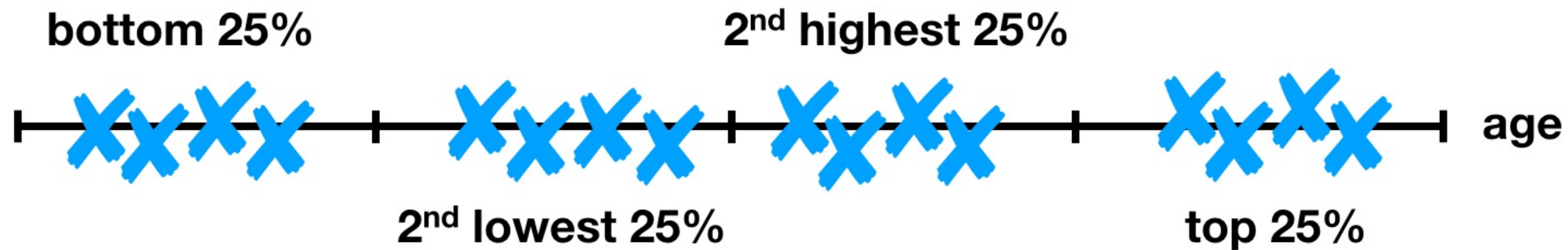


		not evening	evening	
	at work	705	22	
	not at work	933	524	

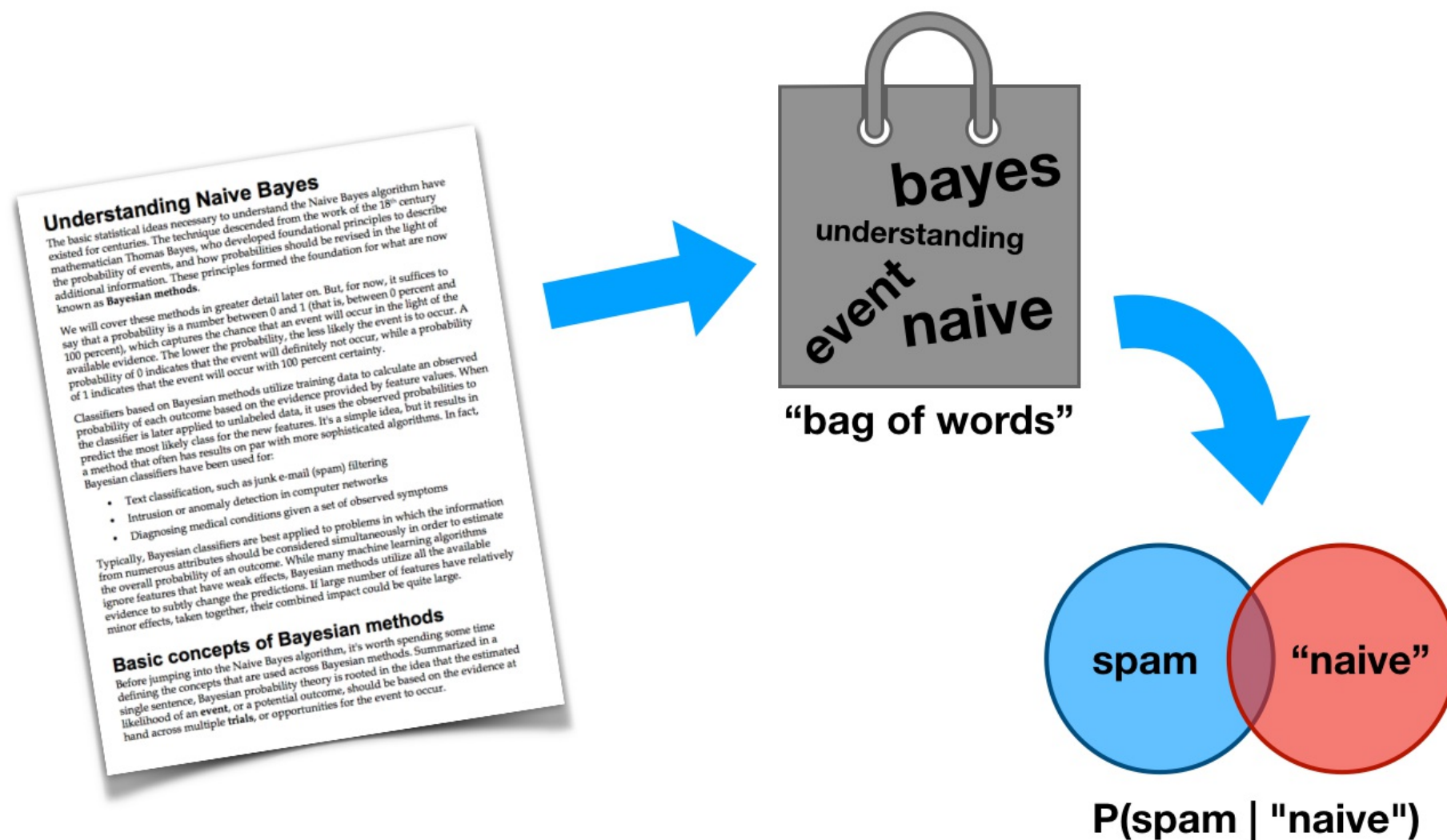




Binning numeric data for Naive Bayes



Preparing text data for Naive Bayes





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Let's practice!