*## Here, because n=20, we can actually enumerate all possible outcomes*

*## There are (n+c-1)! / [(c-1)!n!] different tables with c categories and given margin n*

n = 20

luis = expand.grid**(**0:20**,**0:20**,**0:20**)** *# all possible permutations of numbers 0:20*

head**(**luis**)**

tail**(**luis**)**

dim**(**luis**)**

luis1 = luis**[**rowSums**(**luis**)**==20**,]** *#filter out only those that have a sum of 20*

dim**(**luis1**)** *#this should have (n+c-1)! / [(c-1)!n!] different rows, and it does!*

choose**(**20+3-1**,**3-1**)**

prob0 = c**(**0.6**,**0.3**,**0.1**)** *#null probabilities*

table.probs = apply**(**luis1**,**1**,**function**(**ro**)** dmultinom**(**ro**,**size=n**,**prob=prob0**))** *#this gives the exact probability of every possible table under the null hypothesis*

head**(**cbind**(**luis1**,**table.probs**))**

X2 = apply**(**luis1**,**1**,**function**(**ro**)** sum**((**ro-n\*prob0**)**^2/**(**n\*prob0**)))** *#compute X2 for eachpossible table*

obs = c**(**6**,**5**,**2**)** *#actual observed counts*

X2.obs = sum**((**obs-n\*prob0**)**^2/**(**n\*prob0**))**

p.exact = sum**(**table.probs**[**X2>=X2.obs**])**

p.exact

p.asympt = 1-pchisq**(**X2.obs**,**df=2**)**

p.asympt

*## Generating the exact distribution by randomly simulating from the multinomial under H0:*

n = 186

prob0 = c**(**0.6**,**0.3**,**0.1**)** *#null probabilities*

sims = 10000

tables = rmultinom**(**sims**,**n**,**prob0**)** *#this returns multinomial samples in columns!*

X2 = apply**(**tables**,**2**,**function**(**co**)** sum**((**co-n\*prob0**)**^2/**(**n\*prob0**)))**

obs = c**(**90**,**70**,**26**)**

X2.obs = sum**((**obs-n\*prob0**)**^2/**(**n\*prob0**))**

mean**(**X2>=X2.obs**)** *# this is a pretty accurate approximation of the exact P-value*

hist**(**X2**)**

abline**(**v=X2.obs**,** col="red"**)**

chisq.test**(**obs**,** p=prob0**,** correct=FALSE**)** *#this gives asymptotic P-value*

chisq.test**(**obs**,** p=prob0**,** correct=FALSE**,** simulate.p.value=TRUE**,** B=10000**)** *#this gives exact P-value*

G2 = apply**(**tables**,**2**,**function**(**co**)** 2\*sum**(**co\*log**(**co/**(**n\*prob0**))))**

G2.obs = 2\*sum**(**obs\*log**(**obs/**(**n\*prob0**)))**

mean**(**G2>=G2.obs**)**

hist**(**G2**)**

abline**(**v=G2.obs**,** col="red"**)**