

Stat 19, Probability and Poker. Rick Paik Schoenberg

Outline for the day:

1. R.
2. Discuss harrington1.pdf .
3. Gus and Daniel.
4. Counting and combinations.
5. $P(A\spadesuit \text{ after first ace})$.

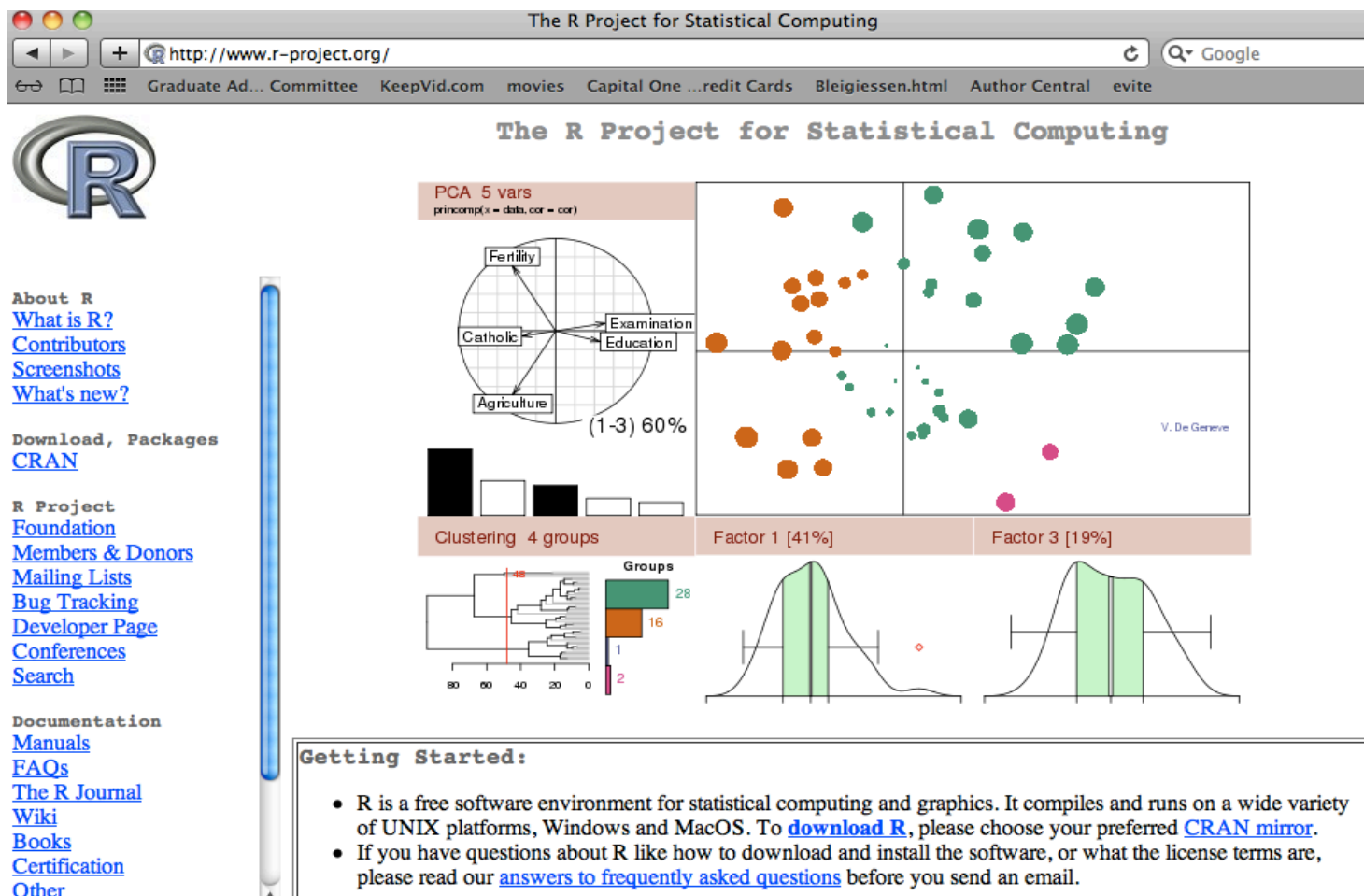
Read harrington2.pdf for next time.

Think of 1-2 questions or comments for next time.

The course website is <http://www.stat.ucla.edu/~frederic/19/F21> .

R. To download and install R, start at www.r-project.org, click on “download R”, scroll down and click on one of the mirrors closest to you.

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The R Project for Statistical Computing

http://www.r-project.org/

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The R Project for Statistical Computing

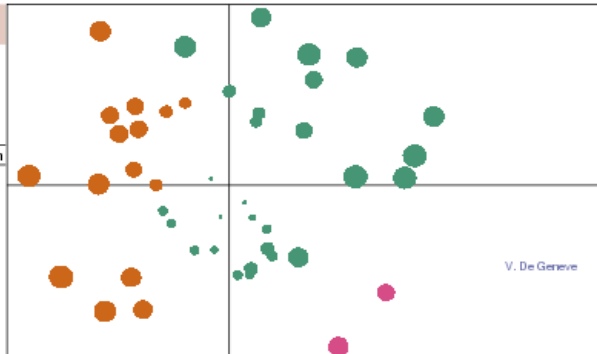
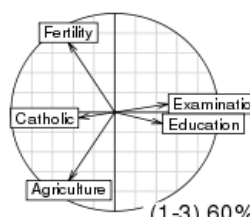
About R
[What is R?](#)
[Contributors](#)
[Screenshots](#)
[What's new?](#)

Download, Packages
[CRAN](#)

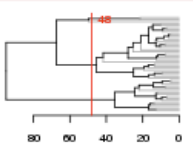
R Project
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[Members & Donors](#)
[Mailing Lists](#)
[Bug Tracking](#)
[Developer Page](#)
[Conferences](#)
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Documentation
[Manuals](#)
[FAQs](#)
[The R Journal](#)
[Wiki](#)
[Books](#)
[Certification](#)
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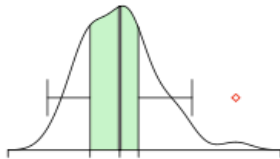
PCA 5 vars
princomp(x = data, cor = cor)



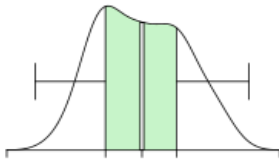
Clustering 4 groups



Factor 1 [41%]



Factor 3 [19%]

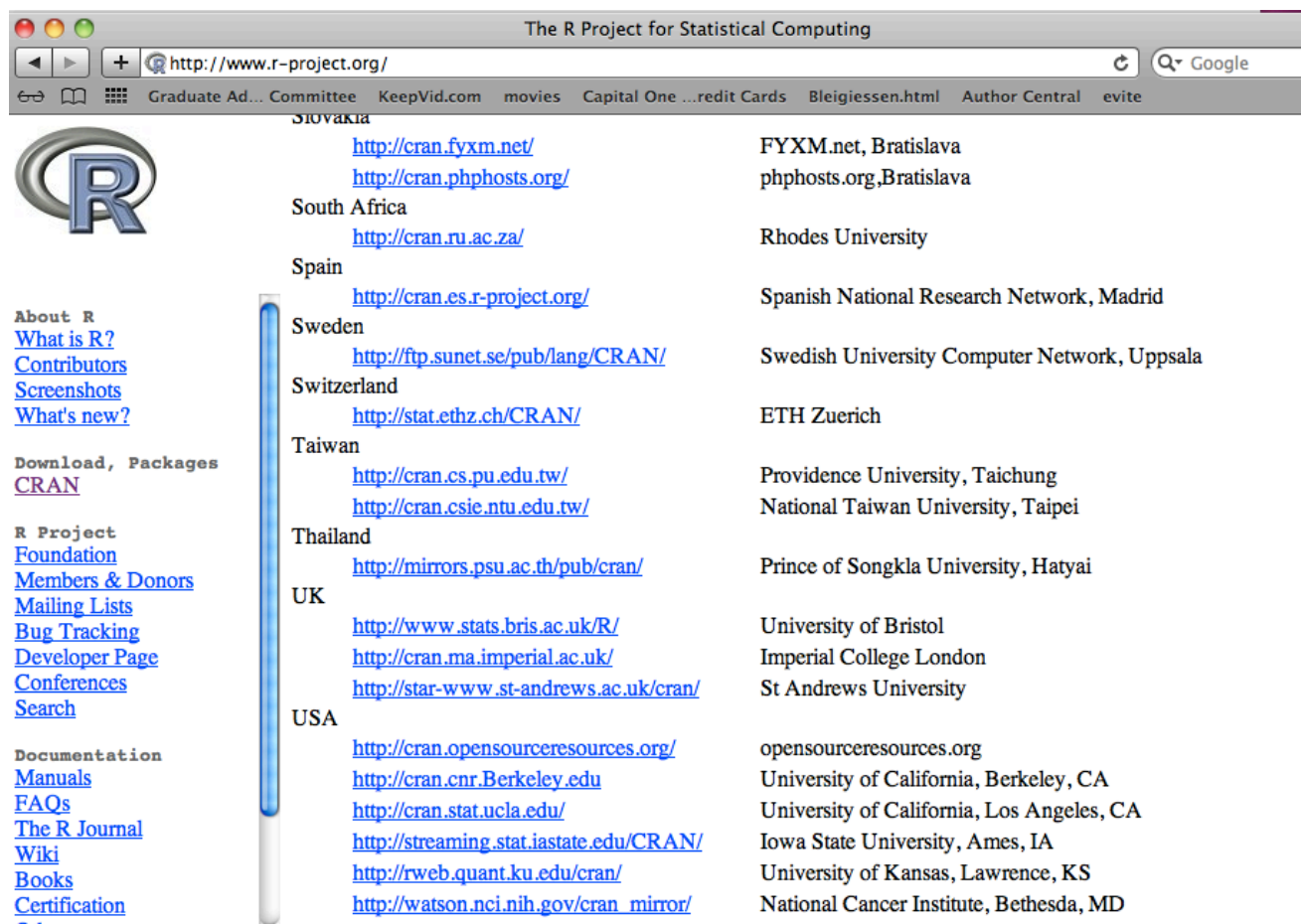


Getting Started:

- R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To **download R**, please choose your preferred [CRAN mirror](#).
- If you have questions about R like how to download and install the software, or what the license terms are, please read our [answers to frequently asked questions](#) before you send an email.

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From there, click on “download R for ...”, and then get the latest version.

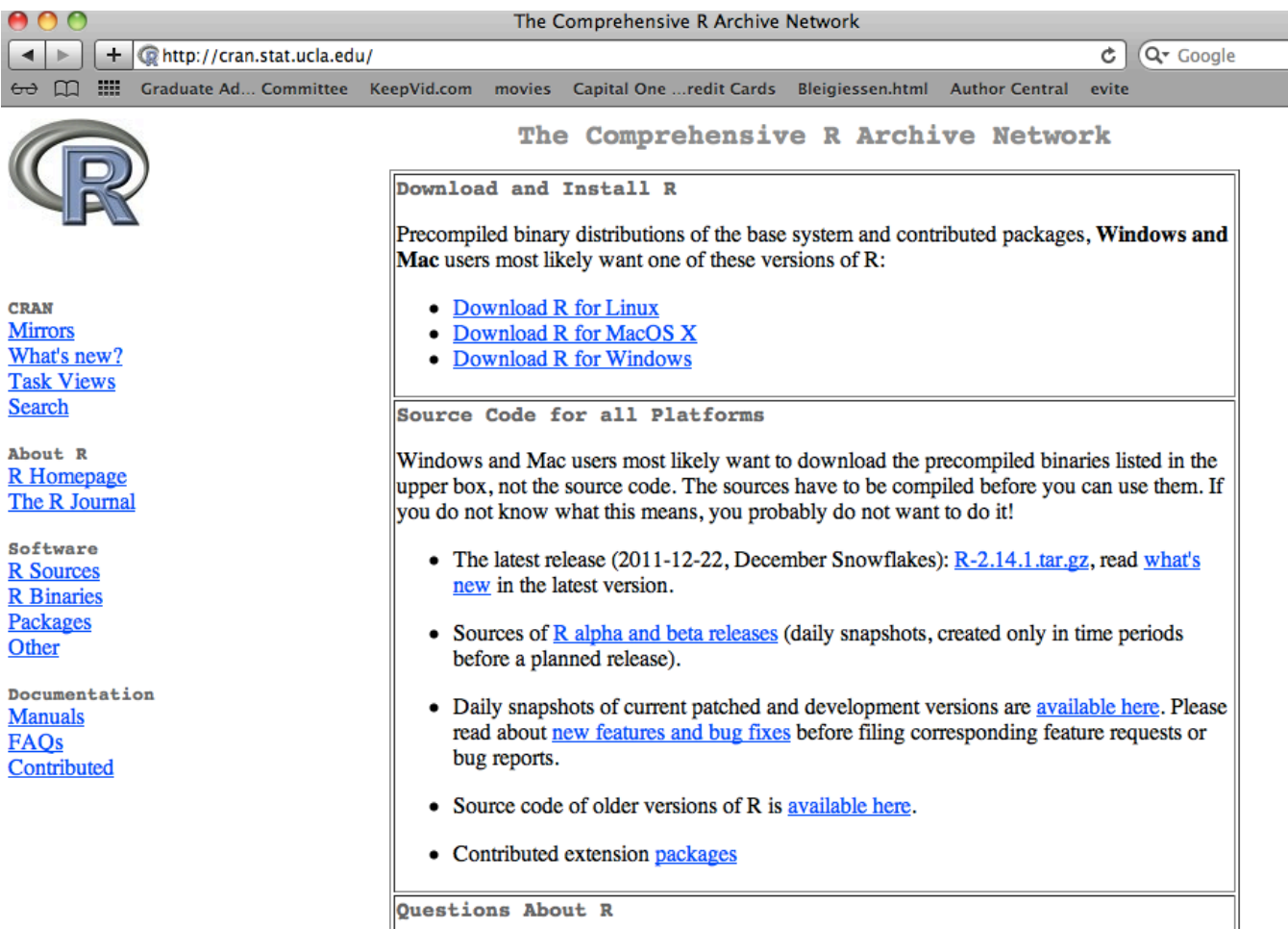


The screenshot shows a web browser window titled "The R Project for Statistical Computing" with the URL <http://www.r-project.org/>. The page features the R logo and a navigation menu on the left. The main content is a list of mirrors organized by country, each with a URL and the name of the hosting institution.

Country	URL	Institution
Slovakia	http://cran.fyxm.net/	FYXM.net, Bratislava
	http://cran.phphosts.org/	phphosts.org, Bratislava
South Africa	http://cran.ru.ac.za/	Rhodes University
Spain	http://cran.es.r-project.org/	Spanish National Research Network, Madrid
Sweden	http://ftp.sunet.se/pub/lang/CRAN/	Swedish University Computer Network, Uppsala
Switzerland	http://stat.ethz.ch/CRAN/	ETH Zuerich
Taiwan	http://cran.cs.pu.edu.tw/	Providence University, Taichung
	http://cran.csie.ntu.edu.tw/	National Taiwan University, Taipei
Thailand	http://mirrors.psu.ac.th/pub/cran/	Prince of Songkla University, Hatyai
UK	http://www.stats.bris.ac.uk/R/	University of Bristol
	http://cran.ma.imperial.ac.uk/	Imperial College London
	http://star-www.st-andrews.ac.uk/cran/	St Andrews University
USA	http://cran.opensourceresources.org/	opensourceresources.org
	http://cran.cnr.Berkeley.edu	University of California, Berkeley, CA
	http://cran.stat.ucla.edu/	University of California, Los Angeles, CA
	http://streaming.stat.iastate.edu/CRAN/	Iowa State University, Ames, IA
	http://rweb.quant.ku.edu/cran/	University of Kansas, Lawrence, KS
	http://watson.nci.nih.gov/cran_mirror/	National Cancer Institute, Bethesda, MD

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The screenshot shows a web browser window titled "The Comprehensive R Archive Network" with the address bar displaying "http://cran.stat.ucla.edu/". The browser's address bar also shows a search engine (Google) and several bookmarks including "Graduate Ad...", "Committee", "KeepVid.com", "movies", "Capital One ...redit Cards", "Bleigiessen.html", "Author Central", and "evite".

The main content area of the page is titled "The Comprehensive R Archive Network" and is divided into several sections:

- Download and Install R**

Precompiled binary distributions of the base system and contributed packages, **Windows and Mac** users most likely want one of these versions of R:

 - [Download R for Linux](#)
 - [Download R for MacOS X](#)
 - [Download R for Windows](#)
- Source Code for all Platforms**

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

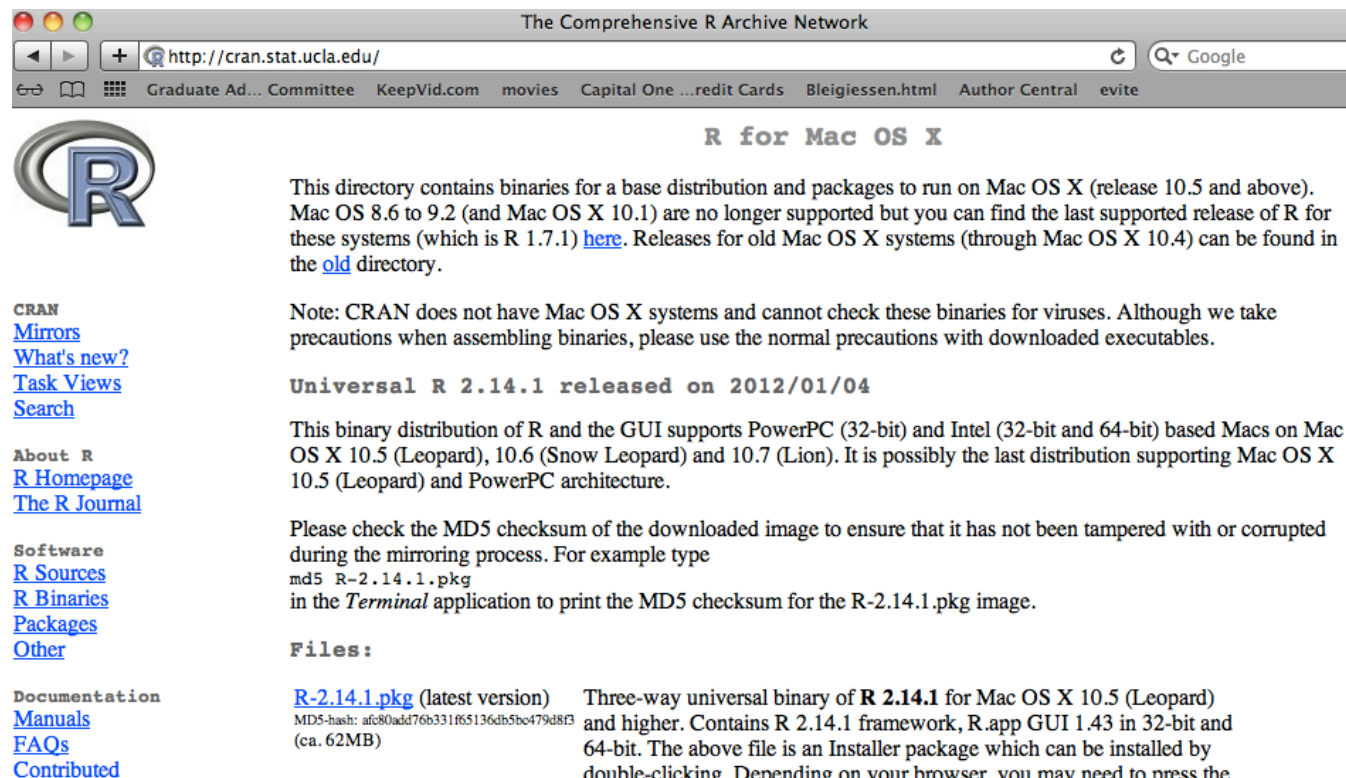
 - The latest release (2011-12-22, December Snowflakes): [R-2.14.1.tar.gz](#), read [what's new](#) in the latest version.
 - Sources of [R alpha and beta releases](#) (daily snapshots, created only in time periods before a planned release).
 - Daily snapshots of current patched and development versions are [available here](#). Please read about [new features and bug fixes](#) before filing corresponding feature requests or bug reports.
 - Source code of older versions of R is [available here](#).
 - Contributed extension [packages](#)
- Questions About R**

On the left side of the page, there is a navigation menu with the following links:

- CRAN
 - [Mirrors](#)
 - [What's new?](#)
 - [Task Views](#)
 - [Search](#)
- About R
 - [R Homepage](#)
 - [The R Journal](#)
- Software
 - [R Sources](#)
 - [R Binaries](#)
 - [Packages](#)
 - [Other](#)
- Documentation
 - [Manuals](#)
 - [FAQs](#)
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The Comprehensive R Archive Network

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R for Mac OS X

This directory contains binaries for a base distribution and packages to run on Mac OS X (release 10.5 and above). Mac OS 8.6 to 9.2 (and Mac OS X 10.1) are no longer supported but you can find the last supported release of R for these systems (which is R 1.7.1) [here](#). Releases for old Mac OS X systems (through Mac OS X 10.4) can be found in the [old](#) directory.

Note: CRAN does not have Mac OS X systems and cannot check these binaries for viruses. Although we take precautions when assembling binaries, please use the normal precautions with downloaded executables.

Universal R 2.14.1 released on 2012/01/04

This binary distribution of R and the GUI supports PowerPC (32-bit) and Intel (32-bit and 64-bit) based Macs on Mac OS X 10.5 (Leopard), 10.6 (Snow Leopard) and 10.7 (Lion). It is possibly the last distribution supporting Mac OS X 10.5 (Leopard) and PowerPC architecture.

Please check the MD5 checksum of the downloaded image to ensure that it has not been tampered with or corrupted during the mirroring process. For example type

```
md5 R-2.14.1.pkg
```

in the *Terminal* application to print the MD5 checksum for the R-2.14.1.pkg image.

Files:

R-2.14.1.pkg (latest version) MD5-hash: <code>afc80add76b331f65136db5bc479d8f3</code> (ca. 62MB)	Three-way universal binary of R 2.14.1 for Mac OS X 10.5 (Leopard) and higher. Contains R 2.14.1 framework, R.app GUI 1.43 in 32-bit and 64-bit. The above file is an Installer package which can be installed by double-clicking. Depending on your browser, you may need to press the control key and click on this link to download the file.
------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

This package **only** contains the R framework, 32-bit GUI (R.app) and 64-bit GUI (R64.app). **For Tcl/Tk libraries (needed if you want to use tcltk) and GNU Fortran (needed if you want to compile packages from sources that contain FORTRAN code) please see [the tools](#)**

CRAN
[Mirrors](#)
[What's new?](#)
[Task Views](#)
[Search](#)

About R
[R Homepage](#)
[The R Journal](#)

Software
[R Sources](#)
[R Binaries](#)
[Packages](#)
[Other](#)

Documentation
[Manuals](#)
[FAQs](#)
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Ly vs. Negreanu.

Ex. Suppose you have two ♣s, and there are exactly two ♣s on the flop. Given this info, what is $P(\text{at least one more } \spadesuit \text{ on turn or river})$?

Answer: $52-5 = 47$ cards left (nine ♣s, 38 others).

So $n = \text{choose}(47,2) = 1081$ combinations for next 2 cards.

Each equally likely (and obviously mutually exclusive).

Two-♣ combos: $\text{choose}(9,2) = 36$. One-♣ combos: $9 \times 38 = 342$.

Total = 378. So answer is $378/1081 = 35.0\%$.

Answer #2: Use the addition rule...

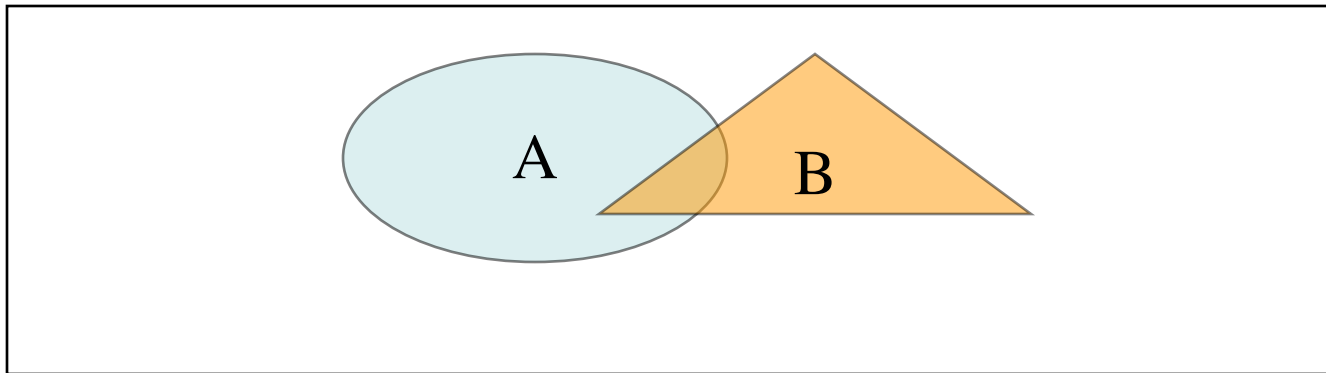
ADDITION RULE, revisited.....

Axioms (initial assumptions/rules) of probability:

- 1) $P(A) \geq 0$.
- 2) $P(A) + P(A^c) = 1$.
- 3) Addition rule:

If A_1, A_2, A_3, \dots are mutually exclusive, then

$$P(A_1 \text{ or } A_2 \text{ or } A_3 \text{ or } \dots) = P(A_1) + P(A_2) + P(A_3) + \dots$$



As a result, even if A and B might not be mutually exclusive,
 $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$.

Ex. You have two ♣s, and there are exactly two ♣s on the flop.
Given this info, what is $P(\text{at least one more } \clubsuit \text{ on turn or river})$?

Answer #1: $52-5 = 47$ cards left (nine ♣s, 38 others).

So $n = \text{choose}(47,2) = 1081$ combinations for next 2 cards.

Each equally likely (and obviously mutually exclusive).

Two- ♣ combos: $\text{choose}(9,2) = 36$. One-♣ combos: $9 \times 38 = 342$.

Total = 378. So answer is $378/1081 = 35.0\%$.

Answer #2: Use the addition rule.

$$\begin{aligned} P(\geq 1 \text{ more } \clubsuit) &= P(\clubsuit \text{ on turn OR river}) \\ &= P(\clubsuit \text{ on turn}) + P(\clubsuit \text{ on river}) - P(\text{both}) \\ &= 9/47 + 9/47 - \text{choose}(9,2)/\text{choose}(47,2) \\ &= 19.15\% + 19.15\% - 3.3\% = 35.0\%. \end{aligned}$$

Counting.

Fact: If A_1, A_2, \dots, A_n are equally likely & mutually exclusive,
and if $P(A_1 \text{ or } A_2 \text{ or } \dots \text{ or } A_n) = 1$,
then $P(A_k) = 1/n$.

[So, you can *count*: $P(A_1 \text{ or } A_2 \text{ or } \dots \text{ or } A_k) = k/n$.]

Ex. You have 76, and the board is KQ54. P(straight)?

[52-2-4=46.] $P(\text{straight}) = P(8 \text{ on river OR } 3 \text{ on river})$

$$= P(8 \text{ on river}) + P(3 \text{ on river}) = 4/46 + 4/46.$$

If there are a_1 distinct possible outcomes on experiment #1, and for each of them, there are a_2 distinct possible outcomes on experiment #2, then there are $a_1 \times a_2$ distinct possible *ordered* outcomes on both.

In general, with j experiments, each with a_i possibilities,
the # of distinct outcomes *where order matters* is $a_1 \times a_2 \times \dots \times a_j$.

Permutations and combinations.

e.g. you get 1 card, opp. gets 1 card. # of distinct possibilities?
 52×51 . [ordered: (A♣, K♦) \neq (K♦, A♣) .]

Each such outcome, where order matters, is called a *permutation*.

Number of permutations of the deck? $52 \times 51 \times \dots \times 1 = 52!$

$$\sim 8.1 \times 10^{67}$$

A combination is a collection of outcomes, where order *doesn't* matter.

e.g. in hold'em, how many *distinct* 2-card hands are possible?

52 x 51 if order matters, but then you'd be double-counting each

[since now (A♣, K♦) = (K♦, A♣)].

So, the number of *distinct* hands where *order doesn't matter* is

$$52 \times 51 / 2.$$

In general, with n distinct objects, the # of ways to choose k *different* ones, *where order doesn't matter*, is

$$\text{"n choose k"} = \binom{n}{k} = \text{choose}(n,k) = \frac{n!}{k! (n-k)!} .$$

$$k! = 1 \times 2 \times \dots \times k. \quad [\text{convention: } 0! = 1.]$$

Deal til first ace appears. Let X = the *next* card after the ace.

$P(X = A\spadesuit)$? $P(X = 2\clubsuit)$?