Using R for Customer Segmentation

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Outline

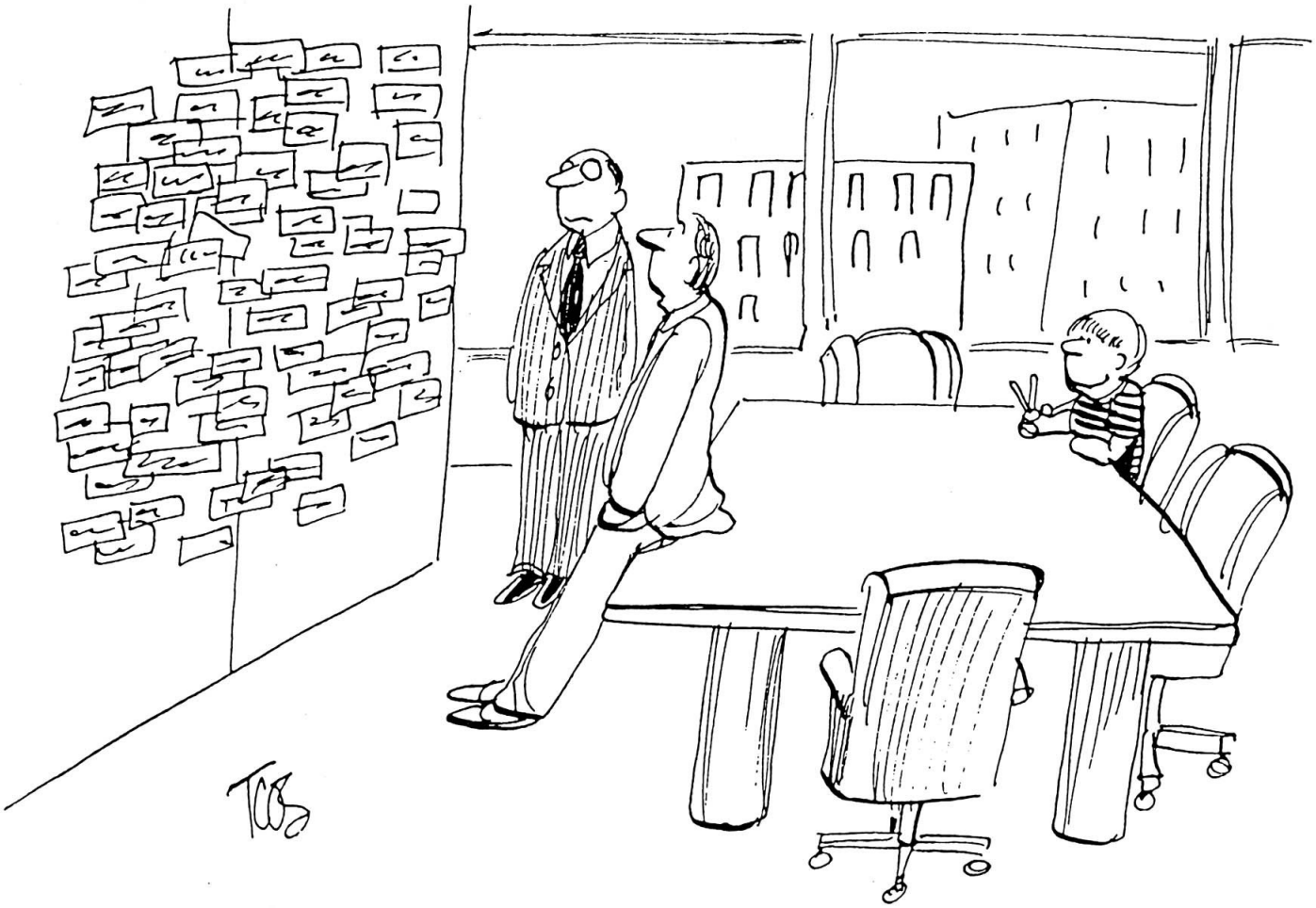
- Two main case study examples
  - Customer purchase behavior data
    - Goal: actionable segments to improve LTV of customer base
  - Prospect intent & interest survey data
    - Goal: actionable segments to better target messaging content and tactics
- Real data from real clients (sanitized)
- Workshop format
  - Hands on
  - Discussion heavy

Introduction

Why Segment?

- Better communication with customers and prospects
  - Recipient should feel that we understand him or her as an individual
  - *"Send the right message to the right person at the right time"*
- Challenges:
  - Widely applicable
    - General rules based on readily available data
    - A new contact can be placed in their segment easily
  - Usable
    - Marketing can relate
    - Technology can deliver

Segmentation in Practice



"We've broken your list into eighty-four subgroups. Our work here is done."

Behavioral Segmentation

What's Behavioral Segmentation?

- Based on what people *actually* do
  - *Not* on what that *say* they do
- Purchase behavior
  - Discuss examples...
- Usage behavior
  - Discuss examples...

Why do Behavioral Segmentation?

- All comes down to interacting with your customer or prospect in the *appropriate* way
  - From customers perspective, *not* yours!
- Ideally a “one-to-one” interaction
  - Not practical in today's world
  - Goal: perceived by customer as “one-to-one”

Today's Purchase Behavior Data Set

- Actual web & phone sales records (sanitized)
  - 541k order detail lines
  - 135k Customers
  - Over 2 ½ years
  - Of ~900 different products
  - In 5 product categories
- Conventional wisdom
  - Strong seasonality
  - Have a loyal customer base
  - But, have retention problem

What we know

Imagine a customer order form:

Date: 10/10/07 Order #: 12345

Customer: 3894832
Sue Smith
1 Short Street
Smallville, ND, 39248

Qty	SKU	Description	Unit Price	Ext Price
1	123	Green Gizzmo	1.50	1.50
3	345	White Widget	2.00	6.00

Total	7.50
Tax	0.60
Shipping	2.00
Grand Total	**10.10**

We get the highlighted data.
Plus: order channel and product (SKU) category

Preloaded as “orders” data frame

```
> load("BehavioralDataSet.Rda")

> str(orders)
'data.frame':  541101 obs. of  9 variables:
 $ SKU_ID   : int  459 459 459 459 459 459 459 459 459 459 ...
 $ ChannelID: int  3 4 3 3 3 3 4 3 3 3 ...
 $ CustID   : int  134945 212174 39861 11227 137271 60982 ...
 $ OrderID  : int  326324 109305 172669 132642 20449 40826 ...
 $ OrderDate:Class 'Date'  num [1:541101] 13211 13649 13670 ...
 $ Quantity : int  1 2 1 3 1 1 1 1 1 1 ...
 $ Amount   : num  18 36 18 54 18 18 18 18 18 18 ...
 $ Channel  : Factor w/ 4 levels "phone1","phone2",..: 3 4 3
  3 ...
 $ Category : Factor w/ 7 levels "*","C","G","I",..: 3 3 3 3
  3 ...
```

orders summary

```
> summary(orders[-(1:2)])
```

```
     CustID          OrderID          OrderDate             Quantity      
 Min.   :     2   Min.   :     2   Min.   :2005-09-01   Min.   :  0.000  
 1st Qu.: 62221   1st Qu.:105292   1st Qu.:2006-07-18   1st Qu.:  1.000  
 Median :124343   Median :210908   Median :2007-02-14   Median :  1.000  
 Mean   :152974   Mean   :207535   Mean   :2007-03-11   Mean   :  1.113  
 3rd Qu.:185119   3rd Qu.:315711   3rd Qu.:2007-12-04   3rd Qu.:  1.000  
 Max.   :506929   Max.   :388319   Max.   :2008-07-14   Max.   :275.000  
                  NA's   :     4                                         
```

```
     Amount          Channel       Category    
 Min.   :   0.01   phone1: 14303   *:     0  
 1st Qu.:  20.00   phone2:    90   C:142147  
 Median :  30.00   web1   :451354   G:114300  
 Mean   :  31.81   web2   : 75354   I: 14961  
 3rd Qu.:  35.00                    N: 50385  
 Max.   :4577.00                    T:199354  
                                    X: 19954  
```

Goal of this exercise?

- Marketers need to come up with a communication strategy & associated tactics which will entice customers to exhibit higher LTV – Long Term Value.

- Segment by past purchase behavior to provide *actionable* subsets of customers
  - When marketers use our subsets, they get *measurably* better results than previous “one size fits all” method.

How are we going to do this?

(Discussion)

Hints

- Live Stage
- Value
- Engagement
- Favorite Products
- Timing

Recency, Frequency, & Monetary Metrics

- Recency
  - How long ago was last purchase? (days)
  - Measured for “As Of Date” of data set
- Frequency
  - How many *orders* in analysis period (2 ½ years)
  - Attempting to measure *engagement*
- Monetary
  - What is total $ value of all orders in analysis period

Question: Do you expect these three to be uncorrelated?

An Aside: Classical RFM

- Invented by direct marketers in 1950's as a way to model response rates (before good stat software was readily available)
- One typical method
  - R, F, & M each scored in quantile (typically 5)
  - Combined score for each recipient was concatenation of the three digits, eg “351”
  - Scores ranked by empirical response rate
  - Mailing then done to top xx% of list
- Today we use, lm, glm, randomForest, ...
- *But*, concepts still valid as conceptional model
- *And*, R & F measures typically very important in any predictive model

I also typically include...

- Breadth
  - How many different SKUs purchased?
- Tenure
  - How long as customer been with us?

Next Step – Aggregate by Customer

- We need some “raw” RFM values

- Make the data frame “RFM_raw”
  - CustomerID: the business key back to database
  - FirstPurchaseDate: interesting for tenure metric
  - LastPurchaseDate: basis of Recency
  - NumberOrders: basis of Frequency
  - NumberSKUs: basis of Breadth (engagement metric)
  - TotalAmount: basis of Monetary
- Also calculate
  - AsOfDate <- max(LastPurchaseDate)

Building the RFM_raw data frame

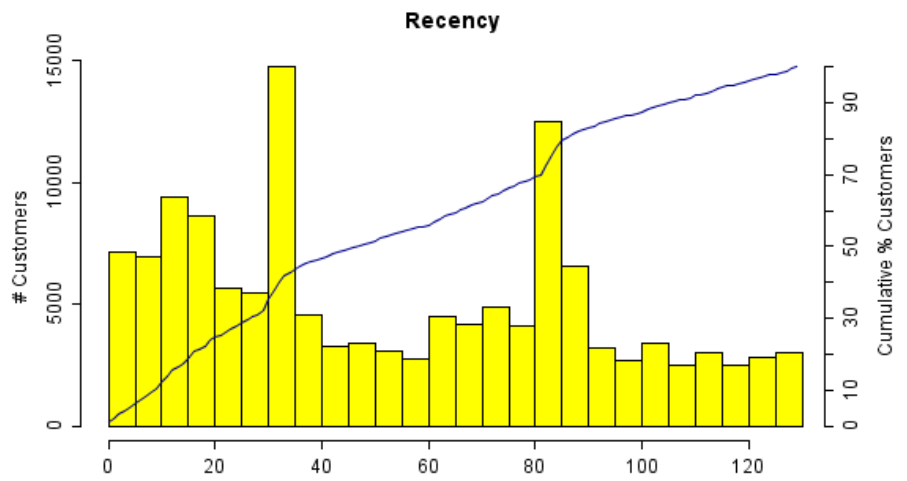
```
## for performance, make OrderDate an integer during aggregation
orders_n <- orders
orders_n$OrderDate <- as.integer(orders_n$OrderDate)

## build up one column at a time
RFM_raw <- with(orders_n, data.frame(CustomerID = sort(unique(CustID))))

RFM_raw <- cbind(RFM_raw, FirstPurchaseDate = with(orders_n,
as.Date(as.integer(by(OrderDate, CustID, min)), "1970-01-01")))

RFM_raw <- cbind(RFM_raw, LastPurchaseDate  = with(orders_n,
as.Date(as.integer(by(OrderDate, CustID, max)), "1970-01-01")))

RFM_raw <- cbind(RFM_raw, NumberOrders      = with(orders_n,
as.numeric(by(OrderID, CustID, function(x) length(unique(x))))))

RFM_raw <- cbind(RFM_raw, NumberSKUs        = with(orders_n,
as.numeric(by(SKU_ID,  CustID, function(x) length(unique(x))))))

RFM_raw <- cbind(RFM_raw, TotalAmount       = with(orders_n,
as.numeric(by(Amount,  CustID, sum))))

AsOfDate <- max(RFM_raw$LastPurchaseDate)

save(RFM_raw, AsOfDate, file = "RFM_raw.Rda")
```

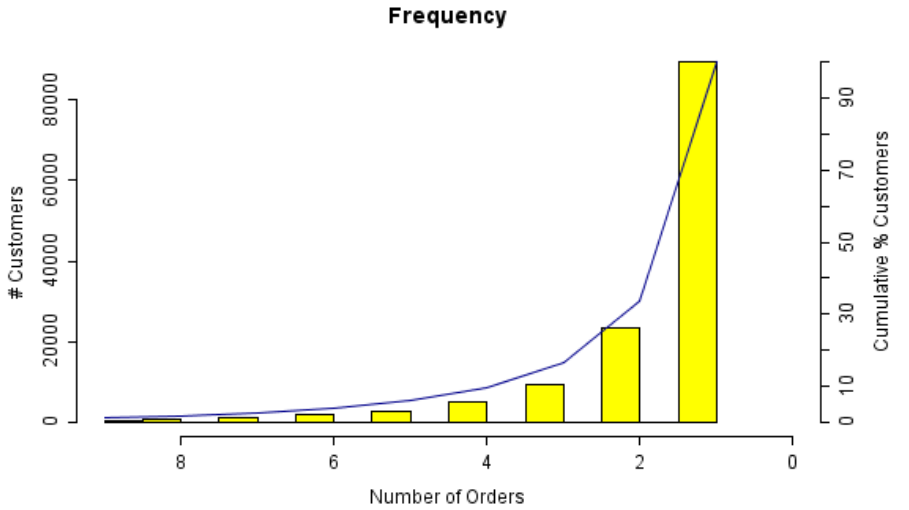
This take a while (1 ½ minutes on my laptop). You may want to download RFM_raw.Rda

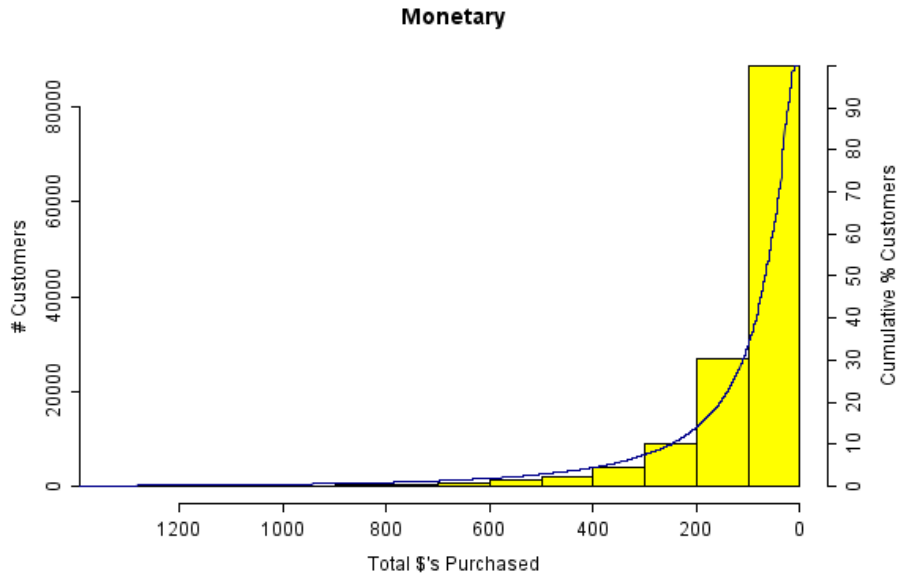
Do some RMF EDA

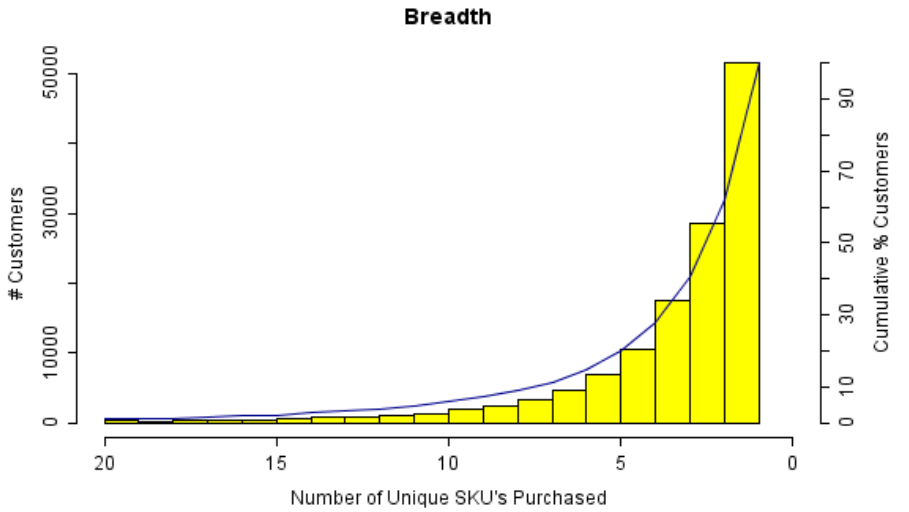
```
## Jim's miscellaneous DMA functions
source("dma_misc.R")

## for interactive games:
attach(RFM_raw)

## EDA plots using base graphics
rfm.plot(as.numeric(AsOfDate - LastPurchaseDate) %/% 7, "rec")
rfm.plot(NumberOrders, "freq")
rfm.plot(TotalAmount, "mon")
rfm.plot(NumberSKUs, "breadth")

## EDA plots using iPlots
ihist(as.numeric(AsOfDate - LastPurchaseDate) %/% 7, title = "Recency")
ihist(NumberOrders, title = "Frequency")
ihist(TotalAmount, title = "Monetary")
ihist(NumberSKUs, title = "Breadth")
```

RFM EDA Plots









In all cases, "best is left."

Assign reasonable RFM breaks

- Recency:
  - Breaks (weeks <=): 25, 51, 77, 103, <else>
  - levels = c("0-5", "6-11", "12-17", "18-23", "24-29"))
    - Note levels labeled in months, not weeks
- Frequency:
  - Breaks (count <=): 1, 3, 7, <else>
  - levels = c("8+", "7-4", "3-2", "1"))
    - Note ordering for best is left.
- Monetary:
  - Breaks (value <=): 50, 100, 200, 400, <else>
  - levels = c("401+", "400-201", "200-101", "100-51", "50-0"))
    - Again ordering is best is left.

Build RFM_segs data frame

```
RFM_segs <- data.frame(Recency_weeks = as.numeric(AsOfDate - RFM_raw$LastPurchaseDate) %/% 7)

row.names(RFM_segs) <- row.names(RFM_raw)

## now label levels with months rather than weeks
RFM_segs$Recency <- ordered(ifelse(RFM_segs$Recency_weeks <= 25, "0-5",
                                   ifelse(RFM_segs$Recency_weeks <= 51, "6-11",
                                     ifelse(RFM_segs$Recency_weeks <= 77, "12-17",
                                       ifelse(RFM_segs$Recency_weeks <= 103, "18-23", "24-29")))),
                                 levels = c("0-5", "6-11", "12-17", "18-23", "24-29"))

RFM_segs$Frequency_count <- RFM_raw$NumberOrders
RFM_segs$Frequency <- ordered(ifelse(RFM_segs$Frequency_count == 1, "1",
                                     ifelse(RFM_segs$Frequency_count <= 3, "3-2",
                                       ifelse(RFM_segs$Frequency_count <= 7, "7-4", "8+"))),
                                   levels = c("8+", "7-4", "3-2", "1"))

RFM_segs$Monetary_value <- RFM_raw$TotalAmount
RFM_segs$Monetary <- ordered(ifelse(RFM_segs$Monetary_value <= 50, "50-0",
                                    ifelse(RFM_segs$Monetary_value <= 100, "100-51",
                                      ifelse(RFM_segs$Monetary_value <= 200, "200-101",
                                        ifelse(RFM_segs$Monetary_value <= 400, "400-201", "401+")))),
                                  levels = c("401+", "400-201", "200-101", "100-51", "50-0"))
```

We typically also add Breadth & Tenure:

```
RFM_segs$Breadth_count <- RFM_raw$NumberSKUs
RFM_segs$Breadth <- ordered(ifelse(RFM_segs$Breadth_count == 1, "1",
                            ifelse(RFM_segs$Breadth_count == 2, "2",
                              ifelse(RFM_segs$Breadth_count <= 4, "4-3",
                                ifelse(RFM_segs$Breadth_count <= 9, "9-5", "10+")))),
                           levels = c("10+", "9-5", "4-3", "2", "1"))

RFM_segs$Tenure_weeks <- as.numeric(AsOfDate - FirstPurchaseDate) %/% 7
RFM_segs$Tenure <- ordered(ifelse(RFM_segs$Tenure_weeks <= 12, "0-12",
                           ifelse(RFM_segs$Tenure_weeks <= 25, "13-25",
                             ifelse(RFM_segs$Tenure_weeks <= 38, "26-38",
                               ifelse(RFM_segs$Tenure_weeks <= 51, "39-51",
                                 ifelse(RFM_segs$Tenure_weeks <= 64, "52-64",
                                   ifelse(RFM_segs$Tenure_weeks <= 77, "65-77",
                                     ifelse(RFM_segs$Tenure_weeks <= 90, "78-90",
                                       ifelse(RFM_segs$Tenure_weeks <= 103, "91-103",
                                                                            "104+")))))))),
                          levels = c("104+", "91-103", "78-90", "65-77", "52-64", "39-51",
                                     "26-38", "13-25", "0-12"))


save(RFM_segs, file = "RFM_segs.Rda")
```

How do customers look in RFM space?

- I like mosaic plots (& especially vcd* package!)
- Set up a “structure table” with assignments:

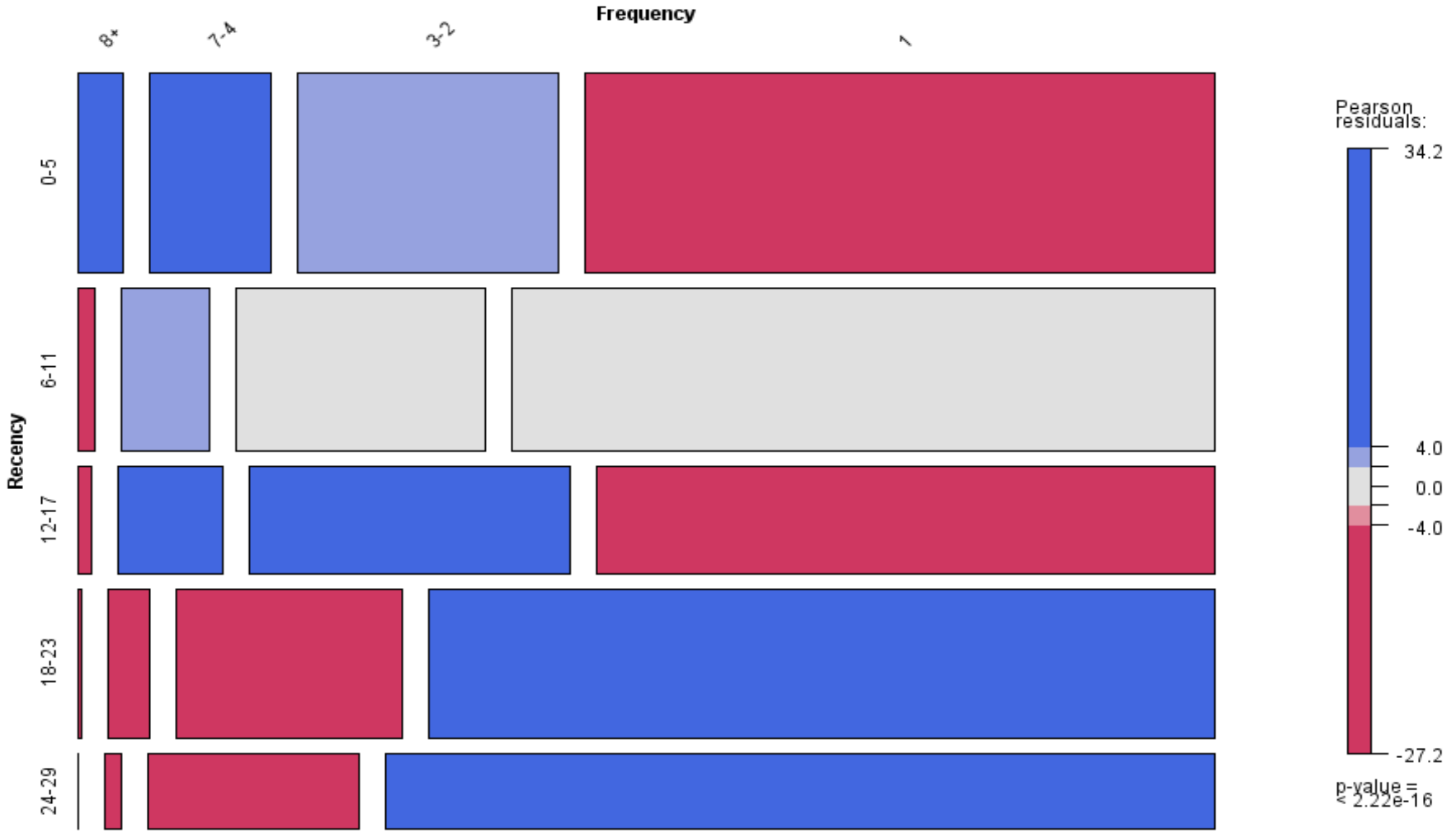
```
require(vcd)
RFM_st <- structable(~ Recency + Frequency + Monetary + Breadth,
                     data = RFM_segs)
```

- And a convenience function for mosaic:

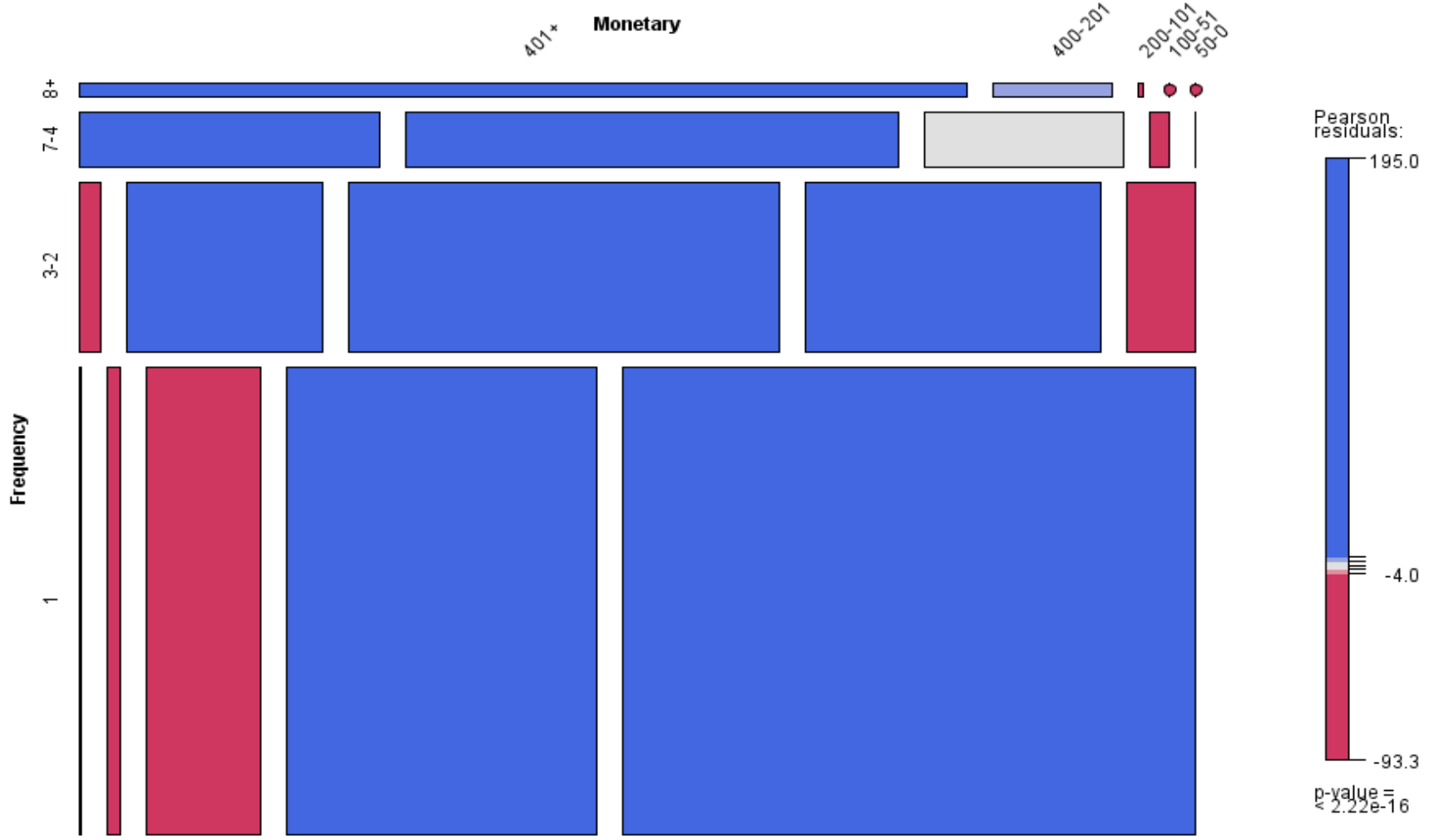
```
mm <- function(f) {
mosaic(f, data = RFM_st,
          shade = TRUE,
          labeling_args = list(rot_labels = c(left = 90, top = 45),
                               just_labels = c(left = "left",
                                               top = "center")),
          spacing = spacing_dimequal(unit(c(0.5, 0.8), "lines")),
          keep_aspect_ratio = FALSE
       )
}
```

* To learn more, attend: *The strucplot framework for Visualizing Categorical Data*. Wed, 11:30. E29

mm(~ Recency + Frequency)

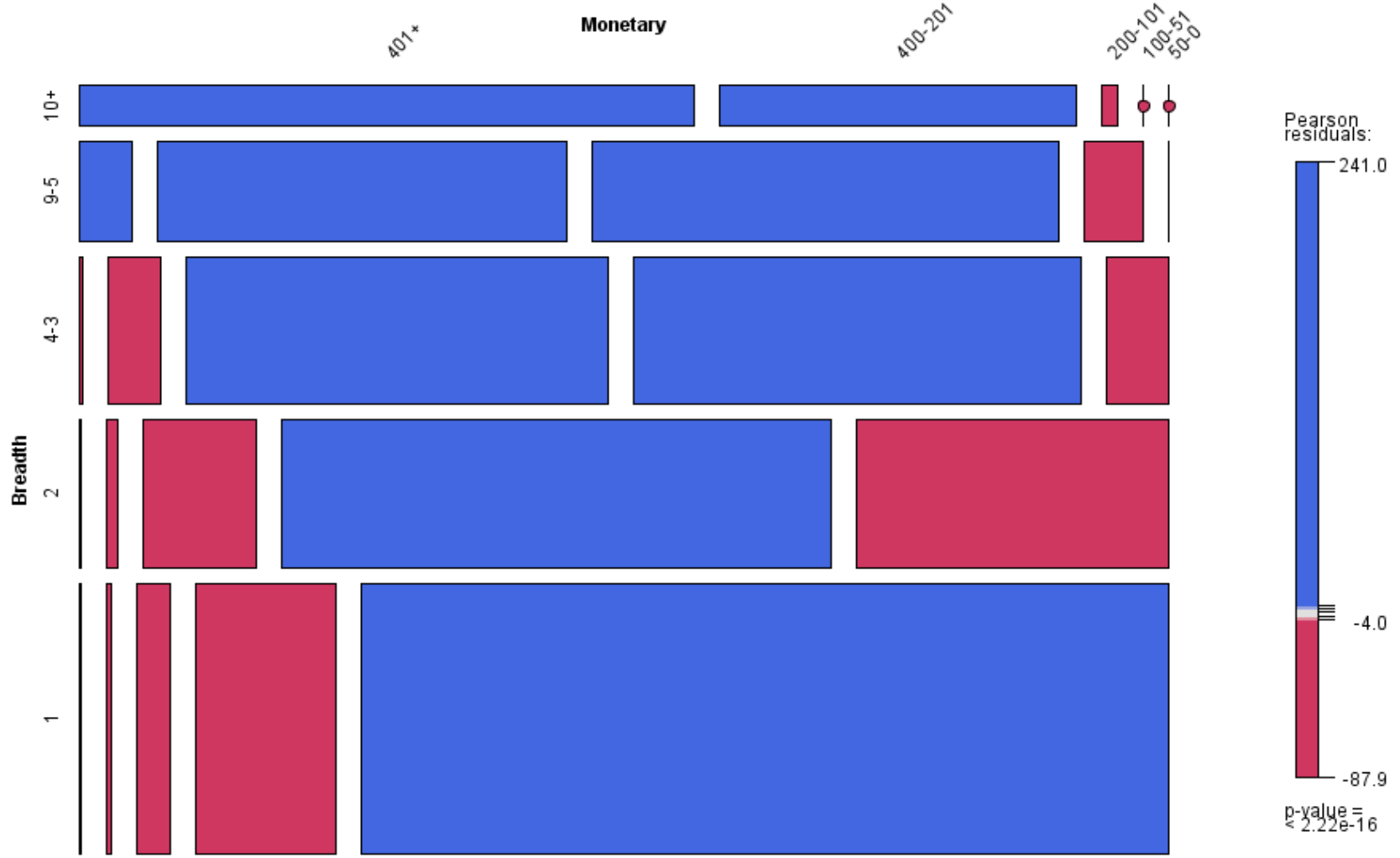


mm(~ Frequency + Monetary)



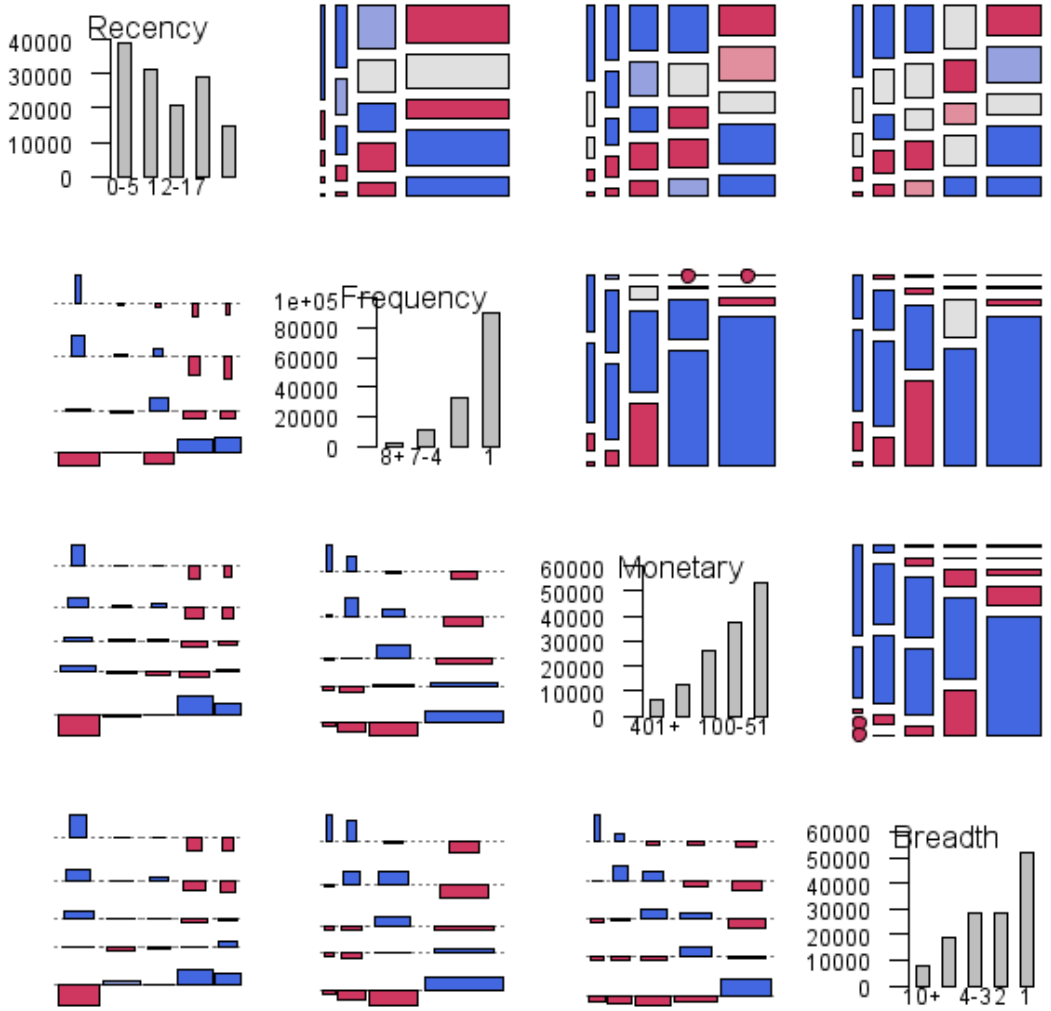
mm(~ Recency + Monetary)

mm(~ Breadth + Monetary)



To really show off vcd!

```
pairs(RFM_st, lower_panel = pairs_assoc, shade = TRUE)
```



Time to get real – remember goal?

Actionable for Marketers

The big two concepts:

1. Lifestage

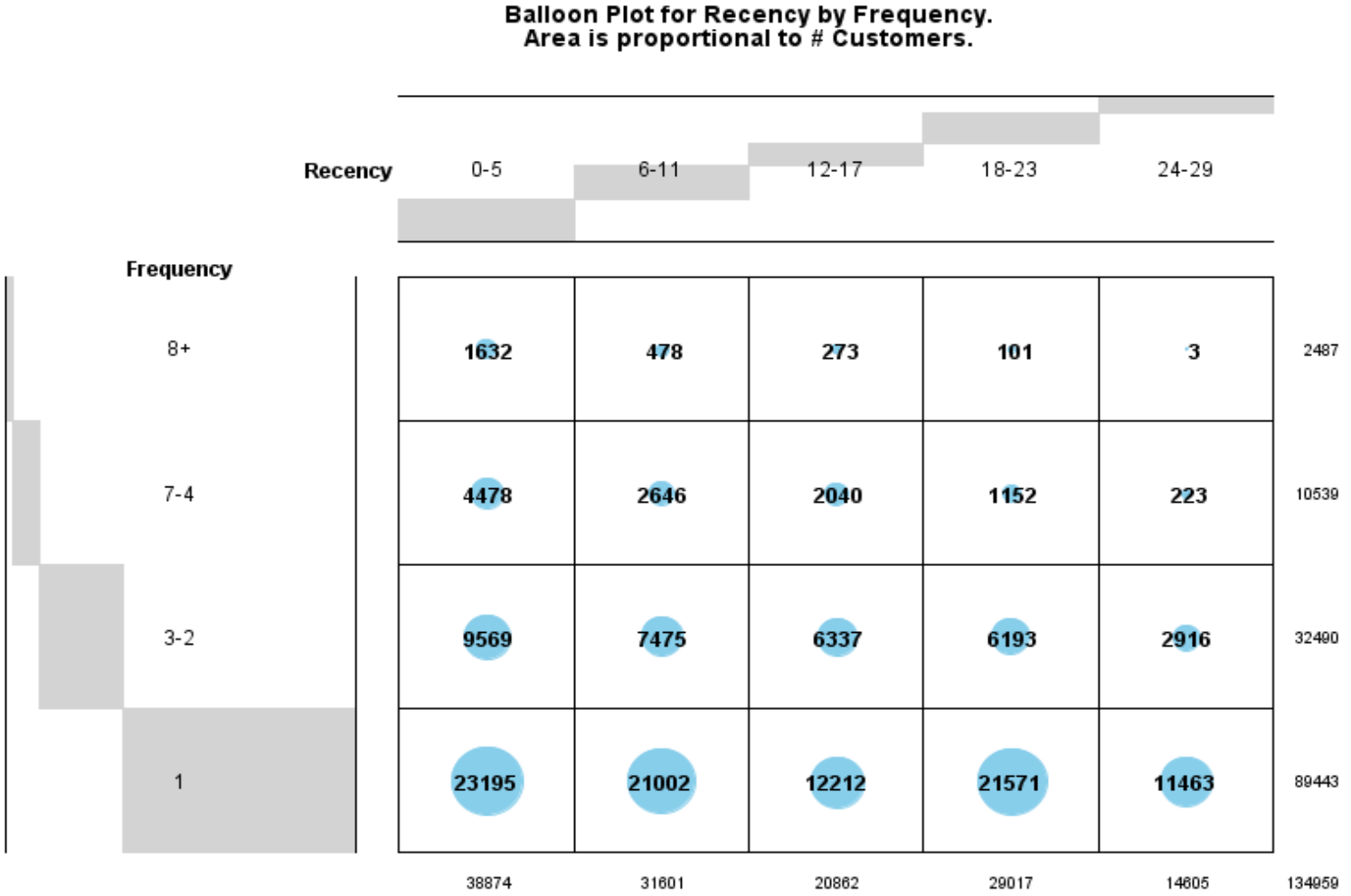
2. Value

Turns out we can do both with Recency & Frequency!

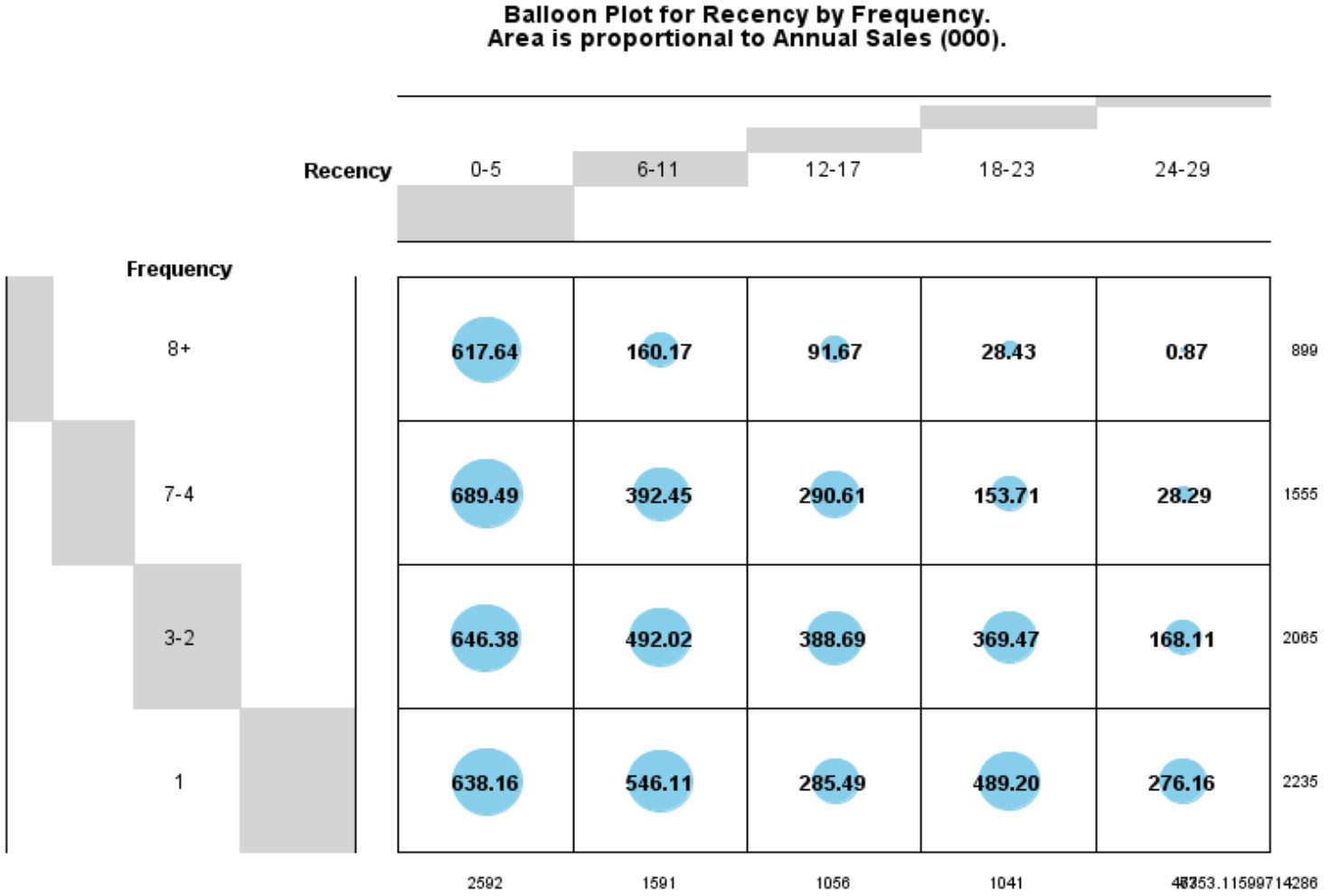
Use Balloon Plots to Communicate

```
require(gplots)

# Recency by Frequence - Counts
RxF <- as.data.frame(table(RFM_segs$Recency, RFM_segs$Frequency,
                           dnn = c("Recency", "Frequency")),
                           responseName = "Number_Customers")
with(RxF, balloonplot(Recency, Frequency, Number_Customers, zlab = "#
Customers"))

# Recency by Frequency - Annual Value (total annual sales to segment)
VbyRxF <- (aggregate(RFM_segs$Monetary_value,
                     by = list(Recency = factor(RFM_segs$Recency),
                               Frequency = RFM_segs$Frequency),
                     sum))
names(VbyRxF)[3] <- "Annual_Sales"
VbyRxF$Annual_Sales <- VbyRxF$Annual_Sales / (28/12) ## normalize to
annual revnue
with(VbyRxF, balloonplot(Recency, Frequency, Annual_Sales / 1000, zlab =
"Annual Sales (000)"))
```

Recency by Frequency - Counts



Recency by Frequency - Value



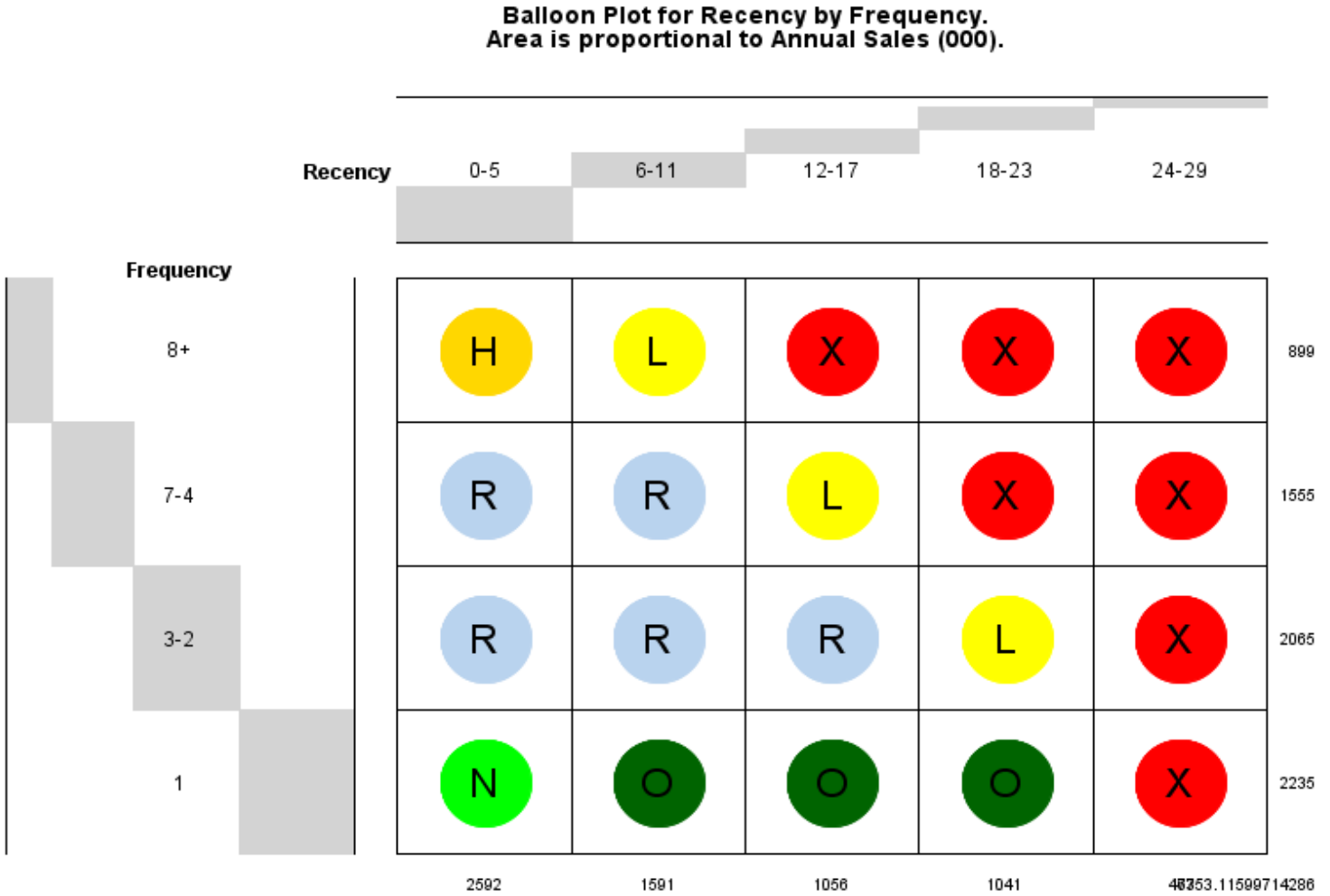
Exercise – Assign Segments

- Lifestage “dimension”
  - New
  - Active
  - Lapsed
  - Lost
- Value “dimension”
  - Gold
  - Silver
  - Bronze
- Combined as
  - High Value, Repeat, New, One-time, Lapsed, & Lost

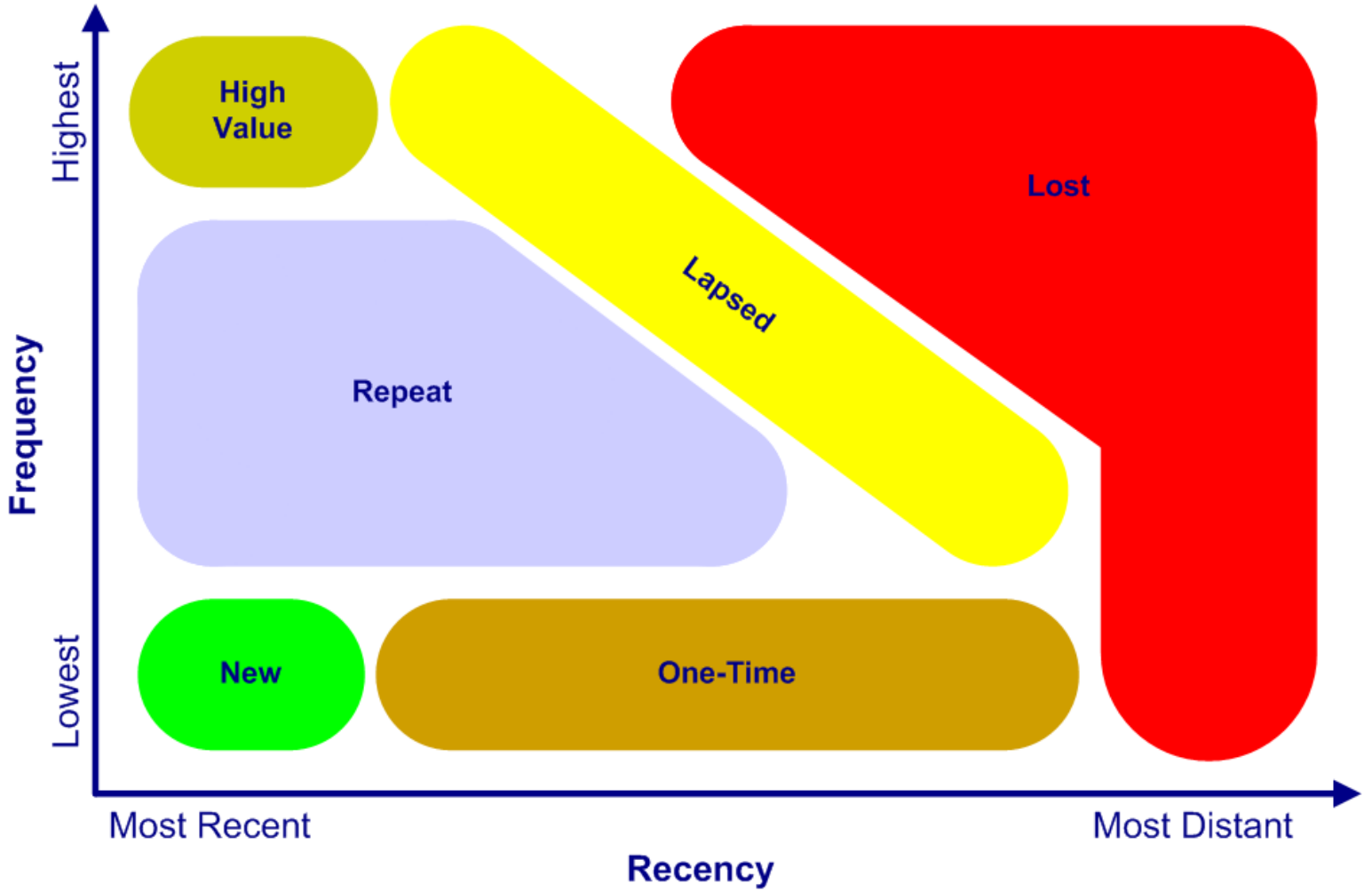
Color & Label Segment Cells

```
# a matrix of segment codes
RF_segs0 <- matrix("", nrow = 4, ncol = 5)
# manually make assignments
object.browser()    ## Fill in H, R, N, L, or O. Save as RF_segs.txt
# get back into R
RF_segs <- as.matrix(read.delim("RF_segs.txt", sep = "\t",
                                na.strings = ""))
RF_segs[is.na(RF_segs)] <- "X"                ## N/A's become "Lost"

# add colors and labels to balloon plot

# Magic values for balloon cell centers
RF_x <- matrix(2:6 + 0.25, nrow = 4, ncol = 5, byrow = TRUE)
RF_y <- matrix(4:1, nrow = 4, ncol = 5, byrow = FALSE)

RF_cols <- sapply(RF_segs, function(x) switch(x, H="gold",
                                              R="slategray2", N="green",
                                              L="yellow", O="darkgreen", "red"))
points(RF_x, RF_y, col = RF_cols, pch = 16, cex = 12)

text(RF_x, RF_y, RF_segs, cex = 2)
```

Final Segments for Marketers



Conceptual RF Segments



Break Time!

Attitudinal Segmentation

Marketing Challenge

- Our client offers free download of software with high perceived value, but
- First asks user to fill out a simple survey
- Challenge is to come up with a “few” segments that will be used by segment to:
  - Prioritize contact strategy
  - Craft marketing messages based on profile

Sample Data

- Surveys from 20k respondents
- All within same time frame (a number of weeks)
- All requested the software download

Survey Description

- 35 check boxes or radio buttons
  - None required. Coded as binary responses
- Arranged in 5 sections
  - License: W and/or X
  - Role: one of D, SA, ITM, ITA, Str, Oth (radio buttons)
  - System: any of S, T, A, B, C, D, O (check boxes)
  - Interest: any of M, O PI, Pr, Sup, 64, Con, Per, DT, Z, Oth. (check boxes)
  - Application: any of Web, Inf, Col, Db, J2, Top, Dev, Per, Other (check boxes)

Data Set

Provided as data frame csb, in InterestPreferenceSurvey.Rda

```
# Getting started
setwd("C:/Data/useR08/R")
require(lattice)
require(grDevices)
require(vcd)
require(flexclust)

load(file = "InterestPreferenceSurvey.Rda")
str(csb)

'data.frame':  20000 obs. of  35 variables:
 $ Lic_W   : int  0 0 0 0 0 0 0 0 0 0 ...
 $ Lic_X   : int  1 1 1 0 1 1 1 1 1 1 ...
 $ Role_D  : int  0 0 0 0 0 0 0 0 1 0 ...
 $ Role_SA : int  0 0 1 0 1 0 0 1 0 0 ...
 $ Role_ITM: int  0 0 0 1 0 0 0 0 0 0 ...
 $ Role_ITA: int  0 0 0 0 0 0 0 0 0 0 ...
```

Proportion Responders by Question

```
> mean(csb)

   Lic_W    Lic_X   Role_D  Role_SA Role_ITM Role_ITA Role_Stu Role_Oth
 0.16040  0.90980  0.19905  0.32910  0.06905  0.08465  0.21080  0.05090

   Sys_S    Sys_T    Sys_A    Sys_B    Sys_C    Sys_D    Sys_O    Int_M
 0.17780  0.39720  0.17020  0.13975  0.09325  0.03510  0.19260  0.36960

   Int_O   Int_Pl   Int_Pr  Int_Sup   Int_64  Int_Con  Int_Per   Int_DT
 0.46810  0.09395  0.10055  0.08985  0.23445  0.21235  0.31420  0.11790

   Int_Z  Int_Oth   Ap_Web   Ap_Inf   Ap_Col    Ap_Db    Ap_J2   Ap_Top
 0.23450  0.05995  0.39640  0.19125  0.18365  0.30125  0.19455  0.30145

  Ap_Dev   Ap_Per Ap_Other
 0.18960  0.20050  0.03735
```

Clustering Strategy

- flexclust package by Fritz Leisch
- See his 2006 paper (on his personal page):
  A Toolbox for κ-Centroids Cluster Analysis
- This is (mostly) an optional response type survey
  - 1 = “yes” is significant
  - 0 is just absence not really a “no”
  - Respondents checking Role_SA have much more in common than those not checking Role_SA
- Following Fritz's argument we use the expectation based Jaccard distance measure.

A First Cluster Run

```
require(flexclust)

## set up flexclust control object
fc_cont <- new("flexclustControl")
fc_cont@tolerance <- 0.1    ## this doesn't seem to work as expected
fc_cont@iter.max <- 30      ## seems to be effective convergence
##fc_cont@verbose <- 1       ## set TRUE if to see each step

my_seed <- 0
my_family <- "ejaccard"
num_clust <- 4

my_seed <- my_seed + 1
set.seed(my_seed)
cl <- kcca(csb, k = num_clust, save.data = TRUE, control = fc_cont,
           family = kccaFamily(my_family))

## This takes ~ 1.5 min. on my laptop
```

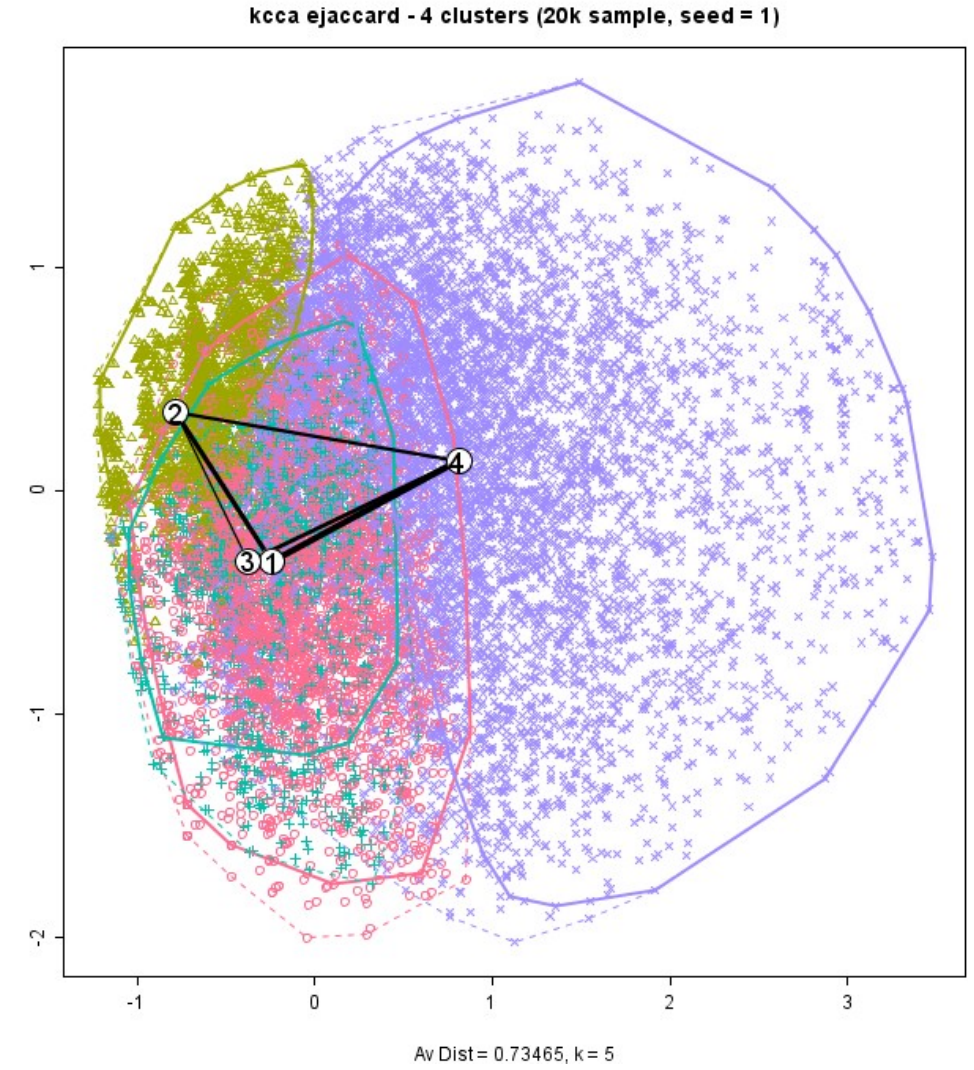
Cluster Summary

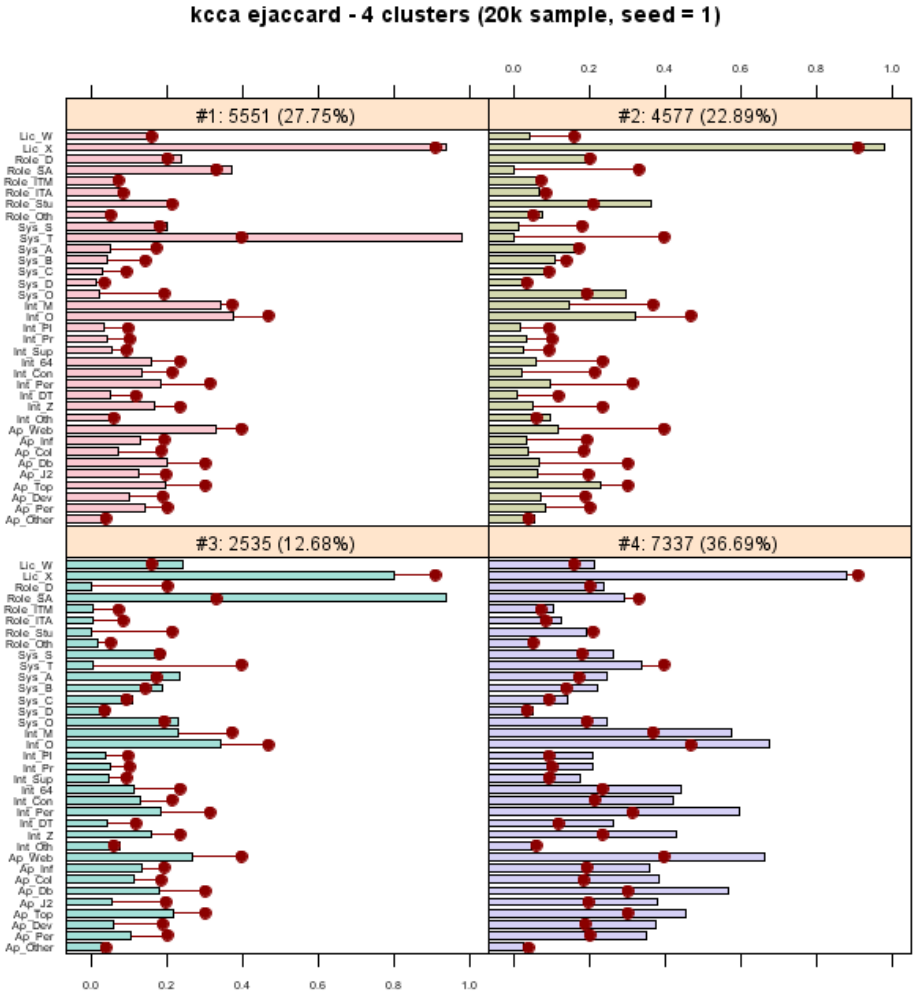
```
> summary(cl)
kcca object of family 'ejaccard'

call:
kcca(x = csb, k = num_clust, family = kccaFamily(my_family),
    control = fc_cont, save.data = TRUE)

cluster info:
  size   av_dist max_dist separation
1 5551 0.7159832        1  0.6766653
2 4577 0.7707523        1  0.7437616
3 2535 0.7482347        1  0.7038259
4 7337 0.7215583        1  0.6732479

no convergence after 200 iterations
sum of within cluster distances: 14693.00
```

Run Plots

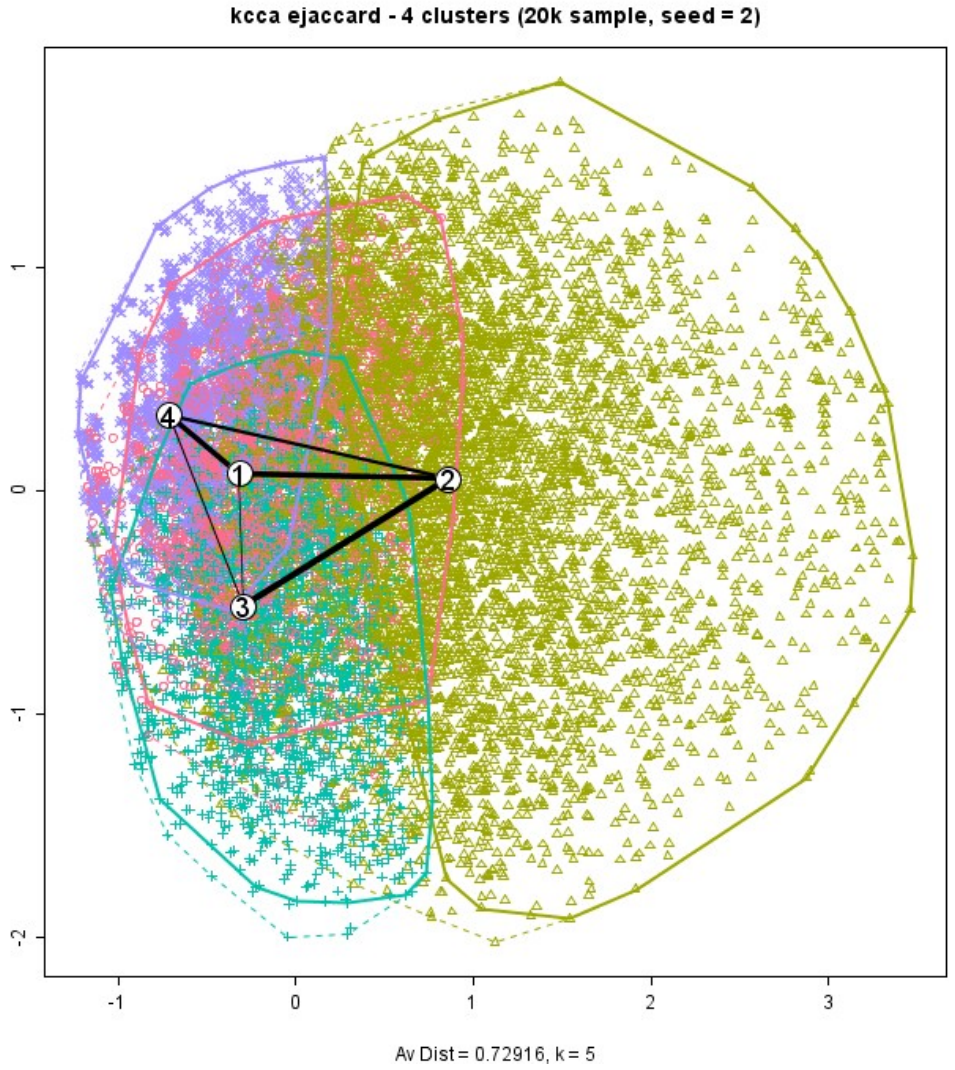
```
pop_av_dist <- with(cl@clusinfo, sum(size*av_dist)/sum(size))
main_txt <- paste("kcca ", cl@family@name, " - ",
                  num_clust, " clusters (",
                  nsamp, "k sample, seed = ", my_seed,
                  ")", sep = "")

# Neighborhood Graph on 1st principle components
csb.pca <- prcomp(csb)
plot(cl, data = as.matrix(csb), project = csb.pca,
     main = main_txt,
     sub = paste("\nAv Dist = ", format(pop_av_dist, digits = 5),
                 ", k = ", cl@k, sep = "")
    )


# Activity Profiles for each segment
print(barchart(cl, main = main_txt, strip.prefix = "#",
               scales = list(cex = 0.6)))
```

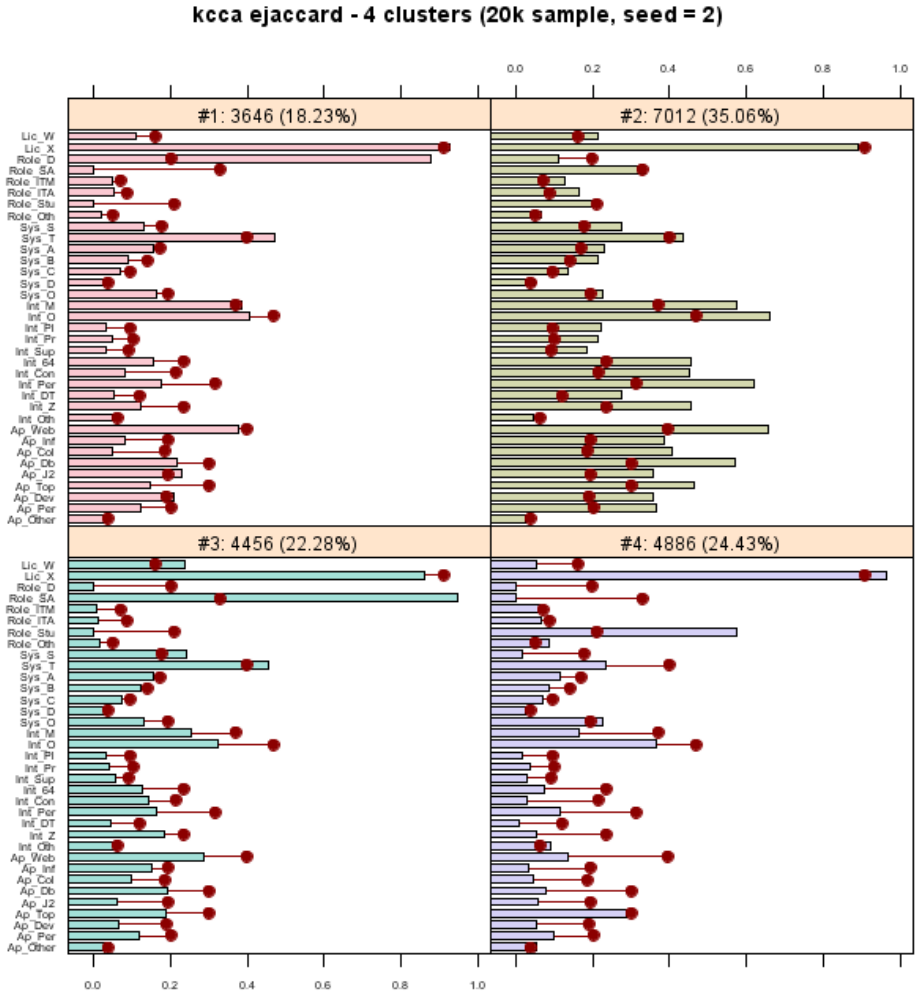
Plots (k=4, seed = 1)



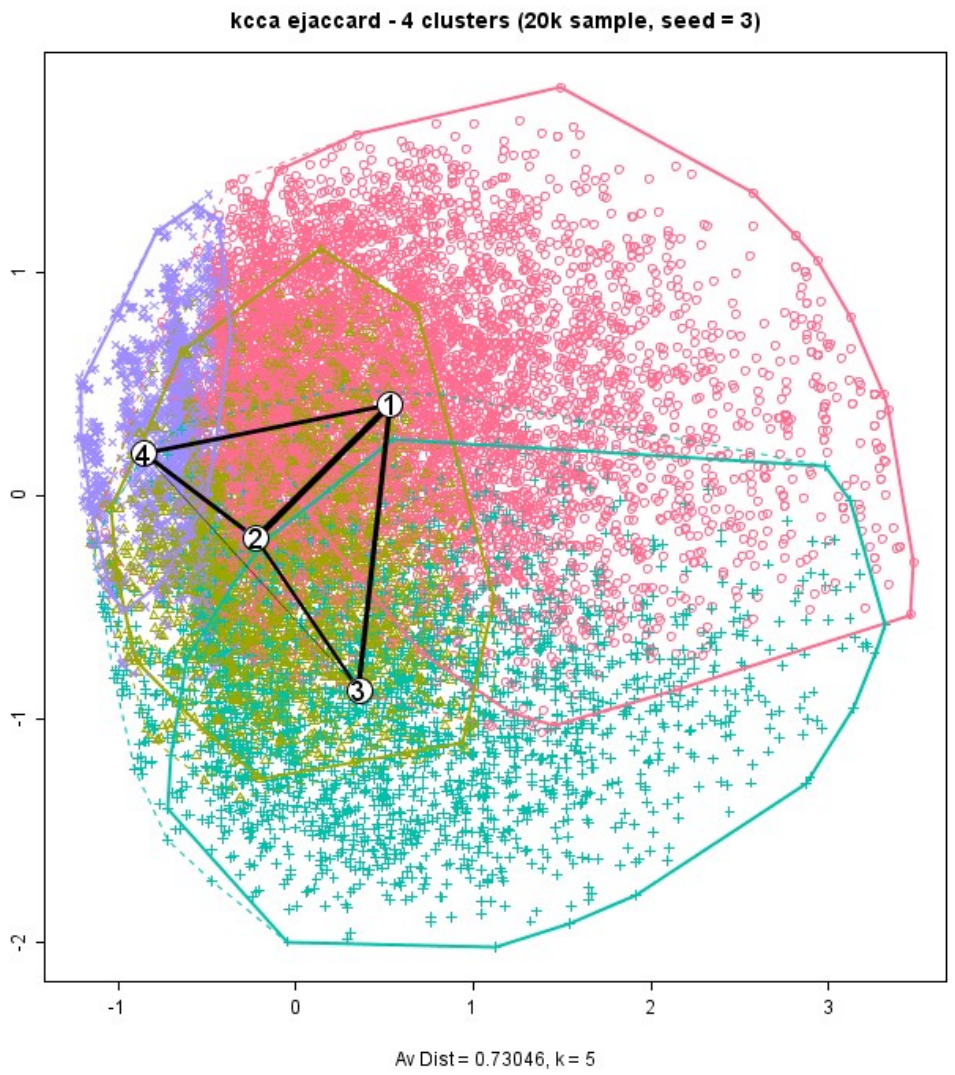


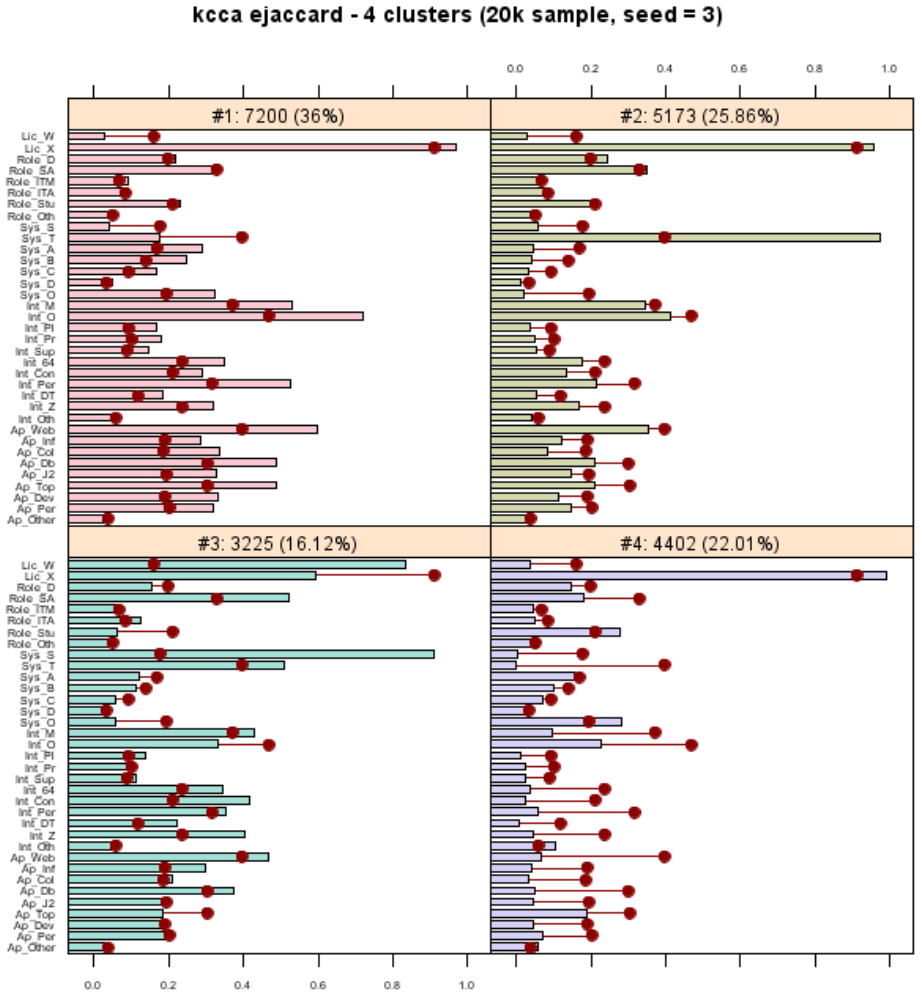
Plots (k=4, seed = 2)





Plots (k=4, seed = 3)





Are any of these any good?

- If so, which?
- How to decide?
- Quoting Fritz (pg 15):

> The actual choice of expectation-based Jaccard with K = 6 clusters ... has been made manually by comparing various solutions and selecting the one which made most sense from the practitioners point of view. This may seem unsatisfying because the decision is subjective, but cluster analysis here is used as a tool for exploratory data analysis and offers simplified views of a complex data set.

Our Selection Criteria

1. Choice of k, must have mostly ~ stable solutions, and
2. Cluster profiles must be interpretable. IOW, what is the story you can tell about each cluster? Will the marketers relate to it?

Your Challenge...

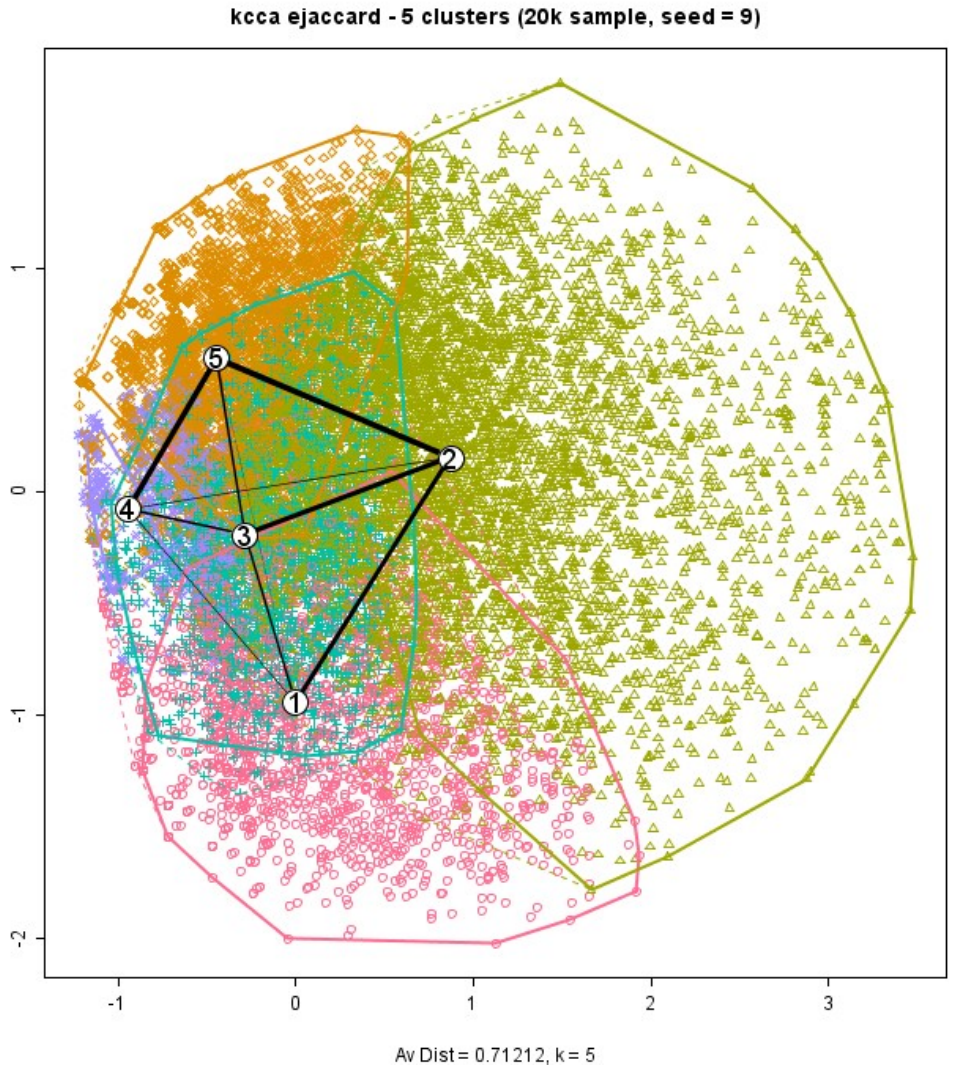
Do what Fritz said:

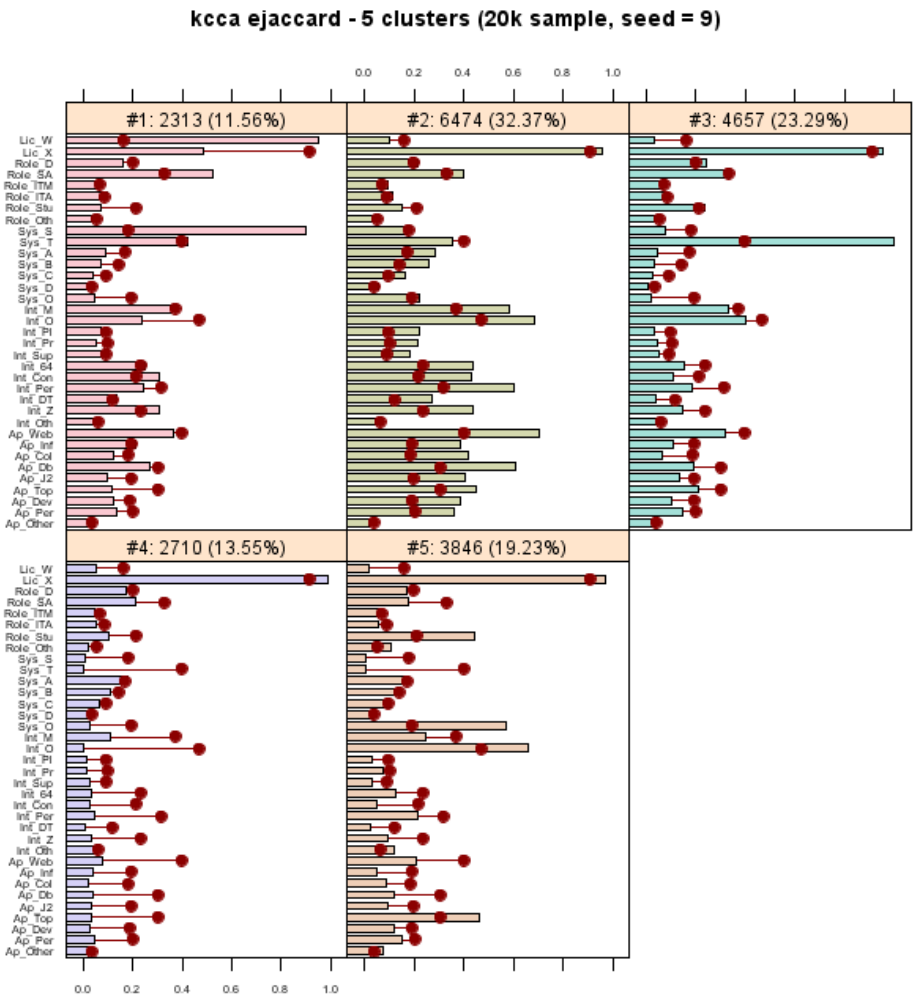
The actual choice ... has been made manually by comparing various solutions and selecting the one which made most sense.

Here are 4 runs for each k = 3 to 8; 24 in all.

Pick the “best” one, make up stories for each cluster, and explain your choice to group.

For the Record. Jim's Pick:





Jim's Stories

Based on knowing a bit more about the client than I can share with you.

#1: An “S” loyalist, high % SA's
#2: Favors name brands, high responders
#3: A “T” loyalist, broad but reduced responses
#4: Favors name brands, but otherwise low resp.
#5: Student, gray box, open source, desktop.

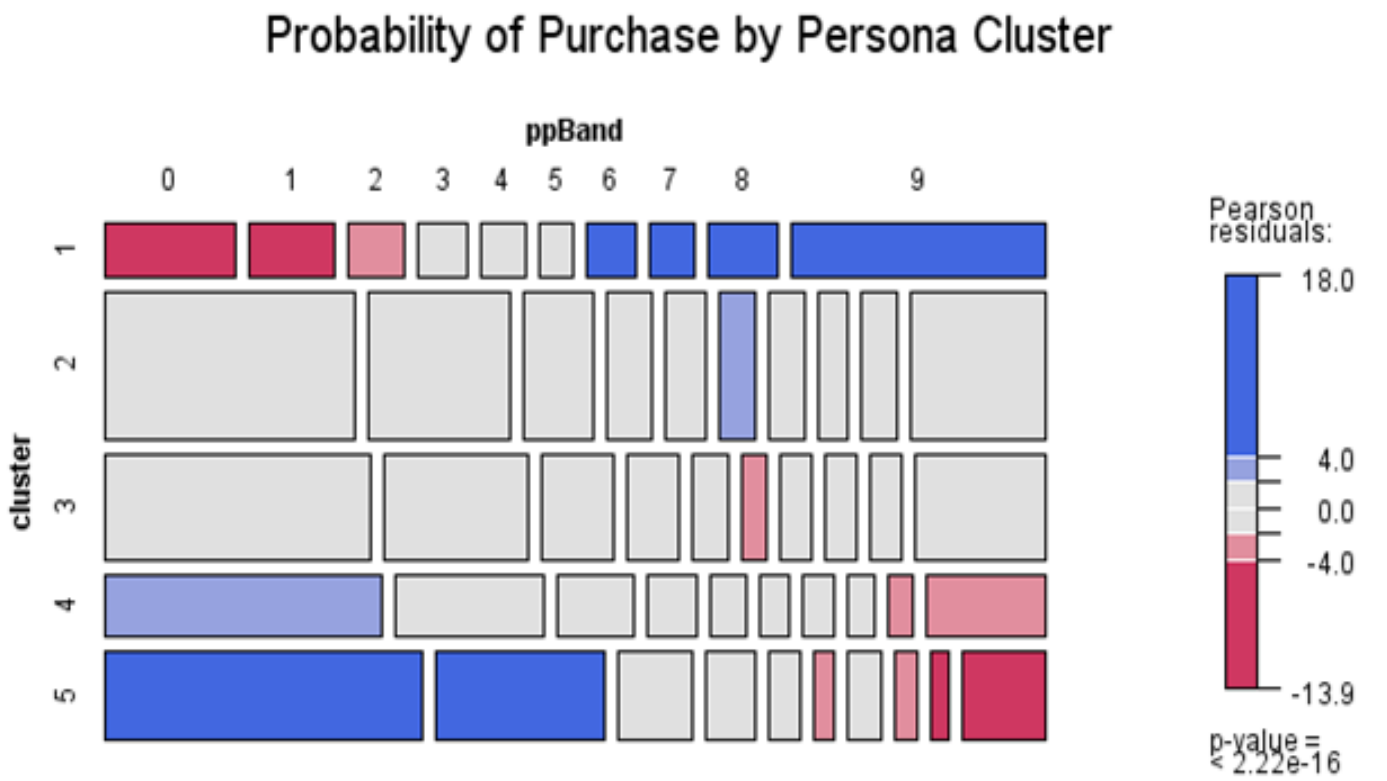
Finally, using predict in flexclust

Once we (analysts & marketers) have decided on a clustering model, we want to use it to assign new respondents to likely segment.

flexclust includes predict:

```
persona <- predict(cl, csb)
head(persona)
str(persona)
PersonaPredict <- as.data.frame(persona)
names(PersonaPredict) <- "cluster"

> table(PersonaPredict)
PersonaPredict
   1    2    3    4    5
2313 6479 4654 2702 3852
```

Closing the Loop – Tying Back to Purchase Model



Where ppBand is probability of purchase band (0 = 0.0 – 0.999, 1 = 0.10 – 0.199, … 9 = 0.90 – 0.999). IOW, 0 is really low & 9 is really high probability of purchase according to the model

Conclusion

Follow up

- Slides and code will be up next week on http://www.porzak.com/JimArchive/useR2008/
- Ping me with questions or comments: jporzak@gmail.com
- Check out the San Francisco useR Group: ia.meetup.com/67/

Thanks!

Appendix

section

Code slide

```
##
```