Loops & Arrays

efficiency

for statements

while statements

Hye-Chung Kum

Population Informatics Research Group

http://research.tamhsc.edu/pinformatics/

http://pinformatics.web.unc.edu/

Course URL:
[http://pinformatics.tamhsc.edu/phpm672]()

What you learned so far…

- Assignment 1
  - Setup work environment
  - Use the SAS software
  - SAS programming basics
    - data step & proc step
    - libname
    - Writing code & Reading logs
- Assignment 2
  - Understand variables (names, types, labels)
  - To write conditional logic codes
  - Subset columns (variables) from a table
  - Subset rows (observations) from a table
  - Recode, rename variables and calculate new variables
  - Label variables and values

Basics

- Vocabulary
  - Directory = folder
  - Observations = rows = obs
  - Variables = columns = var(s)
- `where(date<'18jan2004'd);`
  - `where(date< mdy(1,18,2004) );`
- Line comments
  - * comments;
  - Length limit 256. If you are using it for long lines pay attention to log for messages.

Loops & Arrays

efficiency

for statements

while statements

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Required Reading

- UCLA module
  - http://www.ats.ucla.edu/stat/sas/modules/acrossvars.htm
- Little SAS book
  - 3.11 Simplifying programs with arrays
  - 3.12 Using Shortcuts to Lists of Variable Names
- Most difficult of required content
  - assignment 1 to 4
- But also will come in most handy in doing your research
- READ the required readings

Objective

- use for loops (counting loops)
- use while loops (conditional loops)
- use one dimensional arrays
- Understand how to write reusable code
- Understand how to optimize your programming time: KISS (Keep it simple)

Programming Goals:

- **Correctness**
  - Gives the right answer
  - Never returns the wrong answer
- **Robustness**
  - Program doesn’t crash, even for bad input
- **Maintainable (or *Sustainable*)**
  - Simple code, easy to understand and modify
  - Readable, well-commented, well-structured
- **Fast (Efficient)**
  - Uses efficient algorithms
  - Takes advantage of language features to improve speed

User Efficiency

optimize your own time

- K.I.S.S. Keep it simple …
    - Simple code is easier to understand and fix
    - A simple but **correct** solution is more valuable than a clever elegant but **incorrect** solution.
- Understand your code, **Avoid accidental coding**
    - Find some code, type it in, it seems to work, so …
    - When problems inevitably appear, you can’t fix the bugs, if you don’t understand your own code…
    - Use help & documentation.
    - Play with functionality until you understand it.
- Have a plan (Divide & Conquer)
    - Come up with a plan
    - Break plan into small bite-size chunks
    - Solve each chunk and verify that chunk works properly
    - Assemble all the working chunks to solve original problem

Algorithmic Efficiency

- Reducing the amount of computing resources that an algorithm consumes
  - **Speed:** The amount of time it takes for an algorithm to complete
  - **Space:** The amount of memory or storage used by an algorithm.

- ***Note:*** Most of the problems we solve in class don’t require this extra level of effort.

- If your solution works correctly, but is running too slowly, or is taking too much memory, often the best solution is to find a better algorithm.

Looping Efficiency

- Loops are powerful flexible concepts for solving problems involving repetitive processing of the same task with different data over and over again.
- It makes modifying code efficient
  - You don’t have to changes in multiple places

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Looping

Goal: I have a task (piece of code) that I want to repeat over and over again on a list of data.

How could I do that?

```
* Brute Force:  Cut & Paste & Tweak
if cigever=1 then bcigever=1;
else if cigever=2 then bcigever=0;

if alcever=1 then balcever=1;
else if alcever=2 then balcever=0;

if cocever=1 then bcocever=1;
else if cocever=2 then bcocever=0;

if mjever=1 then bmjever=1;
else if mjever in (0,2) then bmjever=0;
```

Arrays

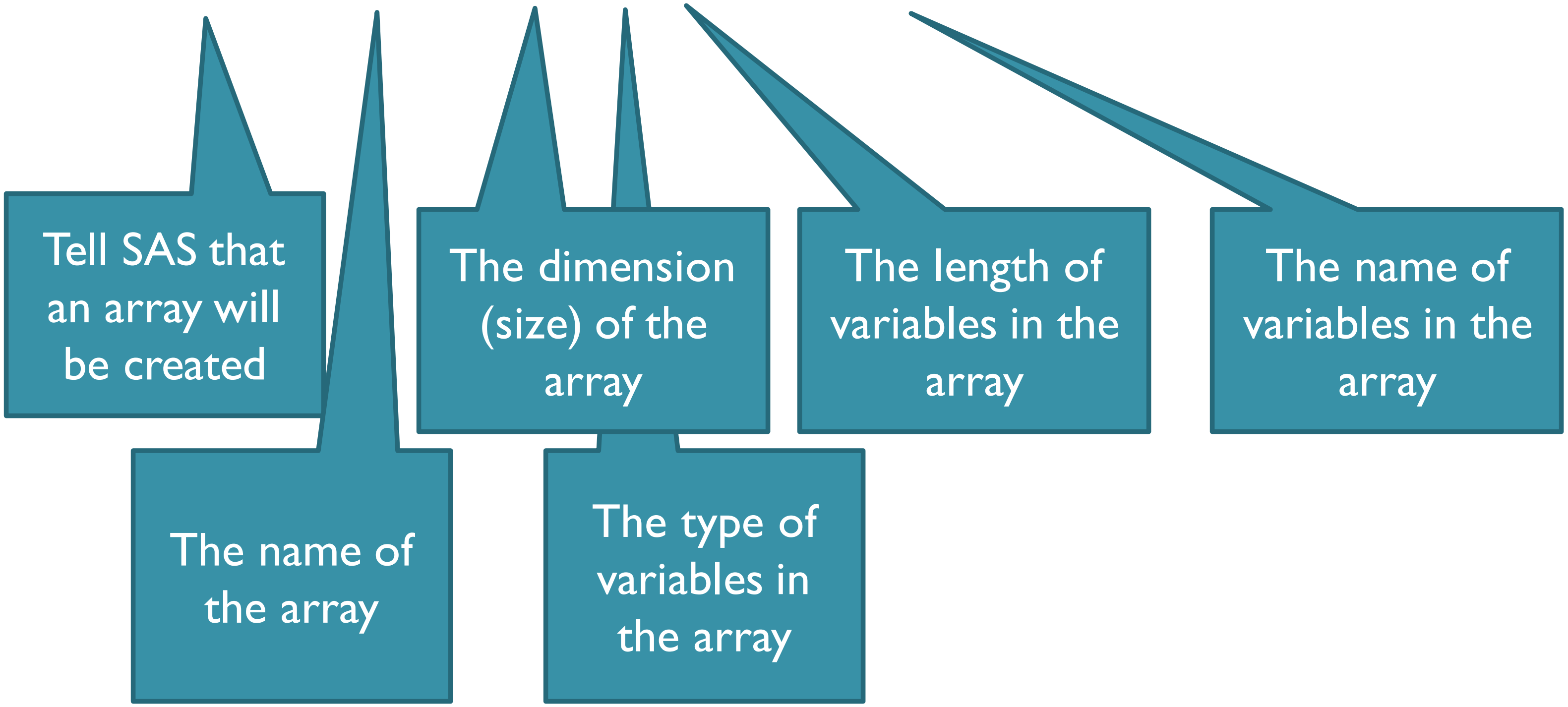
array{1}	array{2}	array{3}	array{4}
rate2005	rate2006	rate2007	rate2008

- A set of variables grouped together for the duration of the data step
- So that all variables in the group can be referred to systematically
- SAS: index typically starts at 1
- Every task that can be done with arrays can also be done without arrays
- Why do we use arrays?
  - Efficient programming: do not need to write repeated codes
  - Accuracy: With fewer lines of codes, easier to debug ERRORs, and maintain code
  - Extensible: Easy to extend your code

SAS: Arrays

array{1}	array{2}	array{3}	array{4}
rate2005	rate2006	rate2007	rate2008

- All variables in one array must be of the same type
- Variables specified within an array do not need to already exist
- array aname {dim} [$len] elements;



Tell SAS that an array will be created

The name of the array

The dimension (size) of the array

The type of variables in the array

The length of variables in the array

The name of variables in the array

- array rate {4} rate2005-rate2008;

SAS: Arrays

array{1}	array{2}	array{3}	array{4}
rate2005	rate2006	rate2007	rate2008

- All variables in one array must be of the same type
- Variables specified within an array do not need to already exist
- array aname {dim} [$len] elements
  - array rate {4} rate2005-rate2008;
  - array rate {*} rate2005-rate2008;
  - array rate {4} ; *implicit: rate1-rate4;
- Dim(Dimension): how many elements
  - Can be implicit by using *
- $len: type and length of variables when strings
  - Omitted for numerical variables
- elements: list of variables
- index: an integer pointer that identifies the element in the array
  - array {index} or array [index]
  - rate2006 is indexed by 2

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Counted (Iterative) Loops

SAS: for loop statement

the **counted loop** solution

```
do <varindex> = <start> to <stop>;
    <Body: do some work with varindex>
end;

do <idx> = <start> to <stop> by <step>;
    <Body: do some work with varindex>
end;
```

ever{1}	ever{2}	ever{3}	ever{4}
cigever	alcever	cocever	mjever

bever{1}	bever{2}	bever{3}	bever{4}
bcigever	balcever	bcocever	bmjever

```
* Brute Force:  Cut & Paste & Tweak
if cigever=1 then bcigever=1;
else if cigever=2 then bcigever=0;

if alcever=1 then balcever=1;
else if alcever=2 then balcever=0;

if cocever=1 then bcocever=1;
else if cocever=2 then bcocever=0;

if mjever=1 then bmjever=1;
else if mjever in (0,2) then bmjever=0;

* Using arrays is much more elegant and accurate;
array ever{4} cigever alcever cocever mjever;
array bever{4} bcigever balcever bcocever bmjever;
do i=1 to 4;
  if ever{i}=1 then bever{i}=1;
  else if ever{i} in (0,2) then bever{i}=0;
end;
```

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ever{1}	ever{2}	ever{3}	ever{4}
cigever	alcever	cocever	mjever

bever{1}	bever{2}	bever{3}	bever{4}
bcigever	balcever	bcocever	bmjever

```
* Brute Force:  Cut & Paste & Tweak
if cigever=1 then bcigever=1;
else if cigever=2 then bcigever=0;

if alcever=1 then balcever=1;
else if alcever=2 then balcever=0;

if cocever=1 then bcocever=1;
else if cocever=2 then bcocever=0;

if mjever=1 then bmjever=1;
else if mjever in (0,2) then bmjever=0;

* Using arrays is much more elegant and accurate;
array ever{4} cigever alcever cocever mjever;
array bever{4} bcigever balcever bcocever bmjever;
do i=1 to 4;
   if ever{i}=1 then bever{i}=1;
   else if ever{i} in (0,2) then bever{i}=0;
end;
```

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ever{1}	ever{2}	ever{3}	ever{4}
cigever	alcever	cocever	mjever

bever{1}	bever{2}	bever{3}	bever{4}
bcigever	balcever	bcocever	bmjever

Indent
Why?

```
* Using arrays is much more elegant and accurate;
array ever{4} cigever alcever cocever mjever;
array bever{4} bcigever balcever bcocever bmjever;
do i=1 to 4;
  if ever{i}=1 then bever{i}=1;
  else if ever{i} in (0,2) then bever{i}=0;
end;


* Even better, more extensible, using arrays;
array ever{*} cigever alcever cocever mjever;
array bever{*} bcigever balcever bcocever bmjever;
do i=1 to dim(ever); * uses the dimension of the array;
  if ever{i}=1 then bever{i}=1;
  else if ever{i} in (0,2) then bever{i}=0;
end;
```

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ever{1}	ever{2}	ever{3}	ever{4}
cigever	alcever	cocever	mjever

bever{1}	bever{2}	bever{3}	bever{4}
bcigever	balcever	bcocever	bmjever

Indent Why?

```
* Using arrays is much more elegant and accurate;
array ever{5} cigever alcever cocever mjever snfever;
array bever{5} bcigever balcever bcocever bmjever
bsnfever;
do i=1 to 5;
   if ever{i}=1 then bever{i}=1;
   else if ever{i} in (0,2) then bever{i}=0;
end;



* Even better, more extensible, using arrays;
array ever{*} cigever alcever cocever mjever snfever;
array bever{*} bcigever balcever bcocever bmjever
bsnfever;
do i=1 to dim(ever); * uses the dimension of the array;
   if ever{i}=1 then bever{i}=1;
   else if ever{i} in (0,2) then bever{i}=0;
end;
```

Indentation & Line Break

Which is more readable?

```
do i=1 to dim(ever);
  if ever{i}=1 then
    bever{i}=1;
  else if ever{i} in (0,2) then
    bever{i}=0;
end;
```

```
do i=1 to dim(ever);
  if ever{i}=1 then bever{i}=1;
  else if ever{i} in (0,2) then
bever{i}=0;
end;
```

Indentation – helps outline code

Which is more readable?

```
do i=1 to dim(ever);
  if ever{i}=1 then
    bever{i}=1;
  else if ever{i} in (0,2) then
    bever{i}=0;
end;
```

```
do i=1 to dim(ever);
if ever{i}=1 then
bever{i}=1;
else if ever{i} in (0,2) then
bever{i}=0;
end;
```

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Looping behavior (Iteration)

```
do i=1 to dim(ever);
   if ever{i}=1 then bever{i}=1;
   else if ever{i} in (0,2) then
bever{i}=0;
end;
```

Body:
This code gets repeated ‘n’ times,
n = dim(ever) = 4

* **Hidden Code:**
Inserted Here

```
i = i + 1;   * changes each iteration
if i <= dim(ever)
   <jump back to top of loop>
else <exit loop> end
```

How to figure out new syntax

- http://support.sas.com/onlinedoc/913/docMainpage.jsp
  - index / do
- http://www.stata.com/help.cgi?foreach
- google
  - stata foreach over multiple varlist
  - http://www.stata.com/statalist/archive/2013-03/msg01241.html

Counted Loops

Code some

Counted Loops vs. Conditional Loops

- **Counted Loops**
  - I want to repeat a task (piece of code) a specified number of times, say `'n'`
    - **Example:** I want to calculate grades for all 40 students in my class
- **Conditional Loops**
  - I want to repeat a task until some condition is satisfied.
    - **Example:** I want to grade as many students as I can between now and when I go home at 5:00 PM.

SAS: conditional loops

- There are 3 forms of the DO statement:
  - The iterative DO statement executes statements between DO and END statements repetitively based on the value of an index variable. The iterative DO statement can contain a WHILE or UNTIL clause.
    - STOP when finished running N times
  - The DO UNTIL statement executes statements in a DO loop repetitively until a condition is true, checking the condition after each iteration of the DO loop.
    - STOP when the condition is TRUE
  - The DO WHILE statement executes statements in a DO loop repetitively while a condition is true, checking the condition before each iteration of the DO loop.
    - STOP when the condition is FALSE

do while loop statement

the **conditional loop** solution (SAS)

```
do while (<test>);
     <Body: do some work>
     <Update: make progress towards exiting loop>
end;
```

If we don’t know ahead of time, how many times we need to loop but we can write a **test** for when we are done; Then the **while** loop is a great solution.

Note: For this to work properly, the <test> needs to evaluate to a logical value.

Note: The body of the `while` loop will continue to get executed as long as the <test> evaluates to `true`. The while loop is exited as soon as the condition evaluates to `false`.

do until loop statement

the **conditional loop** solution

```
do until (<test>);
     <Body: do some work>
     <Update: make progress towards exiting loop>
end;
```

- Very similar to **do while** loop
- The difference ?
  - The **test** is evaluated
    - Until: at the **bottom** of the loop **after** the statements in the DO loop have been executed. **The DO loop always iterates at least once.**
    - While: at the **top** of the loop **before** the statements in the DO loop have been executed.
  - Stops when
    - Until: If the expression is **true**, the DO loop does not iterate again
    - While: If the expression is **false**, the DO loop does not iterate again.

Infinite Loops

```
count = 1;
do while (1);  * test always true;
   * This Loop never stops;
   count = count + 1;
end;
```

Note: Use `<ctrl-c> or STOP or Kill SAS` to exit current execution, if you appear to be stuck in an infinite loop.

For most programs, the **test** expression must eventually become *`false`*, for the loop to be useful.

Counting in a while loop

```
* Initialize variables;
array rate{*} rate2001 - rate2013;
idx = 1;
count = 0;

* Count years with rate > 7;
do while (idx <= dim(rate));

   * Test current element against 7;
   if rate(idx) > 7.0 then
      count = count + 1;

   * Update:  Don’t forget to increment !;
   idx = idx + 1;
end;
```

Better to use the for loop

```
* Initialize variables;
array rate{*} rate2001-rate2013;
count = 0;

* Count years with rate > 7;
do idx=1 to dim(rate);
   * Test current element against 7;
   if rate(idx) > 7.0 then
      count = count + 1;
end;
```

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A good example for while loop
multiple conditions

```
* What year was the 4th year when rate > 7;
array rate{*} rate2001 - rate2013;
idx = 1;
count = 0;

* Count years with rate > 7;
do while (count<4 & idx <= dim(rate));
   * Test current element against 7;
   if rate(idx) > 7.0 then
      count = count + 1;

   * Update:  Don’t forget to increment !
   idx = idx + 1;
end;

if (count=4) then year4=2000+idx;
* else year4=.;
```

leave statement

Terminates for or while loops. breaks flow of control of inner most nested while or for loop containing leave statement.

```
array rate{*} rate2001 - rate2013;
idx = 1;
count = 0;

* What year was the 4th year when rate > 7;
do while ( idx <= dim(rate) );
        if rate(idx) > 7.0 then
      count = count + 1;

  * Jump out of while loop;
  if (count = 4) then leave;
  idx = idx + 1;
end;
* Control flow jumps to here after break;
if (count=4) then year4=2000+idx;
```

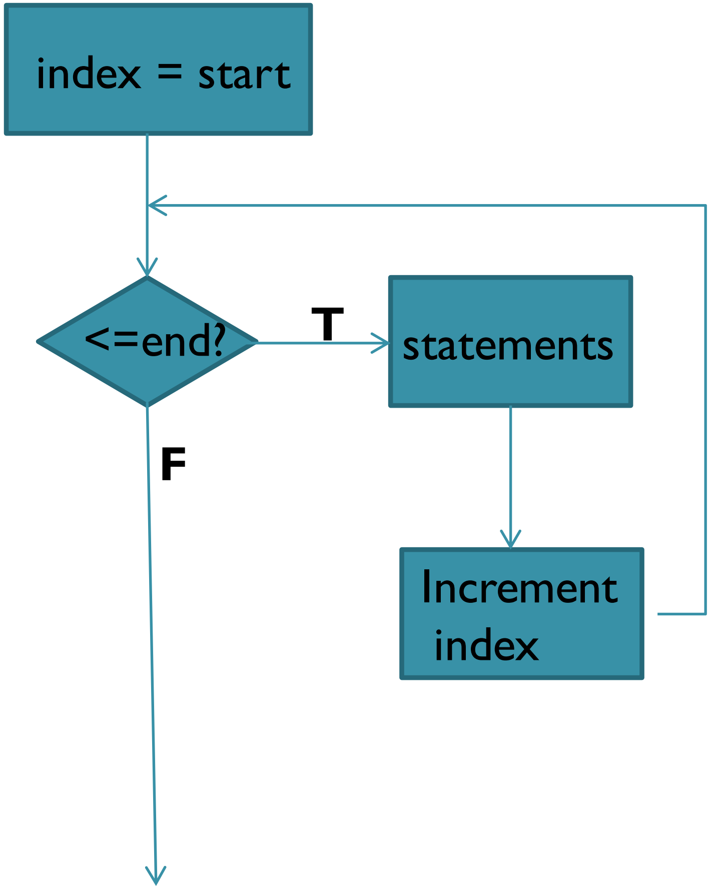
Breaking out of loop

- The LEAVE statement causes processing of the current loop to end.
- The CONTINUE statement stops the processing of the current iteration of a loop and resumes with the next iteration.

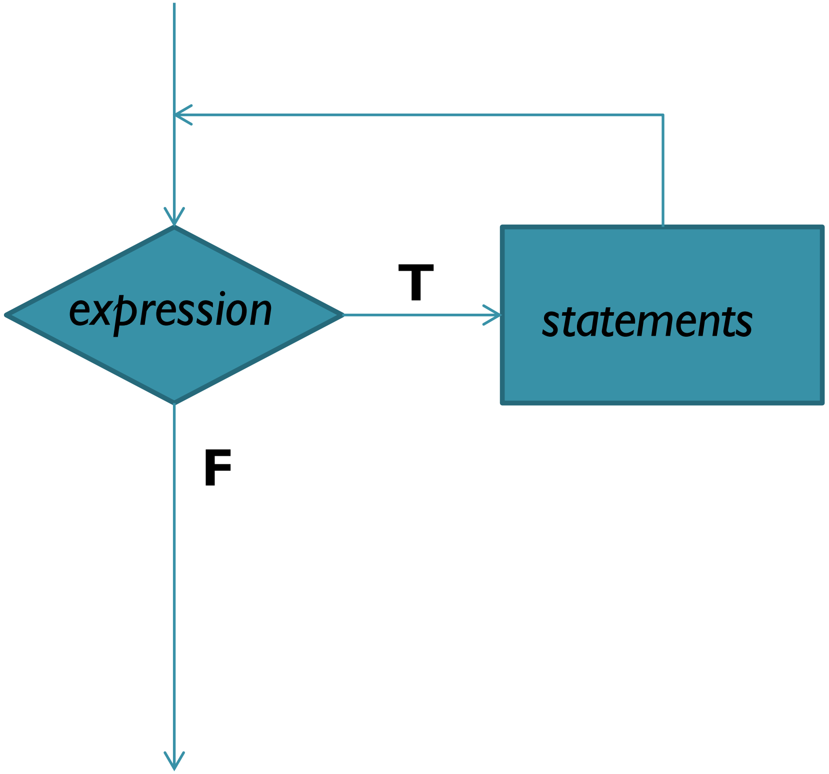
Common Pitfalls

- Forgetting to initialize useful variables
  - Remember to set the running sum or count to zero before you start summing or counting.
  - Remember to set the running product to one before using it
  - Remember to initialize index variables for while loops
- Code not executing
  - Not realizing that it is possible for the body of a while loop to never get executed, depending on your **test** condition.
- Causing an Infinite loop
  - Writing a `while` **test** condition that never fails.
  - Forgetting to **update** index variables in `while` loops

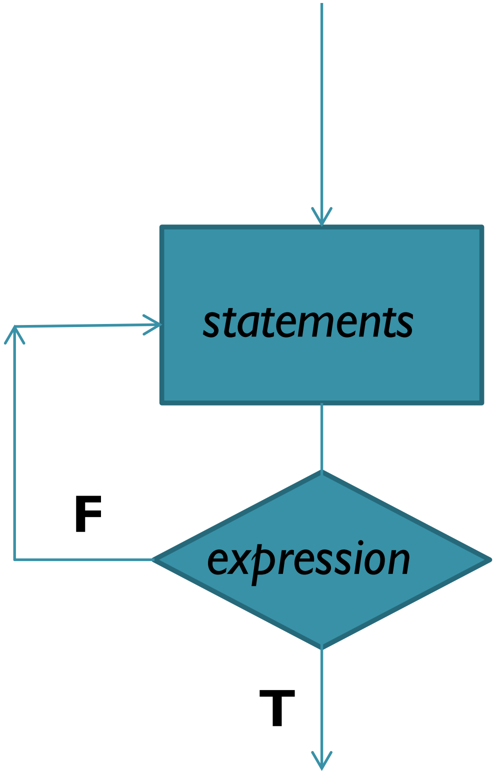
```
do index = start to end by increment;
    statements;
end;
```



```
do while (expression);
    statements;
end;
```



```
do until (expression);
    statements;
end;
```



Conditional Loops

Code some

Multi Dimensional Arrays

- We only looked at one dimensional arrays
  - SAS: Two dimensional arrays (two indices)
  - array m{4,3} $3. month1-month12;
  - first month of each quarter: m{qtr,1}

    where 1<=qtr<=4
  - 4 rows & 3 columns
  - SAS places variables into a two-dimensional array by filling all rows in order, beginning at the upper-left corner of the array (known as row-major order).

month1 (Jan)	month2 (Feb)	month2 (Mar)
month4 (Apr)	month5 (May)	month6 (Jun)
month7 (Jul)	month8 (Aug)	month9 (Sep)
month10 (Oct)	month11 (Nov)	month12 (Dec)

Summary

- Use arrays to recode groups of variables
- Use arrays to create and initialize new groups of variables
- Use arrays to count across a group of variables
- When using arrays/loops you need to look at the code from the perspective of the computer to understand what is happening internally
- Be patient!
    - You will run into many errors when you start writing loops/arrays
    - But practice makes perfect. Practice writing small codes

Use arrays to recode groups of variables

- You have five variables, which were all coded as 99 for refuse to answer
- You want to recode all five variables so that 99 is a missing for analysis

Without using Arrays	Using Arrays
`if var1=99 then var1=.;`	`array v{*} var1-var5;`
`if var2=99 then var2=.;`	`do i=1 to dim(v);`
`if var3=99 then var5=.;`	`   if v{i}=99 then v{i}=.;`
`if var4=99 then var4=.;`	`end;`
`if var5=99 then var5=.;`	

Use arrays to create/initialize groups of variables

- You are creating five new variables to store rates for each month from Jan-May
- You need to initialize all of them to be 0

Without using Arrays	Using Arrays
`jan=1;`	`array m{*} jan feb mar apr may;`
`feb=1;`	`do i=1 to dim(m);`
`mar=1;`	`  m{i}=0;`
`apr=1;`	`end;`
`may=1;`	

Use arrays to count across groups of variables

- You want to know how many assignments were over 90
- Complex if not using arrays
  - Create temporary binary variables for each assignment first
  - Then sum the binary variables

Without using Arrays	Using Arrays
`if assign1>90 then`	`*assign1-assign6;`
` bassign1=1;`	`array assign{6};`
`if assign2>90 then`	`cnt=0;`
` bassign2=1;`	`do i=1 to dim(assign);`
`… for all 6 vars …`	`  if assign{i}>90 then`
`cnt=sum (of assign1-assign6);`	`    cnt=cnt+1;`
`drop bassign1-bassign6;`	`end;`

Algorithms

- Common Idioms
  - Divide & Conquer
  - Iterate
  - Copying
  - Counting
  - Summing
  - Searching
  - Sorting

Reminder

- Review
  - Loops
    - do loops (counting loops)
    - while loops
  - Efficiency concepts
- Due next week
  - Midpoint email
- Read
  - UCLA module
    - http://www.ats.ucla.edu/stat/sas/modules/acrossvars.htm
  - Little SAS book
    - 3.11 Simplifying programs with arrays
    - 3.12 Using Shortcuts to Lists of Variable Names

Lab

Break?

(must start by 11)

File name (7 in total)

- kum2.sas (either your code, or commented my code)
- kum2.log
- kum2.htm or kum2.lst

- kum2lab.sas
- kum2lab.log
- kum2lab.lst

- kum2readme.txt

- Do Not type text into BB during submission.
- Use P1.3 in the comment so I can locate it.

Assignment 1: important to accurately understand what you have

- weekly incident of flu in the United States sorted by States starting from 09/28/2003 till 01/12/2014.
  - estimate
- influenza-related query searches on Google broken down by region in the United States (for this specific file). The data are represented as per 100,000 persons.
  - Not actual query search counts
- the incidence of the flu (measured as estimated number of Influenza-like-illness cases per 100,000 population by the CDC) in the 50 states, Washington DC and several regions and cities once per week for the period 9/28/2003 – 1/12/2014 for a total of 538 observations.

Assignment 1

- Programming Pro
  - Processing of writing solidifies what you are doing
  - Don’t need to jump from mouse to keyboard
  - Sense of more control
  - False feeling I am becoming “good programmer”
- Programming Con
  - Less efficient
  - More prone to error; typos
  - Harder than programming
- Grades
  - No readme (-2)
  - Do not include data

Assignment 2

- Questions on Assignment 2
- Potential typo message
  - NOTE: Variable dfw is uninitialized.
- Midterm check
  - Include computing environment
- Interesting datasets: could share SAS data
  - Todd: National Practitioner Data File
  - Yong: TX inpatient data
  - Chichi: BRFSS
  - Debra: NHANES

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Assignment Plan

- 1: Type what I gave you and run
- 2: Write your own relatively simple
- 3: Write your first real program (reusable elegant code)
- 4: Combining Tables
- 5: Indexing
- 6: Macros
- Final project

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Lab 3 Objective

- use for loops (counting loops)
- use while loops (conditional loops)
- use one dimensional arrays

Start Lab 3

- Who does not have lab2 working? Download from site
- Not allowed to open the full table ever for this class, even if you can.
  - Purpose is to learn to use BIG tables
- Option1: having difficulty reading code
  - Submit fully commented code
    - Add line by line comments (i.e. translate into English)
    - Important to understand what each line does
  - Submit log & results
    - Read the log to understand and add comments
- Option 2: comfortable reading code, not writing code
  - Read my code
  - Try to write it starting from lab2, without looking
- Option 3: comfortable reading & writing code
  - Do small exercise: write code (P2). Must create variables inside dataset
- Review assignment 3 midpoint email together

Assignment 3

- Option 1: structured
  - Download A2 answer (& data)
  - 3.1-3.3: required
    - Rewrite code to use loops & arrays
  - 3.4-3.8: optional
- Option 2: Self Defined
  - Plan your code
  - Write your code

FAQ 1

- **What information is provided by Google Flu Trends?**
  Google Flu Trends provides near real-time estimates of flu activity for a number of countries and regions around the world based on aggregated search queries. Some of these estimates have been validated through comparison with official historic influenza data from the relevant country or region. Generally, countries labeled as "experimental" have not been formally compared against official influenza data. Both validated and unvalidated estimates can be viewed on the Google Flu Trends website or downloaded as a CSV file for analysis.

FAQ II

- **How should the exported data be interpreted?** In most cases, raw numbers in each data file can be interpreted as the estimated number of ILI cases per 100,000 population; however, in Bulgaria, Germany, Ukraine, and South Africa the numbers represent ARI cases per 100,000 population. Australia, Canada, Chile and US flu activity levels are estimated as ILI cases per 100,000 physician visits. Romania flu activity levels are estimated as combined ILI and ARI per 100,000 physician visits.

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Guideline for assignment grading (Total of 8)

- Assignment (Total 4)
  - 1: Submitted code that does not run.
  - 2: Mostly running but incorrect.
  - 3: Correct and meets requirements (i.e uses programming constructs required for the assignment)
  - 4: Correct & Elegant. Comments.
- Answers to questions on the assignment (Total 1)
- Midpoint check email (Total 1)
- Lab (Total 2): recommend submitting after one week to get feedback for assignment

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Submission

- Collaboration (specify what)
  - Programming/debugging/taught general use
- Submitting answer as readme.txt
- Lab (Total 2): recommend submitting after one week to get feedback for assignment
  - Submit into Lab folder on BB, if submitting within one week (only provide feedback for these)
  - Otherwise, submit with assignment into Assignment folder (no feedback)
  - You really should be starting your assignment at least one week before it is due, in order for you to have sufficient time to iterate and seek help when needed.
- Differentiated class: Could have two levels (easy/moderate)
  - Either is fine