Macro Design Ideas: Theory, Template, Practice
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Abstract
Description: This paper provides a set of ideas about design elements of SAS® macros.
Purpose: This paper is a checklist for programmers who write or test macros.
Audience: advanced users or intermediate programmers polishing, testing, or writing macros.
Programs: in this paper are available on:
http://www.sascommunity.org/wiki/Macro_Design_Ideas
Keywords: macro design
Quote: Quality is free, but no one is ever going to know it if there isn’t some sort of agreed-upon system of measurement.
— Philip Crosby: Reflections on Quality

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Introduction

Overview

This section reviews the context in which macros are written.


What? : What is a macro? A macro is a program which can replicate statements around values supplied in parameters.

Why? : Why write macros? These are some reasons to create macros.
   1. reuse
   2. encapsulate complexity
   3. to use either of the macro statements %do or %if
   4. to use either of the macro functions %sysevalf or %sysfunc

When? : When are macros written, or polished? Macros are written after ad hoc programming produces several examples of similar processing that can be simplified into a macro. Polishing is best accomplished before peer review.

Where? : Where are macros? Macros occur in these places:
   • within a program
   • in a program in a project
   • in a site folder available to all projects

Summary

These ideas on macro design are for programmers writing or polishing macros for use in either a project or site.
Theory

Overview

Bricolage is the art of creative tinkering. Closely related is the idea of kludge: a workaround. Many macros start as kludges discovered whilst in bricolage.

The following topics are areas for further study and ideas for consideration during bricolage.

- Logic or Philosophy
- Quality
- Testing
- Vocabulary

Logic or Philosophy

Overview

One of the keys in design of a good macro is conditional processing. This section covers the historical development of logical reasoning from the 19th to the 20th century.

- Boole: not, and, or, xor
- De Morgan: nand, nor
- Venn diagrams for SQL joins

Boole’s Rules

George Boole is the author of rules now recognized as Boolean Logic which are here reduced to three elements.

- unary operation
- binary operators
- precedence rules

unary: The unary operator is not. It flips or reverses its argument.

<table>
<thead>
<tr>
<th>P</th>
<th>not</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
</tr>
</tbody>
</table>

binary: In Boolean Logic there are two binary operators: and, and or. Each can be used to identify a particular combination of two values. In natural language we use the term or instead of the formal term xor meaning exclusive or. This operator is included in this definition for clarity in later discussions of Venn diagrams and SQL (database) joins.

Continued on next page.
This is the truth table of the operators with De Morgan’s extensions.

<table>
<thead>
<tr>
<th>P</th>
<th>Q</th>
<th>and</th>
<th>or</th>
<th>xor</th>
<th>nand</th>
<th>nor</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
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<td>T</td>
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<tr>
<td>F</td>
<td>F</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
</tbody>
</table>

Blanks here are False.

**Notes:**

- Notice that the or operator includes the rows identified by and
- Exclusive or (xor) is true when either one or the other, but not both, are true. Joins in sql identify each of the xor rows: xor(T,F) is outer left, xor(F,T) is outer right. De Morgan’s nand includes both of the xor rows.

**precedence:** Parentheses have been added to the precedence list in acknowledgment of the recursive nature of logical resolution.

1. parentheses
2. negation
3. and
4. or

See also: [SAS Operators in Expressions](#) and the SAS OnLine Documentation: operators, Boolean, page-title: SAS Operators in Expressions.

! → The importance of parentheses in evaluations is addressed by De Morgan’s definitions of nand and nor.

---

**De Morgan’s Laws**

Augustus De Morgan was a contemporary of Boole. De Morgan’s Laws are stated in formal logic.

*Conjunction means and; disjunction means or.*

- **nand**: The negation of a conjunction is the disjunction of the negations.
- **nor**: The negation of a disjunction is the conjunction of the negations.

<table>
<thead>
<tr>
<th>operator</th>
<th>with parentheses</th>
<th>without parens</th>
</tr>
</thead>
<tbody>
<tr>
<td>nand</td>
<td>not(P and Q)</td>
<td>not P or not Q</td>
</tr>
<tr>
<td>nor</td>
<td>not(P or Q)</td>
<td>not P and not Q</td>
</tr>
</tbody>
</table>

! → Notice that the parentheses are necessary!
John Venn was an English logician known for the visual representations of set theory known as Venn diagrams. SQL joins are understood more easily using Venn diagrams.

<table>
<thead>
<tr>
<th>Operator</th>
<th>SQL</th>
<th>SAS</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>and</td>
<td>inner join</td>
<td>intersect</td>
<td>compare nand</td>
</tr>
<tr>
<td>or</td>
<td>full outer join</td>
<td>union</td>
<td></td>
</tr>
<tr>
<td>xor-left</td>
<td>left join</td>
<td>L except R</td>
<td>caution!</td>
</tr>
<tr>
<td>xor-right</td>
<td>right join</td>
<td>R except L</td>
<td></td>
</tr>
<tr>
<td>nand</td>
<td>outer join</td>
<td>xor-left plus xor-right</td>
<td></td>
</tr>
</tbody>
</table>

This diagram illustrates Boole’s logical operator $or(T,?)$ which includes three sets: $and(T,T)$, $xor(T,F)$ and $xor(F,T)$.

A or B: full outer join, union

The logical operator $and(T,T)$ identifies the row where both values are true.

A and B: inner join, intersect

These diagrams illustrate the extensions of Boole’s logical operator Exclusive Or which identifies two combinations: $xor(T,F)$ and $xor(F,T)$.

A xor B: left outer join, except

Continued on next page.
**Xor.Right**

A xor B: right outer join, except

![Diagram of right outer join](image)

For a right outer join in SAS be sure to swap the Right table to the first position!

**Nand: Xor**

This diagram illustrate De Morgan’s logical operator: nand, which includes the two rows identified by xor(T,?): xor-left and –right. Visually, this shows not(and(T,T)).

![Diagram of nand](image)

### Notes:
- See also SAS OnLine Documentation for the following pages:
  - outer joins: page-title: Creating and Using Outer Joins
  - outer joins: full outer joins, page-title: Selecting Data from More than One Table by Using Joins, contains Venn diagrams for inner (and) and outer (xor, xor-left) and full outer (or) joins
  - outer union set operator, page-title: query-expression discusses outer union, (inner) union, except and intersect
  - Fehd, Evaluating Logical Expressions
  - Lafler, Exploring DATA Step Merges and PROC SQL Joins

### Summary

Why do we need an understanding of logic? Because the macro %if statement is one of the reasons for writing a macro.

### Quote

Logic is an organized procedure for going wrong with confidence and certainty — Charles F. Kettering (1876-1958) American inventor, engineer, "Kettering's Law," from address before American Society of Mechanical Engineers (c. 1944)
# Quality

## Overview

Quality is an elusive concept. We use adjectives such as ‘good’ and ‘high’ to modify ‘quality’. But quality assurance is simple: does the product conform to the specifications? This section reviews authors who defined our sense of quality, first quality control and later quality assurance.

- Pareto
- Shewart
- Deming
- Juran
- Crosby

## Pareto

Vilfredo Pareto, an Italian economist, wrote in 1906 that 80% of the land in Italy was owned by just 20% of the population. This idea was named a rule in the 1940s by quality management consultant J. M. Juran who popularized it with the slogan: "the vital few and trivial many". The essence of the idea is that focusing on a few key elements produces the greatest return. In most real-world examples the numbers are not exactly 80/20 but may be 70/30 or 90/10; and their sum does not have to equal 100%.

See Juran's reframe of 'trivial many' to 'useful many' below.

## Shewhart

Walter A. Shewhart is often referred to as the father of statistical quality control based on a memo he wrote while working at Western Electric Company in 1924 which separated assignable-cause (signal) from chance-cause (noise).

Here are his data presentation rules:

- Data have no meaning apart from their context.
- Data contain both signal and noise. To be able to extract information, one must separate the signal from the noise within the data.

**Notes:**
- Shewhart is the author of the acronym PDCA: Plan-Do-Check-Act
- Deming noticed Shewhart’s publication in 1938 and reframed his own vocabulary about measurement error to the terms used by Shewhart.
- See also: SAS documentation for the Shewart and Ishikawa procedures.

**Quote:**
- Information is the difference that makes a difference
Deming

W. Edwards Deming and Juran were contemporaries in the 1940s and 50s; both consulted with Japanese companies during the post-war period. Deming is considered more practical for his focus on statistical process control. Deming’s famous quotation is:

1. When people and organizations focus primarily on quality, defined by the following ratio,

\[
\text{Quality} = \frac{\text{Results of work efforts}}{\text{Total costs}}
\]

quality tends to increase and costs fall over time.

2. However, when people and organizations focus primarily on costs, costs tend to rise and quality declines over time.


Juran

Joseph M. Juran is famous for reframing Pareto’s phrase “the vital few and the trivial many” to: “the vital few and the useful many”. His emphasis during his consulting work in Japan in the 1950s was on educating managers about their cultural concepts of quality. This is Juran’s trilogy for managers:

- quality planning
- quality control
- quality improvement

Juran brought Kaoru Ishikawa’s concept of quality circles to the U.S.

Crosby

Philip B. Crosby is the author of the sound bytes:

- Zero Defects
- Quality is Free
- Do it Right the First Time

Here are his four major principles:

1. The definition of quality is conformance to requirements (requirements meaning both the product and the customer’s requirements).

2. The system of quality is prevention.

3. The performance standard is zero defects (relative to requirements).

4. The measurement of quality (the cost) is the price of nonconformance.

Summary

Why do we need an understanding of quality assurance? Because managerial support for documentation and specifications are necessary when writing macros.
Fred Brooks in his book, *The Mythical Man Month*, provides the following table which describes how much time was spent on testing during development of the operating system for the IBM OS/360 during the 1960s.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
<th>Action</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>1/2</td>
<td>Understand Problem: Education and Research</td>
<td>1/3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Development Coding</td>
<td>1/6</td>
</tr>
<tr>
<td>Testing</td>
<td>1/2</td>
<td>Component or Unit Test</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Systems or Integration Test</td>
<td>1/4</td>
</tr>
</tbody>
</table>

Note the difference between debugging, which occurs during development, and testing which occurs afterwards.

Two decisions are needed in order to write testing statements in a macro.

- name of macro variable, recommended: testing, default = 0==false
- information useful during testing: data structure

```%macro Demo_Testing
(testing=0);
%*reset testing: add value of global testing option(s);
%let testing = %eval( &testing
or %sysfunc(getoption(mprint)) eq MPRINT);
%*...
%if &Testing %then %do;
PROC SQL; describe table &syslast;
quit;
%end;
```

The `describe table` statement writes the data structure to the log.

The `contents` and `datasets` procedures can be used as well; their output is written to the output window.

```PROC Contents data = &syslast;
PROC Datasets library = work;
   contents data = &syslast;
quit;
run;
```

The varieties of testing experience are described by Fehd [11] *nesug2007.cc12*; see also: *Writing Testing-Aware Programs*.

Why do we need an understanding of software testing?

Because testing takes up half our budget!
Vocabulary

Overview
A discussion of vocabulary and assumptions is a necessary precursor to effective communication during project development. This section reviews a few items that macro writers ought to agree on.

- program types
- SAS types
- naming conventions
- style guide

This story illustrates just how different corporate cultures can be.

The $125 million Mars Climate Orbiter crashed on the planet because the Jet Propulsion Laboratory used metric units, while engineers at Lockheed Martin used feet and pounds.

Program Types
These are theoretical types and their definitions are exclusive.

1. module: top level, calls routines and subroutines
2. routine: middle level, calls other routines and subroutines
3. subroutine: lowest level, no calls

The author offers the recommendation that SAS programs have three levels, and in extraordinary circumstances a maximum of four. Having more levels in one program increases the complexity of testing and identifying the source of problems.

SAS Types
Program types in SAS are not so definitive as the theoretical types. These definitions are non-exclusive and therefore may overlap.

1. program: has multiple steps, either data or procedure
2. parameterized %include, is.a program with one or more global macro variables in the calling program which act as parameters
3. macro: replicates one or more statements or steps
4. macro function: is.a subroutine, returns one or more tokens within a statement

Naming Conventions
Refer to the Style Guide item on capitalization to determine whether to use lowercase with underlines or InitCaps to differentiate global from local macro variables.
Style Guide

A Style Guide is a list of preferences for the following items:

- capitalization: lowercase, InitCaps, UPPERCASE
- indentation: tab, 2, 3, 4, 8 spaces
- line width maximum
- naming conventions
- white space

This is the author’s style guide

- capitalization: see also naming conventions
  - lowercase is the default
  - use InitCaps or underlines for nouns
  - UPPERCASE: AVOID! ALL CAPS IS HARD TO READ!
- indentation: data: 3, macros: 4
  replace tabs with spaces to ensure consistent printing
- line width maximum: 72; ensures cross platform compatibility
- one semicolon per line, maximum
- white space between tokens: use to align items for comparison

Why Capitalization Rules?

This story is from the 1980s when printers were 9-pin dot-matrix.

I once programmed a system that came to me with a five-year-old bug. The value of a key data element — shrinkage in the customer’s inventory — always came back zero. . . . The code logs showed that six programmers before me had failed to fix the bug. . . . One day, after some eight weeks of searching, I . . . saw the reason for the zero. . . . a simplified explanation is that the code read:

- key.data_element=l.value (capital l (eye), which had been initialized to zero),
- when it should have read:
- key.data_element=l.value (lower-case l (el), holding the real value).

Now this is truly awful programming. No variables should be given such similar names, especially not when their sole differentiator is two letters nearly identical visually. Six programmers before me, looking at code on our white-on-green character screens, could not tell eye from el. —Ellen Ulman, [Printing](http://www.wired.com) in Wired magazine April 16, 2013.

Summary

The primary purpose of documentation is that it is read and understood by both its creators and users before and after release. A common vocabulary — both stylistic and visual — is necessary for effective communication because readability is the first requirement for reuse.
Templates

Overview
In this section we review the parts of a model macro.

1. documentation
2. macro

Documentation

Overview
The primary audience of documentation is for colleagues before and during peer review. Secondarily, good documentation is the best advertising of the macro for users. Finally, readability is a requirement for reuse.

- identify: name and author
- information:
  - summary
  - contexts
  - specifications
- example
- notes

identify: write a generic file-specification

/*
   Name: <UNC>\SAS-site\macros\callmacr.sas
   Author: Claude Shannon 1963
*/

information: This is advertising that the macro has a design.

Summary: description: does what to which?
          purpose: used when, where?

Contexts: program group: data cleaning, ??
          program type: routine|subroutine
          SAS type: macro
          uses routines: ...

Specifications: input: required:
                optional:
                process:
                output:

examples: If at all possible provide an example, with data sets from the libref sashelp, that will work with no initialization.

Usage Example:
PROC Freq data = sashelp.Class;

Show output from the example: notes in log or listing.
Example

This is the documentation of Fehd [9 scoMacro-CallMacro].

```
/* Name: <UNC>\SAS-site\macros\callmacr.sas
Author: Ronald J. Fehd 2012, 2013
-------------------------------------------------------
Summary : description : call macro using
all values in data set row as parameters
purpose : provide generic method to call macro
using list::control data set of parms
-------------------------------------------------------
Contexts : program group: list processing token generator
program type: routine
SAS type: macro function
uses routines: macro named in the parameter macroname
-------------------------------------------------------
Specifications: input : required: Data, MacroName
optional: MacroParms, Hex16
process: assemble macro-call, call
output : from MacroName
-------------------------------------------------------
Parameters : Data = one- or two-level data set name
,MacroName = name of macro to call
,MacroName = put :: default, for testing
,MacroParms = additional parameters for called macro
+Constraint+: must be enclosed in nrstr:
,MacroParms = %nrstr(data=sashelp.class,var=Sex)
,Hex16 = 1 :: default, convert numerics to hex16
used to pass real numbers accurately
across step boundaries
,Hex16 = 0 :: pass numerics as decimals
,Semicolon = 0 :: no semicolon after macro call
,Semicolon = 1 :: use when macro name is a statement
+Constraint+: must be enclosed in nrstr:
,Testing = 0 :: default, no extra messages in log
,Testing = 1 :: for testing, note: auto-reset when
options mprint source2;
-------------------------------------------------------
Bells,Whistles: writes real time used to log
-------------------------------------------------------
Usage Example:
PROC Freq data = sashelp.Class;
tables Sex
/noprint
out = Work.Freq_Class_Sex;
run;*necessary;
%callmacr(Data = Work.Freq_Class_Sex
,MacroName = Put note:
,MacroParms = %nrstr(data=sashelp.class,var=sex)
)
log:
note:(data=sashelp.class,var=sex
,Sex=F,COUNT=4022000000000000,PERCENT=4047AF286BCA1AE7)
```

Summary

Good documentation is essential to two groups of people:

- colleagues reading before and during peer review, when the majority of errors can be found
- users who want to know how to use the macro

→ remember: readability promotes reuse

see also: Rhodes [17 sgf2013.Programming-Standards]
A Macro

Overview
A macro is similar to a data step:
both contain compile and execution (run-time) statements.

Data Step
A data step has two sets of statements:

- compiler directives which describe the data structure
- execution statements which implement the algorithm

* compiler directives: create input buffer and PDV;
DATA data-set-name
  (label = ’The New stuff’);
  * define new variables;
  attrib VarB length = <$> 4
    label = ’describing Var B’;

* execute algorithm: assignment(s);
do until(EndoFile);
  set libref.data-set-old end = EndoFile;
  * assignments;
  output;
  end;
stop;
run;

Continued on next page.
Macros have a similar set of compile and execute statements:

- **compile:**
  - name
  - parameters
  - description
  - local
- **execute:**
  - assignments
  - assertions: %if
  - program: %do

**name:** The name of the macro can provide answers to the question: Does what action on which object?

The simplest idea is to use a verb and an object in the name. The verb names the process; the noun may be either the input or the output.

**parameters:** Use parameter names that echo their usage in the program; if at all possible provide default values for unit testing.

**description:** Provide a description, which shows up in the catalog procedure output, that indicates where the macro resides: project or site, and what it does, adding more information than the macro name.

**local:** The macro may require temporary variables.

**assignments:** In support of testing a macro may standardize parameter values and logically add values from options. In a user-friendly macro a data set name may be one- or two-level; if assertions need two macro variables then recode.

**assertions:** If parameter values are invalid then exit gracefully.

See also: Fehd [7, sco.Cond-Exec-Global-Stmnts]
Template for a Macro

%macro sort_by_category
  (data = sashelp.class
   ,by = sex
   ,out = work.sorted /* may be one_level or two_level */
   ,testing = 0
  )
  / /* ** store source /* */
  des = 'site: this macro does ...';
%***** allocate temp var names;
%local out_lib out_data;
%*** assignments;
%let data = %lowcase(&data);
%let out = %lowcase(&out);
%let out_lib = work;
%let out_data = &out;
%** if out is a two-level name (has dot) then split;
%if %index(&out,.) %then %do;
%let out_lib = %scan(&out,1,.);
%let out_data = %scan(&out,2,.);
%end;
%** reset: add options info to var testing;
%let testing = %eval(not(0 eq &testing)
   or %sysfunc(getoption(mprint))
   eq %upcase(mprint));
%** assertions;
%if not %sysfunc(exist(&data)) %then %do;
  %put %str(ERR)OR: %sysmacroname &data not exists;
  %return; /* RETURN means jump to mend;
  %* see also %goto exit;
%end;
%** !NOTE!:LIBREF function returns 0 if libref has been assigned;
%if %sysfunc(libref(&out_lib.)) %then %do;
  %put %str(ERR)OR: %sysmacroname libref of &out not assigned;
  %goto exit;
%end;
%if %sysfunc(exist(&out.)) %then %do;
  %put Note: %sysmacroname &out was overwritten;
%end;
PROC Sort data = &data
   out = &out;
   by &by;
%if &Testing %then %do;
  PROC Sql; describe table &syslast;
  quit;
%end;
%exit: %* destination == label of %goto;
run;
%mend <macro-name>;;
Practice: Tricks or Traps

Overview

This section provides examples of common construction items and provides examples of solutions.

- evaluating Oregon
- reducing choices to boolean
- time-used note

Evaluating ORegon

The two-letter postal code abbreviation of the U.S. state named Oregon is OR, which is a logical operator.

The simple test of the value fails because the value is interpreted as a logical operator.

\%if &State eq OR ...
\%*is expanded to:;
\%if OR eq <missing> OR ...

The solution is to quote the strings:

\%if "&State" eq "OR" \%then ...

See also: Fehd \[5\] [sco.Beginners-Tour].

Reduction to boolean

Many problems arise in logical evaluation of expressions which contain user-supplied values written in natural language. Examples for boolean values include: yes/no, true/false, positive/negative, etc. Further complications come from allowing case variations: lowercase, Propcase, or UPCASE.

The problem can be shown as:

\%if &condition eq y or &condition eq Y
or &condition eq yes or &condition eq Yes
or &condition eq YES \%then ...

One solution is to use the macro in operator

\%macro chk_this(condition=0)/minoperator;
\%if %eval(&condition in y Y yes Yes YES)
\%then ...

The author’s solution is to standardize the case, reduce to the first letter and recode.

```
callmacr.sas
1 %if not( &choice eq 0
2 or &choice eq 1) \%then
3 \%let choice=%eval(y eq %lowcase(%substr(&choice,1,1)));
4 %* compare to the radical solution: any response is True=1;
5 \%let choice=%eval(not(0 eq &choice));
```
Time-used Note

A macro function does not return steps, so there are no timing notes written in the log. For a macro function containing a %do loop the following statements can be added to write an elapsed time-used note.

This trick requires local macro variables for the subtraction at the end of the routine. This code shows the initialization at the top of the definition.

```sas
%local TimeStart TimeEnd;
%let TimeStart = %sysfunc(datetime(),hex16.);
```

This is the calculation at the bottom of the definition.

```sas
%let TimeEnd = %sysfunc(datetime(),hex16.);
%Put note: &SysMacroName used real time %sysfunc(putn(&TimeEnd.x-&TimeStart.x,time12.3));
%mend;
```

Notes:
- initialize: save system.datetime as hex16
  ```sas
  TimeStart := ’1234567890abcdef’x
  ```
- termination
  ```sas
  TimeEnd := ’1234567890abcdef’x
  ```
- difference:
  ```sas
  TimeUsed := TimeEnd - TimeStart
  ```
- convert real number to user-readable: hh:mm:ss.sss
  ```sas
  putn(&TimeUsed,time12.3)
  ```

Summary

The primary purpose of a macros is to hide complexity.

Conclusion

A good macro is the result of several ideas coming together:

- First is management support for quality assurance and a style guide.
- Next is design, which leads to good documentation and programming. This produces a macro ready for peer review and testing.
- Finally, readability of documentation, and program, promotes reuse.
Further Reading

- programs: for this paper are in [Macro Design Ideas](#)
- peer review: Rhodes [17](sgf2013.Programming-Standards)
- predecessor: Fehd [12](sgf2008.003) (SmryEachVar) developed a suite of programs to return a list of the frequencies of each variable in a data set or libref. This suite illustrates the three levels of program complexity: module, routines, and subroutines. Programs for SmryEachVar are here: Fehd [8](sco.SmryEachVar).
- quality: Crosby [3](Crosby-Quality-and-Methods) and Crosby [2](Crosby-Quality-is-Free)
- Deming [4](Deming-Out-of-the-Crisis)
- Juran [13](Juran-Architect-of-Quality)
- style guides: Celko [1](Celko.2005-SQL-programming-style)
- This paper was typeset using the TeX program developed by Donald Knuth [14](Knuth-Literate-Programming).
- Martin [15](Martin.2009-Clean-Code)
- McConnell [16](McConnell.2004-Code-Complete-2e)
- examples: One of the best ways to learn to design and write macros is to examine other people's work.
- list: Jiantang Hu wrote a blog entry with a list of macro collections.
- Berry: Roland Rashleigh-Berry has a list of macros that he has developed for clinical reporting. He has good notes on avoiding name collisions.
- Devenezia: Richard A. Devenezia has a page with his macros.
- Fehd: Many of the author's macros are on sas.community.org.
- Fehd [10](sco.Macro-Loops-With-Dates) is in this conference proceedings. Fehd [9](sco.Macro-CallMacro) is the example documentation shown here.
- This program may be useful: Fehd [6](sco.Indexing-Programs)
- Friendly: Michael Friendly has a suite of macros which have internal markup symbols so that they can be processed and an html page extracted from them.
- Schick: Arnold Schick of University of Marburg, Germany, has a collection of macros.

Acknowledgements

Several Alert Readers contributed to a SAS-L thread whose subject contains: Theory: reducing positive/true/yes, etc to boolean, date-start: June 2013. There was disagreement about whether to recode any user-supplied value to true=1 for the macro variable testing. Search for: %eval(not(0 eq &testing)).
Bibliography


Closure

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Technical skill is mastery of complexity
while creativity is mastery of simplicity.

— E. C. Zeeman, British mathematician