```lua
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---   (c) Tim Menzies 2022, BSD-2             . ..:.::o:ooOoOoOO8O8OCCCC"o
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local b4={}; for k,_ in pairs(_ENV) do b4[k]=k end
local the,help={},[[

lua l5.lua [OPTIONS]
L5 == a very little LUA learning lab

OPTIONS (inference):                        | DEFAULT
  -boot    -b P  #bootstrap samples          | 256
  -cohen   -c F  cohen's small effect size   | .35
  -cliffs  -C F  threshold on Cliff's delta  | .147
  -far     -F F  look no further than "far"  | .9
  -keep    -k    items to keep in a number   | 512
  -leaves  -l    leaf size                   | .5
  -conf    -n F  confidence for stats tests  | .05
  -p       -p P  distance calcs coefficient  | 2
  -seed    -S P  random number seed          | 10019
  -some    -s    look only at "some" items   | 512

OPTIONS (housekeeping):
  -dump    -d    on error, exit+ stacktrace  | false
  -file    -f S  where to get data           | ../etc/data/auto93.csv
  -help    -h    show help                   | false
  -rnd     -r S  format string               | %5.2f
  -todo    -t S  start-up action             | nothing
]]
--------------------------------------------------------------------------------
--[[
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LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN
ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.  --]]

--------------------------------------------------------------------------------
-- ## Coding Conventions
--
-- - All config options in "the" (which is generated by parsing the help text)
-- - LOTS OF SHORT FUNCTIONS
-- - Line width = 80
-- - when you can, write functions down on one line
-- - "i" not "self" (so we can fit more on each line)
-- - for loop index variables, do not use i. try j,k instead.
-- - if something holds a list of thing, name the holding variable "all"
-- - no inheritance
-- - only define a method if that is for polymorphism
-- - all config items into a global "the" variable
-- - all the test cases (or demos) are "function Demo.xxx".
--   - If test case assertion crashed, add "1" to Demo.fails
--   - On exit return the value of Demo.fails as the exit status
-- - random seed reset so carefully, just once, at the end of the code.
-- - usually, no line with just "end" on it
--------------------------------------------------------------------------------
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---    |___/ |----|  |  |----|

-- This code reads date from csv files (where "?" denotes "missing value").
local is={}
function is.missing(x) return x=="?" end

-- The names on  row1 of that file define the role of that column.
-- Names in row1 ending with ":" are to be ignored
function is.skip(x) return x:find":$" end

-- Names in row1 starting in upper case are numbers
function is.num(x) return x:find"^[A-Z]" end

-- Names in row1 ending with "!" are classes.
function is.class(x) return x:find"!$" end

-- Names in row1 ending with "-" are objectives to be minimized.
function is.less(x) return x:find"-$" end

-- Names in row1 ending with "+" are objectives to be maximized.
function is.more(x) return x:find"+$" end

-- Objectives or classes are dependent variables.
function is.dependent(x) return is.more(x) or is.less(x) or is.class(x) end

-- For example, in this data file, we will ignore column 3 (Hp:),
-- try to minimize weight (Lbs-) and maximize acceleration and
-- miles per hour (Acc+, Mpg+). Also, with one exception (origin),
-- everything is numeric. Finally,  there are some missing values on
-- lines 3 and lines 7.
--
--      Clndrs, Weight, Hp:, Lbs-, Acc+, Model, origin, Mpg+
--      8,      304.0,  193, 4732, 18.5, 70,    1,      10
--      8,      ?,      215, 4615, 14,   70,    1,      10
--      4,      85,     70,  2070, 18.6, 78,    3,      40
--      4,      85,     65,  2110, 19.2, 80,    3,      40
--      4,      85,     ?,   1835, 17.3, 80,    2,      40
--      4,      98,     76,  2144, 14.7, 80,    2,      40

--------------------------------------------------------------------------------
---     ____  ____   _  ____  ____  ____  ____
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local as = setmetatable
local function obj(   t)
  t={__tostring=o}; t.__index=t
  return as(t, {__call=function(_,...) return t.new(_,...) end}) end

local Sym = obj() -- Where to summarize symbols
function Sym:new(at,s) return as({
  is="Sym",      -- type
  at=at or 0,    -- column index
  name=s or "",  -- column name
  n=0,           -- number of items summarized in this column
  all={},        -- all[x] = n means we've seen "n" repeats of "x"
   most=0,       -- count of the most frequently seen symbol
   mode=nil      -- the most commonly seen letter
  }, Sym) end

local Num = obj() -- Where to summarize numbers
function Num:new(at,s) return as({
  is="Num",      -- type
  at=at or 0,    -- column index
  name=s or "",  -- column name
  n=0,           -- number of items summarizes in this column
  mu=0,          -- mean (updated incrementally)
  m2=0,          -- second moment (updated incrementally)
  sd=0,          -- standard deviation
  ok=false,      -- true if "all" is sorted
  all={},        -- a sample of items seen so far
  lo=1E31,       -- lowest number seen; initially, big so 1st num sends it low
  hi=-1E31,      -- highest number seen;initially, msall to 2st num sends it hi
  w=is.less(s or "") and -1 or 1 -- "-1"= minimize and "1"= maximize
  }, Num) end

local Egs = obj() -- Where to store examples, summarized into Syms or Nums
function Egs:new(names,     i,col,here)  i=as({
  is="Egs",     -- type
  all={},       -- all the rows
  names=names,  -- list of name
  cols={},      -- list of all columns  (Nums or Syms)
  x={},         -- independent columns (nothing marked as "skip")
  y={},         -- dependent columns (nothing marked as "skip")
  class=nil     --  classes
  },Egs)
  for at,name in pairs(names) do
    col = (is.num(name) and Num or Sym)(at,name)
    i.cols[1+#i.cols] = col
    here = is.dependent(name) and i.y or i.x
    if not is.skip(name) then
      here[1 + #here] = col
      if is.class(name) then i.class=col end end end
  return i end
---      _ |  _   _  .  _   _
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---                         _|

function Num.clone(i) return Num(i.at, i.name) end
function Sym.clone(i) return Sym(i.at, i.name) end

local data
function Egs.clone(i,rows,    copy)
  copy = Egs(i.names)
  for _,row in pairs(rows or {}) do  data(copy,row)  end
  return copy end
```

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---  |  | |  ___] |___     |   |__| |__| |___ ___]

local r   = math.random
local fmt = string.format
local unpack = table.unpack
local function push(t,x) table.insert(t,x); return x end
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local thing,things,file2things
function thing(x)
  x = x:match"^%s*(.-)%s*$"
  if x=="true" then return true elseif x=="false" then return false end
  return tonumber(x) or x end

function things(x,sep,  t)
  t={}; for y in x:gmatch(sep or"([^,]+)") do t[1+#t]=thing(y) end
  return t end

function file2things(file,      x)
  file = io.input(file)
  return function()
    x=io.read();
    if x then return things(x) else io.close(file) end end end
---    _   _ _|_    _  _ _|_
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---    _|

local last,per,any,many
function last(a)        return a[ #a ] end
function per(a,p)       return a[ (p*#a)//1 ] end
function any(a)         return a[ math.random(#a) ] end
function many(a,n,  u) u={}; for j=1,n do push(u,any(a)) end; return u end
---   |. __|_
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local firsts,sort,map,slots,copy
function firsts(a,b)  return a[1] < b[1] end
function sort(t,f)    table.sort(t,f); return t end
function map(t,f, u)  u={};for k,v in pairs(t) do push(u,f(v)) end; return u end
function slots(t, u,s)
  u={}
  for k,v in pairs(t) do s=tostring(k);if s:sub(1,1)~="_" then push(u,k) end end
  return sort(u) end

function copy(t,   u)
  if type(t)~="table" then return t end
  u={}; for k,v in pairs(t) do u[copy(k)]=copy(v) end
  return setmetatable(u, getmetatable(t)) end

---    _  _ . _ _|_
---   |_)|  || | |
---   |

local oo,o, rnd, rnds
function oo(t) print(o(t)) end
function o(t,seen,        key,xseen,u)
  seen = seen or {}
  if type(t)~="table" then return tostring(t) end
  if seen[t]           then return "..." end
  seen[t] = t
  key   = function(k) return fmt(":%s %s",k,o(t[k],seen)) end
  xseen = function(x) return o(x,seen) end
  u = #t>0 and map(t,xseen) or map(slots(t),key)
  return (t.is or "")..'{'..table.concat(u," ").."}" end

function rnds(t,f) return map(t, function(x) return rnd(x,f) end) end
function rnd(x,f)
  return fmt(type(x)=="number" and (x~=x//1 and f or the.rnd) or "%s",x) end
---   _|_ _  __|_   _    . _|_ _
---    | (/__\ |   _\|_|| |  (/__\

local Demo, ok = {fails=0}
function ok(test,msg)
  print(test and "PASS: "or "FAIL: ",msg or "")
  if not test then
    Demo.fails=Demo.fails+1
    if the.dump then assert(test,msg) end end end

function Demo.main(todo,seed)
   for k,one in pairs(todo=="all" and slots(Demo) or {todo}) do
     if k ~= "main" and type(Demo[one]) == "function" then
       math.randomseed(seed)
       Demo[one]() end end
   for k,v in pairs(_ENV) do if not b4[k] then print("?",k,type(v)) end end
   return Demo.fails end
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---   |                      |                  _|

local function settings(txt,  d)
   d={}
   txt:gsub("\n ([-]([^%s]+))[%s]+(-[^%s]+)[^\n]*%s([^%s]+)",
    function(long,key,short,x)
      for n,flag in ipairs(arg) do
        if flag==short or flag==long then
          x = x=="false" and true or x=="true" and "false" or arg[n+1] end end
      if x=="false" then the[key]=false elseif x=="true" then the[key]=true else
      d[key] = tonumber(x) or x end end)
  if d.help then print(txt) end
  return d end
---------------------------------------------------------------------------------
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local add
function add(i,x, inc)
  inc = inc or 1
  if not is.missing(x) then
    i.n = i.n + inc
    i:internalAdd(x,inc) end
  return x end

function Sym.internalAdd(i,x,inc)
  i.all[x] = inc + (i.all[x] or 0)
  if i.all[x] > i.most then i.most, i.mode = i.all[x], x end end

function Num.internalAdd(i,x,inc,    d)
  for j=1,inc do
    d     = x - i.mu
    i.mu  = i.mu + d/i.n
    i.m2  = i.m2 + d*(x - i.mu)
    i.sd  = (i.m2<0 or i.n<2) and 0 or ((i.m2/(i.n-1))^0.5)
    i.lo  = math.min(x, i.lo)
    i.hi  = math.max(x, i.hi)
    if     #i.all < the.keep   then i.ok=false; push(i.all,x)
    elseif r() < the.keep/i.n then i.ok=false; i.all[r(#i.all)]=x end end end

function Num.sorted(i)
  if not i.ok then i.all = sort(i.all) end
  i.ok=true
  return i.all end
---    _ _   _ |  _    _|  _ _|_ _
---   | | | (_| |<(/_  (_| (_| | (_|

local file2Egs -- not "local data" (since defined above)
function data(i,row)
  push(i.all, row)
  for _,col in pairs(i.cols) do add(col, row[col.at]) end
  return i end

function file2Egs(file,   i)
  for row in file2things(file) do
    if i then data(i,row) else i = Egs(row) end end
  return i end
---      _       _  _        _  _     . _   _
---   _\|_|| | || | | |(_|| |/_(/_

local mids
function mids(i,rows,cols) return i:clone(rows):mid(cols) end

function Egs.mid(i,cols)
  return map(cols or i.y,function(col) return col:mid() end) end

function Sym.mid(i) return i.mode end
function Num.mid(i) return i.mu end

function Num.div(i) return i.sd end
function Sym.div(i,  e)
  e=0; for _,n in pairs(i.all) do e=e + n/i.n*math.log(n/i.n,2) end
  return -e end
---    _|. __|_ _  _  _  _
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local far,furthest,neighbors,dist
function far(      i,r1,rows,far)
  return per(neighbors(i,r1,rows),far or the.far)[2] end

function furthest( i,r1,rows)
  return last(neighbors(i,r1,rows))[2] end

function neighbors(i,r1,rows)
  return sort(map(rows, function(r2) return {dist(i,r1,r2),r2} end),firsts) end

function dist(i,row1,row2,    d,n,a,b,inc)
  d,n = 0,0
  for _,col in pairs(i.x) do
    a,b = row1[col.at], row2[col.at]
    inc = is.missing(a) and is.missing(b) and 1 or col:dist1(a,b)
    d = d + inc^the.p
    n = n + 1 end
  return (d/n)^(1/the.p) end

function Sym.dist1(i,a,b) return a==b and 0 or 1 end

function Num.dist1(i,a,b)
  if     is.missing(a) then b=i:norm(b); a=b<.5 and 1 or 0
  elseif is.missing(b) then a=i:norm(a); b=a<.5 and 1 or 0
  else   a,b = i:norm(a), i:norm(b)  end
  return math.abs(a - b) end

function Num.norm(i,x)
  return i.hi - i.lo < 1E-32 and 0 or (x - i.lo)/(i.hi - i.lo) end
```

```lua
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local half, cluster, clusters
function half(i, rows,    project,row,some,left,right,lefts,rights,c,mid)
  function project(row,a,b)
    a= dist(i,left,row)
    b= dist(i,right,row)
    return {(a^2 + c^2 - b^2)/(2*c), row}
  end -----------------------
  some  = many(rows,        the.some)
  left  = furthest(i,any(some), some)
  right = furthest(i,left,      some)
  c     = dist(i,left,right)
  lefts,rights = {},{}
  for n, projection in pairs(sort(map(rows,project),firsts)) do
    if n==#rows//2 then mid=row end
    push(n <= #rows//2 and lefts or rights, projection[2]) end
  return lefts, rights, left, right, mid, c  end

function cluster(i,rows,  here,lefts,rights)
  rows = rows or i.all
  here = {all=rows}
  if #rows >= 2* (#i.all)^the.leaves then
    lefts, rights, here.left, here.right, here.mid = half(i, rows)
    if #lefts < #rows then
      here.lefts = cluster(i,lefts)
      here.rights= cluster(i,rights) end end
  return here end

function clusters(i,format,t,pre,   front)
  if t then
    pre=pre or ""
    front = fmt("%s%s",pre,#t.all)
    if not t.lefts and not t.rights then
      print(fmt("%-20s%s",front, o(rnds(mids(i,t.all),format))))
    else
      print(front)
      clusters(i,format,t.lefts, "|".. pre)
      clusters(i,format,t.rights,"|".. pre) end end end
```

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local merge,merged,spans,bestSpan
function Sym.spans(i, j)
  local xys,all,one,last,x,y,n = {}, {}
  for x,n in pairs(i.all) do push(xys, {x,"lefts",n}) end
  for x,n in pairs(j.all) do push(xys, {x,"rights",n}) end
  for _,tmp in ipairs(sort(xys,firsts)) do
    x,y,n = unpack(tmp)
    if x ~= last then
      last = x
      one  = push(all, {lo=x, hi=x, all=Sym(i.at,i.name)}) end
    add(one.all, y, n) end
  return all end

function Num.spans(i, j)
  local xys,all,lo,hi,gap,one,x,y,n = {},{}
  lo,hi = math.min(i.lo, j.lo), math.max(i.hi,j.hi)
  gap   = (hi - lo) / (6/the.cohen)
  for _,n in pairs(i.all) do push(xys, {n,"lefts",1}) end
  for _,n in pairs(j.all) do push(xys, {n,"rights",1}) end
  one = {lo=lo, hi=lo, all=Sym(i.at,i.name)}
  all = {one}
  for _,tmp in ipairs(sort(xys,firsts)) do
    x,y,n = unpack(tmp)
    if   one.hi - one.lo > gap
    then one = push(all, {lo=one.hi, hi=x, all=one.all:clone()}) end
    one.hi = x
    add(one.all, y, n) end
  all          = merge(all)
  all[1   ].lo = -math.huge
  all[#all].hi =  math.huge
  return all end

function merge(b4,      j,n,now,a,b,both)
  j, n, now = 0, #b4, {}
  while j < #b4 do
    j    = j+1
    a, b = b4[j], b4[j+1]
    if   b then
      both = a.all:merged(b.all)
      if    both
      then  a = {lo=a.lo, hi=b.hi, all=both}
            j = j + 1 end end
    push(now,a) end
  return #now == #b4 and b4 or merge(now) end

-- XXX make .marged and function
function Num.merge(i,j,    k)
  k=i:clone()
  for _,x in pairs(i.all) do add(k,x) end
  for _,x in pairs(j.all) do add(k,x) end
  return k end

function Sym.merge(i,j,    k)
  k = i:clone()
  for x,n in pairs(i.all) do add(k,x,n) end
  for x,n in pairs(j.all) do add(k,x,n) end
  return k end

function Sym.merged(i,j,   k,ei,ej,ek)
  k = i:merge(j)
  ei, ej, ek= i:div(), j:div(), k:div()
  if ek*.99 <= (i.n*ei + j.n*ej)/k.n then return k end end

function spans(egs1,egs2,      spans,tmp,col1,col2)
  spans = {}
  for c,col1 in pairs(egs1.x) do
    col2 = egs2.x[c]
    tmp = col1:spans(col2)
    if #tmp> 1 then
      for _,one in pairs(tmp) do push(spans,one) end end end
  return spans end

function bestSpan(spans)
  local divs,ns,n,div,stats,dist2heaven = Num(), Num()
  function dist2heaven(s) return {((1 - n(s))^2 + (0 - div(s))^2)^.5,s} end
  function div(s)         return divs:norm( s.all:div() ) end
  function n(s)           return   ns:norm( s.all.n     ) end
  for _,s in pairs(spans) do
    add(divs, s.all:div())
    add(ns,   s.all.n) end
  return sort(map(spans, dist2heaven), firsts)[1][2]  end
---        _      _  |  _  .  _
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---            |

local xplain,xplains,selects,spanShow
function xplain(i,rows,used,
                    stop,here,left,right,lefts0,rights0,lefts1,rights1)
  used=used or {}
  rows = rows or i.all
  here = {all=rows}
  stop = (#i.all)^the.leaves
  if #rows >= 2*stop then
    lefts0, rights0, here.left, here.right, here.mid, here.c  = half(i, rows)
    if #lefts0 < #rows then
      here.selector = bestSpan(spans(i:clone(lefts0),i:clone(rights0)))
      push(used, {here.selector.all.name, here.selector.lo, here.selector.hi})
      lefts1,rights1 = {},{}
      for _,row in pairs(rows) do
        push(selects(here.selector, row) and lefts1 or rights1, row) end
      if #lefts1  > stop then here.lefts  = xplain(i,lefts1,used) end
      if #rights1 > stop then here.rights = xplain(i,rights1,used) end end end
  return here end

function xplains(i,format,t,pre,how,    sel,front)
  pre, how = pre or "", how or ""
  if t then
    pre=pre or ""
    front = fmt("%s%s%s %s",pre,how, #t.all, t.c and rnd(t.c) or "")
    if t.lefts and t.rights then print(fmt("%-35s",front)) else
      print(fmt("%-35s %s",front, o(rnds(mids(i,t.all),format))))
    end
    sel = t.selector
    xplains(i,format,t.lefts,  "|".. pre, spanShow(sel)..":")
    xplains(i,format,t.rights, "|".. pre, spanShow(sel,true) ..":") end end

function selects(span,row,    lo,hi,at,x)
  lo, hi, at = span.lo, span.hi, span.all.at
  x = row[at]
  if is.missing(x) then return true end
  if lo==hi then return x==lo else return lo <= x and x < hi end end

function spanShow(span, negative,   hi,lo,x,big)
  if not span then return "" end
  lo, hi, x, big  = span.lo, span.hi, span.all.name, math.huge
  if   not negative
  then if lo ==  hi  then return fmt("%s == %s",x,lo)  end
       if hi ==  big then return fmt("%s >= %s",x,lo)  end
       if lo == -big then return fmt("%s < %s",x,hi)  end
       return fmt("%s <= %s < %s",lo,x,hi)
  else if lo ==  hi  then return fmt("%s != %s",x,lo)  end
       if hi ==  big then return fmt("%s < %s",x,lo)  end
       if lo == -big then return fmt("%s >= %s",x,hi)  end
```

```lua
        return fmt("%s < %s and %s >= %s", x,lo,x,hi)  end end
---     __|_ _ _|_ _
---    _\ |  (_| |  _\

local quintiles,smallfx,bootstrap
function quintiles(ts,width,  nums,out,all,n,m)
  width=width or 32
  nums=Num(); for _,t in pairs(ts) do
                for _,x in pairs(sort(t)) do add(nums,x) end end
  all,out = nums.all, {}
  for _,t in pairs(ts) do
     local s, where = {}
     where = function(n) return (width*nums:norm(n))//1 end
     for j = 1, width do s[j]=" " end
     for j = where(per(t,.1)), where(per(t,.3)) do s[j]="-" end
     for j = where(per(t,.7)), where(per(t,.9)) do s[j]="-" end
     s[where(per(t, .5))] = "|"
     push(out,{display=table.concat(s),
               data = t,
               pers = map({.1,.3,.5,.7,.9},
                          function(p) return rnd(per(t,p))end)}) end
  return out end

function smallfx(xs,ys,     x,y,lt,gt,n)
  lt,gt,n = 0,0,0
  if #ys > #xs then xs,ys=ys,xs end
  for _,x in pairs(xs) do
    for j=1, math.min(64,#ys) do
      y = any(ys)
      if y<x then lt=lt+1 end
      if y>x then gt=gt+1 end
      n = n+1 end end
  return math.abs(gt - lt) / n <= the.cliffs end

function bootstrap(y0,z0)
  local x, y, z, b4, yhat, zhat, bigger
  local function obs(a,b,    c)
    c = math.abs(a.mu - b.mu)
    return (a.sd + b.sd) == 0 and c or c/((x.sd^2/x.n + y.sd^2/y.n)^.5) end
  local function adds(t, num)
    num = num or Num(); map(t, function(x) add(num,x) end); return num end
  y,z    = adds(y0), adds(z0)
  x      = adds(y0, adds(z0))
  b4     = obs(y,z)
  yhat   = map(y.all, function(y1) return y1 - y.mu + x.mu end)
  zhat   = map(z.all, function(z1) return z1 - z.mu + x.mu end)
  bigger = 0
  for j=1,the.boot do
    if obs( adds(many(yhat,#yhat)),  adds(many(zhat,#zhat))) > b4
    then bigger = bigger + 1/the.boot end end
  return bigger >= the.conf end

--- xxx mid has to be per and
-- XXX implement same
-- XXX need tests for stats
function scottKnot(nums,      all,cohen)
  local mid = function (z) return z.some:mid()
  end --------------------------------
  local function summary(i,j,    out)
    out = copy( nums[i] )
    for k = i+1, j do out = out:merge(nums[k]) end
    return out
  end ---------------------------
  local function div(lo,hi,rank,b4,       cut,best,l,l1,r,r1,now)
    best = 0
    for j = lo,hi do
      if j < hi  then
        l   = summary(lo,  j)
        r   = summary(j+1, hi)
        now = (l.n*(mid(l) - mid(b4))^2 + r.n*(mid(r) - mid(b4))^2
              ) / (l.n + r.n)
        if now > best then
          if math.abs(mid(l) - mid(r)) >= cohen then
            cut, best, l1, r1 = j, now, copy(l), copy(r)
    end end end end
    if cut and not l1:same(r1,the) then
      rank = div(lo,    cut, rank, l1) + 1
      rank = div(cut+1, hi,  rank, r1)
    else
      for i = lo,hi do nums[i].rank = rank end end
    return rank
  end ------------------------------------------------------
  table.sort(nums, function(x,y) return mid(x) < mid(y) end)
  all   = summary(1,#nums)
  cohen = all.sd * the.cohen
  div(1, #nums, 1, all)
  return nums end

-------------------------------------------------------------------------------
---     _  _  ____  _  _  _
---    |\/| |__| |  |\ |
---    |  | |  | |  | \|

function Demo.the() oo(the) end

function Demo.many(a)
  a={1,2,3,4,5,6,7,8,9,10}; ok("{10 2 3}" == o(many(a,3)), "manys") end

local function normal(m,s)
  local pi, sqrt, cos, log = math.pi, math.sqrt, math.cos, math.log
  local function z() return sqrt(-2*log(r())) * cos(2* pi * r()) end
  return m + s*z() end

function Demo.tiles()
  local function ns(m,s,r,     u)
    u={}; for j=1,r do u[1+#u] = normal(m,s) end; return u end
  local ts={}
  local m=100
  for mu=8,12,.25 do ts[1+#ts] = ns(mu, 5, m) end
  ts= sort(map(ts,sort), function(a,b) return per(a,.5) < per(b,.5) end)
  for j,one in pairs(quintiles(ts,20)) do
    print(fmt("[%s]",one.display),o(one.pers),
                     smallfx(  ts[1], ts[j]),
                     bootstrap(ts[1], ts[j])) end end

function Demo.stats(  t1,t2,inc,n,a,b)
  for _,n in pairs{20} do --25,50,100,250,500,1000} do
    inc=1
    while inc < 3 do
      print("")
      t1={}; for j=1,n            do push(t1, j*r()) end
      t2={}; for j,x in pairs(t1) do t2[j]=x+inc end
      a,b = smallfx(t1,t2), bootstrap(t1,t2)
      for _,x in pairs(quintiles{t1,t2}) do print(rnd(inc), x.display,a,b) end
      inc = inc*1.1 end end end

function Demo.stats1(x)
  x1={0.34, 0.49 , 0.51 , 0.6}
  x2={  0.6,  0.7 ,  0.8 ,  0.9}
  x3={ 0.15 , 0.25 , 0.4 ,  0.35}
  x4={ 0.6 ,  0.7 ,  0.8  , 0.9}
  x5={0.1 ,  0.2 ,  0.3 ,  0.4}
  print(bootstrap(x5,x3))
  print(bootstrap(x3,x1))
  print(bootstrap(x1,x2))
  print(bootstrap(x2,x4))
end


function Demo.egs()
  ok(5140==file2Egs(the.file).y[1].hi,"reading") end

function Demo.dist(i)
  i = file2Egs(the.file)
  for n,row in pairs(i.all) do print(n,dist(i, i.all[1], row)) end end

function Demo.far(  i,j,row1,row2,row3,d3,d9)
  i = file2Egs(the.file)
  for j=1,10 do
    row1 = any(i.all)
    row2 = far(i,row1, i.all, .9)
    d9   = dist(i,row1,row2)
    row3 = far(i,row1, i.all, .3)
    d3   = dist(i,row1,row3)
    ok(d3 < d9, "closer far") end end

function Demo.half(  i,lefts,rights)
  i = file2Egs(the.file)
  lefts,rights = half(i, i.all)
  oo(mids(i, lefts))
  oo(mids(i, rights))
  end

function Demo.cluster(   i)
  i = file2Egs(the.file)
  clusters(i,"%.0f",cluster(i)) end

function Demo.spans(    i,lefts,rights)
  i = file2Egs(the.file)
  lefts, rights = half(i, i.all)
  oo(bestSpan(spans(i:clone(lefts), i:clone(rights)))) end

function Demo.xplain(    i,j,tmp,lefts,rights,used)
  i = file2Egs(the.file)
  used={}
  xplains(i,"%.0f",xplain(i, i.all,used))
  map(sort(used,function(a,b)
        return ((a[1] < b[1]) or
                (a[1]==b[1] and a[2] < b[2]) or
                (a[1]==b[1] and a[2]==b[2] and a[3] < b[3]))end),oo) end


-------------------------------------------------------------------------------
the = settings(help)
Demo.main(the.todo, the.seed)
```