

# Personality research: an open and shared science

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<http://personality-project.org/sapa.html>

## Outline

1. The importance of open science for psychological research.
2. Open source statistics: The R project
3. Open source materials: IPIP and ICAR
4. Open source methodology: Synthetic Aperture Personality Assessment
5. Open source data: *Journal of Open Psychology Data* and *DataVerse*

## Open Science

1. Science is an international collaborative endeavor that benefits when more people from more countries participate.
2. Scientific societies were started (e.g, the Royal Society in London in 1660) as an “invisible college” to facilitate communication and the sharing of ideas.
3. Traditionally we collaborate by publishing our results in scientific journals and by sharing our ideas at national and international conferences.
4. More recently, there is a trend towards sharing our materials, our methods, and our results, even our data, on the web.
5. This makes for better science.

## Open Science and the problem of replication

1. The last several years has seen a plethora of papers reporting failures to replicate results. This has lead some to worry about the strength of our findings and others to question what does it mean to “replicate” or reproduce a result.
2. Others have suggested that we should be more open in our designs, publishing what we plan to do independent of what we actually find.
3. This is an important problem that should not be ignored, although pre-registering might inhibit exploratory research.
4. But, open science is much more than protecting us from type I errors. It is a philosophy of collaboration. That is what I want to emphasize today.



## Four types of openness:

1. Open source software: The R project (R Core Team, 2015)
2. Open source materials:
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  - The International Cognitive Ability Resource (ICAR) (Condon & Revelle, 2014)
3. Open source methodology: The Synthetic Aperture Personality Assessment Project (Revelle, Wilt & Rosenthal, 2010; Revelle, Condon, Wilt, French, Brown & Elleman, 2015)
4. Open source data:
  - Data from the ICAR project (Condon & Revelle, 2015a,b)
  - Data from SAPA studies (Condon & Revelle, 2015d,c)

In the process of summarizing the last several years of research, I will show how we use open source software, items, and methods and then share them with the world.

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## Part I Open Statistics: R

Part I: Open Statistics: R

R: open source statistical system

What is R

Use R for replications and extensions

Getting and using R  
Useful packages

Part II: Open Materials



## R: What is it?

1. R: An international collaboration for applied statistical research
  - Originally developed in New Zealand in 1991-93
  - Comprehensive R Archive (CRAN) run out of Vienna
  - Core R members in Austria (2), Canada, Denmark, France, Germany (2), India, New Zealand (3), Switzerland, US (6), UK
2. R: The open source - public domain version of S+
3. R: Written by statisticians (and some of us) for statisticians (and the rest of us)
4. R: Not just a statistics system, also an extensible language.
  - This means that as new statistics are developed they tend to appear in R far sooner than elsewhere.
  - R facilitates asking questions that have not already been asked.

## Statistical Programs for Psychologists

- General purpose programs
  - R
  - S+
  - SAS
  - SPSS
  - STATA
  - Systat
- Specialized programs
  - Mx
  - EQS
  - AMOS
  - LISREL
  - MPlus
  - Your favorite program

## Statistical Programs for Psychologists

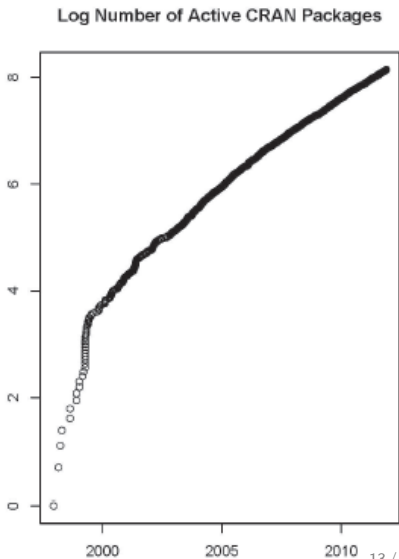
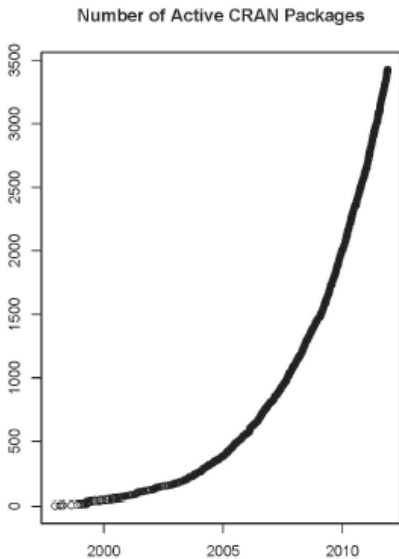
- General purpose programs
  - R
  - \$+
  - \$\$
  - \$\$\$
  - \$TATA
  - \$y\$at
- Specialized programs
  - Mx (OpenMx is part of R)
  - EQ\$
  - AMO\$
  - LI\$REL
  - MPlu\$
  - Your favorite program

## R: A brief history

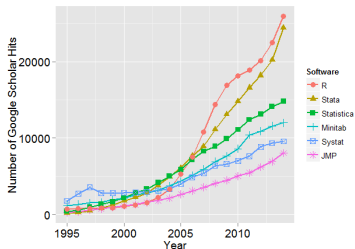
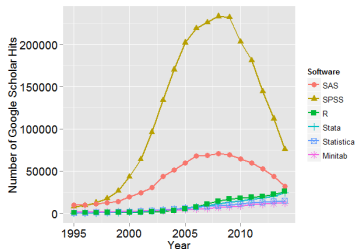
- 1991-93: Ross Ihaka and Robert Gentleman begin work on R project for Macs at U. Auckland (S for Macs).
- 1995: R available by ftp under the General Public License.
- 96-97: mailing list and R core group is formed.
- 2000: John Chambers, designer of S joins the Rcore (wins a prize for best software from ACM for S)
- 2001-2015: Core team continues to improve base package with a new release every 6 months (now more like yearly).
- Many others contribute “packages” to supplement the functionality for particular problems.
  - 2003-04-01: 250 packages
  - 2004-10-01: 500 packages
  - 2007-04-12: 1,000 packages
  - 2009-10-04: 2,000 packages
  - 2011-05-12: 3,000 packages
  - 2012-08-27: 4,000 packages
  - 2014-05-16: 5,547 packages (on CRAN) + 824 bioinformatic packages on BioConductor
  - 2015-05-20 6,678 packages (on CRAN) + 1024 bioinformatic packages + ?,000s on GitHub
  - 2015-10-28 7,408 packages (on CRAN) + 1024 bioinformatic packages + ?,000s on GitHub



## Rapid and consistent growth in packages contributed to R



## Popularity compared to other statistical packages



<http://r4stats.com/articles/popularity/> considers various measures of popularity

1. discussion groups
2. blogs
3. Google Scholar citations ( $> 34,000$  citations,  $\approx 2,000/\text{year}$ )
4. Google Page rank

## R as a way of facilitating replicable science

1. R is not just for statisticians, it is for all research oriented psychologists.
2. R scripts are published in psychology journals to show new methods:
  - *Psychological Methods*
  - *Psychological Science*
  - *Journal of Research in Personality*
3. R based data sets are now accompanying journal articles:
  - The *Journal of Research in Personality* now accepts R code and data sets.
  - JRP special issue in R.
  - The replicability project has released its data and R scripts.
4. By sharing our code and data the field can increase the possibility of doing replicable science.

## Reproducible Research: Sweave and KnitR

*Sweave is a tool that allows to embed the R code for complete data analyses in  $\LaTeX$  documents. The purpose is to create dynamic reports, which can be updated automatically if data or analysis change. Instead of inserting a prefabricated graph or table into the report, the master document contains the R code necessary to obtain it. When run through R, all data analysis output (tables, graphs, etc.) is created on the fly and inserted into a final  $\LaTeX$  document. The report can be automatically updated if data or analysis change, which allows for truly reproducible research.*

Friedrich Leisch (2002). Sweave: Dynamic generation of statistical reports using literate data analysis. I

Supplementary material for journals can be written in Sweave/KnitR so that others can redo or extend the analyses.

## What is so great about reproducible research?

1. Allows us to share methods with our collaborators.
2. This can be other labs who want to know what you did. It can be your students, it can even be you.
3. David Condon has suggested that your closest collaborator is you, six months ago, but you don't answer your emails.
4. That is, scripted analyses are for you.
5. The Reproducibility Project (<https://osf.io/ezcuuj/>) has released their 100 replication data set and the R code to analyze it. If any one finds errors or needs more information, they are happy to provide it.

## Misconception: R is hard to use

1. R doesn't have a GUI (Graphical User Interface)
  - Partly true, many use syntax.
  - Partly not true, GUIs exist (e.g., R Commander, R-Studio).
  - Quasi GUIs for Mac and PCs make syntax writing easier.
2. R syntax is hard to use
  - Not really, unless you think an iPhone is hard to use.
  - Easier to give instructions of 1-4 lines of syntax rather than pictures of menu after menu to pull down.
  - Keep a copy of your syntax, modify it for the next analysis.
3. R is not user friendly: A personological description of R
  - R is Introverted: it will tell you what you want to know if you ask, but not if you don't ask.
  - R is Conscientious: it wants commands to be correct.
  - R is not Agreeable: its error messages are at best cryptic.
  - R is Stable: it does not break down under stress.
  - R is Open: new ideas about statistics are easily developed.

## Misconceptions: R is hard to learn – some interesting facts

1. With a brief web based tutorial <http://personality-project.org/r>, 2nd and 3rd year undergraduates in psychological methods and personality research courses are using R for descriptive and inferential statistics and producing publication quality graphics.
2. More and more psychology departments are using it for graduate and undergraduate instruction.
3. R is easy to learn, hard to master
  - R-help newsgroup is very supportive (usually)
  - Multiple web based and pdf tutorials see (e.g., <http://www.r-project.org/>)
  - Short courses using R for many applications. (Look at APS program).
4. Books and websites for SPSS and SAS users trying to learn R (e.g., <http://r4stats.com/>) by Bob Muenchen (look for link to free version).

## What makes R so powerful are the $> 7,400$ contributed packages

- psych** A general purpose toolkit for psychological research with a particular emphasis upon
- Basic descriptive statistics and basic graphical tools.
  - Basic psychometric procedures including functions for finding  $\alpha (= \lambda_3)$ ,  $\omega_h$ , and  $\omega_t$
  - More advanced data reduction techniques using factor analysis, principal components analysis, and cluster analysis.
  - Introductory Item Response Theory and Multi-level modeling
- lavaan** Basic and advanced structural equation modeling (“The gateway package to R”).
- sem** Structural equation modeling
- lme4** Multilevel modeling.



## Short courses and workshops emphasize training in basic and advanced R

### 1. Symposia

- International Society for Study of Individual Differences (2005)
- 1st World Conference on Personality (2013)
- Society for Personality and Social Psychology (2015)

### 2. Short courses

- European Conference on Personality (2012, 2014)
- Association for Research on Personality (2012)
- Association for Psychological Science (2013, 2014, 2015)
- 1st World Conference on Personality (2013)
- STuP 2015 preconference: Confirmatory factor analysis in the lavaan package (R)

### 3. Summer schools

- Summer school sponsored by ISSID, EAPP and SMEP (2014)

## Part II: Open Materials

### Part II: Open Materials

Temperament, Abilities, and Interests: considering appetites and aptitudes

Temperament, Abilities, and Interests: TAI

IPIP: The International Personality Item Pool

Lew Goldberg and the development of the IPIP

Extending the IPIP to include more domains

ICAR: International Cognitive Ability Resource

An international collaboration to measure ability with open source items

Analysis of ICAR items

### Part III: Open Methods

## Four types of openness:

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## Personality, prediction, and life outcomes

1. It has long been known that to predict real world outcomes we need to study more than just ability (Kelly & Fiske, 1950, 1951; Deary, 2008; Roberts, Kuncel, Shiner, Caspi & Goldberg, 2007).
2. Level of education and jobs differ in their intellectual requirements (Gottfredson, 1997).
3. My colleagues and I have shown that there are also temperamental requirements for educational and job choice (Condon & Revelle, 2014; Revelle & Condon, 2012, 2015a; Revelle, Wilt & Condon, 2011; Wilt & Revelle, 2015)
4. We consider individual differences in Temperament, Ability, and Interests (TAI) as they relate to niche selection in choice of college major and in occupational choice (Bouchard, 1997; Hayes, 1962; Johnson, 2010). as well as to the second and third level of personality analysis (between individuals and between groups of individuals (Revelle & Condon, 2015b)).

## Measuring individual differences

1. A basic problem in the study of individual differences is that there are so many different constructs that interest us. These include constructs from at least four broad domains
  - Temperament
  - Ability
  - Interests
  - Character
2. Each domain has many constructs:
  - Dimensions of Temperament 2-3-5-6-15?
  - Structure of Ability ( $g - g_f, g_c, V-P-R$ )?
  - Hierarchical structure of interests people-things, RIASEC .
  - Range of possible measures of character.
3. But many important measures are proprietary.
4. In addition, showing the utility of TAIC measures requires criterion variables, and should include demographics.
5. Our solution: Use and/or develop open source temperament, ability, and interest items.

## The International Personality Item Pool (Goldberg, 1999)

1. Perhaps one of the greatest contributions from Lew Goldberg was his release of the International Personality Item Pool or IPIP (Goldberg, 1999) s <http://ipip.ori.org>.
2. The IPIP adapted a short stem item format developed in the doctoral dissertation of Hendriks (1997) and items from the Five Factor Personality Inventory developed in Groningen (Hendriks, Hofstee & De Raad, 1999).
3. Goldberg (1999) used about 750 items from the English version of the Groningen inventory, and has since supplemented them with many more new items in the same format.
4. The IPIP items have been translated into at least 39 languages by at least 65 different research teams. This includes Croatian, Serbian, and Slovenian.

## IPIP and other personality inventories

1. The IPIP was originally meant to be short stems to measure the Abridged Five Factor Circumplex structure of adjectives (Hofstee, de Raad & Goldberg, 1992) but also includes items targeted at most major personality tests.
2. Using a panel of roughly 1000 residents from Eugene-Springfield, Oregon, Goldberg administered his original IPIP items along with the NEO-PI-R (Costa & McCrae, 1992), the CPI (Gough & Bradley, 1996), the 16PF (Cattell & Stice, 1957), the MPQ (Tellegen & Waller, 2008), the Hogan PI (Hogan & Hogan, 1995), the TCI (Cloninger, Przybeck & Svrakic, 1994), the JPI-R (Jackson, 1983), and the 6FPQ (Jackson, Paunonen & Tremblay, 2000).
3. Goldberg then developed item stems that were highly correlated to the commercial inventories and put these into the public domain with the formation of the IPIP.
4. The items are available at <http://ipip.ori.org> and the Eugene-Springfield data are available from Goldberg.

## What are the “Big 5”?: Some representative items

Semantic analysis of many (although primarily European) languages suggest 5 broad factors of the ways in which we describe others.

**Conscientiousness** Complete my duties as soon as possible. Do things according to a plan. Like order.

**Agreeableness** Take advantage of others. (R) Am concerned about others. Sympathize with others' feelings.

**Neuroticism** Get upset easily. Get overwhelmed by emotions. Have frequent mood swings.

**Openness/Intellect** Am able to come up with new and different ideas. Am full of ideas. Have a rich vocabulary.

**Extraversion** Like mixing with people. Enjoy meeting new people. Am a talkative person. Am rather lively.

These are sometimes organized as the OCEAN of personality, alternatively, the CANOE of personality.



## Extending the IPIP

1. In addition to the basic temperament items at the IPIP site, there are additional items to measure vocational interests (the ORVIS) (Pozzebon, Visser, Ashton, Lee & Goldberg, 2010) as well as avocational interests (Goldberg, 2010).
2. David Condon has expanded 2500 IPIP item set to include the original IPIP items, the ORVIS, the ORAIS, as well as items from the EPQ (Eysenck, Eysenck & Barrett, 1985), the O\*NET interest profile scales (Rounds, Su, Lewis & Rivkin, 2010). These, and other items make a total set of 4,300 items.
3. These are available at <https://sapa-project.org/MasterItemList/>.

An international collaboration to measure ability with open source items

## The International Cognitive Ability Resource

1. Extending the IPIP to ability: ICAR:Ability::IPIP:Personality
2. ICAR is an international collaboration to develop open source cognitive ability items.
3. Information at <http://www.icar-project.com/>
4. News letter at [http://www.icar-project.com/ICAR\\_News\\_Issue\\_One.pdf](http://www.icar-project.com/ICAR_News_Issue_One.pdf)
5. Key organizers who are coordinating the project:
  - Germany Phillip Doebler (Münster and Ulm) and Heinz Holling (Münster)
  - U.K. Luning Sun and John Rust (Cambridge)
  - U.S.A William Revelle and David Condon (Northwestern)
6. Everyone is welcome to join this international collaboration.
7. Supported by Open Research Area (ORA) for the Social Sciences which includes participation from national funding agencies (Germany:DFG), (UK:ESRC), (US:NSF)

An international collaboration to measure ability with open source items

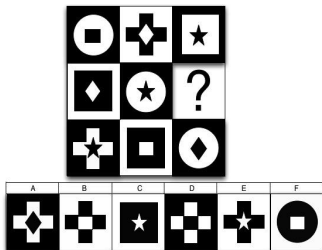
## ICAR: Proof of concept

1. About 60 items were developed as part of a honors thesis at Northwestern by Melissa Liebert (Liebert, 2006).
  - This set was reported at conference in Krakow and in a subsequent book chapter (Revelle et al., 2010).
2. Subsequently David Condon developed some 3 Dimensional rotations items and did some extensive item analysis of the total set.
3. Condon & Revelle (2014) examined the first 60 publicly available items and validated them against self reported SAT exam scores as well as a small sample given the Shipley-2 (Shipley, 2009).
4. The original data set has been released to DataVerse (Condon & Revelle, 2015b) and has been submitted to the Journal of Open Psychology Data (Condon & Revelle, 2015d).

An international collaboration to measure ability with open source items

## Sample ICAR items

### Matrix Reasoning



### Verbal Reasoning

What number is one fifth of one fourth of one ninth of 90

- (1) 2 (2) 3 (3) 4 (4) 5 (5) 6 (6) 7
- \_\_\_\_\_

If the day after tomorrow is two days before Thursday,  
then what day is it today?

- (1) Friday (2) Monday (3) Wednesday  
(4) Saturday (5) Tuesday (6) Sunday

### Letter and Number Series

In the following alphanumeric series, what letter comes next?

I J L O S

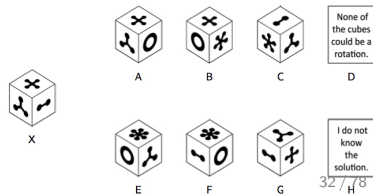
- (1) T (2) U (3) V (4) X (5) Y (6) Z
- \_\_\_\_\_

In the following alphanumeric series, what letter comes next?

Q S N P L

- (1) J (2) H (3) I (4) N (5) M (6) L

### Three-Dimensional Rotation



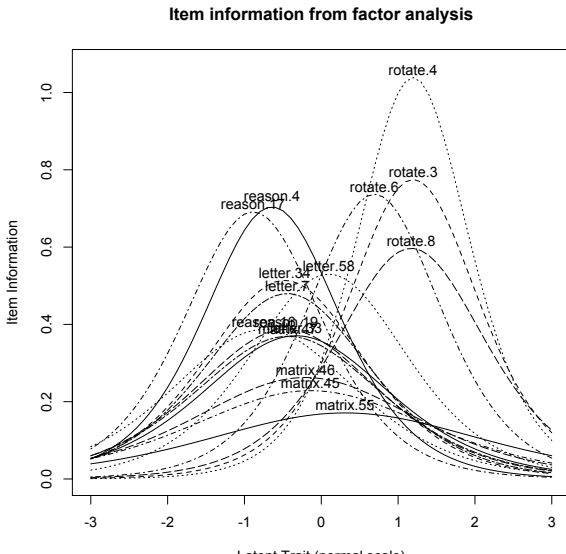
## Sample analysis of ICAR items

- Using basic R functions in the *psych* package (Revelle, 2015) we can evaluate the factor structure of the ICAR items.
- `irt.fa` will do a factor analysis of the items and report the statistics in terms of those statistics more commonly used in Item Response Theory.
  - The two parameters from factor analysis are item difficulty taken from the  $\tau$  parameter from the tetrachoric correlation and the item factor loading  $\lambda$  of the matrix of tetrachoric correlations.

$$a = \frac{\lambda}{\sqrt{(1 - \lambda^2)}} \quad \delta = \frac{\tau}{\sqrt{(1 - \lambda^2)}}$$

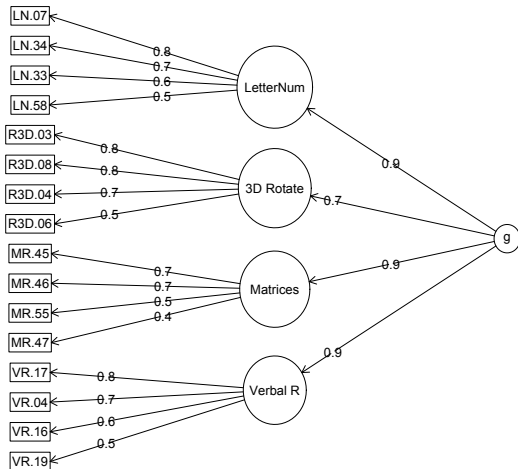
- The hierarchical structure of the ability items may be shown by factoring the factor intercorrelations.
- Loadings on a general factor may then be found by using the `omega` function which applies a Schmid Leiman transformation to the resulting higher level solution.

## Item information curves for the 16 ICAR sample set



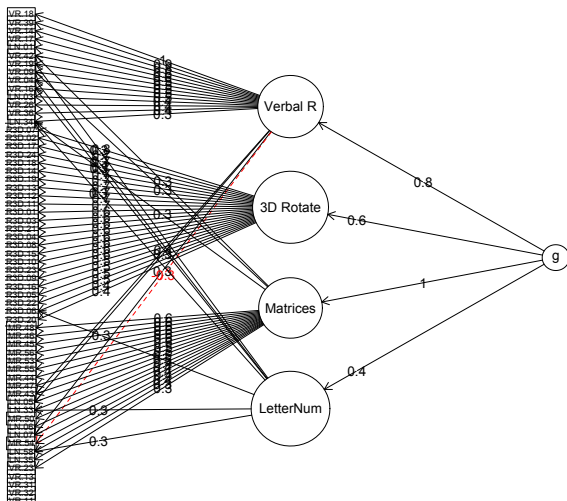
## Structure of sample ICAR 16 items shows a clear 4 factor hierarchical solution $\omega_h = .87$

Omega Hierarchical for ICAR Sample Test



## Structure of ICAR 60 items shows a messier 4 factor hierarchical solution $\omega_h = .76$

Hierarchical structure of ICAR60 items





## Open materials

1. The International Personality Item Pool items (Goldberg, 1999) as well as the extended IPIP are in the public domain and are available to anyone for free.
2. The items from the International Cognitive Ability resource are also in the public domain and are available to registered users. (We are trying to keep the items relatively secure and do not put all of the actual items up on the web.)
  - We have a basic set of 60 ICAR items (Condon & Revelle, 2014) and the ICAR group is developing and validating item generators to automatically produce hundreds of each of a growing number of item types.
  - We encourage others to join us in this mission.

## Part III: Open Methods

### Method: Synthetic Aperture Personality Assessment (SAPA)

Measuring individual differences: the tradeoff between breadth versus depth

Synthetic Aperture Astronomy

#### SAPA theory

Sample items as well as people

Covariance algebra

#### SAPA: practice

Open source software comes to the rescue

## Part IV: Open Data

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Measuring individual differences: the tradeoff between breadth versus depth

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  - Hierarchical structure of interests people-things RIASEC
  - Range of possible measures of character
3. In addition, showing the utility of TAIC measures requires criterion variables



Measuring individual differences: the tradeoff between breadth versus depth

## Breadth vs. depth of measurement

1. Factor structure of domains needs multiple constructs to define structure.
2. Each construct needs multiple items to measure reliably.
3. This leads to an explosion of potential items .
4. But, people are willing to only answer a limited number of items.
5. This leads to the use of short and shorter forms (the NEO-PI-R with 300, the IPIP big 5 with 100, the BFI with 44 items, the TIPI with 10) to include as part of other surveys.

Measuring individual differences: the tradeoff between breadth versus depth

## Many items versus many people

1. Not only do we want many items, we also want many people.
2. Resolution (fidelity) goes up with sample size,  $N$  (standard errors are a function of  $\sqrt{N}$ )

$$\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{N-1}} \quad \sigma_r = \frac{1-r^2}{\sqrt{N-2}}$$

3. Also increases as number of items,  $n$ , measuring each construct (reliability as well as signal/noise ratio varies as number of items and average correlation of the items)

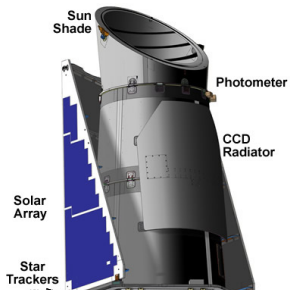
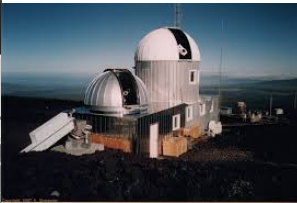
$$\lambda_3 = \alpha = \frac{n\bar{r}}{1+(n-1)\bar{r}} \quad s/n = \frac{n\bar{r}}{(1-n\bar{r})}$$

4. Thus, we need to increase  $N$  as well as  $n$ . But how?



## A short diversion: the history of optical telescopes

Resolution varies by aperture diameter (bigger is better)



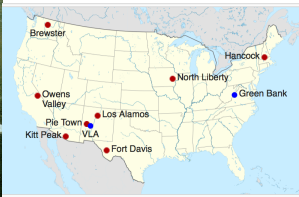


## A short diversion: history of radio telescopes

Resolution varies by aperture diameter (bigger is better)



Aperture can be synthetically increased across multiple telescopes or even multiple observatories





## Can we increase $N$ and $n$ at the same time?

1. Frederic Lord (1955) introduced the concept of sampling people as well as items.
2. Apply basic sampling theory to include not just people (well known) but also to sample items within a domain (less well known).
3. Basic principle of Item Response Theory and tailored tests.
4. Used by Educational Testing Service (ETS) to pilot items.
5. Used by Programme for International Student Assessment (PISA) in incomplete block design (Anderson, Lin, Treagust, Ross & Yore, 2007).
6. Can we use this procedure for the study of individual differences without being a large company?
7. Yes, apply the techniques of radio astronomy to combine measures synthetically and take advantage of the web.

Sample items as well as people

## Subjects are expensive, so are items

1. In a survey such as Amazon's Mechanical Turk (MTURK), we need to pay by the person and by the item.
2. Why give each person the same items? Sample items, as we sample people.
3. Synthetically combine data across subjects and across items. This will imply a missing data structure which is
  - Missing Completely At Random (MCAR), or even more descriptively:
  - Massively Missing Completely at Random (MMCAR)
4. This is the essence of Synthetic Aperture Personality Assessment (SAPA).

Sample items as well as people

### 3 Methods of collecting 256 subject \* items data

a) 8 x 32 complete      b) 32 x 8 complete      c) 32 x 32 MCAR  $p=.25$ 

46213634521143453443645331212414	46323114	. . . 3 . . . 2 . . . 6 . . . . . 4 . 55 . . . . . 44 . . . . .
21243623166421516154432261516513	25443314	. . . . . . . . . . . 4 . . . 6 . 45 . . . 3 . 4 . . . 6 . . . . 1
51661351155165463622224435623344	43315423	6 . . 3 . . . . . . . 6 . 1 . . . . . 6 . 2 . . . . . . . 5 . 6
11141343362332215612152135614522	26314145	. . . . . 3522 . . . . . 5 . 3 . . . . . 3 . . . . . 5 . . . . .
25353121264561433433232246526411	41435614	. . . . . 3 . 2 . . . . . . . 3 . . . . . 2 . . . . . 65 . . 5 .
61335154566424114612641225353516	42236153	. . . . . 51 . . . . . 324 . . . . . . . 23 . . . . . 5
24634342151536242425413513435116	62421344	. . . . . 552 . . . . . . . . . . 25 . . . 54 . 5 . . . .
11554654453123111162423325516334	35234443	. . . 44 . 4 . 5 . . . . . 3 . . 6 . . . . . 6 . . . . . 3 . .
	34514166	. . . . . 61 . 523 . 2 . . . . . 2 . . . . . . . . . . 3 . . . .
	63415154	5 . . . . . . . . . . . 42 . 4 . . 6 . 5 . . . . . 61 .
	44441342	. . . . . 3 . . . . . 3 . 6 . . 1 . 4 . . . . 1 . 5 . . . . . 5 .
	13514321	1 . . . . 54 . . . . . . . . . . 2 . 4 . 33 . 6 . . . . .
	66365663	4 . . . . . 52 . 6 . . . . . 44 . 3 . . . . . . . . . . 2
	12264546	. . 44 . . 1 . . . . . . . 1 . 42 . . . 5 . 1 . . . .
	31466135	. . 1 . 3 . . . . . . . 2 . 3 . 521 . . . . . 6 . . . .
	32645514	. . . . . . . . . . 3 . 142 . . . . . . . . . . 22 . . . . . 12 .
	66151251	. 4 . . 2 . . . . . . . . . . 3 . 162 . . 4 . . . . 4
	14411441	. . 4 . 6 . 3 . 4 . . . . 1 . . . . 5 . 33 . . . . .
	62443636	5 . . . . . . . . . . 243 . 5 . . . . 41 . . . . . 1 . .
	33316236	. . 5 . 3 . 4 . . . . 4 . 4 . 5 . 1 . . . . . . . . . 4 .
	63325425	. . . . . 4 . . . . . 3 . 5 . 2 . . . . 64 . 4 . 4 .
	11531126	. . . 1 . 1 . 2 . . . 6 . . . . 4 . . . . . 55 . . . 2 .
	61155546	. . . . . 3 . 2 . 53 . . . . . 2 . 2 . 3 . 3 . . . . .
	33245361	. . . . . 1 . . 2 . 43 . . 3 . 13 . . . . . . . . . 5 .
	52241654	. . 2 . . . . . . . . . 4 . 54 . . 2 . 3 . 62 . . . .
	63212356	22 . . . . . 332 . 1 . . . . 5 . . . . . 6 . . . . .
	24414663	. . . 5 . 3 . 4 . . . . 3 . . . . 5 . 241 . . . . .
	63661414	. . . . . 63 . 1 . . . . . 6 . . . 5 . 4 . 2 . . . . .
	45555223	. . 2 . 4 . 5 . . . . . . . . . 52 . 4 . . . . 44 . .
	14364433	2 . 55 . . . . 2 . . . . 6 . . . . 6 . . . . 55 . . . .
	21461416	. . . . . 5 . . . . . 4 . . . . 6341 . 4 . . . .

## Synthetic Aperture Personality Assessment

1. Give each participant a random sample of  $pn$  items taken from a larger pool of  $n$  items.
2. Find covariances based upon “pairwise complete data”.
3. Find scales based upon basic covariance algebra.
  - Let the raw data be the matrix  $X$  with  $N$  observations converted to deviation scores.
  - Then the item variance covariance matrix is  $C = XX'N^{-1}$
  - and scale scores,  $S$  are found by  $S = K'X$ .
  - $K$  is a keying matrix, with  $K_{ij} = 1$  if *item* <sub>$i$</sub>  is to be scored in the positive direction for scale  $j$ , 0 if it is not to be scored, and -1 if it is to be scored in the negative direction.
  - In this case, the covariance between scales,  $C_s$ , is

$$C_s = K'X(K'X)'N^{-1} = K'XX'KN^{-1} = K'CK. \quad (1)$$

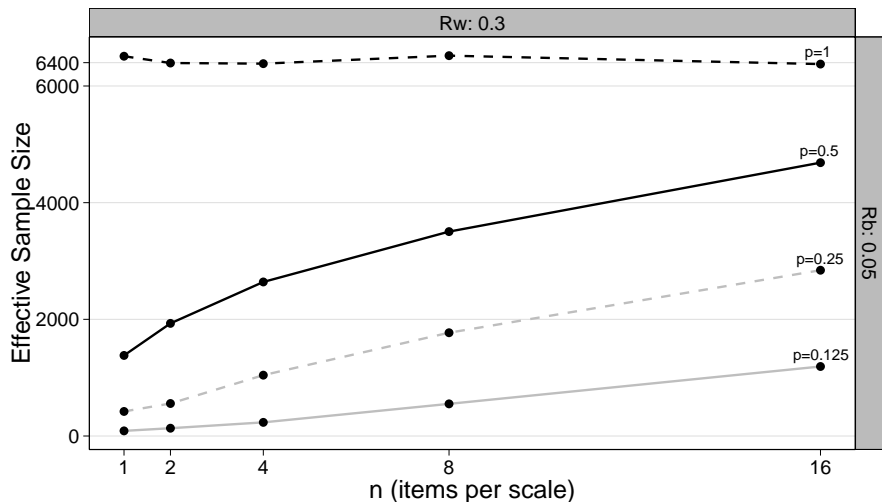
4. That is, we can find the correlations/covariances between scales from the item covariances, not the raw items.

## SAPA standard errors and effective sample size

1. When forming synthetic scales from MMCAR based items, the standard error of correlations decreases as a function of the Total number of subjects ( $N$ ), the percentage of items samples ( $p$ ), *and* the number of items forming the scale ( $n$ ).
2. Ashley Brown has shown this quite clearly by simulation (Brown, 2014).
3. A good way to visualize this is to examine the standard error of correlations as a function of  $N$ ,  $p$ , and  $n$ .
4. An even more dramatic way is to plot the *Effective Sample Size* ( $N_{eff}$ ) which because

$$\sigma_r = \frac{1 - r^2}{\sqrt{N - 2}} \text{ is merely } N_{eff} = \frac{(1 - r^2)^2}{\sigma_r^2} + 2$$

## Effective sample size varies by the size of the composite scale



## SAPA is not magic: We can obtain high accuracy at the structure level but accuracy is much lower at the single subject level

1. Reliability of composite scales is high when formed from synthetic matrices  $C_s = K'CK$  because the number of items per scale/per subject is the nominal amount.
2. Reliability of single scores is much less because very few items measuring a single trait are given to a single subject  $S = K'X$ .
3. However, the precision of the estimate of subject means ( $\bar{x}$ ) is high because  $\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{Np-1}}$  and  $Np$  is large.
4. SAPA technique is very powerful for research of structure, but less powerful for research based upon single subjects.

## How does it work?

1. Give our basic belief in open science, we use public domain items, open source software:
  - Apache webserver, MySQL data bases, PHP and HTML5 web tools, R for statistics.
  - Extensive coding in PHP and MySQL to present item sets in random fashion (Joshua Wilt, David Condon, Jason French)
  - Code written for psychometric measurement and scale construction as implemented in the *psych* package (Revelle, 2015) using R (R Core Team, 2015)
2. Domains measured and item sources
  - Temperament items taken from International Personality Item Pool (IPIP) (Goldberg, 1999) ([ipip.ori.org](http://ipip.ori.org)) and supplemented with other items.
  - Ability items have been validated (Condon & Revelle, 2014) as part of the International Cognitive Ability Resource Project ([ICAR-project.org](http://ICAR-project.org)). (ICAR:Ability::IPIP:Temperament)
  - Interest items taken from Oregon Vocational Interest Survey (ORVIS) (Pozzebon et al., 2010)



Open source software comes to the rescue

## SAPA overview

1. A “Personality Test” is included as a resource at the <http://personality-project.org> and gives feedback to all participants.
2. Some participants then link their feedback to their social media sites which then appeals to yet more to take it.
3. Some professors assign it to their students in various classes.
4. About 120 people per day from around the world visit the [personality-project.org](http://personality-project.org) or [sapa-project.org](http://sapa-project.org) websites. This does not sound like much, but over a year, we get around 40,000 participants.

Open source software comes to the rescue

The SAPA-Project: Explore Your Personality

10/28/15, 12:43 PM

# The SAPA Project

Take the test.

Explore your personality.

Advance the study of individual differences.

Start the test

More info



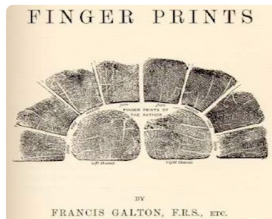
## FAQ about the test

Is it long? (not really) Is it free? (yes)



## The research behind SAPA

How was the test developed?



## Individual Differences

Learn more about differential psychology / 78

## How does it work?: part II

- Participants find us by searching web for “personality tests”, etc. and find [personality-project.org](http://personality-project.org) or [sapa-project.org](http://sapa-project.org)
- Each participant is given a number of web pages
  - Consent Form** Basic description of project and question whether they have taken test before.
  - Demographics** Age, sex, height, weight, education, parental education, country, state, ZipCode (if US), ...
  - TAIC questions** Temperament/Ability/Interest questions (25 per page, 21 T/I, 4 Ability per page)
  - Continuation pages** After each page, told that feedback will be more accurate if they keep going.
  - Optional modules** Creativity, Peer ratings, interests, ...
  - Feedback** Personality feedback based upon scores on temperament items.
- Results are stored (page by page) on the MySQL server.

## How does it work: part III

1. Various data cleaning scripts run using the *SAPA-tools* package (French & Condon, 2015) in R.
  - Screen for duplicate responses based upon a Random Identification Number issued when subjects start the page. We drop all subsequent pages.
  - Screen for subjects  $< 14$  or  $> 90$ .
2. Subsequent analyses are done primarily using functions in the *psych* package (Revelle, 2015) for R.

## Part IV: Open Data

### Part IV: Open Data

#### Measures

- Demographics

- Temperament and Interests

#### Temperament, Ability and Interests: Occupational Choice

- Pooled correlations  $\neq$  within group or between group correlations

- Occupational Choice as niche selection

#### Summary: Open Science

## Four types of openness:

1. Open source software: The R project (R Core Team, 2015)
2. Open source materials:
  - The International Personality Item Pool (IPIP) (Goldberg, 1999)
  - The International Cognitive Ability Resource (ICAR) (Condon & Revelle, 2014)
3. Open source methodology: The Synthetic Aperture Personality Assessment Project (Revelle et al., 2010, 2015)
4. Open source data:
  - Data from the ICAR project (Condon & Revelle, 2015a,b)
  - Data from SAPA studies (Condon & Revelle, 2015d,c)

In the process of summarizing the last several years of research, I will show how we use open source software, items, and methods and then share them with the world.

## Our data

**Time Frame** Data collected at [personality-project.org](http://personality-project.org) and [sapa-project.org](http://sapa-project.org) from August 18, 2010 to September 10, 2015

**Subjects** N = 191,893 (71,438 males, 120,454 females)

**Materials** 947 items (696 temperament, 60 ability, 212 interests, 39 demographic)

**Scales used** 15 Temperament, 4 Ability, 6 Interests

**N in workforce** N = 74,708

**Occupations** 973 separate occupations, following a Pareto distribution with  $\approx 80\%$  represented by the top 20% of occupations

**$N \geq 75$**  195 occupations for 55,902 participants

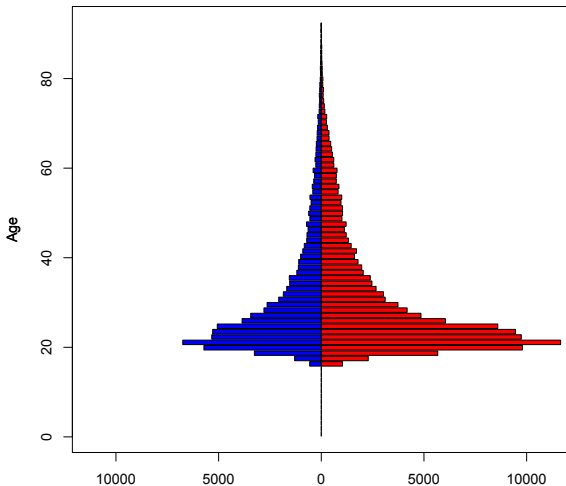
**$N \geq 100$**  114 college majors for 124,004 participants



## Demographics

## Median Age is 22. 63% Female

### Age by males and females



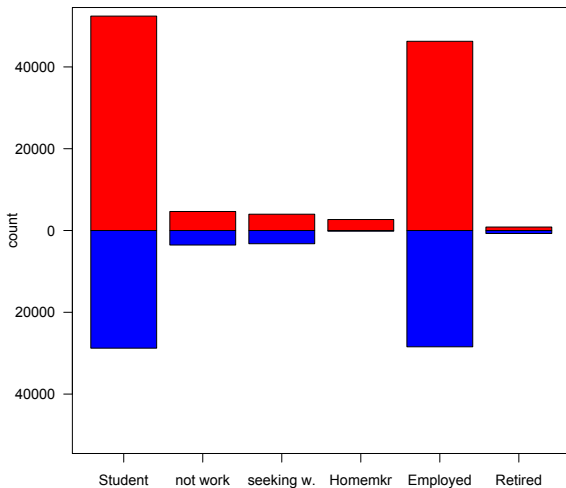




## Demographics

# 81,200 students, 74,708 in the labor force

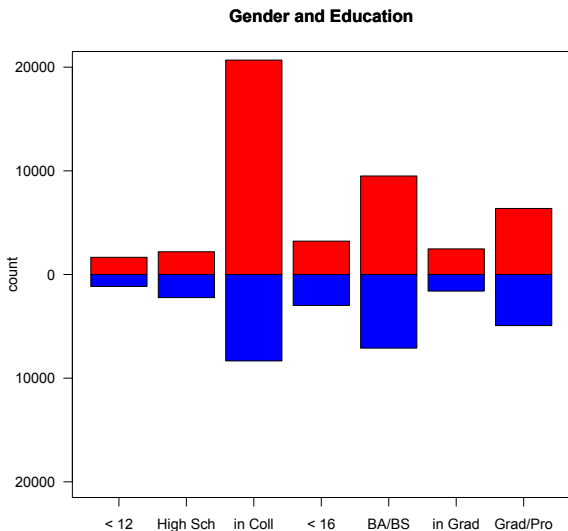
### Gender and Occupation





## Demographics

Of employed: 43% have  $\geq$  a college education, 39% are in college



## Data from the former Yugoslavia

1. Normally, we consider world wide figures, but the Yugoslavian data are very similar.
2. Distribution by countries of the former Yugoslavia: (total N = 875)

```

BIH HRV UNK MKD MNE SRB SVN
82 212 6 29 23 418 105

```

3. Gender distribution matches the international norms:

A table from the psych package in R

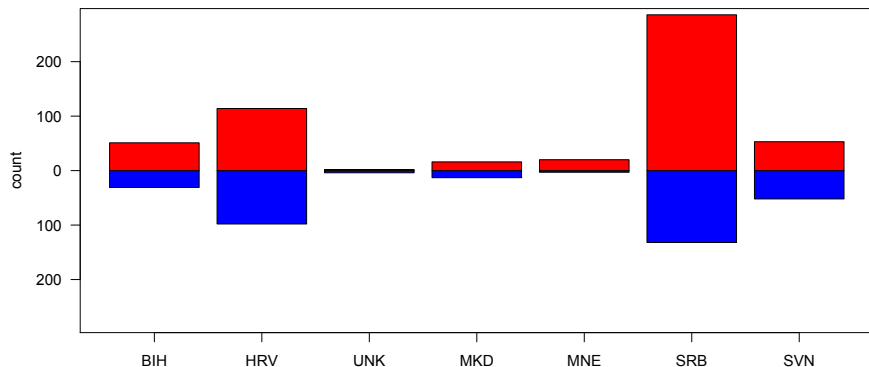
Country	Total	male	female	Proportion female
BIH	82	31	51	.62
HRV	212	98	114	.54
UNK	6	4	2	.33
MKD	29	13	16	.55
MNE	23	3	20	.87
SRB	418	132	286	.68
SVN	105	52	53	.50
Total	875	333	542	.62



## Demographics

## Gender by country distribution for the former Yugoslavia

Gender distribution by country (former Yugoslavia)



## Multiple solutions to the dimensionality of temperament

1. Digman alpha and beta (Digman, 1997), DeYoung stability and plasticity (DeYoung, Peterson & Higgins, 2002)
2. Eysenck "Giant 3" (Eysenck, 1994)
3. The "Big 5" (Digman, 1990; Goldberg, 1990)
4. The HEXACO 6 (Lee & Ashton, 2004; Ashton, Lee & Goldberg, 2007)
5. Tellegen 7-9 (Tellegen & Waller, 2008)
6. Comrey 8-9 (Comrey, 2008)
7. Cattell 16 Personality Factors (Cattell, 1957)
8. Condon (2014, 2015) examined 696 non-overlapping items from IPIP:100, IPIP:NEO, IPIP:MSQ, BFAS, EPQ, etc.  
(Goldberg, 1999; DeYoung, Quilty & Peterson, 2007; Eysenck et al., 1985)  
Found meaningful 3, 5, and 15 factor solutions.
9. The Condon 3/5/15 form a heterarchical and non hierarchical structure (i.e., lower levels are not cleanly nested in higher levels.)

## The best items from the 15 scale solution

**Table :** Sample items from the Short Personality Inventory 15 factor solution

Each scale has 8-10 items

SPI	Item	Item
Fear	Panic easily.	Begin to panic when there is danger.
Volatility	Get irritated easily.	Lose my temper.
Outlook	Dislike myself.	Feel a sense of worthlessness or hopelessness.
Compassion	Sympathize with others feelings.	Am sensitive to the needs of others.
Trust	Trust others	Trust what people say.
Easygoing	Let things proceed at their own pace.	Take things as they come.
Industrious	Start tasks right away.	Get chores done right away.
Mach	Use others for my own ends.	Cheat to get ahead.
Impulsivity	Act without thinking.	Do things without thinking of the consequences.
Sociability	Am mostly quiet when with other people.	Tend to keep in the background on social occasions.
Boldness	Love dangerous situations.	Take risks.
Serious	Seldom joke around.	Am not easily amused.
Conventional	Don't like the idea of change.	Prefer to stick with things that I know.
Intellectual	Am quick to understand things.	Catch on to things quickly.
Open	Enjoy thinking about things.	Love to reflect on things.

## 6 factors of interests

1. 6 factors from the O\*NET interest profiler scales (60 items; Rounds et al., 2010)
2. 8 factor Oregon Vocational Interest Scales (92 items; Pozzebon et al., 2010)
3. Oregon Avocational Interest Scales (199 items; Goldberg, 2010)
4. Formed into 6 scales fitting a “RIASEC” structure (60 items)
  - Realistic “Like to work with tools and machinery.”
  - Investigative “Would like to do laboratory tests to identify diseases.”
  - Artistic “Would like to write short stories or novels.”
  - Social “Would like to help conduct a group therapy session.”
  - Enterprising “Would like to be the chief executive of a large company.”
  - Clerical “Would like to keep inventory records”

Pooled correlations  $\neq$  within group or between group correlations

## Personality at 3 levels of analysis (Revelle & Condon, 2015b)

Personality can be examined at three levels of analysis

1. Personality as a unique temporal signature of one's Affect, Behavior, Cognition and Desires (ABCDs) as they change over time and space within a single individual.
  - Measuring within person patterning requires repeated measures on single subjects over time. We do this with open source text messaging procedures e.g., (Wilt, Funkhouser & Revelle, 2011; Wilt, 2014).
2. Personality is also how people differ in their patterning of the ABCDs between people.
  - This can be multilevel modeling of data collected within subjects showing that the correlational structure within subjects differs across subjects (Wilt et al., 2011; Revelle & Wilt, 2015).
  - It is also the more conventional structure of personality items as collected from the SAPA project.
3. But people choose groups such as college major or occupation based upon their unique aptitudes and appetites.
  - We can analyze this niche selection in terms of the covariance of the mean personality of the group.



Pooled correlations  $\neq$  within group or between group correlations

## TAI for groups is not the same as TAI for individuals

- How do occupational groups differ on TAI?
  - The mean scores for groups allow us to compare the groups
  - But it is the structure of these group means that are particularly interesting
- Overall correlation is a function of within group correlations and between group correlations.
- Correlations of aggregate scores  $r_{xy_{bg}}$  (between groups)  $\neq$  aggregate of correlations  $r_{xy_{wg}}$  (within groups)
- The overall correlation  $r_{xy}$  is a function of the within and the between correlations

$$r_{xy} = \eta_{x_{wg}} * \eta_{y_{wg}} * r_{xy_{wg}} + \eta_{x_{bg}} * \eta_{y_{bg}} * r_{xy_{bg}}$$

- These multi level correlations sometimes lead to what is known as the Yule-Simpson paradox (Kievit, Frankenhuis, Waldorp &

Borsboom, 2013; Simpson, 1951; Yule, 1903)

- These are independent and useful information.

## Temperament, Ability, and Interests – within and between groups

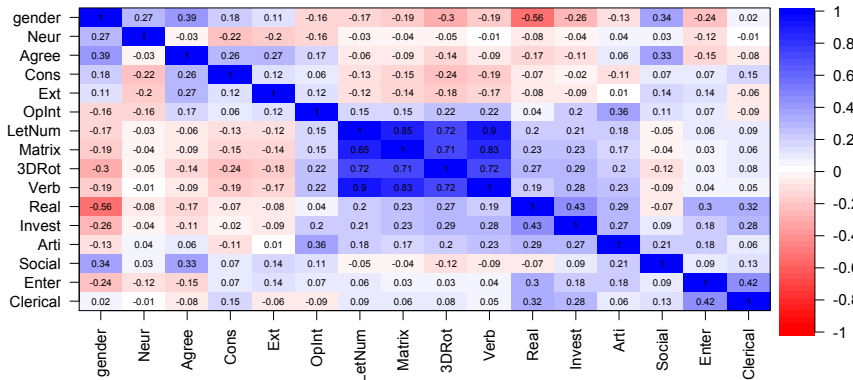
1. Examined the factor structure of the TAI scales at the normal, between subjects (across groups) level.
  - This produces the normal factor structure of temperament, of ability and of interests
  - Can show these correlations as a “heatmap”
2. But when analyzing the structure of the mean scores for each of 196 occupational groups (minimum size of 75 members), the structure is drastically different.
  - Several dimensions of temperament and interests are now negatively correlated with ability, others are orthogonal
  - Can also show these correlations as a “heatmap”



## Occupational Choice as niche selection

## Subject Level data of 5 personality scales, 6 interests, 4 ability

TAI for employed

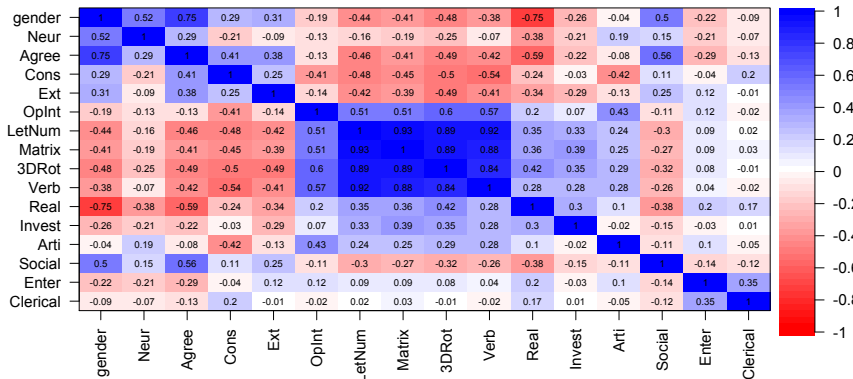




## Occupational Choice as niche selection

## Group Level data of 15 personality scales, 6 interests, 4 ability

TAI between groups



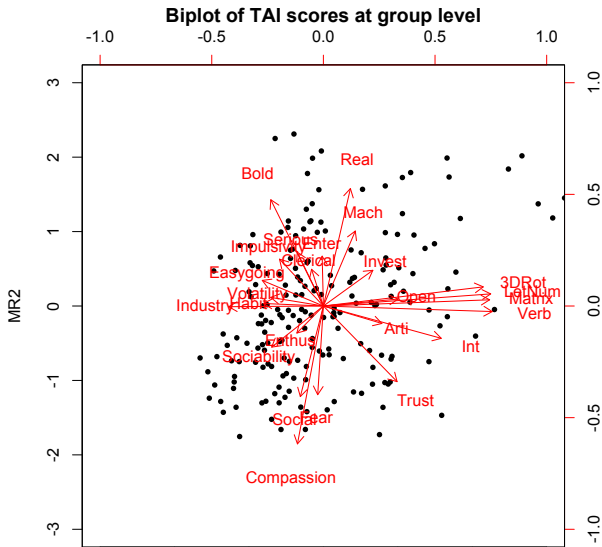
## Niche selection

1. Occupations differ systematically in the intellectual Ability they require.
2. But they also differ in the Interests and Temperament they require.
3. A simple two factor solution shows that high ability can trade off for low Industry or Conscientiousness and that Boldness (low Anxiety) and Realistic interests differs from high Anxiety and Social interests.
4. We can examine the extent to which this second dimension a difference of gender using factor extension.



Occupational Choice as niche selection

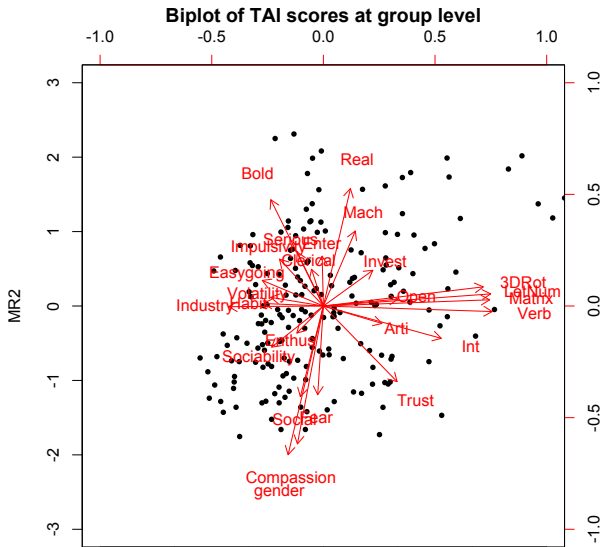
## Biplot of a two factor solution to the group level data





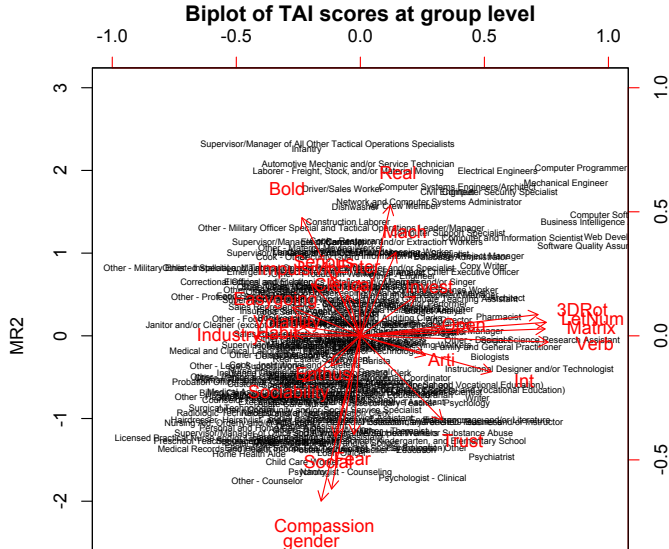
## Occupational Choice as niche selection

## Add gender to the extended factor solution of the group data



Occupational Choice as niche selection

# Biplot of a two factor solution to the group level data





# Part V

## Open Scientific Research

## Summary and Conclusions

1. Ability, temperament and interests all provide useful information about human personality.
2. Intellectual and Personality development is the process of experiencing and choosing niches.
3. When we describe the intellectual requirements of a profession, we should not ignore that appropriate interests and temperaments guide occupational choice.
4. We need to consider appetites along with aptitudes.
5. The statistics, materials, methods, and data from all of these studies are done using Open Source Science.
6. Join us in this journey.
7. For more information and for these slides go to <http://personality-project.org/sapa.html>

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