Ability, Temperament, and Interests: their joint predictive power for job choice

The International Society for the Study of Intelligence
Albuquerque, New Mexico

William Revelle and David Condon

Northwestern University
Evanston, Illinois USA
Partially supported by a grant from the National Science Foundation: SMA-1419324

September 19, 2015

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

Outline

NORTHWESTERN UNIVERSITY

Personality, prediction, and life outcomes

1. Has long been known that to predict real world outcomes we need more than just ability (Kelly & Fiske, 1950, 1951; Deary, 2008; Roberts, Kuncel, Shiner, Caspi & Goldberg, 2007).
2. Jobs differ in their intellectual requirements (Gottfredson, 1997).
3. We would add that there are also temperamental requirements.
4. We will consider individual differences in Temperament, Ability, and Interests as they relate to niche selection in occupational choice (Bouchard, 1997; Hayes, 1962; Johnson, 2010) .

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. In addition, showing the utility of TAIC measures requires criterion variables, and should include demographics.
4. Our solution: Use basic sampling theory as discussed by Lord (1955) sampling items as well as people.

NORTHWESTERN UNIVERSITY

Subjects are expensive, so are items

1. In a survey such as 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 descriptive:
   - Massively Missing Completely at Random (MMCAR)
4. This is the essence of Synthetic Aperture Personality Assessment (SAPA).

3 Methods of collecting 256 subject * items data

a) 8 x 32 complete

```
46213634521143453443645331212414
21243623166421516154432261516513
51661351155165463622224435623344
11141343362332215612152135614522
25353121264561433433232246526411
61335154566424114612641225353516
24634342151536242425413513435116
11554654453123111162423325516334
```

b) 32 x 8 complete

```
46323114
25443314
43315423
26314145
41435614
42236153
62421344
35234443
34514166
63415154
44441342
13514321
66365663
12264546
31466135
32645514
66151251
14411441
62443636
33316236
63325425
11531126
61155546
33245361
52241654
63212356
24414663
63661414
45555223
14364433
```

c) 32 x 32 MCAR p=.25

```
..3..2..6.....4.55.......44.....
..........4..6..45..3.4..6....1
6..3.......6.1.....6.2.......5.6
....3522......5.3...3......5....
....3.2.2.......3..2......65..5.
.....51....324.........23......5
....552............25...54.5....
...44.4.5....3..6...6........3..
....61.523.2....2...........3...
5.............42.4..6.5......61.
....3....3.6..1.4...1..5......5.
1....54..........2.4.33..6......
4.....52..6.....44.3...........2
..44...1........1..42....5..1...
..1..3.......2..3.521.......6...
.......3.142.........22......12.
.4...2..........3..162...4.....4
..4..6..3.4...1....5.33.........
5..........243..5....41......1..
..5..3..4...4.4..5..1.........4.
.....4.......3..5.2.....64.4..4.
...1.1.2...6....4......55....2..
.....3..2..53.....2..2.3.3......
......1...2..43...3.13........5.
...2.........4..54...2.3..62....
22.......332..1.....5......6....
...5..3.4.....3....5.241.......5
......63.1.......6...5..4..2....
..2.4..5..........52.4.....44...
2.55.....2.....6.....6.....55...
```

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 $\boldsymbol{X}$ with N observations converted to deviation scores.
   - Then the item variance covariance matrix is $\boldsymbol{C} = \boldsymbol{X}\boldsymbol{X}'N^{-1}$
   - and scale scores, $\boldsymbol{S}$ are found by $\boldsymbol{S} = \boldsymbol{K}'\boldsymbol{X}$.
   - $\boldsymbol{K}$ is a keying matrix, with $\boldsymbol{K}_{ij} = 1$ if $item_i$ 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, $\boldsymbol{C}_s$, is

$$\boldsymbol{C}_s = \boldsymbol{K}'\boldsymbol{X}(\boldsymbol{K}'\boldsymbol{X})'N^{-1} = \boldsymbol{K}'\boldsymbol{X}\boldsymbol{X}'\boldsymbol{K}N^{-1} = \boldsymbol{K}'\boldsymbol{C}\boldsymbol{K}. \quad (1)$$

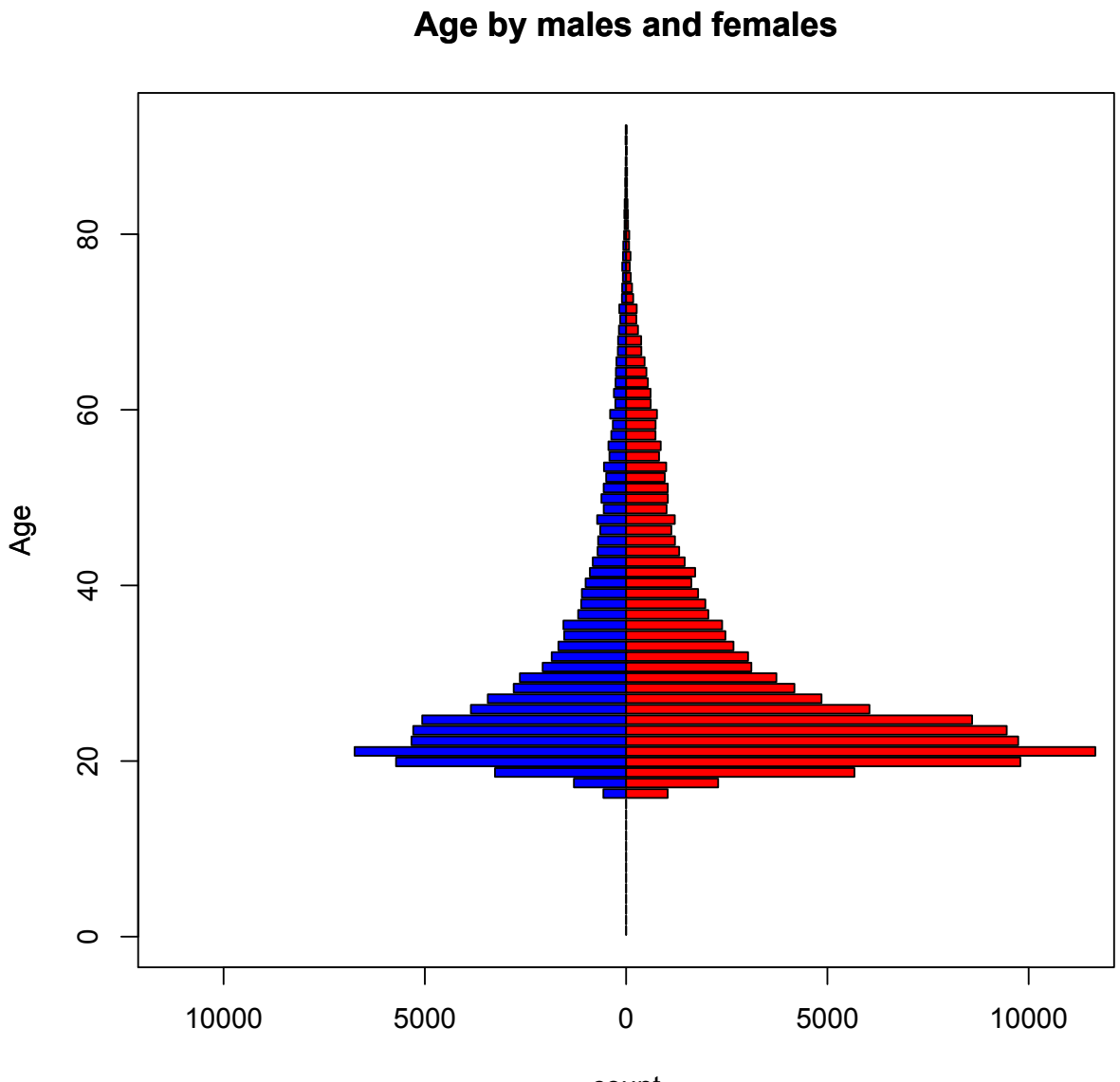
4. That is, we can find the correlations/covariances between scales from the item covariances, not the raw items.

Our data

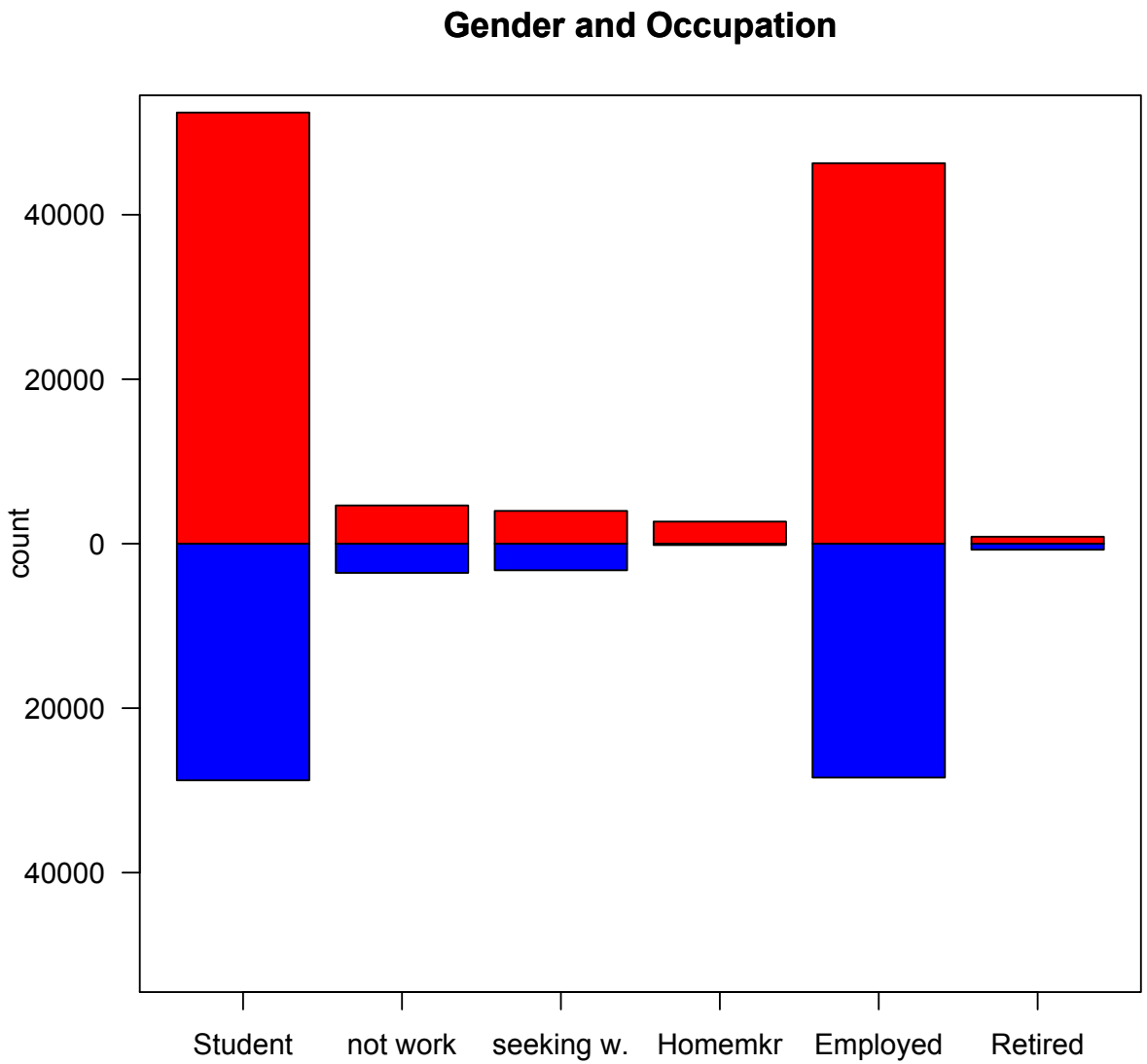
Time Frame	Data collected at personality-project.org and sapa-project.org from August 18, 2010 to September 10, 2015
Subjects	N = 191,893 (71,438 males, 120,454 females)
Materials	947 items (696 temperament, 60 ability, 212 interests, 39 demographic)
Scales used	15 Temperament, 4 Ability, 6 Interests
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

NORTHWESTERN UNIVERSITY

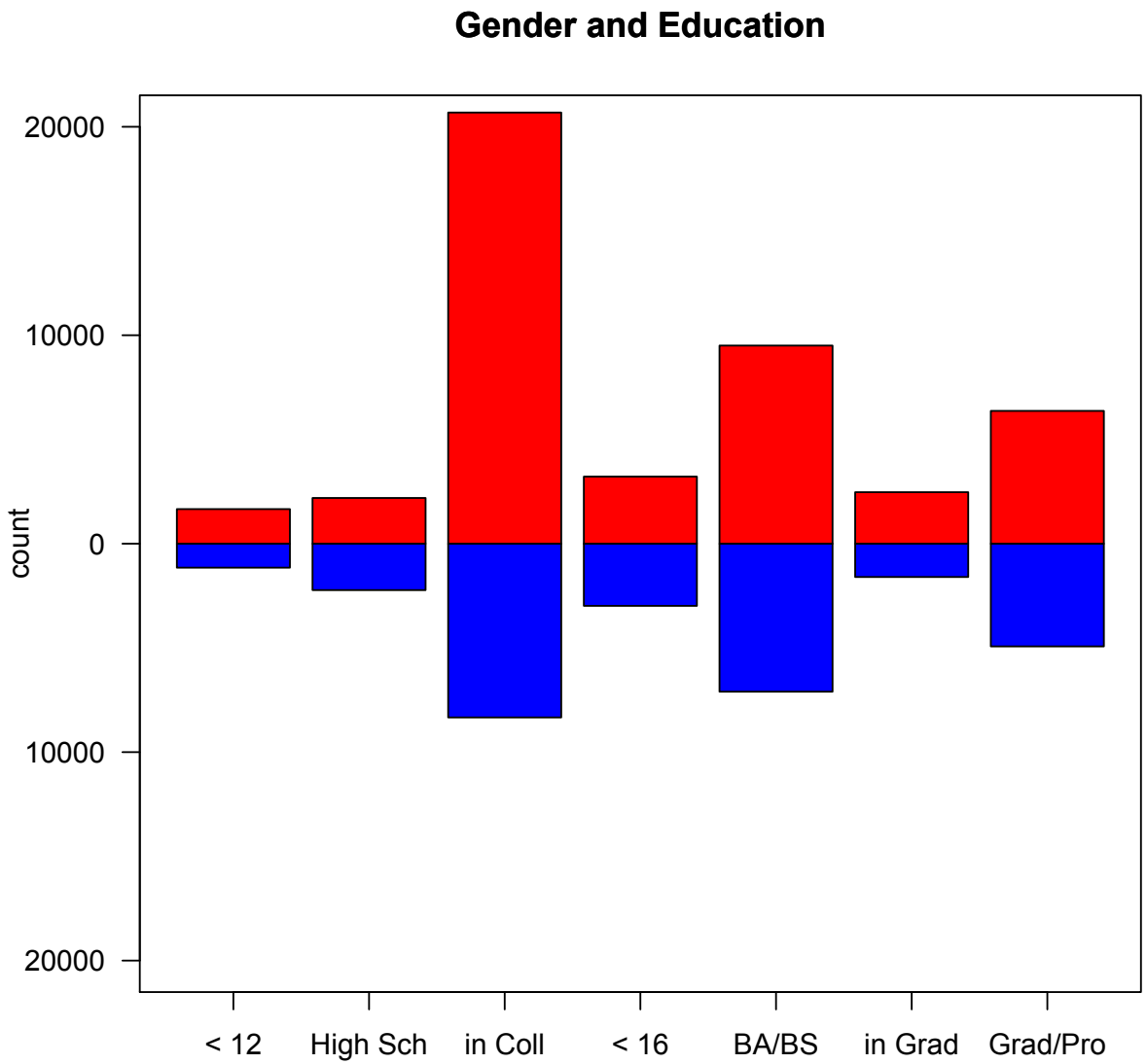
Median Age is 22. 63% Female



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



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



The International Cognitive Ability Resource

1. An international collaboration to develop open source cognitive ability items.
2. ICAR:Ability::IPIP:Personality
3. http://www.icar-project.com/
4. News letter at http://www.icar-project.com/ICAR_News_Issue_One.pdf
5. Key organizers
   - 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
7. Supported by Open Research Area (ORA) for the Social Sciences which includes participation from national funding agencies (Germany:DFG), (UK:ESRC), (US:NSF)

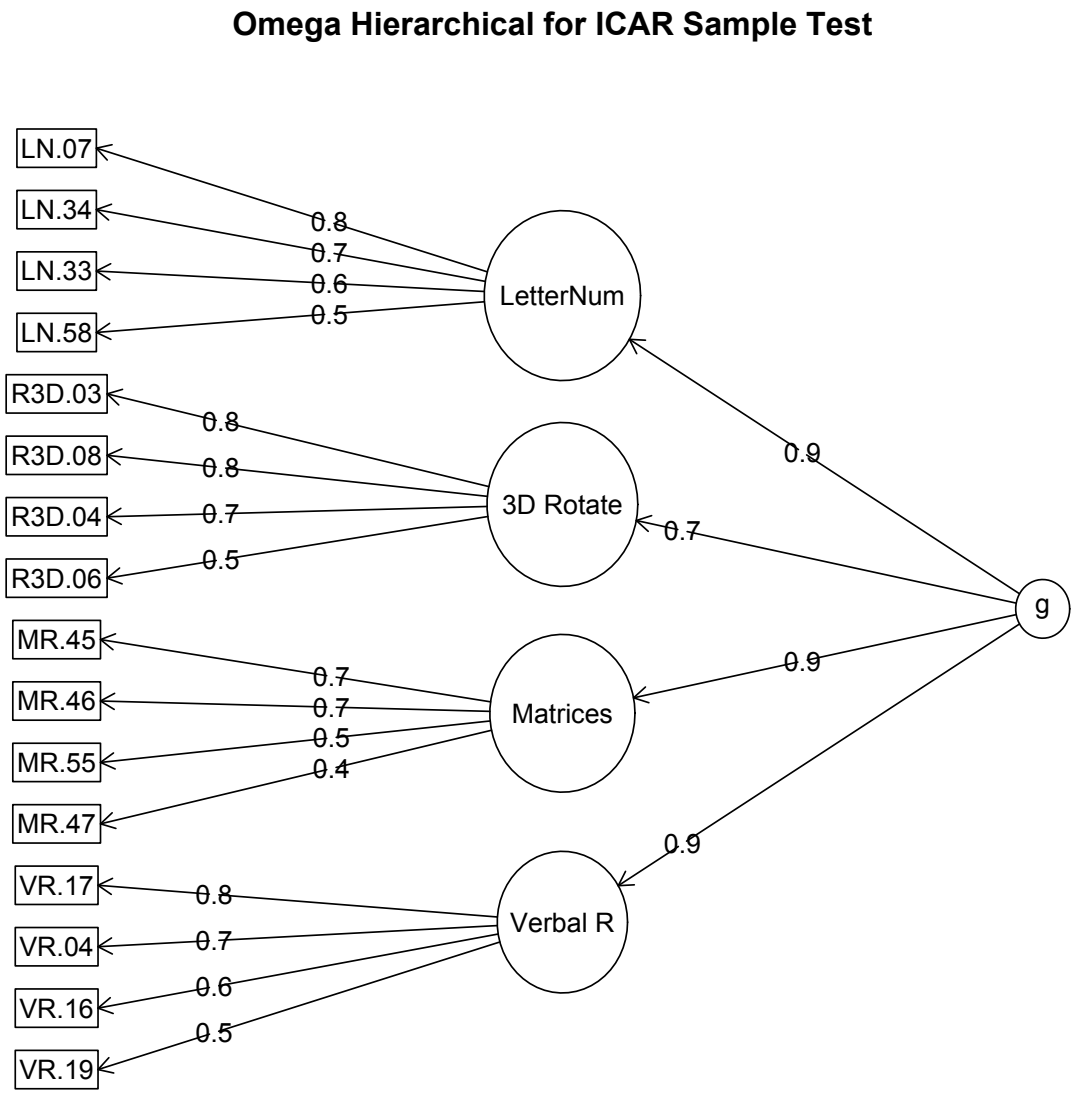
NORTHWESTERN UNIVERSITY

ICAR: Proof of concept

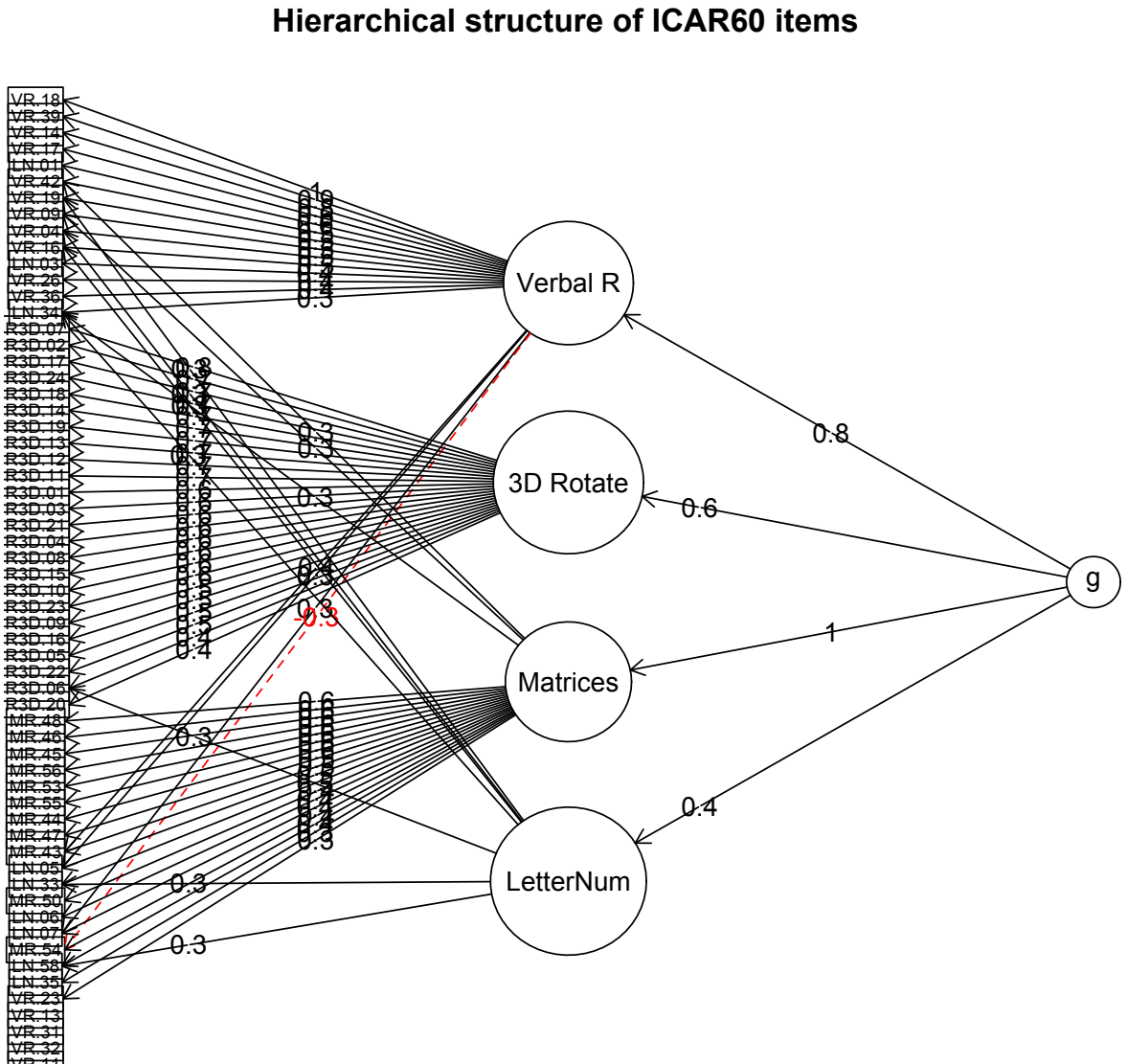
1. Condon & Revelle (2014) examined the first 60 publicly available items.
2. We are using them here to examine how ability relates to dimensions of temperament and of interest.
3. Domains measured and item sources
   - Temperament items taken from International Personality Item Pool (IPIP) (Goldberg, 1999) (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). (ICAR:Ability::IPIP:Temperament)
   - Interest items taken from Oregon Vocational Interest Survey (ORVIS) (Pozzebon, Visser, Ashton, Lee & Goldberg, 2010)

NORTHWESTERN UNIVERSITY

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



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



Multiple solutions to the dimensionality of temperament

1. Eysenck "Giant 3" (Eysenck, 1994)
2. The "Big 5" (Digman, 1990; Goldberg, 1990)
3. 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, Eysenck & Barrett, 1985)

   Found meaningful 3, 5, and 15 factor solutions.
4. 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, Su, Lewis & Rivkin, 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"

TAI for groups is not the same as TAI for individuals

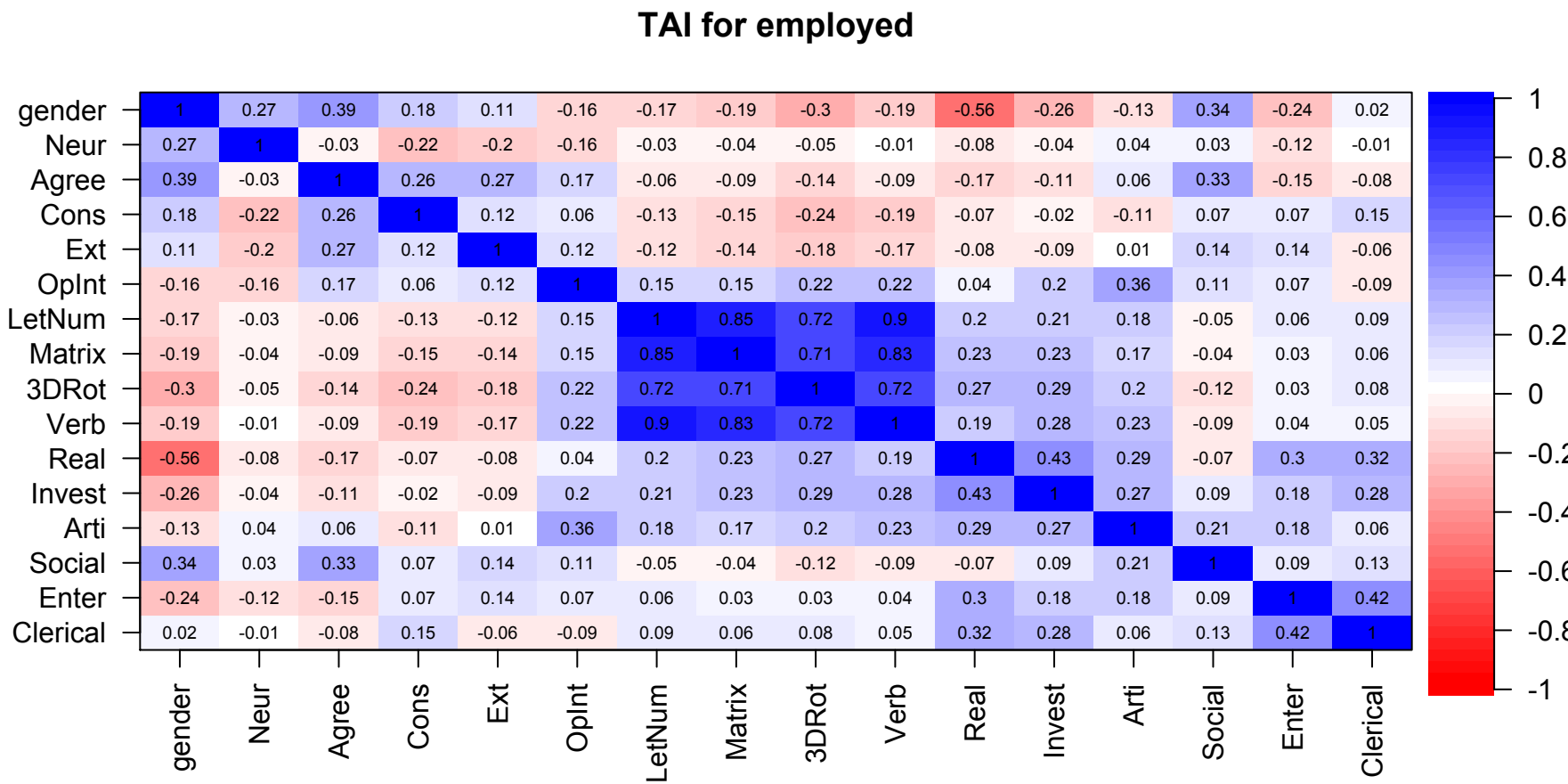
1. How do occupational groups differ on TAI?
   - The mean scores for groups allow us to compare the groups
   - But it is the structure of these group means that are particularly interesting
2. Overall correlation is a function of within group correlations and between group correlations.
3. Correlations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

   $r_{xy} = eta_{x_{wg}} * eta_{y_{wg}} * r_{xy_{wg}} + eta_{x_{bg}} * eta_{y_{bg}} * r_{xy_{bg}}$
5. 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.

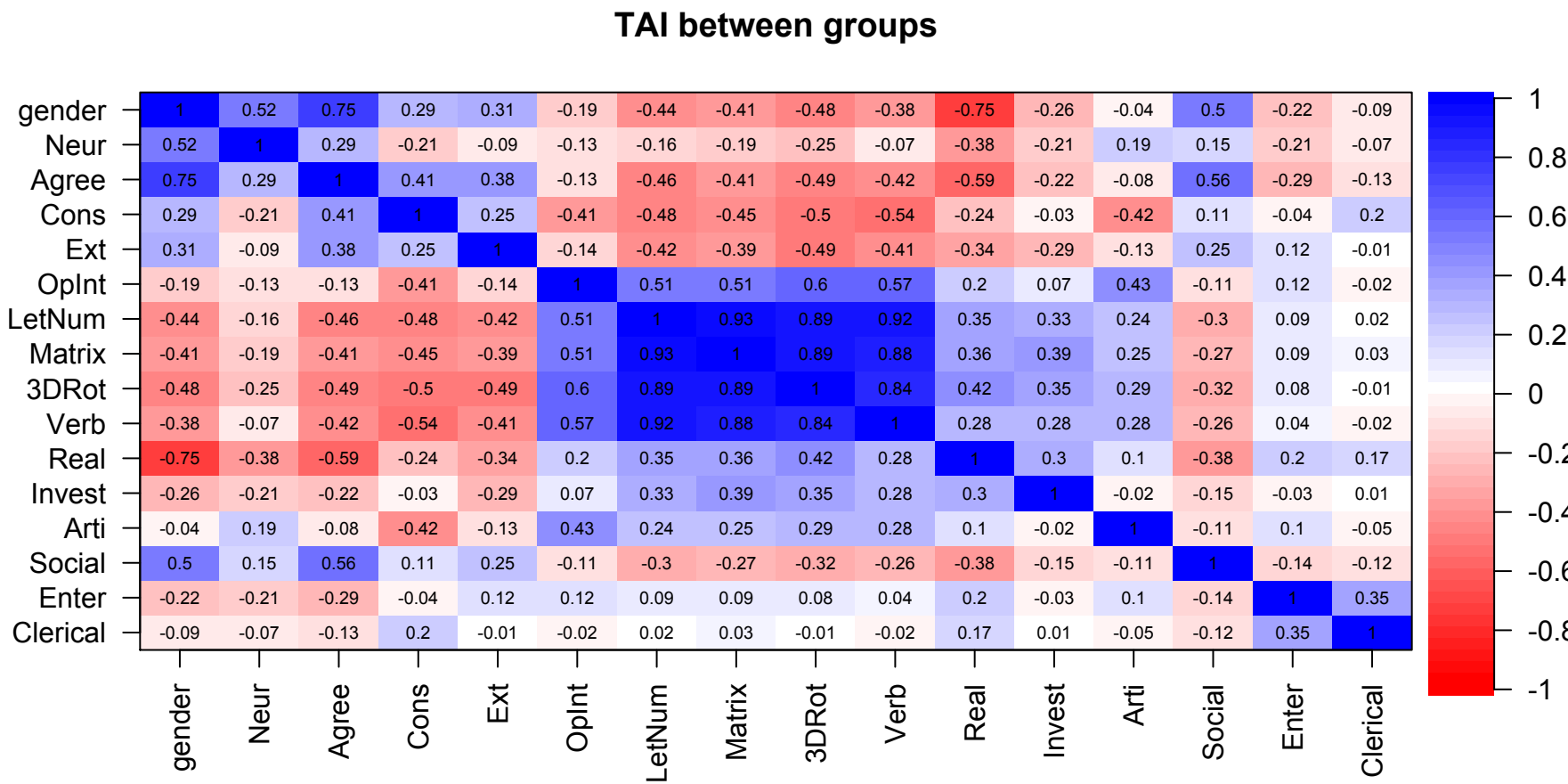
Temperament, Ability, and Interests – within and between groups

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"

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



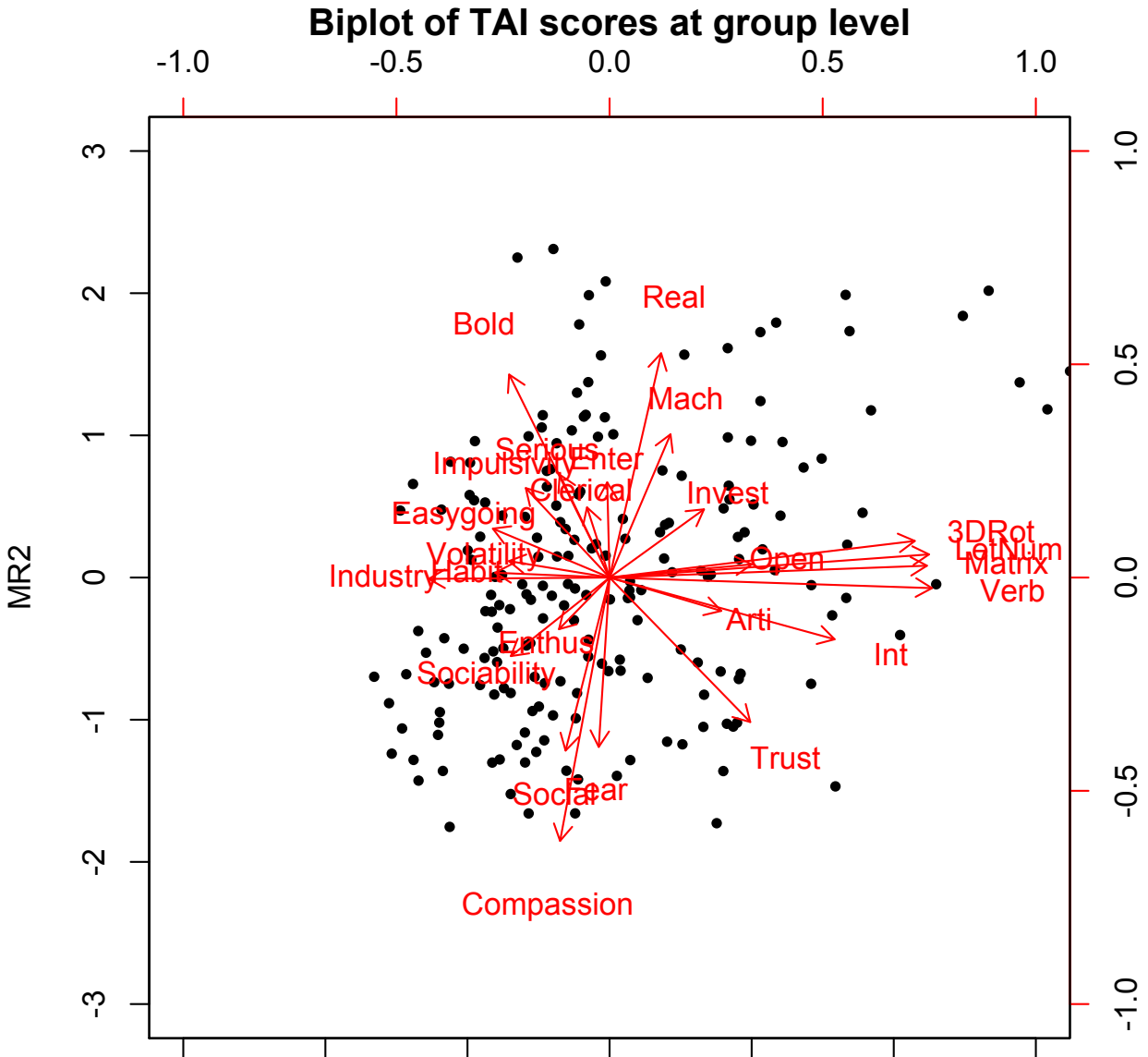
Group Level data of 15 personality scales, 6 interests, 4 ability



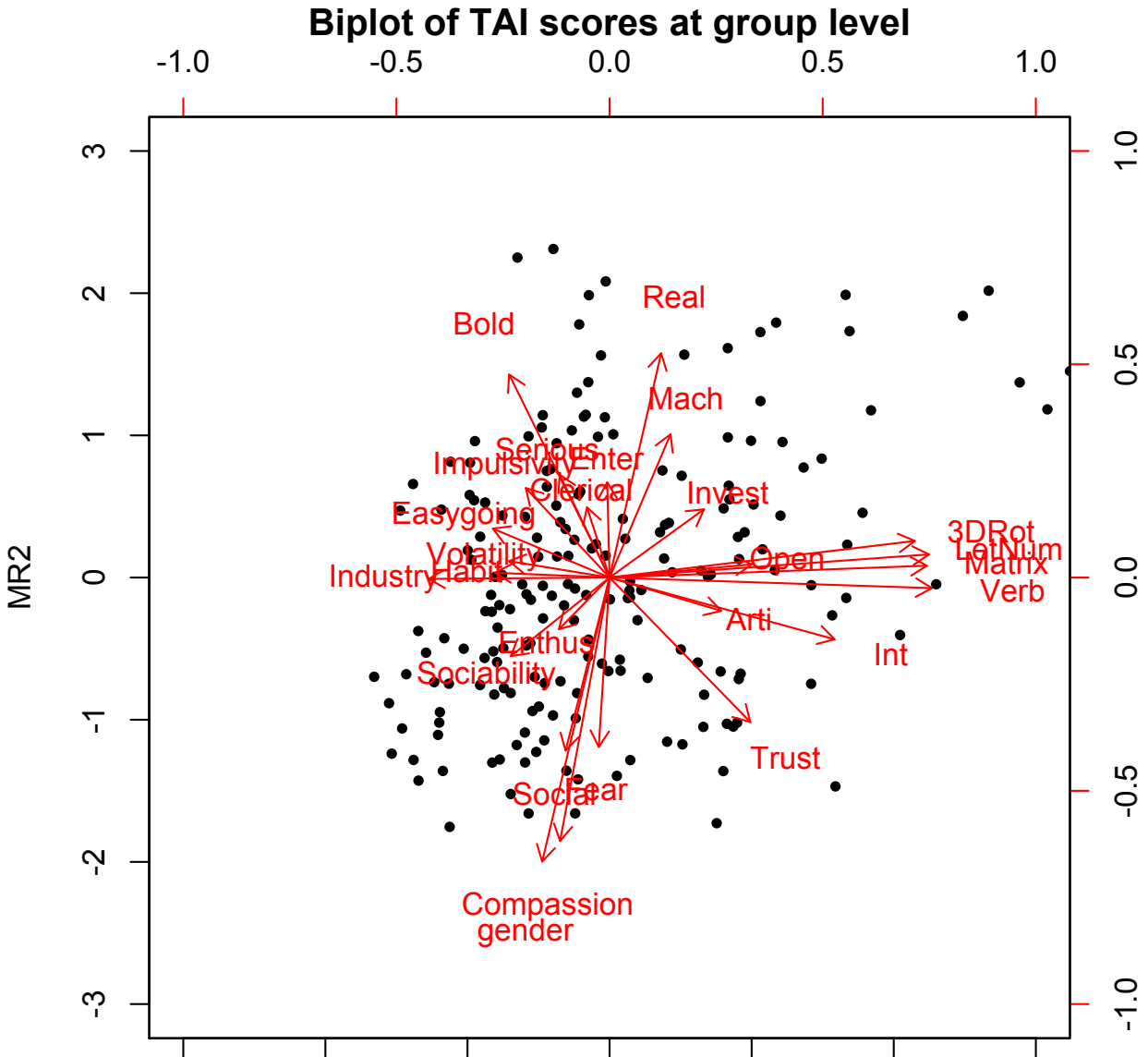
Niche selection

1. Occupations differ systematically in intellectual Ability required
2. But they also differ in Interests and Temperament required.
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.

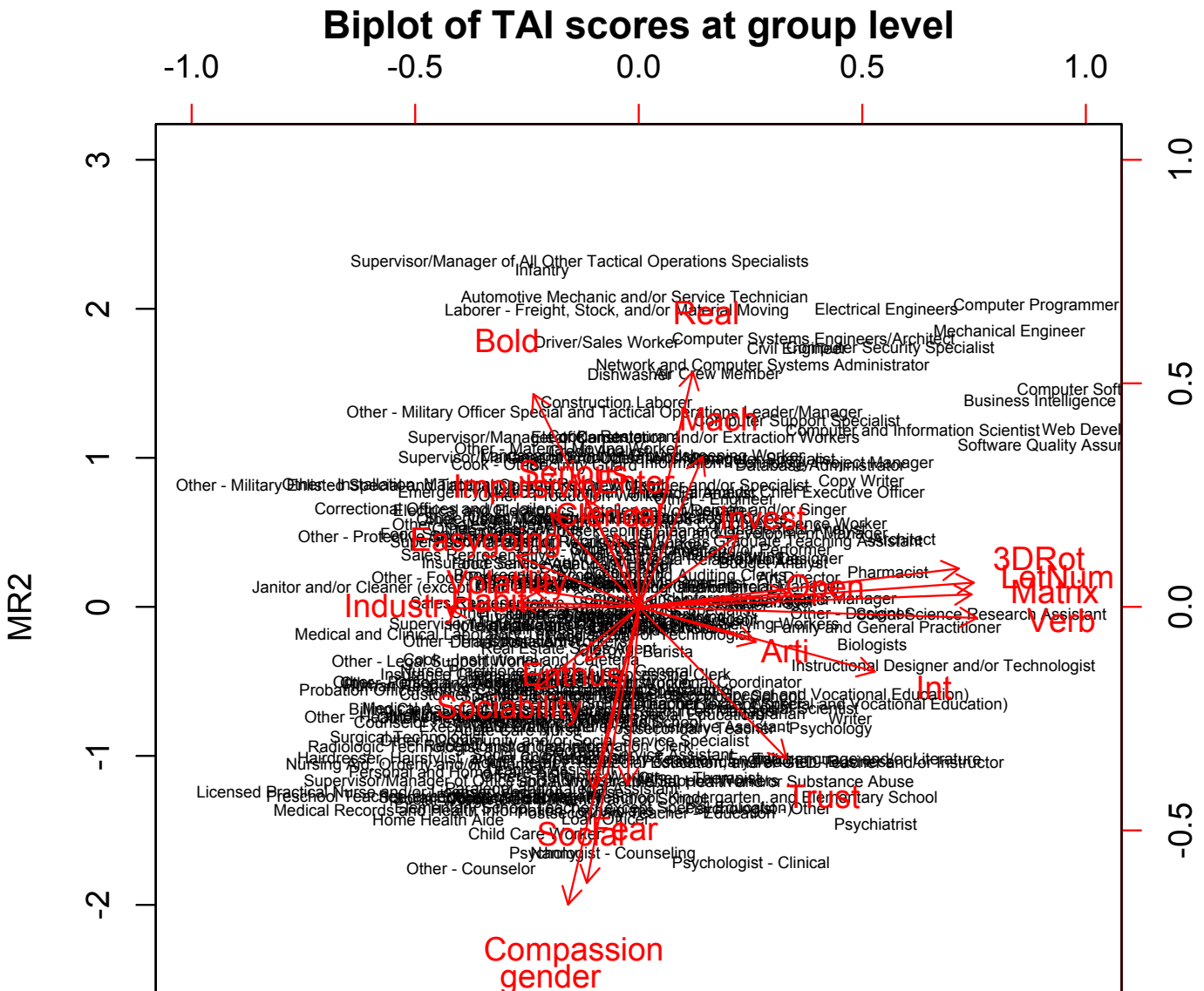
Biplot of a two factor solution to the group level data



Add gender to the extended factor solution of the group data



Biplot of a two factor solution to the group level data



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. For more information and for these slides go to http://personality-project.org/sapa.html

Bouchard, T. (1997). Experience producing drive theory: how genes drive experience and shape personality. *Acta Paediatrica*, *86*(S422), 60–64.

Condon, D. M. (2014). *An organizational framework for the psychological individual differences: Integrating the affective, cognitive, and conative domains*. PhD thesis, Northwestern University.

Condon, D. M. (2015). The many little items of "big five" measures: Hierarchy, heterarchy, and predictive utility in personality structure. Long Beach, California. Society of Personality and Social Psychology.

Condon, D. M. & Revelle, W. (2014). The International Cognitive Ability Resource: Development and initial validation of a public-domain measure. *Intelligence*, *43*, 52–64.

Deary, I. (2008). Why do intelligent people live longer? *Nature*, *456*(7219), 175–176.

NORTHWESTERN UNIVERSITY

DeYoung, C. G., Quilty, L. C., & Peterson, J. B. (2007). Between facets and domains: 10 aspects of the big five. *Journal of Personality and Social Psychology*, *93*(5), 880–896.

Digman, J. M. (1990). Personality structure: Emergence of the five-factor model. *Annual Review of Psychology*, *41*, 417–440.

Eysenck, H. J. (1994). The big five or the giant three: Criteria for a paradigm. In C. F. Halverson, G. A. Kohnstamm, & R. P. Martin (Eds.), *The developing structure of temperament and personality from infancy to adulthood* (pp. 37–51). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Eysenck, S. B. G., Eysenck, H. J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality and Individual Differences*, *6*(1), 21 – 29.

Goldberg, L. R. (1990). An alternative "description of personality": The big-five factor structure. *Journal of Personality and Social Psychology*, *59*(6), 1216–1229.

Goldberg, L. R. (1999). A broad-bandwidth, public domain, personality inventory measuring the lower-level facets of several five-factor models. In I. Mervielde, I. Deary, F. De Fruyt, & F. Ostendorf (Eds.), *Personality psychology in Europe*, volume 7 (pp. 7–28). Tilburg, The Netherlands: Tilburg University Press.

Goldberg, L. R. (2010). Personality, demographics and self reported acts: the development of avocational interest scales from estimates of the mount time spent in interest related activities. In C. Agnew, D. Carlston, W. Graziano, & J. Kelly (Eds.), *Then a miracle occurs: Focusing on the behavior in social psychological theory and research* (pp. 205–226). New York, NY: Oxford University Press.

Gottfredson, L. S. (1997). Why g matters: The complexity of everyday life. *Intelligence*, *24*(1), 79 – 132.

Hayes, K. (1962). Genes, drives, and intellect. *Psychological Reports (Monograph Supplement 2)*, *10*, 299–342.

NORTHWESTERN UNIVERSITY

Johnson, W. (2010). Extending and testing tom bouchard's experience producing drive theory. *Personality and Individual Differences*, *49*(4), 296 – 301. Collected works from the Festschrift for Tom Bouchard, June 2009: A tribute to a vibrant scientific career.

Kelly, E. L. & Fiske, D. W. (1950). The prediction of success in the VA training program in clinical psychology. *American Psychologist*, *5*(8), 395 – 406.

Kelly, E. L. & Fiske, D. W. (1951). *The prediction of performance in clinical psychology*. Ann Arbor, Michigan: University of Michigan Press.

Kievit, R. A., Frankenhuis, W. E., Waldorp, L. J., & Borsboom, D. (2013). Simpson's paradox in psychological science: a practical guide. *Frontiers in Psychology*, *4*(513), 1–14.

Lord, F. M. (1955). Estimating test reliability. *Educational and Psychological Measurement*, *15*, 325–336.

Pozzebon, J. A., Visser, B. A., Ashton, M. C., Lee, K., & Goldberg, L. R. (2010). Psychometric characteristics of a public-domain self-report measure of vocational interests: The oregon vocational interest scales. *Journal of Personality Assessment*, *92*(2), 168–174.

Roberts, B. W., Kuncel, N. R., Shiner, R., Caspi, A., & Goldberg, L. R. (2007). The power of personality: The comparative validity of personality traits, socioeconomic status, and cognitive ability for predicting important life outcomes. *Perspectives on Psychological Science*, *2*(4), 313–345.

Rounds, J., Su, R., Lewis, P., & Rivkin, D. (2010). O* NET® interest profiler short form psychometric characteristics: Summary.

Simpson, E. H. (1951). The interpretation of interaction in contingency tables. *Journal of the Royal Statistical Society. Series B (Methodological)*, *13*(2), 238–241.

NORTHWESTERN UNIVERSITY

Yule, G. U. (1903). Notes on the theory of association of attributes in statistics. *Biometrika*, *2*(2), 121–134.