Personality structure beyond the Big 5:
Expanding the boundaries of personality research

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Outline

1. Levels of analysis
   - Personality structure can be examined at four different levels
   - Level 1: Within person over time

2. Temperament, Abilities and Interests
   - Beyond Affect, Behavior, Cognition and Desire:
     - Temperament, Ability and Interests
   - A need for integrative studies

3. SAPA and Telemetrics
   - Conceptual overview
   - Technical Overview
   - Item selection

4. Levels 2 & 3
   - Analytical Technique
   - Level 2: Between persons at one time
   - Level 3: Between people over time

5. Niche selection
   - Level 4: niche selection - the example of college majors
Personality as the coherent patterning of the ABCDs

Personality is the study of the coherent patterning over time and space of affect, cognition, and desires as they lead to behavior. That is, personality is the study of patterns over time of how what we do is the consequence of how we feel, what we think, and what we want.

This definition leads to studies of coherency over time within subjects as well as to studies of stable patterns of individual differences at any one time and studies of patterns of change over time. One of the consequences of differences in patterns may be found in the behavioral choices we make that reflect our long term patterns of affect, cognition and desires.

All of these areas are important issues for those of us who study personality.
At least four levels of analysis of personality structure

1. Structure of personality within individuals across time
   - Dimensions of affect are not the same for all individuals.

2. Structure of personality between individuals at one time
   - Identity
   - Reputation
   - Behavior

3. Structure of personality between individuals over time
   - Does the structure change over time?
   - What is the structure of change?

4. Structure of personality differences between groups of individuals
   - People choose niches based upon their temperaments, abilities, and interests.
   - What are the structures of these niches?
Personality structure can be examined at four different levels

**Multilevel analysis can yield surprising results**

Although it is well known that the structure within a level does not imply anything about the structure at a different level, this distinction is frequently forgotten.

1. **Various names for the phenomena:**
   - Yule-Simpson paradox (Simpson, 1951; Yule, 1903)
   - The fallacy of ecological correlations (Robinson, 1950)
   - The within group–between group problem (Pedhazur, 1997)
   - Ergodicity (Molenaar, 2004)

2. **Observed correlations may be decomposed into with group correlations and between group correlations**
   
   \[
   r_{xy} = \eta_{x_{wg}} \times \eta_{y_{wg}} \times r_{xy_{wg}} + \eta_{x_{bg}} \times \eta_{y_{bg}} \times r_{xy_{bg}}
   \]
   - \( r_{xy} \) is the within group correlation
   - \( r_{xy_{wg}} \) is the between group correlation
   - \( \eta_{x_{wg}} \) is correlation of the data with the within group values
   - \( \eta_{x_{bg}} \) is correlation of the data with the between group values

3. **We consider several examples of multi-level analysis.**
Personality structure can be examined at four different levels.

**Observed correlations when** \( r_{wg} = \pm 1 \) **and** \( r_{bg} = \pm 1 \)**
Level 1: Within person over time

Previous results from the Telemetrics Lab demonstrate Level 1 effects

1. Personality and the structure of affect using the Motivational State Questionnaire (Revelle & Anderson, 1997) and the EPI (Eysenck & Eysenck, 1964) show
   - Independence of Positive Affect and Negative Affect between individuals cross sectionally
   - Low correlations of PA with Extraversion and NA with Neuroticism

2. Within subject correlation of PA and NA and Energetic Arousal and Tense Arousal varies a great deal
   - Measured multiple times per day within subjects across 2-4 weeks
   - Using daily diaries or Palm Pilots (Rafaeli, Rogers & Revelle, 2007)
   - Using cell phones and text messaging Wilt, Funkhouser & Revelle (2011)
Level 1: Within person over time

Variability and between subject correlations of within subject measures (Wilt et al., 2011)
Hogan (1982) distinguishes between personality as identity and personality as reputation. To this we would add actions.

1. **Identity**
   - How we see ourselves
   - Studies of the structure of self report

2. **Reputation**
   - How others see us
   - Studies of the structure of peer report

3. **Actions**
   - What we actually do
   - Studies of the residues of our choices and our actions.
   - One important outcome is choice of college major.
   - Another is the choice of occupation.
Beyond Affect, Behavior, Cognition and Desire: Temperament, Ability and Interests

Going beyond the ABCDs: Personality as Temperament, Ability, and Interests

1. Temperament: what we usually do
   - Identity, Reputation, and Actions
   - Affective, Cognitive and Behavioral reactions to situations: the “Big 5” (Goldberg, 1990), the “Giant 3” (Eysenck, 1990)

2. Ability: What we can do

3. Interests: What we like to do
   - 6 dimensions: Realistic, Investigative, Artistic, Social, Enterprising, Conventional (aka RIASEC Holland, 1996)
   - 2 dimensions (e.g., people vs. things/facts vs. ideas, Prediger & Vansickle, 1992) of interests
Traditional model of Temperament, Abilities, and Interests

Temperament
- 2-5 dimensions reflecting individual differences in Affect, Behavior, Cognition, Desire

Abilities
- g
- gf gc

Interests
- 2 broad dimensions organizing 6-8 specific interests
  1. People vs. Things
  2. Facts vs Ideas
Personality as Temperament, Ability, and Interests

It has long been known that Temperament, Ability and Interests (TAI) are interrelated predictors of long term outcomes (Kelly & Fiske, 1950). Although not an issue in Europe, among most Americans, the following generalizations are true:

- The study of interests has been relegated to vocational counselors
- Ability has been studied by educational psychologists and Industrial Organizational psychologists.
- Need to integrate these in a general theory of personality.

A few groups do try to integrate temperament and ability

- These include Lubinski & Benbow (2000); Lubinski, Webb, Morelock & Benbow (2001); Lubinski & Benbow (2006)
- Ackerman (1997), Ackerman & Heggestad (1997)
- Kuncel, Campbell & Ones (1998); Kuncel, Hezlett & Ones (2001); Kuncel, Crede & Thomas (2005)
- von Stumm, Chamorro-Premuzic & Ackerman (2011); DeYoung, Grazioplene & Peterson (2012)
Traditional model of Temperament, Abilities, and Interests

Temperament

Temperament

Abilities

Interests
A need for integrative studies

- Prior work has shown that there is a need to integrate Temperament, Abilities and Interests.
- But how to do it?
- To integrate the areas requires large sample sizes, ease of data collection, and a diverse subject population.
- Some do this through meta analysis, some use broad based national samples.
- Is it possible for single labs to do integrative studies?
A need for integrative studies

How to do integrative studies?

- Problem of small samples sizes based upon college undergraduates. Typical subject pools are neither large enough nor diverse enough.

- Expensive to get access to large and diverse populations
  - Exceptions include national and international survey samples using preselected items:
    - National Longitudinal Study of Youth (NLSY)
    - Program for International Student Assessment (PISA)
    - German Socio-Economic Panel (SOEP)

- Is it possible to do large based sampling with tailored items?

- Yes, use the web.
Synthetic Aperture Personality Assessment (SAPA)

- Using the web and open source materials to collect data on temperament, ability and interests
  - Synthetically form large covariance matrices from smaller subsets of items
  - Each subject given $\approx 50$ personality, $10$ interest, and $14-16$ ability items sampled from the larger pool.
  - Total pool of items $> 1000$
    - $\approx 400$ personality items primarily from International Personality Item Pool Goldberg (1999)
    - 92 interest items for Oregon Vocational Interest Scales (Pozzebon, Visser, Ashton, Lee & Goldberg, 2010)
    - 80 ability items (home brewed at NU)
    - Demographic items include age, sex, education, race, country, college major, occupation (if appropriate)
    - Resulting sample sizes $> 50,000 - 250,000$

- College major, occupational status and interest items added in 9/10
- Data to be summarized include $\approx 70,000$ participants
Method

   - ≈ 120/day participants are recruited to test.personality-project.org
   - Each participant is given 60-70 items
   - Total set of items being analyzed > 500

2. Item content being sampled
   - 100 “IPIP” Big 5 items
   - ≈ 200 other temperamental items
   - 56-80 home brewed ability items
   - 92 Oregon Vocational Interest items (ORVIS)

3. Although > 230,000 participants have been run in all, we will report only those data from the last 70,000

4. Demographic information included
   - Age, Gender, Level of education, country of residence
   - College major and broad field (if appropriate)
   - Occupation (if appropriate)
SAPA: what the subject sees

A

ab

B
### SAPA: what the subject sees

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Conceptual overview
Conceptual overview

SAPA: what the subject sees

A

ad

D
### Conceptual overview

**SAPA: what the subject sees**

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### SAPA: what the subject sees

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Conceptual overview

**SAPA: what the subject sees**
SAPA: what the experimenter sees: A Synthetic matrix

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<td>ad</td>
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<td></td>
<td>D</td>
</tr>
</tbody>
</table>

Conceptual overview
SAPA: Technical overview

1. n x n synthetic covariance matrices are formed by giving items with probability p to Np subjects
   - N  Total number of subjects
   - n  Total number of items in synthetic matrix
   - p  Probability of any item being given
   - pN Number of subjects taking any one item
   - p^2N Number of subjects for any pair of items

2. Basic statistics
   - Data are Massively Missing at Random
   - Means and Variances are based upon pN subjects
   - Covariances are based upon p^2N subjects

3. Power of large samples and sampling of items
   - 100-150 people per day => 40,000 subjects per year
   - 700-1000 subjects/week
   - By varying p, one can prototype items rapidly.
Item selection

Items were selected from the T A I domains

1. Temperament items from the International Personality Item Pool (IPIP) (Goldberg, Johnson, Eber, Hogan, Ashton, Cloninger & Gough, 2006)
   - 100 Big 5 items
   - 3-500 experimental items to clarify structure

2. 92 Vocational interest items from the Oregon Vocational Interest Survey (ORVIS) which is available as part of the IPIP

3. 80 ability items developed at Northwestern
   - Untimed (power) items
   - Item purification over several years
International Personality Item Pool (IPIP) Big 5: sample items

- **Conscientiousness**: Do things according to a plan.
- **Agreeableness**: Inquire about others’ well-being.
- **Neuroticism/Stability**: Have frequent mood swings.
  - **Openness**: Am full of ideas
- **Extraversion**: Make friends easily
Oregon Vocational Interest Scales: sample items

- **Adventure**: Would like to be a professional athlete.
- **Altruism**: Like to care for sick people.
- **Analytic**: Would like to be a chemist.
- **Artistic**: Create works of art.
- **Erudition**: Would like to be a translator or interpreter.
- **Leadership**: Like to make important things happen.
- **Organization**: Would like to be the financial officer for a company.
- **Practical**: Would like to care for cattle or horses.
Cognitive Ability items

1. Self reported values on standardized tests
   - SAT Verbal
   - SAT Quantitative
   - ACT

2. Open source items developed for the SAPA project
   - Analytic Alphanumeric sequences
   - Matrix Analogous to Raven’s matrices
   - 3 D rotation Difficulty created by number of rotations
   - Verbal Basic vocabulary
   - Full IQ Weighted sum score of the parts
Analytical approach: All analyses done in R

1. R: An international collaboration [http://R-cran.org](http://R-cran.org)
2. R: The open source - public domain version of S+
3. R: Written by statistician (and all 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.
   - For example, a recent issue of *Psychological Methods* had at least three articles with examples or supplementary work done in R
   - R facilitates asking questions that have not already been asked.
5. Special functions for SAPA have been written in R and are included in the `psych` package (Revelle, 2012).
Analytical reporting

1. Given the sample sizes, statistical significance is not an issue, but rather the size of the effects.
2. Correlation is an appropriate effect size measure
   - Correlations between continuous variables are reported as Pearson r
   - Correlations between dichotomous variables are reported as tetrachoric correlations
   - Correlations between continuous and dichotomous are reported as biserial
   - These last two correlations make assumptions of normal distributions of latent traits
3. Data displays are graphical techniques for showing the complex, multivariate structure of the data
   - Correlation strength reported as a “heat map” with positive correlations shaded as progressively darker shades of blue, negative correlations as darker shades of red.
   - Some multidimensional plots
Demographic characteristics of the sample

Table: Characteristics of the sample

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Females</th>
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<tr>
<td></td>
<td>count</td>
<td>count</td>
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<td>Age</td>
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<td>Mean</td>
<td>26.3</td>
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<td>Median</td>
<td>25.1</td>
<td>23.7</td>
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<td>Education</td>
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<td>2.0</td>
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<td>Parental Ed</td>
<td>2.97</td>
<td>3.0</td>
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<tr>
<td>SATQ *</td>
<td>612</td>
<td>620</td>
</tr>
<tr>
<td>SATV*</td>
<td>613</td>
<td>630</td>
</tr>
<tr>
<td>ACT*</td>
<td>25.74</td>
<td>26.0</td>
</tr>
</tbody>
</table>

*self reported
Spatial distribution of the sample

Table: Country of origin of the sample

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>54,144</td>
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<tr>
<td>Canada</td>
<td>3,288</td>
</tr>
<tr>
<td>UK</td>
<td>1,638</td>
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<tr>
<td>Malaysia</td>
<td>1,374</td>
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<td>Australia</td>
<td>1,360</td>
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<td>Philippines</td>
<td>767</td>
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<td>India</td>
<td>738</td>
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<td>Germany</td>
<td>385</td>
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<tr>
<td>Sweden</td>
<td>358</td>
</tr>
<tr>
<td>Singapore</td>
<td>302</td>
</tr>
<tr>
<td>19 others</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>
Big 5 scale scores used an Item Response Theory (IRT) algorithm

- With complete data, IRT and simple sum scores are almost identical.
- SAPA data are Massively Missing at Random and are better estimated using IRT techniques.
  - Two parameter model: item difficulty, item location
  - One parameter model: item difficulty

Ability measures

- SATV, SATQ, SATW and ACT were self reported
- iq measure was based upon IRT analysis and scoring
Heat map of the 100 Big 5 items suggests a 5 cluster structure
Cluster analysis of the 100 Big 5 items shows a 5 cluster structure
IRT parameters for best 16 IQ items

Item information from factor analysis

-3 -2 -1 0 1 2 3
0.0 0.2 0.4 0.6 0.8 1.0 1.2
Item Information

rotate.3
rotate.4
rotate.6
rotate.8
reason.17
reason.4
letter.34
letter.58
matrix.45
matrix.46
matrix.47
matrix.55
rotate.3
rotate.4
rotate.6
rotate.8

-3 -2 -1 0 1 2 3
Test information for the best 16 IQ items
Best 16 ability items show a clear g + group factor structure

\[ \omega_g = .78 \text{ for best 16 iq items} \]
The relationships of Temperament, Ability and Interests across subjects

1. The three broad domains show low to moderate within domain correlations
   - Strongest within the ability domain (.31)
   - Lower correlations in the temperamental domain (.22)
   - Even lower inter-interest correlations (.13)

2. On average, the three broad domains show low across domain relationships
   - Openness-Intellect correlates with all the IQ measures
   - Openness-Intellect correlates with most interest measures
   - Agreeableness and Altruism, Conscientious and Organization, Extraversion and Leadership

<table>
<thead>
<tr>
<th></th>
<th>Temperament</th>
<th>Ability</th>
<th>Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperament</td>
<td>0.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability</td>
<td>0.06</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Interests</td>
<td>0.06</td>
<td>0.05</td>
<td>0.13</td>
</tr>
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</table>
Temperament, Ability and Interests from SAPA
Level 3 considers trends across time

Measures over time can be either cross sectional or longitudinal

1. For the SAPA set, we can examine cross sectional differences in TAI
   - The means will partly reflect various sampling biases
   - (Consider the openness of a 90 year old filling out a web based survey).

2. The age trends we show agree with other cross sectional studies.

3. The across age correlations show how temperament, ability and interests covary over age
Big 5 + IQ estimates change across age groups
Level 3: Between people over time

Structure of TAI within age groups is the standard finding

Within group correlations of TAI
Structure of TAI across age groups shows a very different pattern

Between age group correlations of TAI
Level 4: the personality of groups

Level 4 is the analysis of personality of groups. This is how the composition of groups differ in the average personality characteristics of their members.

1. People differ in their temperaments, abilities and interests.
2. College majors differ in their social and intellectual challenges.
3. We can see this by examining the TAI mean scores for each of 84 majors.
   - Majors with more than 100 students
   - Data from students who had not declared majors were deleted.
4. Correlations can be found within and between these groups.
5. These level 4 between group correlations are not between people but of the means of the majors. This leads to the structure of group differences.
Choice of college major reflects temperament, abilities and interests

1. Undergraduate majors/concentration provide feedback to students based upon performance.
2. Performance reflects both ability and time spent on the task
   - Students choose majors which reinforce their talents
   - Interests grow in response to feedback
3. Although many students can do well in many majors, they end up choosing those majors that maximally meet their needs.
4. Multiple ways of displaying these data
   - Majors sorted by ability
   - Majors sorted by a particular temperament (e.g., conscientiousness)
   - Majors in a multi-dimensional space of abilities x temperament
### Top and bottom 6 majors sorted by IQ

<table>
<thead>
<tr>
<th>Major</th>
<th>FullIQ</th>
<th>Intel</th>
<th>Agree</th>
<th>Consc</th>
<th>Neuro</th>
<th>Extra</th>
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<tr>
<td>Physics</td>
<td>0.91</td>
<td>0.80</td>
<td>-0.60</td>
<td>-0.35</td>
<td>-0.29</td>
<td>-0.41</td>
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<tr>
<td>Neuroscinc</td>
<td>0.77</td>
<td>0.52</td>
<td>-0.39</td>
<td>-0.24</td>
<td>0.10</td>
<td>-0.36</td>
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<td>Mathematics</td>
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<td>-0.50</td>
<td>-0.30</td>
<td>-0.05</td>
<td>-0.47</td>
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<tr>
<td>Glgcl.Scnc</td>
<td>0.73</td>
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<td>-0.49</td>
<td>-0.24</td>
<td>-0.13</td>
<td>-0.48</td>
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<td>Linguistics</td>
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<td>Economics</td>
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<td>-0.37</td>
<td>-0.09</td>
<td>-0.15</td>
<td>-0.08</td>
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<tr>
<td>Social.Wrk</td>
<td>-0.40</td>
<td>-0.26</td>
<td>0.50</td>
<td>0.15</td>
<td>-0.01</td>
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<td>-0.18</td>
<td>0.34</td>
<td>0.51</td>
<td>0.01</td>
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<td>0.26</td>
<td>0.40</td>
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<td>0.16</td>
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## Top and bottom 6 majors sorted by Agreeableness

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<th>Agree</th>
<th>Consc</th>
<th>Extra</th>
<th>Neuro</th>
<th>Intel</th>
<th>FullIQ</th>
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<td>-0.01</td>
<td>-0.26</td>
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<tr>
<td>Hlth.Svc.A</td>
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<td>0.01</td>
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<td>-0.50</td>
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<tr>
<td>K.preK.Edu</td>
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<td>0.03</td>
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<td>0.19</td>
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TAI and motivational choice

Structure of TAI within college majors is the standard structure
Structure of TAI between college majors is very different

TAI between group correlations

gender.bg
Agree.bg
Consc.bg
Extra.bg
Neuro.bg
Intel.bg
FullIQ.bg
ANiq.bg
MXiq.bg
R3Diq.bg
VEdiq.bg
Produ.bg
Adven.bg
Analy.bg
Organ.bg
Leade.bg
Altru.bg
Erudi.bg
Artis.bg
TAI and motivational choice

Scatter plot and unweighted between group correlations for ability and Big 5 Temperament
Factor structure of TAI based upon mean scores of college majors
TAI and motivational choice

A biplot of TAI and college majors locates majors in two space

A two dimensional TAI structure

Emotional vs. Organized

Gender

Neuro"
The study of personality structure may be done at at least four levels

1. **Level 1**: The within individual structure of coherent patterns of Affect, Cognition, Desire and Behavior over time and space
   - Dimensions within individuals ≠ dimensions between individuals

2. **Level 2**: The normal between subject structure reflects individual differences in these patterns
   - Three broad domains of Temperament, Abilities and Interests with low but non zero interrelationships

3. **Level 3**: Structure between subjects over time reflects systematic development and change.

4. **Level 4**: Structure between self selected groups reflects the process of niche selection
   - Although people are assorting into groups based upon their individual characteristics the structure of personality traits at the group level ≠ the structure of individuals
An invitation for cooperation

1. We have demonstrated the advantages of large data sets in order to do analyses at multiple levels of analysis.

2. The use of telemetric techniques (e.g., SAPA) are easy to implement using open source computer languages and code.

3. We have developed open source ability items with the same motivation as the original International Personality Item Pool, with the hope of providing fellow researchers with a common set of measures.

4. We invite cooperation with other researchers either in developing similar SAPA sites, or in cooperative explorations using the current site.
The Croatian writer, Marco Marulić, was probably the first person to use the term psychology. This statue is by Ivan Mestrovic.


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.


