Chapter 2
Individual Differences in Cognition: New Methods for Examining the Personality-Cognition Link

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Overview

Understanding how all people are the same, some are the same, and yet none are the same is a fundamental challenge to personality and individual differences theorists in particular and psychologists in general (Kluckhohn & Murray, 1953; Revelle, 1995). Unfortunately, there is little work that actually addresses the challenge of Kluckhohn and Murray. As is true for the rest of psychology, there is a strong trend toward fragmentation of the field of individual differences. Particularly in the United States, there is a tendency in personality and individual differences toward the lack of integration of theories of (non-cognitive) personality dimensions with individual differences in cognition. The chapters of this book are partly meant to rectify this shortcoming. We will do our part by reviewing some of the prior research on the effects of non-cognitive variables upon cognition and then introduce a new procedure, "Synthetic Aperture Personality Assessment" (SAPA) as a tool for exploring cognitive and non-cognitive aspects of personality.

Although most of the current taxonomic research in personality emphasizes three (giant) to five (big) dimensions of personality, an alternative framework is to organize personality in terms of the four fundamental aspects of human nature that have long been subjects of psychological theory. Sources and descriptions of differences in Affect, Cognition, and Desire have been studied as predictors and explanations of Behavior (the ACDs of B or, more simply, the ABCDs) since Plato at least. How people differ in what they feel, what they think, and what they want largely determines what they do. But to study the ABCDs requires studying them together rather than in isolation. The central theme of this book is the integration of individual differences in cognition with non-cognitive dimensions of personality. This is a beginning, but a full-fledged integration will require a better understanding of all aspects of the ABCDs.

The ABCDs of Personality

Personality is an abstraction used to explain consistency and coherency in an individual's pattern of Affects, Cognitions, Desires, and Behaviors. What one feels, thinks, wants, and does changes from moment to moment and from situation to situation but shows a patterning across situations and over time that may be used to recognize, describe, and even to understand a person. The task of the personality

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A. Gruszka et al. (eds.), *Handbook of Individual Differences in Cognition: Attention, Memory, and Executive Control*, The Springer Series on Human Exceptionality,
DOI 10.1007/978-1-4419-1210-7_2, © Springer Science+Business Media, LLC 2010

researcher is to identify the consistencies and differences within and between individuals (what one feels, thinks, wants, and does) and eventually to try to explain them in terms of a set of testable hypotheses (why one feels, thinks, wants, and does; Revelle, 2007).

Early Greek philosophers explained the distinction between thoughts, feelings, and desires as representing the activity of the brain, the heart, and the liver. Although this biological model is now seen as a curiosity, the triology of mind (Hilgard, 1980) still drives current psychological theory (Ortony, Norman, & Revelle, 2005). Indeed, entire subfields of psychology have organized around what we feel (consider the journal of *Emotion* and the International Society for Research on Emotion), what we think (e.g., the journal *Cognition*, the International Society for Intelligence Research and publications on cognitive science and cognitive neuroscience), and what we want (e.g., the journal *Motivation*, and the recently created Society for the Study of Motivation) as explanations of what we do. The International Society for the Study of Individual Differences includes members who study all four of the ABCDs and many who try to integrate pairs or triplets of these aspects.

In an analysis of the role of emotions in man and machine that emphasized the role of emotions in effective functioning, Ortony et al. (2005) argued that it is necessary to consider the interaction of the ABCDs at three broad levels of functioning: the *reactive*, the *routine*, and the *reflective*. Environmental cues at the *reactive* level evoke fixed action patterns, while at the *routine* level they evoke action tendencies, which in turn elicit actions. In a negative feedback loop, these actions, in turn, reduce the action tendencies that evoked them (Atkinson & Birch, 1970; Revelle & Michaels, 1976; Revelle, 1986). The *reflective* layer is a control layer for the two lower ones that monitors and steers the performance of the reactive and routine levels. This multilevel control model of the ABCDs owes much, of course, to the prior work of Broadbent (1971), MacLean and Kral (1973), Sloman, Chrisley, and Scheutz (2005) and had been proposed in a less complete form earlier (Revelle, 1993).

The ABCDs may be used as a conceptual framework for the study of a particular personality dimension, (e.g., extraversion (Wilt & Revelle, 2009) – see Table 2.1), or as a framework for integrating

Table 2.1 Using the ABCD approach to organize personality studies: the example of extraversion. Representative studies have been chosen for each of the four basic components and the six "edges" of extraversion

Component	Study	Finding
A	Lucas and Fujita (2000)	A meta-analysis of 35 studies revealed an average correlation close to .40 between extraversion and positive affect
B	Paunonen (2003)	Extraversion was positively related to alcohol consumption, parties attended, dating variety, and exercise
C	Uziel (2006)	Extraversion was related to cognitive evaluations of hypothetical events as more positive but not less negative
D	Roberts and Robins (2000)	Extraversion was related to endorsing more economic, political, and hedonistic goals
Edge	Study	Finding
A–B	Fleeson, Malanos, and Achille (2002)	Regardless of an individual's trait level of extraversion, instructions to "act extraverted" in a group discussion increased concurrent positive affect
A–C	Robinson, Meier, and Vargas (2005)	Among individuals scoring low on extraversion, quickness to categorize threatening stimuli as threatening related to experiencing negative affect in daily life
A–D	Elliot and Thrash (2002)	Scales measuring extraversion, positive affect, and approach motivation loaded together on a higher-order factor termed "approach temperament"
B–C	Lucas and Diener (2001)	Extraversion related to the cognitive interpretation of social behavior as highly rewarding under pleasant conditions
B–D	Heller, Komar, and Lee (2007)	Goals categorized as approaching positive outcomes were related to extraverted behavioral content
C–D	Lieberman and Rosenthal (2001)	Extraversion related to higher performance on the cognitive task of nonverbal decoding when individuals held conversation–maintenance goals

research across disparate fields. The four fundamental components can be analyzed separately, or as six pairwise "edges" (e.g., Affect×Cognition, Affect×Behavior, etc.), four "facets" of triples (e.g., Affect×Behavior×Cognition, etc.) or a complete integration of all four. Examples of "edge" studies that include the cognitive aspect include the effect of affective biases in cognitive appraisal (Rogers & Revelle, 1998; Weiler, 1992), the effect of cognitive representations upon behavioral variability (Klirs & Revelle, 1986), the effect of the trait of obsessiveness upon cognitive biases (Yovel, Revelle, & Mineka, 2005), and the effect of affective states upon categorization (Gasper & Clore, 2002).

Examples of Lab-Based Studies of the ABCD "Edges"

Affective Biases in Cognitive Processing

Experimental personality research as well as experimental psychopathology has long been interested in the effect of short-term (state) and long-term (trait) differences in affect on cognitive processing (Mineka & Gilboa, 1998). Indeed, a classic theory of depression associates trait/state depression with a cognitive bias toward remembering negative events (Beck & Weishaar, 1989). Many studies of anxiety use the "dot probe" task (using choice reaction time measures to a dot presented following positive, negative, or neutral cues). Using this paradigm, it is possible to show attentional biases toward or away from threat that vary as a function of state and trait anxiety (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). Trait anxiety affects the speed at which threatening faces "pop-out" of a crowd (Gilboa-Schechtman, Ben-Artzi, Jeczemien, Marom, & Hermesh, 2004) and the likelihood of categorizing faces as threatening versus neutral after exposure to punishment (Yoon & Zinbarg, 2007). The speed at which people recover from an emotional induction can be assessed by the persistence of impaired reaction times to naming the color of emotionally valenced words (Williams, Mathews, & MacLeod, 1996) following an emotion induction (Gilboa & Revelle, 1994; Gilboa-Schechtman, Revelle, & Gotlib, 2000).

Affective Versus Cognitive Processing

Many words include both semantic and affective content. Consider which phrase in the following triplet does not belong (or is least similar to the other two): drown, fall down, or swim? Drown and fall down both have a negative valence, but drown and swim are semantic associates. On a more positive note, consider hug, smile, and face. Hug and smile share positive valence, but face and smile are semantic associates. Based upon the interpretation of Gray's original Reinforcement Sensitivity Theory (Gray, 1987), Weiler (1992) showed how individual differences in sensitivity to pleasant (SPS) versus sensitivity to unpleasant stimuli (SUPS) were independent of each other (Table 2.2) and related to the tendency to classify words based upon their positive affect (sensitivity to pleasant) or negative affect (sensitivity to unpleasant). As would be expected, SPS was associated with Extraversion, Sociability, and Surgency while SUPS was related to Neuroticism (Weiler, 1992).

State and Trait Effects on Affective Versus Cognitive Processing

In a follow up of Weiler's study (Weiler, 1992), Rogers & Revelle (1998) examined the effect of mood state and personality trait on similarity in judgments of words differing on affective and semantic content. Trait extraversion and trait neuroticism interacted in judging word pairs differing

Table 2.2 Representative items from Weiler's sensitivity to pleasant and unpleasant stimuli scale. Factor loadings for the first two factors are shown

SPS	SUPS	Item
−0.56	0.02	The beauty of sunsets is greatly over-rated
−0.55	−0.06	I prefer to take my bath or shower as quickly as possible just to get it over with
−0.51	0.09	The warmth of an open fireplace does not especially sooth or calm me
0.51	0.11	When I pass by a bakery, I just love the smell of fresh baked breads and pastries
0.50	−0.04	Beautiful scenery can touch something deep and strong inside me
0.47	−0.22	I have been fascinated with the dancing of flames in a fire place
−0.45	0.12	I don't find anything exhilarating about a thunderstorm
0.44	0.05	Having my back massaged feels wonderful to me
0.18	0.52	I am always adjusting the thermostat, or wishing I could
0.15	0.49	It is very annoying to me when a radio isn't tuned quite right
0.15	0.49	I find body odor extremely offensive
0.15	0.48	I find it very disappointing when something doesn't taste as good as I thought it would
−0.05	−0.47	Bad odors have seldom bothered me
0.12	0.46	Even the smallest piece of gravel in my shoe just drives me crazy until I can get it out
−0.09	0.44	I have terrible feelings when I am not sure that I will succeed
0.31	0.42	It is important to me to get the water temperature just right when I take a bath or shower

in affective content. High levels of neuroticism were associated with judging affectively negative word pairs as more similar than affectively positive pairs, but only for high levels of extraversion. More extraverted participants judged positive word pairs as more similar than negative pairs, but only if they were low on neuroticism. State Negative Affect was associated with faster response times in categorizing negative words than positive words, even when trait extraversion and neuroticism were controlled statistically.

But stimuli need not be valenced or threatening to be affected by affective state. When judging the similarity of objects, one can use global or local characteristics to make the judgments. Induced positive affect increases the use of global cues while induced negative affect increases the use of local cues (Gasper & Clore, 2002).

Individual Differences in Cognitive Representation and Behavioral Variability

A fundamental finding from cognitive psychology is that behavior is a function not of the objective environment, but of the environment as perceived and cognitively structured. How individuals organize their views about their world (their life space) determines their behaviors in the actual world (Lewin, Adams, & Zener, 1935). As an elegant example of this concept, Wish, Deutsch and Biener (1970) found that individuals categorized nations along several independent dimensions: e.g., developed–less developed, communist–noncommunist, northern–southern. Using a program for scaling individual differences in multidimensional scaling, INDSCAL (Carroll & Arabie, 1980; Carroll & Chang, 1970), Wish et al. (1970) found that individual differences in how much these dimensions were weighted predicted attitudes toward the Viet Nam War. Those who weighted the developed–undeveloped dimension more were much more in favor of withdrawing from Viet Nam, while those who weighted the communist–non communist dimension more were in favor of continued hostilities.

At a more individual level, an INDSCAL analysis of stressful situations showed that college students reported greater consistency of behaviors between situations that they thought of as similar (based upon their personally weighted multidimensional space) rather than situations judged as

similar by the entire group (Klirs & Revelle, 1986). Individual differences in breadth of cognitive processing are related to obsessive compulsive behaviors (Yovel et al., 2005). Highly obsessive individuals (as judged by self report) are much more hindered by details when asked to do a speeded classification task of large letters made up of conflicting smaller letters using the "forest-trees" task of Navon (1977).

These studies of the "edges" of the ABCDs are merely examples of the ways in which individual differences in affect, cognition, and desires affect behavior. They are all examples of what can be done in lab-based studies and are thus limited in sample size as well as generalizability. In the rest of this chapter, we consider a new technology for studying individual differences in the ABCDs that does not have this limitation.

Synthetic Aperture Personality Assessment: Using the Web for Data Collection

Studies of individual differences in cognitive and non-cognitive aspects of personality are frequently limited by the sample sizes available in the typical university research setting. Small but stable relationships are difficult to detect when one is limited to 50–100 subjects, and detecting complex relationships between multiple measures is difficult when participants are limited to short 1 or 2-h studies. Alternative procedures might involve large research groups collecting data across many research sites (e.g., the Programme for International Student Assessment – PISA), but these can be costly and time consuming to conduct. A relatively new procedure is to use web-based data collection techniques to increase the sample size both numerically as well as in breadth with little loss of validity (Fraley, 2004; Gosling, Vazire, Srivastava, & John, 2004; Skitka & Sargis, 2006). Although some very large samples are available this way (e.g., the >300,000 reported by Gosling et al.), the studies are typically limited to short questionnaires or basic cognitive tasks (Greenwald, Nosek, & Banaji, 2003).

A variation of standard web-based assessment methods is to borrow by analogy a technique used in radio and optical astronomy: Synthetic Aperture Measurement. The resolution of a telescope is limited by its diameter which may be functionally increased a great deal by combining input from multiple, linked sites into one coherent image. Effectively, a very large telescope is created by synthesizing the input of many smaller ones. A classic example in radio astronomy is the Very Large Array in Socorro, New Mexico where 27 relatively small (≈25 m) radio telescopes are spread out in a Y-shaped configuration to simulate the resolution of a 36 km telescope. The configuration is adjustable so that the telescope can either emphasize resolution (by maximizing the distance covered) or sensitivity (by concentrating the telescopes close to each other). Similar techniques are used in optical inferometry at the Keck Observatory in Hawaii with "outriggers" to supplement the main telescope.

These techniques are available for psychologists taking advantage of the internet and web browsers. Rather than combining signals from the same source using different telescopes as is done in astronomy, the structure of personality can be studied by combining the responses of many people across more items than any one person is willing to take.[1] This, not actually a new procedure for the Educational Testing Service, has long used the very large samples available when students take the SAT or GRE

[1]The analogy is not perfect, for in astronomy the synthetic aperture technique provides a clearer image of one object, but when done by synthesizing covariance matrices, the higher resolution is applied to the structure of the measures, rather than to any individual.

to develop new items by randomly giving small subsets of items to much smaller (but still quite large, e.g., $N \approx 1{,}000$) subsamples of students. Now, by using open source and public domain software, this procedure is available to all of us.

The basic procedure is very simple. From a large set of personality and ability items ($P > 400$), a smaller subset of items ($n \approx 60$–75) are presented to any one subject. With random sampling of the items, all possible pairs of $P^*(P-1)/2$ are eventually presented. As the number of subjects grows (currently $N > 84{,}000$), each item has been given to $N^*(n/P)^2$ subjects, and each pair of items has been given to subjects.

The SAPA Methodology

Item Pool

During the past century, the measurement of personality and ability has tended to be fragmented by separate groups of individuals using proprietary sets of measures. Indeed, the proprietary nature is partly seen in the choice of names for these inventories and tests: the Minnesota Multiphasic Personality Inventory, the California Personality Inventory, the Eysenck Personality Inventory/Questionnaire/Profiler, the Freiburg Personality Inventory, Guilford-Zimmerman Temperament Survey, the Hogan Personality Inventory, the Jackson Personality Research Form, the Meyers-Briggs Type Inventory, the Stanford-Binet, the Wechsler Adult Intelligence Scale, the Wechsler Intelligence Scale for Children, etc. Each of these tests was carefully developed by researcher groups, and each is protected by copyright. Although some groups allow non-profit use of the measures for minimal cost, this is the exception. Many of these inventories have similar sounding scales, but given the expense, there are a limited number of studies directly comparing the inventories (Grucza & Goldberg, 2007).

A welcome alternative to the proprietary nature of personality measurement is the International Personality Item Pool (IPIP) developed by Lewis Goldberg (1999). Including more than 2,400 items in the form of sentence stems, the IPIP collaboratory has at least 269 scales targeted at everything from achievement striving to vitality/zest and includes particular scales designed to provide public domain scales meant to be parallel to those found in at least 17 commonly used personality inventories. All of the IPIP items and the common personality inventories have been given to the same community sample in Eugene/Springfield, Oregon, and item statistics are freely available from Goldberg and his associates. Some have questioned the open and free use of the IPIP items with respect to the possibility of the public learning to fake personality tests used in employment settings. Others have worried about whether the freedom to select items will lead to fragmentation of constructs rather than the hoped-for integration (Goldberg et al., 2006).

Even more proprietary than non-cognitive personality scales and items are measures of intellectual ability. Items and scales are either under copyright or completely idiosyncratic to particular labs and usually not openly published. Finding open source measures of ability is very difficult. Thus, to create a set of open source, public domain ability items, it is necessary to develop and validate our own. The hope is that this endeavor will inspire others to add items to the basic pool. As of now, 56 ability items have been constructed by writing items to measure vocabulary, verbal and mathematical reasoning, and abstract reasoning using geometric analogies. The analogies were constructed following the principles discussed by Mulholland, Pellegrino, and Glaser (1980) and involved the varying levels of memory load by varying the number of transformations between elements of the analogy (Leon & Revelle, 1985). The geometric analogy items appear somewhat similar to items from a Raven's progressive matrix (Raven, 1989). Plans are to develop more items and add them to the total pool. Here, we report an initial validation of these items against themselves as well as against self-reported measures of scholastic ability.

Subjects

The Personality Project (http://personality-project.org) is part of an effort to increase the scientific literacy and understanding of personality theory of the general population. *The Personality Project*, and its affiliated site, *Great Ideas in Personality* which was developed lovingly by G. Scott Acton until he died, provide information about personality theory and research for the interested web surfer. The roughly 1–3,000 daily visitors to these two sites see a small notice about a web-based personality test that offers personal feedback. On the *Personality Project* this is just a single line on the first page, on the *Great Ideas* site, this is one of many tests listed in a section on personality tests.

From these 1–3,000 visitors, as well as those who come from the results of online search engines, about 100 per day visit the site http://test.personality-project.org. That is, about 36,000 people per year flow through the SAPA procedure. As discussed in reviews of web-based research (Fraley, 2004; Gosling et al., 2004; Skitka & Sargis, 2006), the participants are demographically diverse but not a representative sample of anybody other than those who want to take web-based surveys. They are 70% female, with a median age of 23 (Table 2.3). However, they are probably more diverse than participants available through any means other than an international random survey. Roughly 1/3 of the participants have completed less than 14 years of schooling, 1/3 are attending college, and 1/3 have finished college. 1/6 have completed a graduate or professional degree (Table 2.3). Although roughly 4/5 of the participants are from North America, 16 countries (representing almost 92% of the total) have more than 250 participants each (Table 2.4).

Software and Hardware

The testing site, as well as the *Personality Project* and *Great Ideas* sites, is maintained on two Apple Macintosh G4 desktop computers[2] running an open source web server application, Apache. The code for the test is written in two open source languages, PHP and HTML and makes use of a powerful

Table 2.3 Age and education statistics of the first 80,471 subjects

	All participants	Males	Females
Age			
Minimum	10	10	10
First quartile	19	19	19
Median	23	23	24
Third quartile	34	34	34
Maximum	99	99	99
Mean	27.56	27.37	27.65
10% trimmed mean	25.91	25.61	26.06
Education			
Less than 12 years	13	15	12
High school graduate	8	9	7
Some college, did not graduate	10	10	10
Currently attending college	34	32	36
College graduate	17	16	18
Graduate or professional degree	17	18	17
N	80,471	25,476	55,045

[2]These machines are not particularly powerful and as of this writing are three generations older than what is currently available. That is, the SAPA procedure is not computationally intensive.

Table 2.4 Although 80% of the participants are from North America, substantial numbers of participants report coming from other countries. Of the 207 countries represented, 92% of the participants come from those 16 countries with 250 or more respondents. There are 38 countries with more than 100 respondents

Country	Count	Cumulative	Percent	Cumulative %
USA	59,792	59,792	74.30	74.30
Canada	4,180	63,972	5.19	79.50
UK	2,731	66,703	3.39	82.89
Australia	2,305	69,008	2.86	85.76
India	1,169	70,177	1.45	87.21
Philippines	505	70,682	0.63	87.84
Malaysia	412	71,094	0.51	88.35
China	411	71,505	0.51	88.86
Mexico	394	71,899	0.49	89.35
Sweden	389	72,288	0.48	89.83
Germany	370	72,658	0.46	90.29
Singapore	369	73,027	0.46	90.75
Poland	289	73,316	0.36	91.11

(and also open source and free) database program, mySQL. All analyses reported are done using the open source and publicly available statistics and data analysis language R (R Development Core Team, 2007). All of the code for this project is available from the senior author.

Procedure

When a participant arrives at the first page of the SAPA personality inventory, they are given a brief welcome screen, and then asked to agree to a consent form. The next page asks some basic demographic information (age, sex, education, and country of residence). If they are from the United States, they are then asked about their ethnic identity and if they have taken either or both of the SAT and the ACT. If so, they are asked to report their SAT Verbal and Quantitative scores, and their ACT total score.[3]

Following the demographic pages, participants are given 60 personality items with a six point response format ranging from "very inaccurate" to "very accurate." For Study 3 (see below), this was then followed by 12 music preference items. For studies 3–6 and ongoing, they are then given 14 ability items.

When participants finish all of the above items, they are then given feedback on their personality scores. This feedback is adapted from that given by John Johnson on an alternative (and longer) web-based Big 5 inventory (Johnson, 2005). Scores are reported as means (on the 1–6 scale for the items) as well as percentile equivalents (estimated from earlier data). The results are presented numerically, graphically, and in paragraph form. The paragraphs distinguish between high, medium, and low scores. Participants are given a personalized URL with their scores that they are encouraged to put into their own personal web page or blog (which then entices more participants to the site).

The personality items used in the SAPA project so far mainly represent a subset of the 2,400 International Personality Item Pool (IPIP) items made available by Goldberg (1999), with a particular emphasis on those used to assess "Big 5" dimensions as well as detailed studies focusing on particular content domains. Although the ideal case would sample items at random from the entire set, it was necessary to be somewhat systematic in order to recruit participants. Each set of items includes 50

[3]For the first year, the questions about SAT and ACT were not given. For the first part of the second year, just total SAT was requested, but since January, 2006, all participants were asked for their SAT V and SAT Q scores.

items (sampled from 100) that were developed as markers of five personality dimensions, "the Big 5" (Goldberg, 1990; Goldberg et al., 2006), and an additional 10–20 exploratory items sampled from 300 to 400 items of current interest. Scores on the "Big 5" items are reported using paragraph descriptors developed by John Johnson at Pennsylvania State University for another web-based survey and using norms developed locally.

Analytical Techniques for SAPA Data

As is obvious from the description of the data collection, there are no participants with complete data. Thus, descriptive statistics, correlation matrices, factor analyses, cluster analyses, and regressions are based upon pairwise rather than casewise deletion of subjects with missing data. Given the sampling design, some pairs of items have far more observations than do other pairs. All structural analyses (factor analysis and regression analysis) were done on the pairwise deleted correlation matrix. Intercorrelations between scales were calculated by synthetically forming the within and between scale correlation matrices from the composites of the raw item correlation matrices. Functions were developed for the R computing environment (R Development Core Team, 2007) to do these operations on the synthetically combined data matrices. Many of these functions are available to the R user in the psych package (Revelle, 2008), available from the Comprehensive R Archive Network (CRAN) http://cran.r-project.org website. This website serves as a repository for more than 1,300 packages that have been contributed to R.

The multidimensional structure of the personality and ability items was investigated using both factor analysis and cluster analysis technique of the composite matrices. Principal Axis factor analysis was done using the factor.pa function and cluster analysis was done using the ICLUST function. The ICLUST algorithm (Revelle, 1979) has been adapted to R and is included as part of the psych package. Originally, it was developed with the specific goal of dimensional reduction of "messy" matrices such as those found with personality or ability items. The algorithm is similar to most hierarchical clustering algorithms in that it:

1. Forms a matrix of proximities (correlations).
2. Finds the most similar pair.
3. Combines this pair if the pair would be better (in terms of alpha and beta) than each part.
4. Repeats steps 2 and 3 until no pairs meet the criterion.

ICLUST differs from many clustering algorithm in that it stops clustering when the internal consistency estimates (either the α or β coefficients) fail to increase. α is an estimate of internal consistency based upon the average inter-item correlation as well as the number of items (Cronbach, 1951), β is an estimate of the worst split half reliability of a test and is an estimate of the general factor saturation of the test (Revelle, 1979). Zinbarg, Revelle, Yovel, and Li (2005) compare these two estimates with yet another estimate of the general factor saturation, ω_h (McDonald, 1999), and conclude that ω_h is superior in most cases, although β is useful as a criterion in clustering applications. Revelle & Zinbarg (2009) consider these and eight other estimates of reliability as well.

Data Cleaning

A typical problem in web-based surveys is to distinguish legitimate unique responders from people who are trying the test multiple times. Because of concerns about confidentiality, some identifying information (e.g., MAC numbers of the computer or TCP/IP numbers for the network connection) are not collected. Participants are asked if they have taken the test before, and if so, are excluded from the subsequent analysis. To detect multiple responses from the same user over a brief period

of time, a random identification number is generated and stored for the duration of the connection. Only the first record of information with this unique number is processed. In addition, screening is done for similar patterns of responses across all the items (Johnson, 2005). Given the random nature of the items presented, it is unlikely that two people will get the exact same patterns of items and, if they do, even less likely that they will agree in almost all their responses. However, participants who respond to the questions, get their feedback, and then see what will happen if they change a few items that are detected this way and are excluded. Finally, participants with reported ages less than 10 or more than 100 are considered to have been deceptive and are rejected.

Personality and Ability as Assessed by the SAPA Methodology

The use of the SAPA procedure is an ongoing project of the Personality, Motivation, and Cognition Laboratory at Northwestern University. Here, we briefly outline results from seven different studies that have been conducted so far. The first four studies are relatively smaller demonstrations of the power of the SAPA technique to quickly focus on a particular target construct and will be summarized briefly. We spend considerably more time discussing the power of SAPA as shown in the last three studies.

SAPA Can Provide High Resolution of Particular Traits

Study 1: Proof of Concept: Right Wing Authoritarianism[4]

The study of the Authoritarian personality (Adorno, 1950) was particularly active immediately following World War II but fell out of favor in the 1960s and 1970s. More recently, the concept has become a topic of study in terms of Right Wing Authoritarianism–RWA, (Altemeyer, 1988) which is seen as a tendency to be hierarchical, conventional, and intolerant (Butler, 2000). Prior work has shown systematic (negative) correlations with openness and positive correlations with social dominance. As a demonstration and proof of concept of the SAPA technique, we examined whether the findings from these prior studies could be replicated in a web-based study. The answer was a clear "yes." For the first ≈2,500 participants sampled, the items of the Big 5 allowed for a recovery of five dimensions, and the pattern of correlations with RWA matched that of prior studies. RWA correlated .23 with Conscientiousness and −.33 with Openness (Revelle & Laun, 2004).

Study 2: Personality, Music Preference and Cognition[5]

The second study used the SAPA method to examine the relationship of personality dimensions with music preferences, and introduced the study of cognitive ability into the SAPA procedure. Prior work (Rentfrow & Gosling, 2003) had shown systematic differences in preferences for various musical genres. In terms of interpersonal behavior, musical preferences are one of first things people discover about each other in social interactions (Rentfrow & Gosling, 2006). Measuring musical preferences seemed to be a very logical extension of the SAPA procedure.

[4]Conducted as part of an honors thesis by Gregory Laun.

[5]Participants numbering 2,557 were collected as part of an honors thesis by Melissa Liebert, subsequent data have been collected as a continuing part of the SAPA project.

Sixty musical preference items were presented, representing the 14 genres included in the Short Test of Music Preferences (STOMP) developed by Rentfrow & Gosling (2003) and incorporating additional items adapted from Litle & Zuckerman (1986). 52,065 subjects responded to 12 item samples of the 60 music items. Because there were large gender differences in endorsement frequencies for some genres (e.g., women particularly liked Broadway musicals and TV soundtracks; men particularly liked heavy metal) factor and cluster analysis were done for males and females separately. As is true for all correlation or covariance matrices, determining the optimal dimensionality is more art than science. Cluster analysis solutions using ICLUST showed a single cluster for men and four clusters for women. Using the Very Simple Structure criterion (which compares goodness of fit of solutions of progressively more complex structure (Revelle & Rocklin, 1979)), it was clear that music preferences were not simple structured and that the best solution was one of complexity two for six factors. (Complexity reflects the number of non-zero loadings per item. Thus, a complexity one solution attempts to recreate the correlation matrix from a simple structure factor matrix where all except the largest loadings are set to 0. A complexity two solution sets all but the largest two to zero.) Considering complexity one solutions, only three broad factors showed substantial factor congruence across gender. These factors then broke down into more complicated solutions within gender. The three broad factors could be interpreted as representing (1) classical, folk, and jazz, (2) rock, and (3) popular/easy listening.

These three music factors were then correlated with the personality and demographic data. The classical, folk, and jazz items were most related to openness (.34), age (.30), agreeableness (.25), and education (.25). Preference for the rock items were negatively correlated with age (−.25) and positively with openness (.15). Preferences for popular and easy listening music was correlated with agreeableness (.33), gender (females preferred it more, $r = .26$), conscientiousness, (.19) and extraversion (.17). At the item level, of the 323 IPIP, ability, and music items, the single item most correlated with gender was a preference for Broadway musicals ($r = .28$).

Study 3: Measurement of Trust and Trustworthiness[6]

Trust and trustworthiness are essential elements of social interaction. It is difficult to conceive of daily life without exhibiting trust in others. The detection of cheating is important for humans as well as fish (Bshary & Grutter, 2002, 2006). To what extent are these two essential concepts represented in standard measures of personality? In a two-part study, Evans & Revelle (2007) examined the factorial structure and correlations with Big 5 measures using SAPA technology, and then validated their scales using an experimental procedure known as the Investment Game (Berg, Dickhaut, & McCabe, 1995; Bohnet & Croson, 2004). With $N = 8{,}183$, Trust and Trustworthiness correlated highly with each other (.50) but did show differential patterns of correlations with Big 5 scales: Trust correlated positively with Agreeableness (.65), and Extraversion (.58), and negatively with Neuroticism (−.61). Trustworthiness correlated positively with Conscientiousness (.60) and Agreeableness (.62). Multiple regression showed that trust was best predicted by agreeableness and negative neuroticism while trustworthiness was predicted by agreeableness and conscientiousness.

Study 4: Measurement of Machiavellianism[7]

In a follow up study, examining the basis of trusting behavior in the Investment Game setting, the trust items from Study 3 were supplemented with items taken from Machiavellianism (Mach) scales, which are intended to measure a person's willingness to manipulate others (Paulhus & Williams, 2002).

[6]Conducted as part of an honors thesis by Anthony Evans.

[7]Conducted as part of an honors thesis by Samantha Holland.

With $N > 16{,}000$ participants, Mach items were shown to have a two dimensional structure. Factor 1 was related to the traditional definition of Mach, the tendency to manipulate and deceive others for personal gain. Factor 2 was related to the belief that the true nature of other people is basically self-serving and unethical. These factors were labeled "Inner Mach" and "Outer Mach," respectively, in order to capture the contrast between the first factor's emphasis on the self and the second factor's emphasis on others.

SAPA Can Resolve Broader Traits

The following three studies will be presented in more detail in order to illustrate how the SAPA technique can be applied in a variety of ways. The first study shows how the synthetic "telescope" can be focused to address questions pertaining purely to personality theory, while the second generalizes the technique to answer questions about cognitive ability. The last study reviews the findings concerning the overall structure of Big 5 scales as they relate to each other, to ability, and to various demographic characteristics.

Study 5: Measurement of Extraversion Facets

The higher-order trait dimension of extraversion has been identified as one of the fundamental dimensions of personality through biological and taxometric approaches (Costa & McCrae, 1992; Digman, 1990; Eysenck & Himmelweit, 1947; Eysenck, 1970, 1973; Goldberg, 1990; Norman, 1963). However, disagreements about how to best characterize the core of extraversion and its facets remain prominent in the personality psychology literature (Ashton, Lee, & Paunonen, 2002; Costa & McCrae, 1998; DeYoung, Quilty, & Peterson, 2007; Hofstee, Raad, & Goldberg, 1992; Lucas, Diener, Grob, Suh, & Shao, 2000; Watson & Clark, 1997; Wilt & Revelle, in press). One possible reason that consensus definitions for the core and facets of extraversion have not been achieved is that most items used to measure extraversion comprise a mixture of affective and behavioral components (Pytlik Zillig, Hemenover, & Dienstbier, 2002) that fail to delineate extraversion into conceptually distinct facets reflecting purely positive affect, behavioral activity, and the desire for social attention. Study 5 is an illustration of how to use SAPA methodology to construct and evaluate personality facet scales measuring positive affect, behavioral activity, and desire for social attention. We selected items that seemed to be pure measures of each distinct facet by searching through the items used to measure extraversion in the IPIP (Goldberg, 1999), which contains items targeted to measure the most commonly used extraversion scales such as the NEO instruments (Costa & McCrae, 1992), the Abridged Big-Five Circumplex (AB5C) (Hofstee et al., 1992), and the newly developed Big-Five Aspect Scale (DeYoung et al., 2007). Items used to measure each facet are shown in Table 2.5. As of this writing, over 16,000 subjects have taken these facet scales. From the synthetic correlation matrix, we evaluated the properties of the new facet scales. The facets were highly correlated with each other and each facet had high internal consistency (Table 2.5). The general factor saturation of the items was estimated by an ω_h of 0.55, indicating that a common latent variable (hypothesized as extraversion in this case) accounted for a 55% of the variance of the items (Revelle & Zinbarg, 2009; Zinbarg et al., 2005). ω_h is found by extracting a general, second order factor from the obliquely rotated first order factors, and then through a Schmid–Leiman transformation, finding the amount of item variance accounted for by that general factor. The lower order factors that emerged closely resemble the hypothesized structure of the facet scales, as items in each scale generally had their highest loading on the appropriate factor (see Table 2.5).

Table 2.5 Items measuring positive affect, behavioral activity, and desire for social attention facets and their factor loadings on three oblique factors

Facets and Items	Factor 1	Factor 2	Factor 3
Positive affect			
Laugh a lot	.80	−.11	.01
Have a lot of fun	.78	−.02	.06
Express childlike joy	.66	−.16	.17
Radiate joy	.62	.10	.21
Laugh my way through life	.60	−.06	.16
Feel that I have a lot of inner strength	.54	.26	−.21
Feel healthy and vibrant most of the time	.47	.25	.09
Have great stamina	.16	.47	−.10
Behavioral activity			
Try to lead others	−.10	.86	.13
See myself as a good leader	−.05	.84	−.05
Have leadership abilities	−.07	.78	.08
Automatically take charge	.08	.69	−.04
Can easily push myself forward	.27	.55	−.24
Have a strong personality	.03	.48	.26
Maintain high energy throughout the day	.35	.41	−.10
Am usually active and full of energy	.55	.40	−.01
Wait for my turn (R)	.34	.01	−.55
Desire for social attention			
Like to attract attention	.05	.08	.78
Demand to be the center of interest	−.02	−.08	.71
Enjoy being part of a loud crowd	.21	−.06	.71
Can't do without the company of others	.08	−.07	.55
Love large parties	.17	.23	.54
Usually like to spend my free time with people	.14	.12	.49
Boast about my virtues	−.25	.11	.43
Rarely enjoy being with people (R)	.22	.28	.39
Don't like crowded events (R)	.27	.16	.36
Am afraid to draw attention to myself (R)	.11	.29	.32
Would not enjoy a job that involves social interaction (R)	.24	.26	.26
Like to amuse others	.34	.07	.15
Act comfortably with others	.31	.32	.08

To examine the convergent and discriminant validity of the facets, we found the correlations between each facet and each Big 5 domain scale. Table 2.6 shows that the social attention facet had very high convergent and discriminant validity, as indicated by high correlations with the extraversion scale but not the other Big 5 scales. The positive affect and behavioral activity facets also had high convergent and discriminant validity, as both of these facets correlated more strongly with the extraversion domain scale than any other Big 5 domain. These results could be interpreted as meaning that the social attention facet was a better marker of extraversion than the positive affect and behavioral activity facets. However, the pattern of correlations between the extraversion facets and the Big 5 domains may be unique to the item pool used to measure extraversion facets in this study. If items were drawn from extraversion scales emphasizing affective content, such as the Multidimensional Personality Questionnaire (Tellegen, 1982) or behavioral content, such as the Eysenck Personality Inventory (Eysenck & Eysenck, 1968), it is possible that the positive affect or

Table 2.6 Extraversion facet scales and Big 5 domain scales. Number of items in each scale, scale reliabilities, and correlations between extraversion facet scales and Big 5 domain scales are shown

Scale	*N*	Cronbach's α	Positive affect	Behavioral activity	Desire for social attention
Positive affect	8	.84	–	–	–
Behavioral activity	9	.83	.56	–	–
Desire for social attention	13	.85	.56	.55	–
Extraversion	20	.93	.62	.72	.83
Agreeableness	20	.90	.48	.30	.35
Conscientiousness	20	.92	.22	.32	−.03
Emotional stability	20	.93	.37	.28	.08
Openness	20	.83	.30	.42	.15

behavioral activity facets would have emerged as the better markers of extraversion than the social attention facet. Summing across analyses, the new facet scales seem to be a generally good but not optimal way to measure extraversion and its distinct components. Future efforts to improve the scales should focus on raising the discriminant validity of the positive affect and behavioral activity facets and determining whether additional facets (such as a cognitive facet) should be added to the scales. The SAPA technique provides another advantage pertinent to improving scales, as it is "easy" to add and subtract items from the active item pool using PHP, allowing for increased flexibility and adaptation in scale construction.

Study 6: Public Domain Assessment of Ability

Although originally developed as an open source procedure for studying non-cognitive aspects of personality, the SAPA procedure has been applied to studying individual differences in cognitive ability. Starting in 2005, each participant was given 14 items thought to measure cognitive ability. These items were sampled in two sets of seven from a total pool of 56 items developed by Liebert (2006). The items were written to test alphanumeric pattern recognition, general knowledge, vocabulary, logical reasoning, and spatial reasoning. Example items from this set are in Table 2.5 and Fig. 2.1. In addition to these 14 items, any participant from the United States was asked if he/she had taken either the SAT or ACT exam, and if so, to report her/his scores. The hope was to be able to validate the new items against each other as well as against the (self-reported) standardized tests. Prior work has shown that self-reported SAT scores are highly correlated with actual scores, although self-reports are somewhat inflated (Kuncel, Crede, & Thomas, 2005; Mayer et al., 2007). Basic descriptive statistics for these standardized tests (Table 2.7) are remarkably similar to actual scores for college undergraduates (Mayer et al.).

For the SAPA procedure to be useful in assessing ability online, the items need to show basic psychometric properties. They need to span the difficulty range, need to correlate with each other and to correlate with known markers of ability. The results so far suggest that we were successful in all of these objectives. Item difficulties (percent correct) ranged from .15 to .96 with a mean of .58, a median of .62, and the first and third quartiles of .40 and .77. The average intercorrelation of all 56 items was .08. The average correlations with SAT, SATV, SATQ, and ACT were .12, .10, .12, and .12. All of these values are for unselected items. The results are much more promising when basic item analysis is done. Because exploratory work suggested that 1 parameter (Rasch) or 2 parameter Item Response Theory estimates (Embretson & Reise, 2000) were not particularly better than simple sum scores, we report the sum scores analysis.

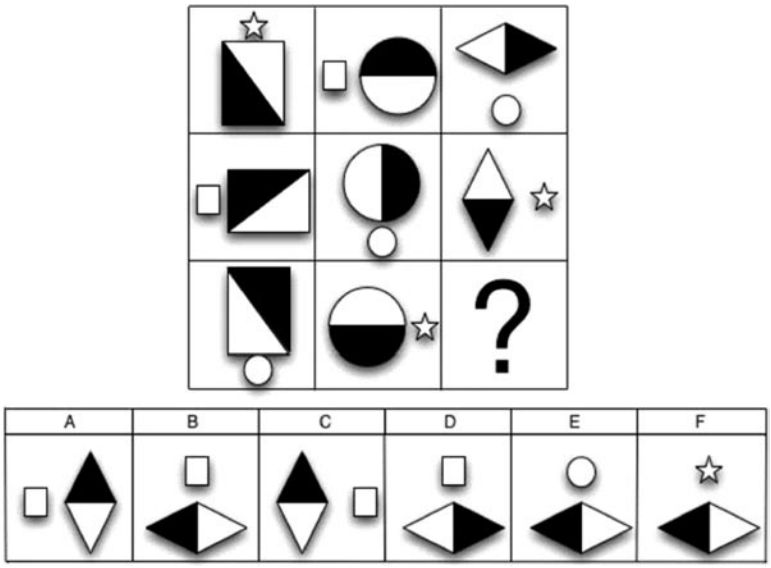

Fig. 2.1 An example of a geometric reasoning problem. Each problem differs in the number of elements and number of transformations per element. The participant is to choose the response that replaces the ?

Table 2.7 Descriptive statistics for the self-reported SAT, SATV, SATQ, and ACT

	N	Mean	Sd	Median
All participants				
SAT	3,378	1,194	215	1,200
SATV	10,987	613	110	620
SATQ	10,852	606	112	610
ACT	16,020	25.6	5.0	26
Males				
SAT	1,357	1,214	223	1,210
SATV	4,285	613	111	620
SATQ	4,248	622	114	640
ACT	4,845	25.9	5.4	26
Females				
SAT	2,021	1,180	208	1,190
SATV	6,702	614	110	620
SATQ	6,604	595	109	600
ACT	11,175	25.5	4.9	26

There are a number of ways to analyze these scales. Each participant took two 7-item scales. All possible pairs of scales (i.e., 14 items each) were then given across participants. Although each person took 14 ability items, the intercorrelations of these scales cannot be found directly from the data or can be calculated synthetically. The analysis can be done at the scale level (7 or 14 items per scale) or the overall covariance structure level (56 items). For both analyses, it is possible to validate the scales or overall factor structure by using the SAT/ACT scores.

Given the exploratory status of the 56 items (see Table 2.8 for example items), we examined the structure of the entire (synthetic) correlation matrix. From prior work on the structure of ability, we expected a hierarchical structure with several correlated primaries and a higher order *g* factor. This structure was confirmed by using the Very Simple Structure (Revelle & Rocklin, 1979)

Table 2.8 Example ability items with the number of items presented and an estimate of internal consistency (all items were multiple choice)

Type	*N*	α	Example item stem
General knowledge	7	.46	Tycho Brahe was a famous:
Classification	7	.28	Please mark the word that does not match the other words
Pattern	7	.58	In the following alphanumeric series, what letter comes next?
Math reasoning	7	.63	Adam and Melissa went fly-fishing and caught a total of 32 salmon Melissa caught three times as many salmon as Adam. How many salmon did Adam catch?
Vocabulary	6	.35	The opposite of an "ambiguous" situation is a/an (blank) situation
Verbal analogy	8	.28	CLOCK is to TIME as SCALE is to?
Geometric analogy	14	.64	See Fig. 2.1

Table 2.9 The correlations of self-reported ability measures and unit weighted factor estimates. After the first ≈5,000 participants, total SAT was replaced by the two subtests (SATV and SATQ), and thus there are no cross correlations between these measures. α reliabilities are reported on the diagonal for the factor estimates. Combined reflects unit weighted scores of the best 36 items, reasoning, spatial, and verbal are unit weighted scores of the salient items on the corresponding oblique factors. The correlations between the combined score and the three factors are inflated due to item overlap. Correlations above the diagonal are corrected for attenuation. There is no correction for the reliabilities of education, age, or the SAT and ACT scores. Gender was coded 1 for M, 2 for F

	M/F	Edu	Age	SAT	SATV	SATQ	ACT	Reas	Spat	Verb	Comb
Gender	1.00	0.03	0.01	−0.08	0.01	−0.12	−0.04	−0.15	−0.09	0.16	−0.09
Education	0.03	1.00	0.45	0.02	0.11	0.09	0.12	0.35	0.25	0.03	0.23
Age	0.01	0.45	1.00	−0.04	0.04	0.01	0.12	0.24	0.09	0.03	0.09
SAT	−0.08	0.02	−0.04	1.00	NA	NA	0.65	0.48	0.32	0.13	0.31
SATV	0.01	0.11	0.04	NA	1.00	0.62	0.54	0.50	0.25	0.12	0.25
SATQ	−0.12	0.09	0.01	NA	0.62	1.00	0.57	0.50	0.38	0.10	0.36
ACT	−0.04	0.12	0.12	0.65	0.54	0.57	1.00	0.55	0.35	0.13	0.34
Reasoning	−0.13	0.30	0.21	0.41	0.43	0.43	0.47	0.73	0.75	0.43	0.77
Spatial	−0.08	0.22	0.08	0.28	0.22	0.33	0.30	0.56	0.77	0.38	1.25
Verbal	0.10	0.02	0.02	0.08	0.08	0.06	0.08	0.24	0.22	0.42	0.92
Combined	−0.08	0.27	0.15	0.37	0.34	0.40	0.41	0.84	0.88	0.45	0.83

criterion which showed a clear one factor solution for complexity one, and a three factor solution for complexity two. The ω_h value when three lower order factors were extracted was .64. The alpha value for the entire 56 items was .88, and the ω_t was .89. See Revelle & Zinbarg (2009) for the meaning of these three and other estimates of reliability. The 14 salient items on the first factor were a mix of reasoning and vocabulary items, the 18 salients on the second factor were seven alphanumeric series questions and 11 spatial analogies, and the six salients on the third factor were verbal logic items. The salient items on the *g* factor as extracted using either omega (38 items) or ICLUST (37 items) were chiefly a mix of items from the first two factors.

Internal structure is not enough to show the utility of these factors. Unit weighted scales were used to predict real world criteria such as education and age as well as the self-reported test scores (Table 2.9). The independent contribution of the three oblique ability factors for predicting the criteria may be seen in a set of multiple regressions (Table 2.10). It is clear that for research purposes, we can use short online ability measures to predict level of education or standardized ability measures. It is interesting that the short reasoning factor (assessed with just 14 items and an α of

Table 2.10 Regressions predicting demographic and test performance from the SAPA ability factors. Values are standardized beta weights and multiple Rs

	Gender	Education	Age	SAT	SATV	SATQ	ACT
Reasoning	−0.15	0.28	0.25	0.39	0.47	0.38	0.45
Spatial	−0.03	0.08	−0.04	0.08	−0.04	0.13	0.07
Verbal	0.14	−0.05	−0.03	−0.05	−0.02	−0.06	−0.03
Multiple R	0.19	0.32	0.22	0.43	0.44	0.46	0.48

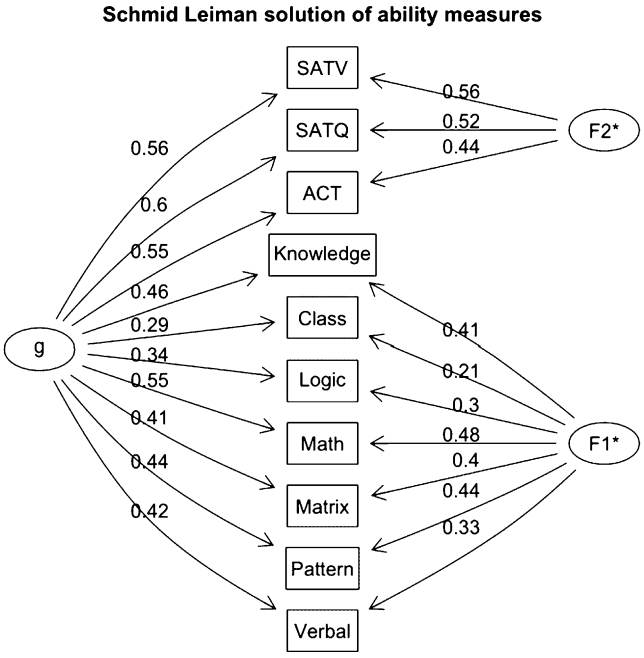

Fig. 2.2 Using a Schmid Leiman transformation, the structure of the self reported ability tests and the web based assessment can be revealed with a common general factor as well as two orthogonal residual factors

just .73), is such a good measure. The Spatial factor, although not the best predictor of any of the standardized tests, is clearly assessing a component of ability not tapped by the reasoning factor.

The hierarchical structure of the self-reported ability measures and the online ability measures can be seen graphically by plotting the results of a Schmid–Leiman transformation (Schmid & Leiman, 1957) to extract a general factor and two orthogonal residual factors (Fig. 2.2). The residual factors clearly represent method: one being self-reported ability, the second being our online (and shorter and thus less reliable) measures.

The relationships can be examined in more detail in two ways: (1) what is the effect of the demographic and ability measures on Big 5 scales (Table 2.13) and (2) what is the effect of the Big 5 on demographic and ability measures (Table 2.14). In two sets of hierarchical regressions, it is clear that the Big 5 scales are systematically related to Gender (Stability and Agreeableness), to age and education (Conscientiousness), and to intellectual ability, assessed either by our new procedures, or conventional standardized tests (Openness). But these relations go both ways, for gender, education, age, and the ability scales all could be meaningfully predicted by the Big 5 measures (Table 2.13).

Table 2.11 Hierarchical regression predicting SAPA ability factors from self-reported standardized tests. Values are standardized beta weights and multiple Rs

	Combined	Reasoning	Spatial	Verbal
Step 1				
SATV	0.12	0.27	0.00	0.07
SATQ	0.34	0.27	0.33	0.02
Multiple R	0.42	0.49	0.33	0.08
Step 2				
SATV	0.04	0.18	−0.06	0.05
SATQ	0.24	0.16	0.25	−0.01
ACT	0.25	0.29	0.20	0.07
Multiple R	0.46	0.54	0.36	0.10

Table 2.12 Correlations between the Big 5 measures, demographics, and ability measures. Reliabilities for the Big 5 are shown in the appropriate diagonal

	Extra	Stability	Cons	Agree	Open
Gender	0.07	−0.20	0.13	0.25	−0.10
Education	0.00	0.05	0.18	0.10	0.16
Age	−0.01	0.09	0.20	0.10	0.13
SAT	−0.11	0.02	−0.08	−0.14	0.25
SATV	−0.07	0.02	−0.08	−0.05	0.33
SATQ	−0.05	0.09	−0.02	−0.08	0.23
ACT	−0.05	0.04	−0.01	−0.06	0.30
Combined	−0.08	0.10	0.00	0.00	0.28
Reasoning	−0.08	0.09	−0.02	−0.03	0.30
Spatial	−0.07	0.09	0.01	0.00	0.20
Verbal	0.04	0.02	0.08	0.12	0.10
Extraversion	0.93	0.28	0.14	0.41	0.30
Stability	0.28	0.93	0.17	0.17	0.17
Conscientiousness	0.14	0.17	0.92	0.25	0.13
Agreeableness	0.41	0.17	0.25	0.90	0.21
Openness	0.30	0.17	0.13	0.21	0.83

Study 7: Integrating Cognitive and Non-cognitive Measures of Personality: The "Big 5" Meet IQ

To examine the relationship of "non-cognitive" and "cognitive" aspects of personality we correlated the Big 5 composite scores with the ability scores discussed in Study 6. We did this for the >66,000 participants with Big 5 and IQ items. Each of the Big 5 composite scales was estimated by using 20 composite items. The IQ factors were estimated by unit weighted composites of the salient items. In addition to these measures, we also examined the relationships with the demographic variables of age, gender, and education (Table 2.12). These zero order correlations show that gender (male = 1, female = 2) was positively correlated with Agreeableness (.25) and negatively correlated with Emotional Stability (−.20). Older and more educated participants were more Conscientious (.18 and .20) and more Open (.13 and .16). Of the Big 5, Openness was most related to the ability measures ($.23 < r < .33$). The correlation of ability with openness partly reflects the emphasis on "intellect" in the choice of the openness scales from the IPIP (Tables 2.13 and 2.14).

Table 2.13 Hierarchical regressions predicting Big 5 measures from demographic and ability measures. Values are standardized beta weights and multiple Rs

	Extra	Stability	Cons	Agree	Open
Step 1					
Gender	0.07	−0.20	0.12	0.25	−0.11
Education	0.00	0.02	0.11	0.05	0.13
Age	−0.01	0.08	0.15	0.07	0.07
Multiple R	0.07	0.22	0.26	0.27	0.20
Step 2					
Gender	0.05	−0.20	0.10	0.23	−0.08
Education	0.03	0.01	0.13	0.07	0.06
Age	−0.01	0.08	0.16	0.08	0.05
Reasoning	−0.07	0.01	−0.11	−0.07	0.23
Spatial	−0.05	0.06	0.02	0.01	0.04
Verbal	0.06	0.03	0.08	0.11	0.04
Multiple R	0.12	0.23	0.28	0.29	0.32
Step 3					
Gender	0.05	−0.19	0.11	0.23	−0.10
Education	0.03	0.01	0.13	0.07	0.07
Age	−0.01	0.08	0.16	0.08	0.05
Reasoning	−0.05	0.00	−0.09	−0.03	0.08
Spatial	−0.06	0.05	0.00	0.01	0.05
Verbal	0.06	0.03	0.09	0.10	0.05
SATV	−0.06	−0.04	−0.13	−0.02	0.24
SATQ	0.03	0.08	0.09	−0.02	−0.07
ACT	0.00	−0.02	0.02	−0.05	0.13
Multiple R	0.13	0.24	0.30	0.30	0.41

Table 2.14 Hierarchical regression predicting demographic and ability measures from the Big 5 measures. Values are standardized beta weights and multiple Rs. Note that the Giant 2 of Extraversion and Emotional Stability have the weakest effects in predicting demographic or ability measures

	Gender	Edu	Age	SAT	SATV	SATQ	ACT
Step 1							
Extraversion	0.14	−0.02	−0.04	−0.13	−0.08	−0.08	−0.07
Stability	−0.24	0.05	0.10	0.06	0.04	0.11	0.06
Multiple R	0.24	0.05	0.10	0.12	0.08	0.12	0.08
Step 2							
Extraversion	0.12	−0.03	−0.06	−0.12	−0.07	−0.08	−0.07
Stability	−0.26	0.03	0.07	0.07	0.05	0.12	0.06
Conscientiousness	0.16	0.18	0.20	−0.07	−0.08	−0.03	−0.03
Multiple R	0.28	0.18	0.22	0.14	0.11	0.12	0.08
Step 3							
Extraversion	0.06	−0.10	−0.11	−0.15	−0.16	−0.11	−0.13
Stability	−0.26	0.01	0.06	0.04	0.02	0.10	0.03
Conscientiousness	0.12	0.15	0.17	−0.07	−0.10	−0.03	−0.02
Agreeableness	0.27	0.07	0.07	−0.13	−0.05	−0.10	−0.08
Openness	−0.15	0.15	0.12	0.33	0.40	0.27	0.35
Multiple R	0.39	0.24	0.25	0.35	0.39	0.29	0.34

Summary and Conclusions

The proper study of personality integrates affect, behavior, cognition, and desires. But to study all of these aspects at the same time would seem to require large samples of participants taking many different instruments. We have an introduced an alternative procedure, Synthetic Aperture Personality Assessment, which allows us to combine data from many different individuals taking overlapping but non-identical surveys. These techniques have been used to explore structural questions about cognitive and non-cognitive aspects of personality as well as to explore the link between these two aspects of an individual. Although some of the results are merely demonstrations of the technique, others provide greater insight into the structure of cognitive ability and non-cognitive sensitivities. The goal of the SAPA project is to allow others to take advantage of these open source procedures and to proceed to build a greater understanding of personality structure and processes.

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