Applying Network Analysis to Ideal Point Personality Item Responses

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Abstract

Personality researchers have recently taken interest in two methodological innovations network analysis and ideal point item writing strategies. The former suggests that personality is best understood as a system of mutually reinforcing actions while the latter allows more precise measurement of personality components. Here, we explore the value of integrating these two innovations by exploring the network properties of a Big Five inventory constructed with ideal-point items.

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Introduction

Recent findings suggests self-report inventories conform to an ideal point process in which persons endorse items only to the extent the item content reflects the respondent's level of the attribute, or Θ. Modeling the correct response process in personality assessment produces several psychometric benefits, such as improved dimensionality, higher total test information, and revelation of curvilinear effects (Drasgow, Chernyshenko, & Stark, 2010). One reason for such gains is the ideal point perspective retains items assessing low, intermediate, and high trait values and, thus, creates an instrument providing greater measurement precisions across a broad range of a targeted attribute.

Due to its methodological nature, ideal-point research has focused largely on technical issues, such as appropriate item writing strategies, model fitting, or validity gains. Surprisingly little work has been done to explore the advantages of ideal-point inventories to understanding personality itself, such as explaining where traits come from, how they operate, and how they produce differences in behavior. These questions lie at the heart of the discipline (Fleeson & Jayawickreme, 2015) and carry theoretical implications for understanding why personality predicts work behavior and how personality changes over time (i.e., selection and development). Given that ideal-point inventories capture a wider array of elemental differences in emotions, thoughts, and behaviors constituting the Big Five, they may especially suited to identifying plausible mechanisms through which personality processes (deliberation, emotional regulation) accrue to form traits (individual differences).

Drawing upon a psychometric network approach to individual differences (Cramer et al., 2012), we recast the Big Five as a dynamic system of directly interacting feelings, thoughts, and behaviors. Rather than treat "hidden traits" as causal forces lying behind stable behavioral patterns, the network approach models traits as consequences of mutually reinforcing interactions between specific thoughts, feelings, and behaviors (see Figure 1 for illustration). From this perspective, discrete actions like working hard to attain long-term

goals, planning one's week, and focusing on a task to completion in a person high on Conscientiousness do not co-occur because of a top-down latent disposition, but because deciding to care about a long-term goal leads one to be more disciplined in allocation of personal resources. Forces bonding autonomous acts into trait clusters might be shared biological origins, learning principles, socially enforced norms, or functional aims that produce accretion of multiple explanatory mechanisms which unite for causal, homeostatic, or logical reasons (Cramer et al., 2012; Fleeson & Jayawickreme, 2015; Wood, Gardner, & Harms, 2015).

More importantly, the network perspective can provide a better view of the cognitive, motivational, and functional dynamics characterizing the development of the personality system, therefore favoring empirical investigations of such mechanisms. Incorporating ideal point items may offer further insight into trait development by pinpointing intermediate ranges of a trait continuum (i.e., nodes) which incrementally "bridge" personality components across distinct clusters (Borsboom & Cramer, 2013). For instance, the conscientiousness item "I tend to be disorderly but also like to keep certain things tidy" may bridge the agreeableness item of "I don't like to let others down" to the remaining network of conscientiousness items. Why? Because development in compassion arising from social roles (e.g., serious relationships, care for family) might elevate conscientiousness by causing individuals to start bringing personal affairs in order. That is, when we begin caring about others we may try to get our "act together" in order to meet social responsibilities. Such effects may be less evident in extreme items (I always keep my affairs in order) because developmental processes are gradual and better seen in intermediate steps. By finding and pulling these functional levers (i.e., intermediate items), we may be able to nudge people to change in productive ways on multiple dimensions (or traits) which has implications for executive coaching and trait interventions.

The current study unifies these methodological innovations by applying network analyses to a Big Five instrument developed with ideal-point item writing strategies. We

contrast four major network properties with research exploring similar properties of common Big Five inventories (Cramer et al., 2012; Constantini et al., 2015; Constantini & Perugini, 2016). The first is the topology, or *large-scale structure*, of the Big Five including global node arrangement and degree to which nodes cluster together while distances between any two nodes remain small (*small-worldness*; Constantini et al., 2015). Two, we identify the nature and content of cross-trait item pairings to identify possible *bridging* components explaining observed covariance between trait factors (e.g., why do agreeable people tend to be conscientious). Three, we compare the most "central" and "peripheral" nodes with the nature of the central facets identified in past publications. Nodes which are central play a more prominent role in connecting elements of the personality system and, consequentially, may be idea targets for intervention if desiring to shift one's personality. Finally, given the general importance of emotional stability and conscientiousness for job performance across occupations, we examine the *shortest* pathways that may explain the route through which changes in emotional stability (conscientiousness) may facilitate changes in conscientiousness (emotional stability). In all cases, we highlight areas where ideal-point items play a role in facilitating information flow in the Big Five network.

Methods and Results

Given space limits yet novelty of network terminology, the methods and results are presented concurrently.

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

Measure

Material

Procedure

Data analysis

We used R (3.3.1, R Core Team, 2016) and the R-packages *bitops* (1.0.6, Steve Dutky initial R port, Martin Maechler; revised, & Steve Dutky, 2013), *bootnet* (1.0.0, Epskamp, Borsboom, & Fried, 2017), *careless* (1.0, Yentes, 2016), *corrr* (0.2.1, Jackson, 2016), *dplyr* (0.5.0, Wickham & Francois, 2016), *Formula* (1.2.1, Zeileis & Croissant, 2010), *ggplot2* (2.2.1, Wickham, 2009), *Hmisc* (4.0.3, Harrell Jr, Charles Dupont, & others., 2017), *kableExtra* (0.4.0, Zhu, 2017), *knitr* (1.17, Xie, 2015), *lattice* (0.20.33, Sarkar, 2008), *lavaan* (0.5.23.1097, Rosseel, 2012), *mgm* (1.2.1, Haslbeck & Waldorp, 2016), *pander* (0.6.0, Darczi & Tsegelskyi, 2015), *papaja* (0.1.0.9492, Aust & Barth, 2017), *psych* (1.6.12, Revelle, 2016), *purrr* (0.2.2, Wickham, 2016), *qgraph* (1.4.2, Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012), *RCurl* (1.95.4.8, Lang & CRAN team, 2016), *readr* (1.0.0, Wickham, Hester, & Francois, 2016), *stringr* (1.2.0, Wickham, 2017a), *survival* (2.40.1, Terry M. Therneau & Patricia M. Grambsch, 2000), *tibble* (1.2, Wickham, Francois, & Mller, 2016), *tidyr* (0.6.1, Wickham, 2017b), and *tidyverse* (1.1.1, Wickham, 2017c) for all our analyses.

Estimating and Visualizing the Network. Personality networks present items as nodes connected by edges representing statistical relationships. We implemented a Gaussian Graphical Model (GGM) on a polychoric correlation matrix using a graphical least absolute shrinkage and selection (glasso) with the extended EBIC criterium in *qgraph* 1.4.3 (Epskamp, Borsboom, & Fried, 2017; Friedman et al., 2008). There are two things to note. First, the glasso avoids spurious associations by using *regularization* to assign penalties so all edges are shrunk with small edges being set to zero. This results in a *sparse* (i.e., conservative) network that safeguards against overfitting by modeling covariance among components with

as few connections as possible. Second, because the network uses partial correlations, all edges imply a relationship exists after controlling for all other nodes. Because the model is uniquely specified, it facilitates clear and unambiguous interpretation of edge-weight parameters as the strength of *unique* associations providing a putative causal skeleton. Given the larger number of items, the EBIC hyperparameter was set to a conservative .8 to err on the side of caution and we hide all partial correlations less than .05 for visual clarity.

The initial network presented in Figure 1 (item labels are provided in Table 1) has 1,339 nonzero edges out of 11,175 possible edges (12%) suggesting a relatively sparse network. Several insights can be inferred about the general architecture and generating processes of the Big Five. One, similar to Cramer et al (2012), there is clustering for four of the Big Five with Openness showing less cohesion. Two, it is possible to identify "pockets" of high interactivity (i.e., facets or unique item effects) by highlighting nodes with numerous, densely connected edges as well as their pathways to the larger network. For instance, there is a leadership pocket in the bottom of the extraversion network consisting of items about taking charge (Ex33), following others (Ex31), or enjoyment of project leadership (Ex34). Notice this cluster – while embedded in extraversion – is also distinct because it is only connected to the larger network by a few nodes, such as the belief one is able to persuade (Ex35) and make friends (Ex15) coupled with efforts to engage others (Ex5) and being averse to mediocre work (Co16). Its distinction and peripheral placement may suggest assertive aspects of Extraversion arise from social skills, effort to meet others, and a desire to improve the status quo (i.e., not be mediocre). This reasoning is aligned with a cognitive-affective processing and functional approach to personality in which abilities, values, and efficacy produce trait covariation (Wood et al., 2015). Three, items along the Big Five borders may illuminate unique developmental pathways or feedback loops through which change spreads between traits. Take the borders between conscientiousness and openness. The nodes in the lower left suggest the enjoyment of solving complex problems (O2, O3, O8) is positively linked to a high drive for achievement (Co17, Co18, Co19) whereas nodes in the center left

show tolerance for variety (O9, O10, O11) as *negatively* linked to preference for order (Co8, Co7, Co6, Co9). This suggests countervailing forces such that mutually reinforcing gains in two Openness components may be associated with diverging effects in a person's Conscientiousness network (e.g., more industrious but lower order). Interestingly, there are multiple boundary spanning items with ideal-point properties (e.g., O9, Es16, Es27, Ex17, Ex18, Co2, Co8, Co11, Co12, Ag7, Ag14, Ag21) suggesting they help elaborate unique ways trait networks collide.

The small world index was 2.35, which is higher than the values of 1.01 reported on the HEXACO facets (Constantini et al., 2015) but slightly lower than the 3 threshold recommended for describing the entire network as a small-world (Watts & Strogatz, 1998). As noted by Constantini and Perugi (2016), a small-world structure may be masked when items conform to a simple structure. This suggests the current inventory is more clearly organized into separate sub-systems (e.g., the Big Five with exception of Openness) which themselves influence one another by means of bridging connections. When a network shows small-worldness, changes in any random part of the network could quickly spread across the whole system (Watts & Strogatz, 1998).To illustrate the bridging components linking the larger Big Five network, the initial network was arranged by the Big Five clusters with only partial correlations $> .10$ displayed (see Figure 2). Eighteen cross-trait item pairings remained (presented in Table 2) which might explain the often-substantial inter-correlations observed between personality factors. Whereas the reason for some linkages is not apparent (Ag23/Co3), others are commonly alluded to in the literature such as the demand for both positive affect and difficult goals in being driven at work (e.g., Co15/Ex22).

Centrality Estimation. A typical way of assessing node importance is to compute centrality indices of the network structure (Costantini et al., 2015; Newman, 2010; Opsahl, Agneessens, & Skvoretz, 2010). Three such measures are (1) *node strength*, quantifying how well a node is directly connected to other nodes by summing all of its absolute edges, (2) *closeness*, quantifying how well a node is indirectly connected to other nodes by taking the

inverse of all shortest path lengths between the node and all other nodes, and (3) *betweeness*, quantifying how important a node is in the average path between two other nodes. While such indices often agree, it is possible for a node to be high on one index but low on another. For instance, the Amsterdam airport would score high on *strength* as many airports fly planes in and out of Amsterdam. Comparatively, the airport in Anchorage, Alaska, while low on strength in terms of absolute number of connections, is actually higher than Amsterdam on *betweenness* because it serves as a common hub indirectly connecting many international airports to each other via oversea flights.

The centrality plots appear in Figure 4. Several Agreeableness and Conscientiousness items stand out as highly influential, especially those dealing with manipulation and indifference to others (Ag25, Ag26, Ag31), deliberation in action and decision making (Co1, Co5, Co20) or completing the bare minimum to get by (Co31). The items Ex24 (Compared to extremely energetic people I am somewhat less energetic), Es18 (I always feel great about the person that I am), Es2 (I like to consider myself a very easygoing person), and O7 (I enjoy having abstract or philosophical conversations) had relatively high betweeness-centrality, meaning they occupied strategic positions connecting several groups of nodes that would be connected by longer paths without these particular items. ..Conversely, the items Es26 (Occasionally I panic but usually I do not), Es20 (On occasion I feel blue but most of the time I don't feel blue), Ag17 (While I sometimes forgive others to avoid confrontation I also challenge others), Ex21 (I always take my time even when a faster pace may be needed), Ex38 (Thought I often look on the bright side of life I am usually more realistic in my outlook), and O29 (If I were given two problems to work on, one familiar and the other novel, I'd spend an equal amount on both.) were low on multiple centrality indices suggesting they ...

Shortest Pathway between Emotional Stability and Conscientiousness. Finally, a network illustrating the shortest paths between all conscientiousness and emotional stability items was computed (see Figure 5). In comparison to the first network, these

networks clarify possible pathways and mediating items between these two factors. The shortest path between 2 nodes represents the minimum number of steps needed to go from one node to another, and is computed using Dijkstra's algorithm (Dijkstra, 1959). This can be seen as a roadmap including all possible routes from destination A to destination B, but only one of these routes being quicker—this would then be the route highlighted in the shortest path network. Our network illustrates the shortest path between multiple items hence highlights a diverse array of routes linking conscientiousness and emotional stability. A few general observations. First, the nodes Co21 (Tendency to misjudge situations), Es13 (Sometimes do things I later regret), and, more indirectly, Es18 (Always feel great about person I am), Es14 (Feel most alive when giving into urges), and Co31 (Do just enough work to get by) are primary hubs for multiple pathway which link both item sets. Interestingly, several of these intermediate items share a self-reflective, guilt-laden connection, such that taking time to correctly assess the consequences of one's decision lessens the likelihood of impulsively engaging in actions which lead to remorse and low self-esteem. It may be possible the links between regulation of emotions and motivation can be explained by a realization hasty actions lead to bad consequences. Second, the specific extraversion and agreeableness items of Ex8 (I like to focus on the positive side of things), Ex9 (I always look at the bright side of things), Ex37 (I seldom joke around), Ex39 (I am a fairly tame and calm person), Ag6 (I am extremely self-centered), and Ag33 (I like to brag about my accomplishments) helped bridge the connection from being Es18 (I always feel great about the person that I am) to Co(). These correspond to the NEO-PI facets of xx and xx. Finally, whereas most of the emotional stability items clustered together to flow into conscientiousness, the more diffuse conscientiousness network flowed down into emotional stability through a few, primarily ideal-point oriented behaviors of Co24 (Pride myself on unwavering ability to act responsibly), Co25 (Although capable of self-motivation, I prefer to have someone else provide direction), and Co31 (Do just enough work to get by). In other words, there appear to be many routes for emotional stability change to affect conscientiousness but only a few

primary routes for conscientiousness to spread into emotional stability.

Discussion

References

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## Warning in styling_latex_scale_down(out, table_info): Longtable cannot be
## resized.
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Labels	Items
O1	I find theoretical conversations extremely boring
O2	I dislike focusing on difficult problems
O3	I dislike thinking too hard about things
O4	I prefer to focus on mentally stimulating projects but sometimes it is nice to have time to ment
O5	Sometimes I enjoy solving complex problems
O6	I enjoy solving complex problems
O7	I enjoy having abstract or philosophical conversations
O8	I really enjoy trying to tackle the most complex problems imaginable
O9	I prefer stability or consistency to variety and change
O10	I like change but I also need stability
O11	While I do somewhat prefer variety I also enjoy stability or consistency
O12	I find all artwork to be similar
O13	Listening to poetry or music seems to be a waste of time
O14	While listening to music is nice it is pointless
O15	From time to time I like to appreciate the beauty around me
O16	There have been times when a song has made me emotional
O17	I see some value in art and beauty
O18	I like to think about real world problems
O19	People have told me I am emotionally inept
O20	I am unable to reciprocate when someone talks about their feelings
O21	It takes me a long time to understand other people s emotions

(continued)

Labels	Items
O22	Unless someone tells me how they feel I won t know for sure
O23	I sometimes can tell how people feel
O24	If an emotion is really obvious then I can probably identify it
O25	For the most part I understand others emotions
O26	People talk to me because I can empathize with how they feel
O27	I have a deep understanding of others emotions
Es1	I am rarely frustrated by anything
Es2	I like to consider myself as a very easygoing person
Es3	I rarely get irritated by others
Es4	I am somewhat balanced in my experience of anger
Es5	I am somewhat balanced in my experience of frustration
Es6	I get angry easily
Es7	I get frustrated easily
Es8	I have a very short temper
Es9	I often resist my temptations
Es10	People say I have great self control
Es11	I have a good amount of control on my cravings
Es12	I indulge reasonably when I feel inclined to do so
Es13	Sometimes I do things I later regret
Es14	I feel most alive when I give into my urges
Es15	I rarely get stressed out about things
Es16	Sometimes I get caught up in my problems and other times I try not to worry about things tha
Es17	I get caught up in my problems

(continued)

Labels	Items
Es18	I always feel great about the person that I am
Es19	I seldom feel down in the dumps
Es20	On occasion I feel blue but most of the time I don t feel blue
Es21	My mood changes about half the time
Es22	My mood changes all the time
Es23	I rarely become embarrassed
Es24	I am always extremely afraid that I will do the wrong thing
Es25	I rarely panic
Es26	Occasionally I panic but I usually do not
Es27	Sometimes I panic easily and other times I do not
Es28	My emotions usually get the best of me
Ex1	I am a socially awkward person
Ex2	I sometimes feel uncomfortable when surrounded by a big crowd
Ex3	I prefer to socialize in small groups
Ex4	I like to do most things in large groups
Ex5	I constantly try to engage with different people
Ex6	People often refer to me as a downer
Ex7	I am somewhat of a fun person to be around
Ex8	I like to focus on the positive side of things
Ex9	I always look at the bright side of life
Ex10	I am an incredibly joyful person to be around
Ex11	I am incredibly uptight around others
Ex12	I always hide my true feelings from people

(continued)

Labels	Items
Ex13	I usually find it hard to make friends
Ex14	I am usually quiet when I meet new people
Ex15	I usually find it easy to make friends
Ex16	I am always friendly to people
Ex17	I don t mind loud parties but I don t prefer them either
Ex18	I tend to seek adventure
Ex19	Loud parties can definitely be fun
Ex20	I couldn t live without adventure
Ex21	I always take my time even when a faster pace may be needed
Ex22	I generally prefer activities that require little energy
Ex23	Half of the time I prefer leisurely activities and half of the time I prefer activities to be fast pac
Ex24	Compared to extremely energetic people I am somewhat less energetic
Ex25	My fast paced lifestyle keeps me more busy than most
Ex26	My lifestyle requires a high energy level
Ex27	I always try to live life to the fullest extent that I possibly can
Ex28	Compared to most people I live a very fast paced life
Ex29	I hate leading groups
Ex30	I have no interest in leadership
Ex31	I would rather follow directions than lead
Ex32	From time to time I enjoy taking charge on projects but some other times I prefer others to tak
Ex33	I am often the person to take charge of a group
Ex34	I enjoy taking the lead on new projects
Ex35	I can always persuade people to follow my lead

(continued)

Labels	Items
Ex36	I always end up leading the groups I participate in
Co1	I find that most all of my decisions are impulsive
Co2	I sometimes make decisions based on instinct rather than facts and sometimes I prefer facts
Co3	On occasion it can be helpful to consider all options when making decisions
Co4	I prefer to have backup plans
Co5	It is best to be careful when a decision has significant consequences
Co6	I have difficulties working on a clean and organized desk
Co7	Organization is not a priority for me
Co8	While I like order and regularity I also enjoy when things are a bit chaotic
Co9	I keep my workstation somewhat clean and tidy
Co10	I like to plan my days in advance
Co11	I have lied to protect other people
Co12	I aim to tell the truth as often as possible but I can think of numerous situations that have req
Co13	I try to keep all of the promises I make but sometimes I am unable to deliver on them
Co14	Regardless of the situation I always tell the truth
Co15	I avoid setting goals but when I do I set extremely easy goals
Co16	I am fine being an average worker
Co17	I have a drive to succeed in my work
Co18	I aspire to do well in more areas compared to most people
Co19	I work extremely hard to be the very best at everything I do
Co20	I put little thought into my actions
Co21	I have a tendency to misjudge situations
Co22	I tend to perform in most areas at the average level of other people

(continued)

Labels	Items
Co23	While I often excel in what I do I also have much to learn to be better
Co24	I pride myself on my unwavering ability to act responsibly
Co25	Although I am capable of motivating myself to complete tasks I prefer to have someone else pro
Co26	More often than not I depend on myself rather than others for the motivation needed to succes
Co27	Even when tasks are difficult I find a way to complete them
Co28	I always get my work in on time
Co31	I do just enough work to get by
Co32	I find it difficult to start my work
Co33	I prefer making decisions quickly rather than after thoroughly thinking things through
Ag1	Being a winner is much more important than being cooperative
Ag2	Cooperating with others is equally as important as winning
Ag3	When someone is in need I feel as though I have to help
Ag4	Cooperating with others is more important than winning
Ag5	I always put the needs of others before my own
Ag6	I am extremely self centered
Ag7	I sometimes help a friend because it s the right thing to do other times is because I want somet
Ag8	I frequently think about how others are doing
Ag9	I worry about how people are doing
Ag10	I live to serve others
Ag11	Everyone has hidden intentions
Ag12	I find it easier to trust in some people than in others
Ag13	Honesty is the foundation of any good relationship
Ag14	I feel the urge to confide in others

(continued)

Labels	Items
Ag15	If someone wrongs me it is difficult for me to forgive them
Ag16	Sometimes I am easy to satisfy but other times I can seem a bit pushy
Ag17	While I sometimes forgive others to avoid confrontation I also often challenge others
Ag18	People who know me would likely say I am generally a forgiving person
Ag19	I usually try to satisfy others needs rather than my own when I sense conflict emerging
Ag20	People who know me would say I am an extremely forgiving person
Ag21	I shy away from credit sometimes but other times it is nice to be recognized
Ag22	Sometimes the work I do is really excellent other times it is mediocre
Ag23	When I give money to a charity I am fine with being anonymous
Ag24	I always share the credit I receive on teamwork
Ag25	I always hide my motives to get what I want
Ag26	Manipulating others can be helpful
Ag27	I use flattery on occasion when dealing with others
Ag28	People often tell me that I am a genuine person

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Table 2

Eighteen Bridging Item Pairs

ItemLabels	FirstItem	SecondItem
Ag28.O26	People often tell me Im a genuine person	People talk to me because I empathize with how they feel
Ag13.Co5	Honesty is the foundation of any good relationship	It is best to be careful when a decision has significant consequence
Ag14.Co25	I feel the urge to confide in others	Although I am capable of motivating myself to complete tasks I prefer to have someone else prompting
Ag26.Co11	Manipulating others can be helpful	I have lied to protect other people
Ag23.Co3	Fine being anonymous when giving money to charity	On occasion it can be helpful to consider all options when making decisions
Co5.O24	It is best to be careful when a decision has significant consequences	If an emotion is really obvious then I can probably identify it
Co10.O9	I like to plan my days in advance	I prefer stability or consistency to variety and change
Co18.O8	I aspire to do well in more areas compared to most people	I really enjoy trying to tackle the most complex problems imaginable
Co3.O24	On occasion it can be helpful to consider all options when making decisions	If an emotion is really obvious then I can probably identify it
Co15.Ex22	I avoid setting goals but when I do I set extremely easy goals	I generally prefer activities that require little energy
Ex9.Es18	I always look at the bright side of life	I always feel great about the person that I am
Ex16.Es2	I am always friendly to people	I like to consider myself as a very easygoing person
Ex22.O3	I generally prefer activities that require little energy	I dislike thinking too hard about things
Ex12.O20	I always hide my true feelings from people	I am unable to reciprocate when someone talks about their feelings
Co1.Es14	I find that most all of my decisions are impulsive	I feel most alive when I give into my urges
Co11.Es13	I have lied to protect other people	Sometimes I do things I later regret
Ag25.Ex12	I always hide my motives to get what I want	I always hide my true feelings from people
Ag3.Ex16	When someone is in need I feel as though I have to help	I am always friendly to people

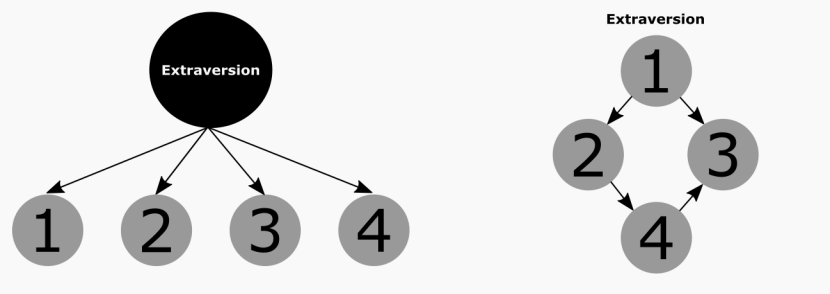

Figure 1. Trait model according to a latent variable (left panel) and a network perspective (right panel)

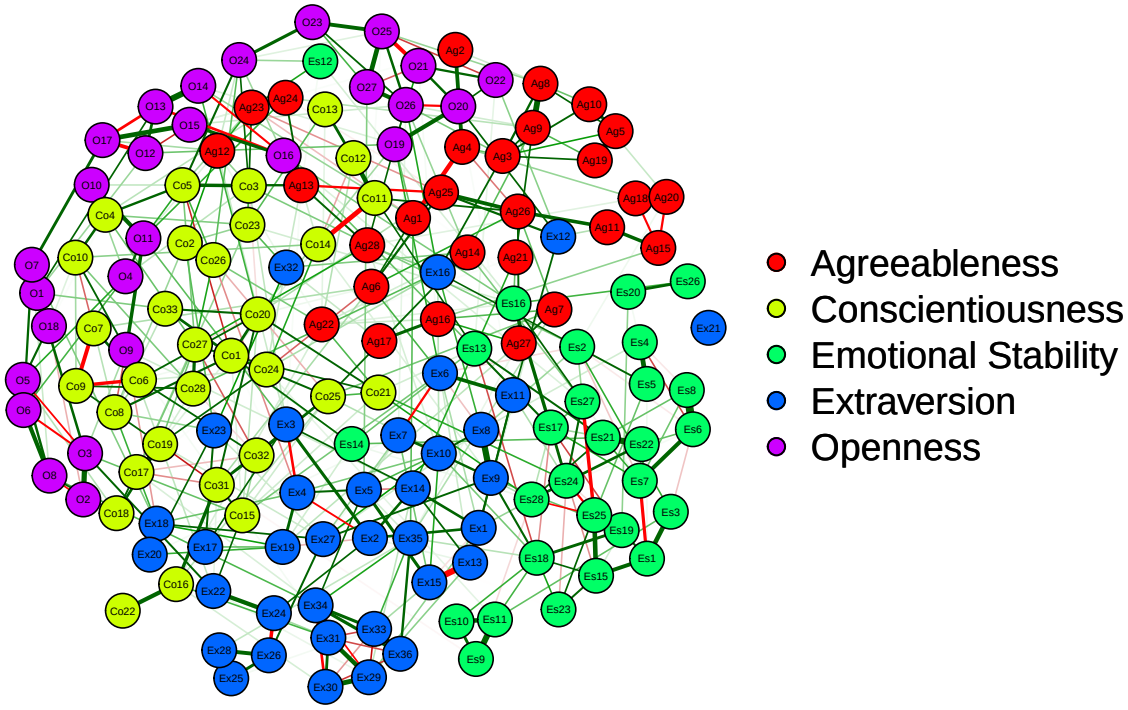

Figure 2. Network representation of 168 ideal-point inventory modeled after the NEO-PI facet structure. Each item is represented by a node, and the node number corresponds to the item statements in Table 1. Nodes are connected by green (red) lines if they are positively (negatively) correlated. Line thickness corresponds to correlation strength. The spring-bsaed algorithm (Fruchterman & Reingold, 1991) used to generate the graph places strongly correlated nodes closely together and towards the middle of the graph.

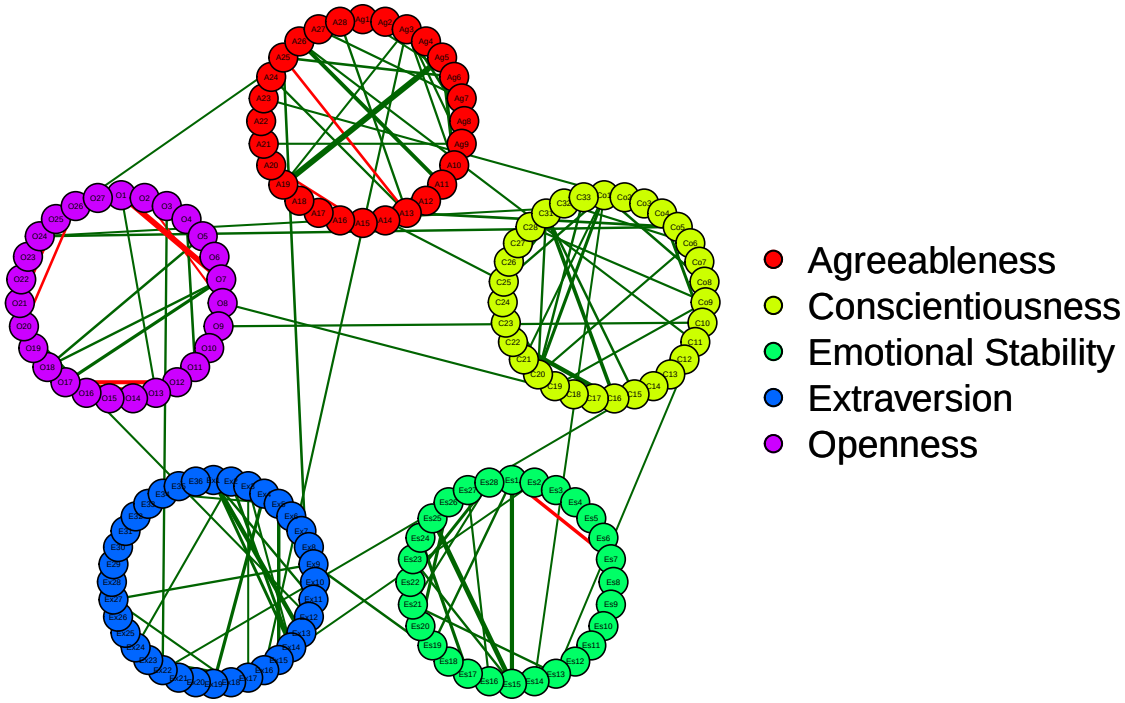

Figure 3. Same network results from Figure 1 rearranged by Big Five groupings and restricted to display partial correlations .10 or greater. Visualized edges depict strong residual item associations within and between trait factors.

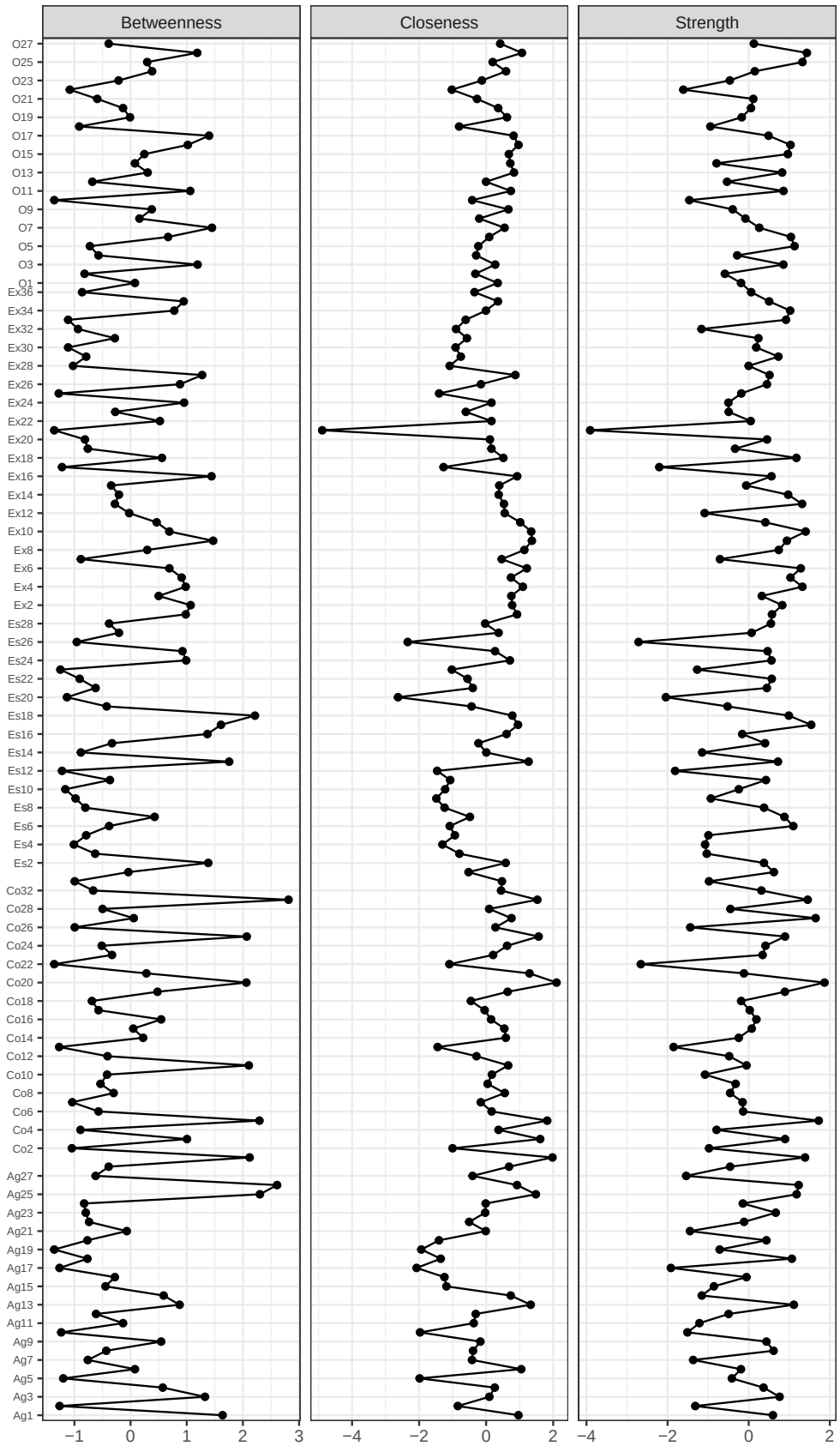

Figure 4. Centrality plot depicting the betweenness, closeness, and strength of each node.

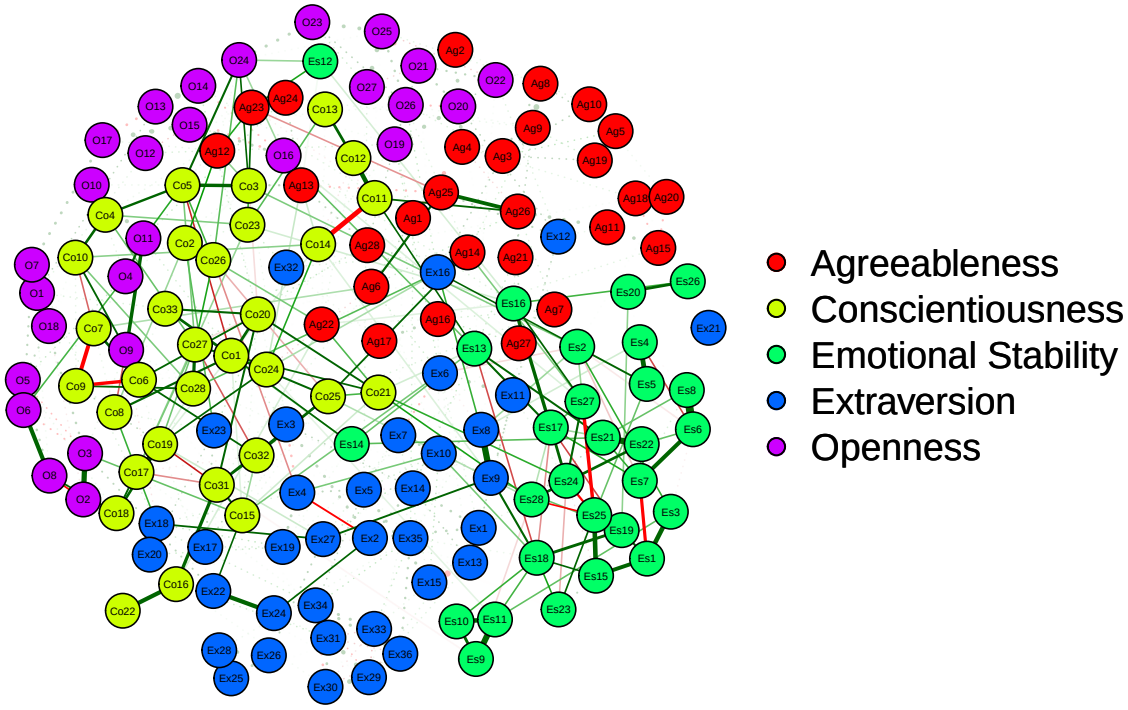

Figure 5. Network depicting the shortest paths between Conscientiousness and Emotional Stability items. Edges belonging to the shortest-paths are full, while the other edges are dashed.