1   Applying Network Analysis to Ideal Point Personality Item Responses

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11   Abstract

12   Personality researchers have recently taken interest in two methodological innovations

13   network and analysis and ideal point item writing strategies. The former suggests that

14   personality is best understood as a network while the latter allows personality traits to be

15   measured more precisely. Here, we explore the value of integrating these two innovations.

16   *Keywords:* ideal point, personality, network analysis

17   Word count: XXXX

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19   **Introduction**

20   There has long been a call to explain where personality traits come from, how they

21   operate, and how they produce differences in behaviors. Despite offering useful descriptive

22   summaries, the Big Five are largely atheoretical, non-explanatory entities (Block, 1995;

23   Hampson, 2012). A novel solution to this issue has been proposed by the emerging

24   psychometric network approach (Cramer et al., 2012). Rather than treat "hidden traits" as

25   causal forces behind stable behavioral patterns, the network approach models the Big Five as

26   a densely clustered system of directly interacting feelings, thoughts, and behaviors (Cramer

27   et al., 2012). From this perspective, discrete actions like working hard to attain long-term

28   goals, planning one's week, and focusing on a task to completion in a person high on

29   Conscientiousness do not co-occur because they are the result of a top-down biological

30   structure or disposition, but because deciding to care about a long-term goal leads one to be

31   more disciplined in allocation of personal resources. Over time these actions become

32   mutually reinforcing, settle into a stable equilibrium, and manifest themselves as a coherent

33   set of relatively enduring activities.

34   Figure 1 illustrates the distinction. The standard latent variable model treats traits as

35   causes of thoughts, feelings, and behaviors – an idea which implicitly dominates usage of

36   weighted factor scores – whereas the networks sees traits as *consequences* of the interactions

37   between these components. For instance, liking people makes it more likely to accept party

38   invitations, and going to parties and interacting with new people makes the person more

39   talkative, and so forth (Cramer et al., 2012). Forces bonding specific clusters together might

40   be shared biological origins, learning principles, socially enforced norms, or functional aims

41   that produce accretion of multiple explanatory mechanisms which logically unite and

42   reinforce specific personality components (Cramer et al., 2012; Fleeson & Jayawickreme,

43   2015; Wood, Gardner, & Harms, 2015). For example, Jane may greatly value learning. This

44   may drive her to purposefully exercise greater curiosity and imagination in order to attain

45 the goal of absorbing information (Wood et al., 2015). Over time, Jane seeks environments

46 affording more opportunities for mental expansion which leads to inquisitiveness, problem

47 solving, vocabulary acquisition, and exposure to competing ideas. These components

48 co-evolve because they are mutually dependent – it is hard to solve complex problems

49 without asking questions, acquiring descriptive prowess, or tolerating diversity. The

50 synchronization of such actions leads to a steady-state equilibrium we label Openness to

51 Experience. Based on this perspective, traits are not common causes but, rather, properties

52 that emerge from the complex organization of many interacting parts. This perspective can

53 provide a better view of the cognitive, motivational, and functional dynamics that

54 characterize the development of the personality system, therefore favoring empirical

55 investigations of such mechanisms (Wood et al., 2015).

56   Multiple papers have applied network models to personality (Costantini & Perugini,

57 2016), attitudes (Dalege, Borsboom, van Harreveld, Waldorp, & van der Maas, 2017), and

58 clinical disorders (McNally, Robinaugh, Wu, Wang, Deserno, & Borsboom, 2015). While this

59 approach points to interesting implications for validity, development, dynamics, and change

60 (Schmittmann, Cramer, Waldorp, Epskamp, Kievit, & Borsboom, 2011), one major

61 limitation is almost all network investigations use inventories built with dominance rather

62 than ideal-point measurement models. **Review by Chris. . .** This leads to two major

63 limitations. First, network models assume all major components constituting the network

64 have been effectively codified in current personality inventories. Failure to meet this

65 principle can result in spurious connections and false conclusions about which elements of

66 the personality system consistently activate one another (Borsboom, 2017). Second, the

67 intermediacy of ideal-point items may better capture "bridging" components linking distinct

68 trait clusters. For instance, the conscientiousness item "I tend to be disorderly but also like

69 to keep certain things tidy" may serve as a bridge between an agreeableness item of "I don't

70 like to let others down" and the remaining network of conscientiousness items. Why?

71 Because development in compassionate items arising from social roles (e.g., serious

72 relationships, care for family) may directly elevate conscientiousness by causing individuals

73 to start bringing their personal affairs in order. That is, when we begin caring about others

74 we may get our "act together" to better meet social responsibilities. Such effects may be less

75 evident in extreme items (I always keep my affairs in order) because developmental processes

76 are gradual and better reflected through intermediate steps such as beginning to organize

77 parts of one's life.

78 Ideal point models, like many latent factor models, assumes unidimensionality.

79 Unfortunately, many items are inherently multidimensional (e.g., midrange and extreme

80 items). These items are often associated with high standard errors, if they survive analysis.

81 Network models are less restrictive. They can show how multidimensional items reside in a

82 network. Theoretical approaches by Woods and colleagues suggests that personality

83 descriptions can reflect functional in addition to structural constructs.

Methods

85 We report how we determined our sample size, all data exclusions (if any), all

86 manipulations, and all measures in the study.

Participants

Material

Procedure

Data analysis

91 We used R (3.3.1, R Core Team, 2016) and the R-packages *bitops* (1.0.6, Steve Dutky

92 initial R port, Martin Maechler; revised, & Steve Dutky, 2013), *bootnet* (1.0.0, Epskamp,

93 Borsboom, & Fried, 2017), *careless* (1.0, Yentes, 2016), *corrr* (0.2.1, Jackson, 2016), *dplyr*

94 (0.5.0, Wickham & Francois, 2016), *Formula* (1.2.1, Zeileis & Croissant, 2010), *ggplot2* (2.2.1,

95 Wickham, 2009), *Hmisc* (4.0.3, Harrell Jr, Charles Dupont, & others., 2017), *lattice* (0.20.33,

96 Sarkar, 2008), *lavaan* (0.5.23.1097, Rosseel, 2012), *mgm* (1.2.1, Haslbeck & Waldorp, 2016),

97 *papaja* (0.1.0.9492, Aust & Barth, 2017), *psych* (1.6.12, Revelle, 2016), *purrr* (0.2.2,

98 Wickham, 2016), *qgraph* (1.4.2, Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom,

99 2012), *RCurl* (1.95.4.8, Lang & CRAN team, 2016), *readr* (1.0.0, Wickham, Hester, &

100 Francois, 2016), *stringr* (1.2.0, Wickham, 2017a), *survival* (2.40.1, Terry M. Therneau &

101 Patricia M. Grambsch, 2000), *tibble* (1.2, Wickham, Francois, & Mller, 2016), *tidyr* (0.6.1,

102 Wickham, 2017b), and *tidyverse* (1.1.1, Wickham, 2017c) for all our analyses.

103   **Estimating and Visualizing the Network.**   Network psychometrics represents

104 items and facets by nodes connected by edges representing statistical relationships. When

105 based on correlations, such networks are often weighted (e.g., show strength of connection),

106 signed (e.g., positive or negative), and undirected. To avoid spurious associations,

107 cross-sectional networks are estimated using regularized partial correlations with graphical

108 least absolute shrinkage and selection (glasso; Epskamp, Borsboom, & Fried, 2017; Friedman

109 et al., 2008). In such networks, edges imply a relationship exists after controlling for all other

110 nodes; likewise, the absence of an edge means two nodes are *conditionally independent* given

111 all others nodes. *Regularization* avoids estimation of false positive associations by assigning

112 penalties so all edges are shrunk with small edges being set to zero. This results in a *sparse*

113 (i.e., conservative) network that safeguards against overfitting by modeling covariance among

114 components with as few connections as possible. Because such models are well-defined and

115 uniquely specified, they facilitate clear and unambiguous interpretation of edge-weight

116 parameters as the strength of *unique* associations between variables, which may in turn

117 highlight potential causal linkages. In the current study we estimated the glasso on a

118 polychoric correlation matrix using the extended EBIC criterium (Epskamp, Costantini,

119 Haslbeck, Cramer, Waldorp, Schmittmann, & Borsboom, 2017) and, given the larger number

120 of items, set the EBIC hyperparameter to a more conservative .8 to err on the side of caution.

121   To visualize the final graphs we used the Fruchterman-Reingold algorithm

122 (Fruchterman & Reingold, 1991) that places nodes with stronger and/or more connections

123 more closely together. Positive edges are displayed in green, negative ones in red, and

strength of connection is reflected in thicker, more saturated lines. We set the minimum edge value across all networks to .05 to improve interpretability (see Figure 2). An alternative presentation groups all components into their respective Big Five categories with a higher minimal edge value of .10 (Figure 3). This latter figure illustrates multiple dependent item pairings across traits after controlling for all other associations, a direct violation of the latent factor assumption of local independence.

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.

Shortest Pathway.

Results

Discussion

References

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
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
O28	I can see the value of abstract or theoretical conversations but I prefer to do something better
O29	If I were given two problems to work on one is familiar and the other is novel I d spend an equa
O30	While I sometimes like trying new things I usually do what s accepted or expected
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
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
Es29	I am easily irritated
Es30	I usually overreact to situations that others would merely find somewhat unpleasant
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
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
Ex36	I always end up leading the groups I participate in
Ex37	I seldom joke around
Ex38	Though I often look on the bright side of life I am usually more realistic in my outlook
Ex39	I am a fairly tame and calm person
Ex40	I avoid drawing attention to myself
Ex41	I tend to keep my opinions to myself
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
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
Co29	I am not bothered by disorder
Co30	I misrepresent facts as needed
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
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
Ag29	I believe that people should fend for themselves
Ag30	I don t always trust what other people tell me
Ag31	I am indifferent to the feelings of others
Ag32	While I might forgive another s wrongdoings I will never forget them
Ag33	I like to brag about my accomplishments
Ag34	I am willing to do whatever it takes to get ahead

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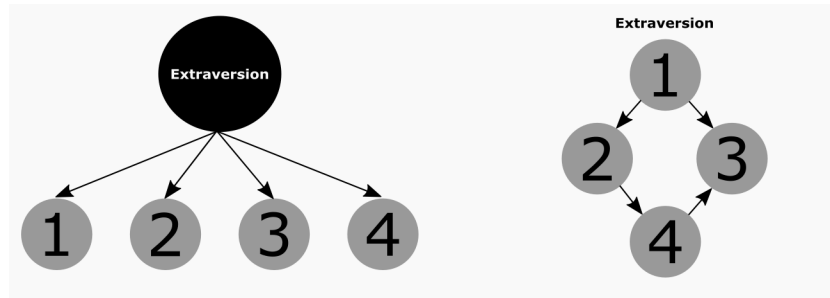
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Figure 1. Trait model according to a latent variable (left panel) and a network perspective (right panel)
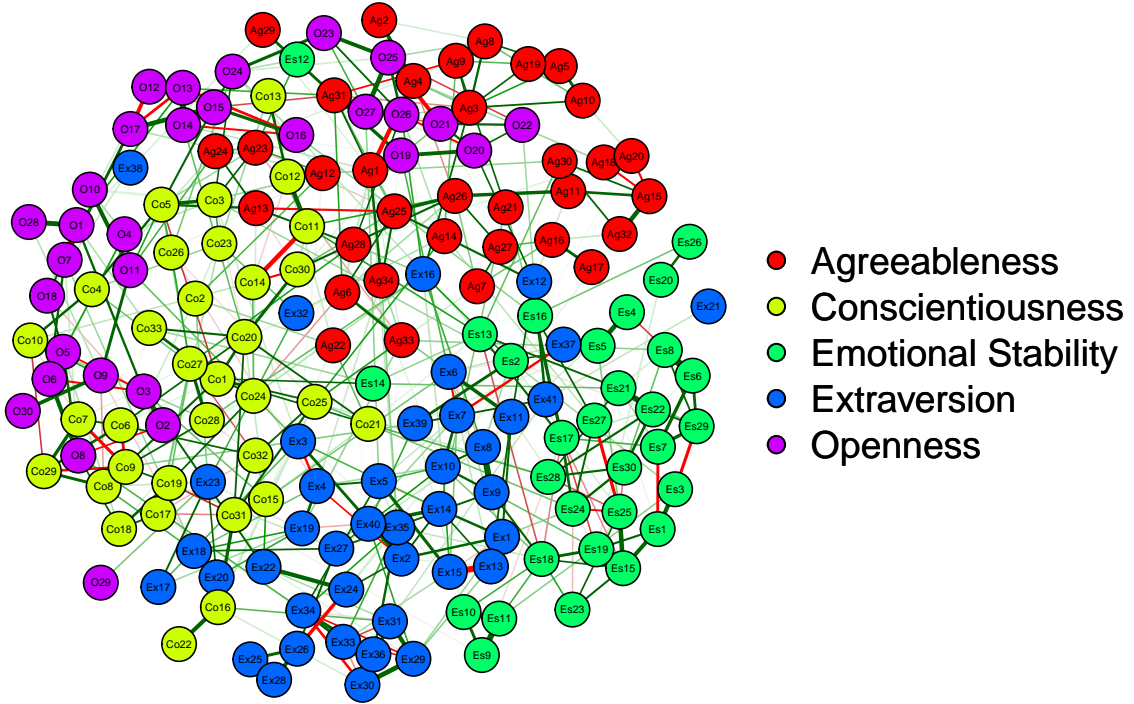
Figure 2. Network representation of 168 ideal-point inveneotry modeled after the NEO-PI facet structure. Each item is represented by a node, and the node number corresponds to the item statements in Table 1. Nodes are connected by green (red) lines if they are positively (negatively) correlated. Line 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.
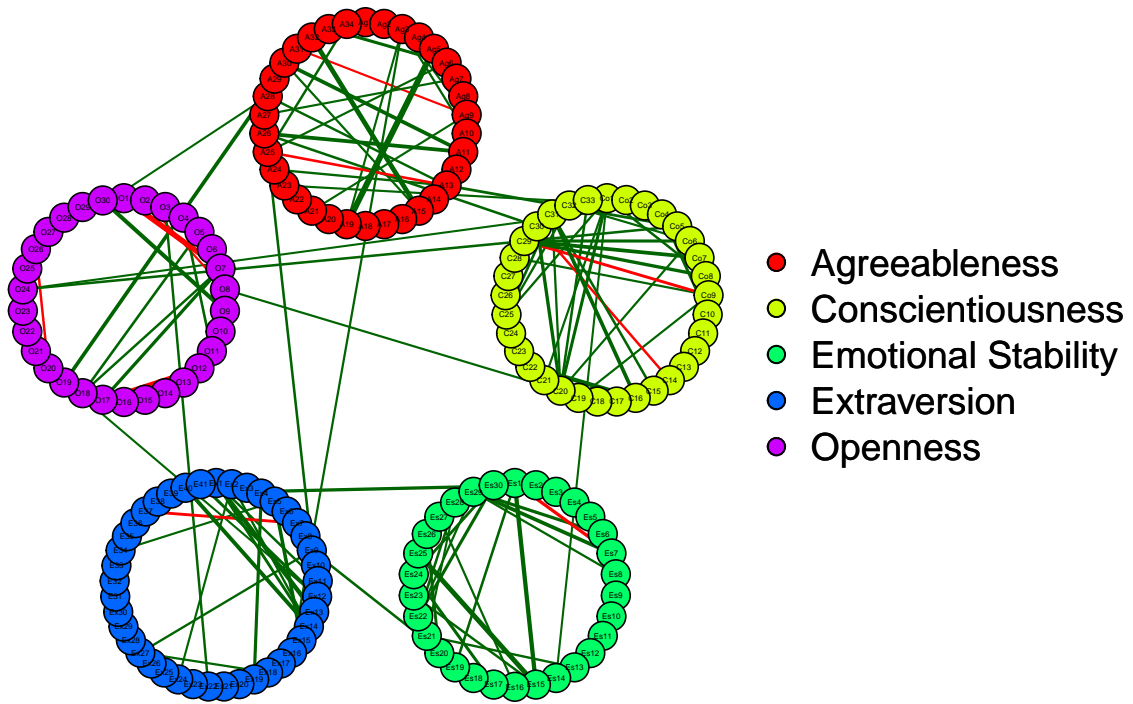
Figure 3. Same network results from Figure 1 rearranged by Big Five groupings and restricted to display only partial correlations .10 or greater.
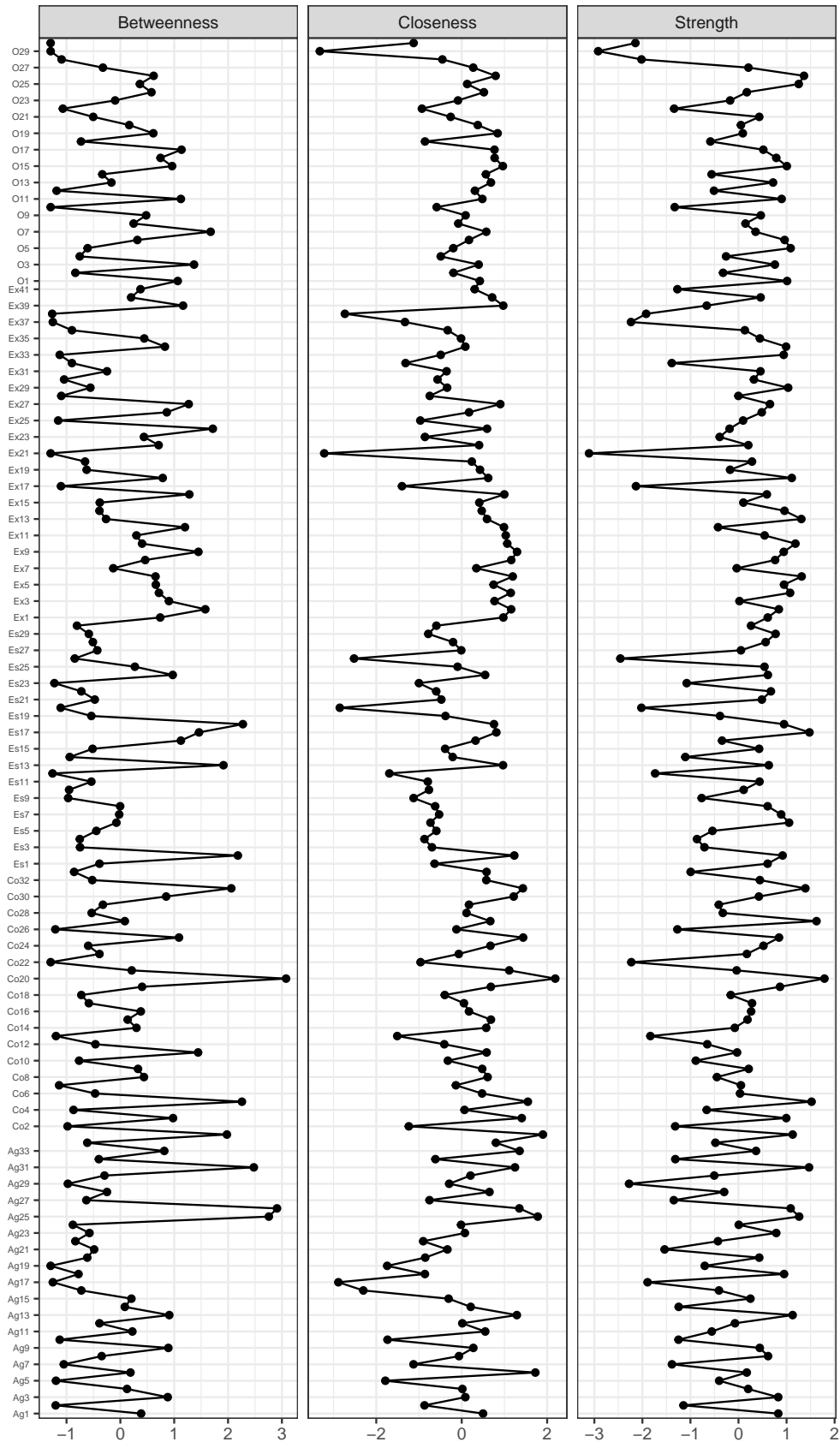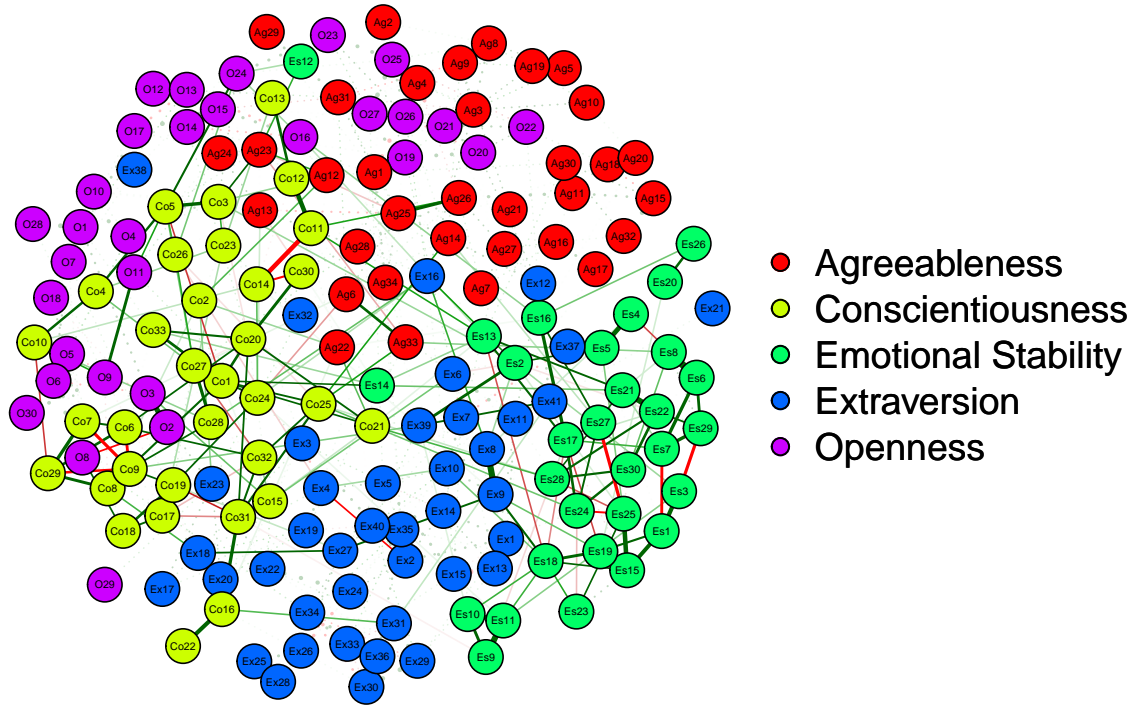
Figure 4

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.