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Uncovering the structure of personality space, with a focus on the ZKA-PQ

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Objective*: The Zuckerman-Kuhlman-Aluja Personality Questionnaire provides scores for the five dimensions of the Alternative 5, namely Extraversion, Neuroticism, Sensation Seeking, Aggressiveness, and Activity. What is the degree of interdependence among these five traits (dimensions) of the ZKA-PQ? What do we know about the internal structure of the multidimensional space defined by the Alternative 5?* Method*: To address these questions, we employ a multiway classification of our 460 participants, using independent median splits along these five dimensions, resulting in a partitioning of the dimensional space into its 2^5 (= 32) sectors. This results in a multiway frequency table that we analyze using the log-linear model.* Results*: The Alternative 5 defines a multidimensional space wherein all these combinations (profiles) do exist—hence providing testimony to the adequacy of this conceptualization. In our two-dimensional plots, we see both the non-homogeneity of personality space and areas in which personality types might well be found.* Conclusions*: The contribution of a log-linear model here is to go beyond these surface-level, two-way relationships, and to take into account the higher-order interactions present in the model. How to relate the complexity of the analysis (model) while achieving an understanding of the nature of this personality space is worthy of further study*.

Keywords: Alternative 5, ZKA-PQ, log-linear model, gestalt

Consider the three-factor structure of personality identified with Eysenckian theory (Eysenck & Eysenck, 1985), namely the Big 3 of Extraversion (E), Neuroticism (N) and Psychoticism (P), which are considered to comprise a space defined by orthogonal dimensions. Given such orthogonality,[1] one can apply the logic underlying the statistical procedure of analysis of variance (ANOVA) to view the possible non-additivity (hence, *gestalt*-like nature) of these dimensions in predicting behavior (Glicksohn & Nahari, 2007). If personality structure is one whose "parts are dynamically connected" (Allport, 1937, p. 361), then such non-additivity of the traits will be revealed by the presence of interactions. As Allport (1937, p. 341) argues, "traits are not wholly independent of one another." We note that such interacting traits might result from the fact that a trait such as N acts "… as an 'emotional amplifier', exaggerating existing personality tendencies to the point where unhealthy behavior takes over from healthy functioning" (Claridge & Davis, 2001, p. 395). Furthermore, as Depue and Collins (1999, p. 497) suggest, "…the intrinsically interactive trait of extraversion interacts with neuroticism, entailing the further influence of at least one more neurobiological variable, to form the emergent trait of impulsivity." Hence, the gestalt properties of personality will be revealed through a detailed analysis of the trait-trait interactions.

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The non-homogeneity of personality space

Eysenckian personality space is not necessarily populated in a homogeneous manner: Certain regions of this space might well be more densely populated than others. Thus, for example, Buckingham, Charles, and Beh (2001), citing Eysenck, noted that while E and N are viewed as being orthogonal dimensions, especially for the normal population, "they tend to be negatively correlated in neurotic populations and among subjects with very high N-scores" (p. 770). Or, as Pickering, Díaz, and Gray (1995) remarked regarding their own study, in order for them to achieve "an approximately uniform filling of the whole E × N personality space" they

[1]We need to clarify here that orthogonality, while not being a prerequisite for the identification of interactions, most certainly aids in presenting an ANOVA-type model, within which interactions are indicative of the non-additivity of these orthogonal (i.e., independent) dimensions. Interactions can be uncovered within the context of hierarchical multiple regression (Glicksohn & Nahari, 2007), wherein the dimensions are not necessarily orthogonal. Furthermore, even Eysenckian personality space is not quite orthogonal, and neither is that of personality space of higher dimensionality, be this the space of the Big 5, or the space of the Alternative 5, that we investigate here. As Aluja, Kuhlman, and Zuckerman (2010, p. 426) have suggested, "the lack of perfect orthogonality in personality questionnaires appears to be the rule rather than the exception."

had to exclude "certain personality types (e.g. stable extraverts) from becoming disproportionately represented" (p. 544). Non-homogeneity of the personality space indicates that not all combinations of traits are equally plausible.

How might one investigate the non-homogeneity of such a personality space? One option is to investigate the frequency of incidence of individuals within what Eysenck and Eysenck (1985) refer to as the *octants* of this three-dimensional space. For example, it would be psychopathic individuals who should appear as "clusters of points in the E+ N+ P+ octant" (Eysenck, 1995, p. 556), as should impulsive individuals (Díaz & Pickering, 1993, p. 304; Eysenck, 1987, p. 489), and sensation seekers (Eysenck, 1984, p. 440; Eysenck & Eysenck, 1985, p. 71; Zuckerman & Glicksohn, 2016). Anxious individuals, in contrast, should occupy the E-N+P- octant (Díaz & Pickering, 1993, p. 298). Hence, if one employs a trivariate median split to determine low and high values on E, N, and P, one can investigate the non-homogeneity of Eysenckian personality space by investigating the distribution of individuals within this three-way frequency table. Our goal in this paper is to show just how this may be accomplished using *log-linear modelling* (Upton, 1978; 1991). We stress a common assumption underlined by Ashton and Lee (2002, p. 187): "It is possible that individuals are not distributed in a multivariate normal fashion throughout this space; rather, there may be several regions within the space that are densely populated and separated from each other by more sparsely-populated regions…." Indeed, as McCrae, Terracciano, Costa, and Ozer (2006a, pp. 29-30) emphasize, "the typological approach presumes that there are regions of the five-factor space in which persons are more densely clustered than would be predicted from a multivariate normal distribution." Prior to presenting our approach, however, we have to address two issues.

The structure of personality space

The first issue arises from a statement made by Eysenck (1995, p. 556), who stresses that "clearly a system of diagnosis referring each point in this globular universe to the three dimensions, as a three-digit number, would be more reliable and more valid than a verbal type of construct….". While agreeing in principle with this point (made with reference to the construct of psychopathy), it is nevertheless the case that one can use the same three-way classification of octants to investigate the structure of personality space. Our argument here is that a completely homogeneous space would result in a completely additive model underlying E × N × P space. In contrast, interactions of these dimensions would indicate that certain combinations of traits are more likely than are others. For example, Claridge and Davis (2001) have made a strong argument for considering N to be a moderator variable. Given this, one would expect to see an E × N interaction within the model, whereby E-N+ is more predominant in disturbed individuals (Buckingham et al., 2001, p. 770). Hence, even if, theoretically, E, N, and P are orthogonal dimensions (Eysenck & Eysenck, 1985), the internal structure of this personality space will reveal that certain octants are more or less densely populated, if one's sample is sufficiently heterogeneous.

The second issue that we must address concerns the very nature of personality space. Contemporary personality theory has made the transition from a focus on a three-factor structure of personality space identified with Eysenckian theory (Eysenck & Eysenck, 1985), to one of a higher dimensionality. Most predominantly, this is the space of the Big Five or Five Factor Model (McCrae & Costa, 1997), namely E, N, Conscientiousness (C), Agreeableness (A) and Openness to Experience (O). This five-factor model not only describes normative personality, but also profiles personality disorders and embeds their description within this same space (Costa & McCrae, 1992). Its paradigmatic status is such, that twenty years ago Ozer and Reise (1994, p. 361) could proclaim that "Personality psychologists who continue to employ their preferred measure without locating it within the five-factor model can only be likened to geographers who issue reports of new lands but refuse to locate them on a map for others to find ...." Were we to investigate the internal structure of this space using five separate median splits, followed by a five-way log-linear analysis, we would be looking at "32 regions (e.g., + N + E + O + A + C, + N + E + O + A –C, +N + E + O –A + C, + N + E + O –A –C). These broad regions exist even though we are not able to visualize them…." (O'Connor, 2015, [p. 26]). And the same questions of interest noted earlier would be raised here. As O'Connor (2015, [p. 25]) writes: "The five dimensions are presumably orthogonal and have normal distributions, but we do not know if people are evenly spread out or dispersed in this space. Some regions may be more populated with people than others. Do homogeneous groupings of people exist? If so, how many groupings are there and where are they located?"

The 'alternative' Big Five personality space

The Big Five, while being the predominant personality structure in the literature, is certainly not the only player in the field. An alternative five-factorial model or the Alternative 5 (Zuckerman, 2005), namely E, N, Sensation Seeking (SS), Aggressiveness (Ag) and Activity (Act), is a viable alternative indeed. As with all current higher-order spaces of personality in which Eysenckian space can be embedded (Zuckerman & Glicksohn, 2016), the two dimensions of E and N predominate (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993), even if they are somewhat different in the Big 3, the Big Five or the Alternative 5. Thereafter, the paths of hyperspace diverge: P relating to both C and A in the Big Five, and to SS in the Alternative 5; O being unique to the Big Five; Ag and Act being unique to the Alternative 5.

Of course, the Big Five and the Alternative 5 do match to a certain degree. E in both models loads on the same factor (Aluja, García, & García, 2002; Zuckerman et al., 1993), as does N in both models (Aluja et al., 2002; García, Escorial, García, Blanch, & Aluja, 2012)—and one would certainly be surprised if this weren't the case. But note that the impulsivity facet of the Big Five N correlates much lower with Alternative 5 N (García et al., 2012) than do the other facets—as one would expect, given that impulsivity is not viewed to be a component of the Alternative 5 N (Zuckerman & Glicksohn, 2016). Other dimensions seem to be polar opposites, allowing for their negative correlation; thus Ag of the Alternative 5 and A of the Big Five are negatively correlated (Aluja et al., 2002; Zuckerman et al., 1993).

The original assessment of the Alternative 5 was accomplished by means of the 99-item Zuckerman-Kuhlman Personality Questionnaire (ZKPQ; Zuckerman et al., 1993). In more recent years, a broader assessment of these traits has been accomplished by means of the 200-item Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ; Aluja et al., 2010). This questionnaire enables an analysis at both the trait level (E, N, SS, Ag, and Act), and at the facet level (four facets underlying each trait). For SS, for example, these facets are the familiar Thrill and Adventure Seeking, Experience Seeking, Disinhibition, and Boredom Susceptibility subscales of SS, introduced and discussed by Zuckerman (1994; see also Glicksohn & Zuckerman, 2013, for a recent overview). For N, these are Anxiety, Depression, Dependency, and Low Self-Esteem. Note that these facets constitute only some of the traits originally presented by Eysenck in the Big 3 (Eysenck & Eysenck, 1985), and do not include a facet such as Moodiness. As noted in a previous publication (Glicksohn & Nahari, 2007), it is important to stress that N of the Big 3 is not equivalent to N of the Big Five, which includes impulsivity as one of its facets. In addition, SS of the ZKA-PQ subsumes impulsivity under its Boredom Susceptibility facet, while impulsivity and sensation seeking are viewed as comprising two facets of the trait of Impulsivity-Sensation Seeking (ImpSS) of the ZKPQ. Thus, SS takes on a wider definition in the ZKA-PQ, and the N of the Big 3, the N of the Big Five, and the N of the Alternative 5 is not quite the same N. In this paper, we take a close look at the internal structure of the personality space of the Alternative 5, at the trait level (namely, the five dimensions).

Investigating trait-trait interactions

Of course, a high-dimensional space presents enormous challenges for the present project. One way to simplify the exploration of this space is to look at the two-dimensional projections. In the Big Five, so called "personality styles" are defined by crossing each pair of the five dimensions, resulting in what is termed a "style graph" (Wiggins, 2003, p. 269). A complementary notion is that underlying the use of a circumplex to plot trait-trait interactions—most notably the Abridged Big Five Circumplex (AB5C) model (Burns, Morris, & Wright, 2014; De Raad, 1988; Hofstee, De Raad, & Goldberg, 1992; Markey & Markey, 2006). In the present paper, we will be looking at such two-dimensional planes, defined for the space of the Alternative 5. Within these 10 planes, we can study the two-way trait-trait interactions.

Two two-way interactions are quite familiar from the literature, perhaps reflecting a problem in assuming strict orthogonality of these dimensions: E × N (Aluja et al., 2010, p. 425; Glicksohn & Nahari, 2007), and E × Act (Aluja et al., 2010, p. 417). A further seven might be implicated in a number of personality disorders. In the SS × Ag plane, SS+Ag+ is considered to be an antisocial personality (Aluja et al., 2010, p. 425; Aluja, Cuevas, García, & García, 2007, p. 1317). In the E × Ag plane, E-Ag- is considered to indicate a schizotypal personality (Huang et al., 2011, p. 323). In the N × Ag plane, N+Ag+ is considered to be a borderline personality (Aluja, Blanch, García, García, & Escorial, 2012), and N+Ag- is considered to be a dependent personality (Aluja et al., 2012). In the N × SS plane, N+SS+ is considered to be a schizotypal personality (Aluja et al., 2007).[2] In the N × Act plane, N+Act- is considered to reflect an avoidant personality (Huang et al., 2011, p. 323); in the SS × Act plane, SS-Act+ is considered compulsive (Aluja, Blanch, & Balada, 2013, p. 294); and in the E × SS plane, E+SS+ is considered to be histrionic (Aluja et al., 2007, p. 1317). We suggest that in the Ag × Act plane, one finds either passive (Act-), or 'active' aggression (Act+). Hence, these interactions uncover certain combinations of traits that together underscore that person's personality. We shall take a close look at the degree of homogeneity within each such plane.

METHOD

Participants

A total of 460 individuals (349 females, 92 males, and 19 not reporting their gender), ranging in age between 18 and 68 (*M* = 27, SD = 7.4), completed the Hebrew version of the ZKA-PQ (Aluja et al., 2010) online. The majority of these (*n* = 362) took part in this study as part of a cross-cultural project, supervised by the fourth author, and recently reported by Rossier et al. (2016). Participation in the study was based on email invitations to students, and to the academic and non-academic staff of a number of universities and colleges in Israel.

Personality assessment

The Hebrew version of the Zuckerman-Kuhlman-Aluja Personality Questionnaire (ZKA-PQ) comprises 200 items, from which we derived scores for the five dimensions of the Alternative 5 (Zuckerman, 2005): Extraversion (E), Neuroticism (N), Sensation Seeking (SS), Aggressiveness (Ag) and Activity (Act). Participants typed in their response to each item on a 4-point scale, ranging from *strongly disagree* (1) to *strongly agree* (4).

In developing the Hebrew version of the ZKA-PQ, we went through the following steps: First, the second and third authors jointly translated the items into Hebrew. Following this step, the first author then translated the Hebrew version back into English, staying as closely as possible to the idiomatic language of the Hebrew. This back translation was then sent to the fifth author, who suggested some changes, which we then implemented in the final Hebrew version of the questionnaire. An analysis of the equivalence of the back-translated English version and the original English version was performed using a text-mining procedure, as

[2] In line with the above, a schizotypal personality should therefore require a specific combination of 4 traits: E-Ag- N+SS+.

Table 1. Pearson correlations and descriptive statistics for the five dimensions of the Alternative 5, assessed using the ZKA-PQ.

	1	2	3	4	min	mean	median	SD	max	skewness
1. Sensation Seeking					52	93.3	93	15.8	133	.056
2. Aggression	.17**				49	87.9	87	17.1	147	.300
3. Activity	.08	-.06			57	110.0	109	16.1	152	-.091
4. Neuroticism	-.10*	.28**	-.11*		45	93.5	93	20.5	155	.110
5. Extraversion	.14**	-.12*	.28**	-.42**	55	120.0	122	17.3	155	-.615

$^*p < .05$. $^{**}p < .005$ (Bonferroni criterion)

reported by Blanch and Aluja (2016). As reported in that paper, 2.5% of the 200 items in our version required some modification before the Hebrew form of the ZKA-PQ could be approved.

As reported in Rossier et al. (2016), internal consistencies for the five dimensions for the Israeli sample ranged between .89 and .94. In the somewhat larger sample that we report here, alpha reliabilities were as follows: E (α = 0.93), N (α = 0.94), SS (α = 0.88), Ag (α = 0.92), and Act (α = 0.90). These values match quite well those previously reported in the literature (Aluja et al., 2010, p. 425). In addition, the congruence coefficients for the Hebrew version of the ZKA-PQ with respect to the normative Spanish factorial structure ranged between .96 and .99 for the five trait-factors (Rossier et al., 2016).

Log-linear modelling

We employed independent median splits along the five dimensions,[3] and fully crossed these grouping factors, resulting in a broad partitioning of the dimensional space into 2^5 (= 32) sectors. We employed a corresponding multiway frequency table (Table 1), and analyzed it using the log-linear model (Upton, 1978). Such a multivariate technique enables a detailed analysis of the interactive nature of the personality dimensions, and not just of their simple linear addition. To clarify what a two-way, trait-trait interaction refers to, consider the following: When a two-way A × B contingency table is viewed in terms of a log-linear model, the A × B *interaction* in the log-linear model is equivalent to the *dependence* of A and B, which is put to test in a standard χ^2 analysis of the two-way contingency table. Hence, a trait-trait interaction refers to the dependence of trait A and trait B. In high-dimensional contingency tables, the pattern of dependence among the variables can be such, that some interactions are significant, while others are not. Given the hierarchical nature of log-linear modelling,[4] we can adequately deal with any inconsistency that might exist between levels (i.e., Simpson's paradox; cf. Kievit, Frankenhuis, Waldorp, & Borsboom, 2013). This five-way contingency table, E × N × SS × Ag × Act, was submitted to hierarchical log-linear analysis (Upton, 1978, 1991), using SPSS.

RESULTS

General

Looking first at the trait scores prior to their categorization, we note sizeable intercorrelations, particularly between E and both Act and N (see Table 1). Hence, strict orthogonality of the dimensions cannot be upheld. Of all 5 dimensions, it seems that E is the most problematic, exhibiting acute negative skew. This seems to be a robust finding in the population (Glicksohn & Abulafia, 1998).

We employed separate median splits (see Table 1) of E ('low' $\leq$ 122), N ('low' $\leq$ 93), SS ('low' $\leq$ 93), Ag ('low' $\leq$ 87), and Act ('low' $\leq$ 109), and fully crossed these grouping factors, resulting in a broad partitioning of the dimensional space into 2^5 (= 32) sectors. Table 2 presents the E × N × SS × Ag × Act contingency table, and as can be clearly seen, all 32 combinations were found in the sample.

A total of 32 different effects can be investigated here: (1) 5 main effects for trait (E, N, SS, Ag, and Act); (2) 10 two-way, trait-trait interactions (E × N, E × SS, E × Ag, E × Act, N × SS, N × Ag, N × Act, SS × Ag, SS × Act, and Ag × Act); 10 three-way interactions (E × N × SS, E × N × Ag, E × N × Act, E × SS × Ag, E × SS × Act, E × Ag × Act, N ×

[3] We are surely not the first in the literature to make the transition from continuous variables (dimensions) to categorical ones, purely for the purpose of multidimensional categorical data analysis. For example, Hu, Joshi, and Johnson (2009) looked at high-dimensional genomic data in terms of log-linear modelling, with a particular focus on the detection of interactions. Given the affinity of their data-analytic approach to our own, we can also agree with them when they write, that "one potentially important disadvantage of our method is that the discretization of continuous variable to generate high-dimensional contingency tables results in the loss of information." Our use of median splits for the specific purpose of generating such a high-dimensional contingency table seems to be qualitatively different from the use of median splits to generate a two-way or three-way ANOVA design. In the case of ANOVA, the question whether the grouping factors are correlated or not, prior to the use of median splits (Iacobucci, Posavac, Kardes, Schneider, & Popovich, 2015) is of paramount importance. But, even then, the choice of median splits can be justified, for as Iacobucci et al. (2015, p. 661) write, "if constructs X and Y measured in their continuous form were correlated 0.5, say, then their median split forms would be correlated a mere 0.32….Researchers could report the phi coefficient—the Pearson product-moment correlation coefficient on the 2 × 2 table formed by the two median splits—to defend their use if the correlation was insignificant." As we note in this paper, 8 of the 10 bivariate phi (ϕ) values that we report are not that strong, ranging between .06 and .19.

[4] It is true that log-linear modelling can also be employed in a non-hierarchical fashion (Rindskopf, 1990). The advantage that hierarchical modelling has is that such modelling requires the forced entry of lower-level terms into the equation, as a prerequisite for entering higher-order interactions. That is to say, in order for an A × B × C three-way interaction to be considered in the model, the model must already include the following terms: A, B, C, A × B, A × C, and B × C.

Table 2. The SS × Ag× N × Act × E contingency table. Cell counts together with percentages (in parentheses).

			E-		E+	
			Act-	Act+	Act-	Act+
SS-	Ag-	N-	18 (3.91)	10 (2.17)	20** (4.35)	27 (5.87)
		N+	22 (4.78)	12 (2.61)	7 (1.52)	13 (2.82)
	Ag+	N-	12 (2.61)	4* (0.87)	6 (1.30)	9 (1.96)
		N+	34 (7.39)	16 (3.48)	11 (2.39)	13 (2.82)
SS+	Ag-	N-	11 (2.39)	9 (1.96)	13 (2.82)	27 (5.87)
		N+	11 (2.39)	12 (2.61)	3* (0.65)	11 (2.39)
	Ag+	N-	7 (1.52)	13 (2.82)	15 (3.26)	30** (6.52)
		N+	30** (6.52)	17 (3.70)	7 (1.52)	10 (2.17)

Note: Cell counts marked with an asterisk have either a significantly larger (**) or significantly lower (*) count, relative to expected *n*, if one assumes a uniform distribution of participants to cells.

Table 3. Summary statistics for the effects appearing in the hierarchical model fitting the data for the ZKA-PQ.

Effect	lambda
E	.050
N	.006
SS	.022
Ag	.005
Act	-.042
E × N	-.295*
E × SS	.023
E × Ag	**-.049**
E × Act	**.229***
N × SS	-.124*
N × Ag	.200*
N × Act	-.012
SS × Ag	.140*
SS × Act	.135*
Ag × Act	-.053
E × N × SS	**.077**
N × SS × Ag	.086
N × SS × Act	.033
N × Ag × Act	.076
SS × Ag × Act	-.006
N × SS × Ag× Act	**-.063**

Note: Primary higher-order interactions of the hierarchical model fitted to the data appear in bold. Lambda is the weight assigned to a particular effect in the model. *$p < .05$

SS × Ag, N × SS × Act, N × Ag × Act, and SS × Ag × Act); 5 four-way interactions (E × N × SS × Ag, E × N × SS × Act, E × N × Ag × Act, E × SS × Ag × Act, and N × SS × Ag × Act); and 1 five-way interaction (E × N × SS × Ag × Act).

The following hierarchical model was found to be optimal, after a backward selection procedure of 10 steps from the saturated model, which includes all 32 effects: N × SS × Ag × Act, E × N × SS, E × Ag, E × Act [$G^2(10) = 4.46$, $p = .925$].[5] In this model, only 21 effects are required, 10 of which comprise the complete set of two-way trait-trait interactions. We further note that 6 of these 10 trait-trait interactions are significant at the .05 level. Table 3 presents summary statistics for this model.

While all 10 two-way interactions are required in the model, on inspection, 8 of these are not that strong, having ϕ values ranging between .06 for E × SS and .19 for N × Ag. Relative to these, both the E × N ($\phi = .31$)[6] and the E × Act ($\phi = .24$) interactions stand out, as can clearly be seen in their weighting (lambda values) in the model.[7]

Simulation study

Even though we focus in this paper on the set of 10 trait-trait interactions, one should question to what degree the hierarchical model uncovered here is replicable, given the fact that median splits of the data were utilized. We therefore ran a simulation study, incorporating the following steps: (1) a standard normal transformation of the scores within each dimension, together with the correlation matrix presented in Table 1, served as the multivariate normal base from which 400 data sets could be generated, using MATLAB; (2) each data set was subsequently subjected to separate median splits, and each of the 460 rows (corresponding to participants in the original data set) was assigned a profile of ‘low’ (0) or ‘high’ (1) values for the five dimensions; (3) each

[5] G^2 is the likelihood ratio χ^2 statistic.

[6] ϕ (phi) is a measure of dependence for a 2 × 2 contingency table, and is equivalent to a standard Pearson correlation computed on two dichotomous variables (see note 3).

[7] Note that the rank ordering of 2-way interactions in Table 3 closely mirrors the correlation matrix in Table 1.

Table 4. Descriptive statistics for the 10 pairwise correlations pertaining to the five dimensions of the Alternative 5, computed over 400 simulated data sets.

Correlation	min	mean	median	SD	max	original value
E × *N*	-.515	-.428	-.426	.038	-.318	**-.424**
E × *SS*	-.011	.137	.139	.045	.268	**.140**
E × *Ag*	-.253	-.128	-.129	.046	-.001	**-.121**
E × *Act*	.161	.274	.276	.043	.390	**.275**
N × *SS*	-.228	-.094	-.093	.045	.063	**-.097**
N × *Ag*	.152	.280	.286	.045	.286	**.281**
N × *Act*	-.269	-.112	-.114	.055	.294	**-.108**
SS × *Ag*	.018	.168	.168	.048	.311	**.170**
SS × *Act*	-.057	.075	.077	.047	.201	**.075**
Ag × *Act*	-.207	-.066	-.065	.047	.066	**-.062**

Table 5. Percentage of occurrence of each of the 25 interactions appearing in the five-way hierarchical log-linear analyses, computed over 400 simulated data sets.

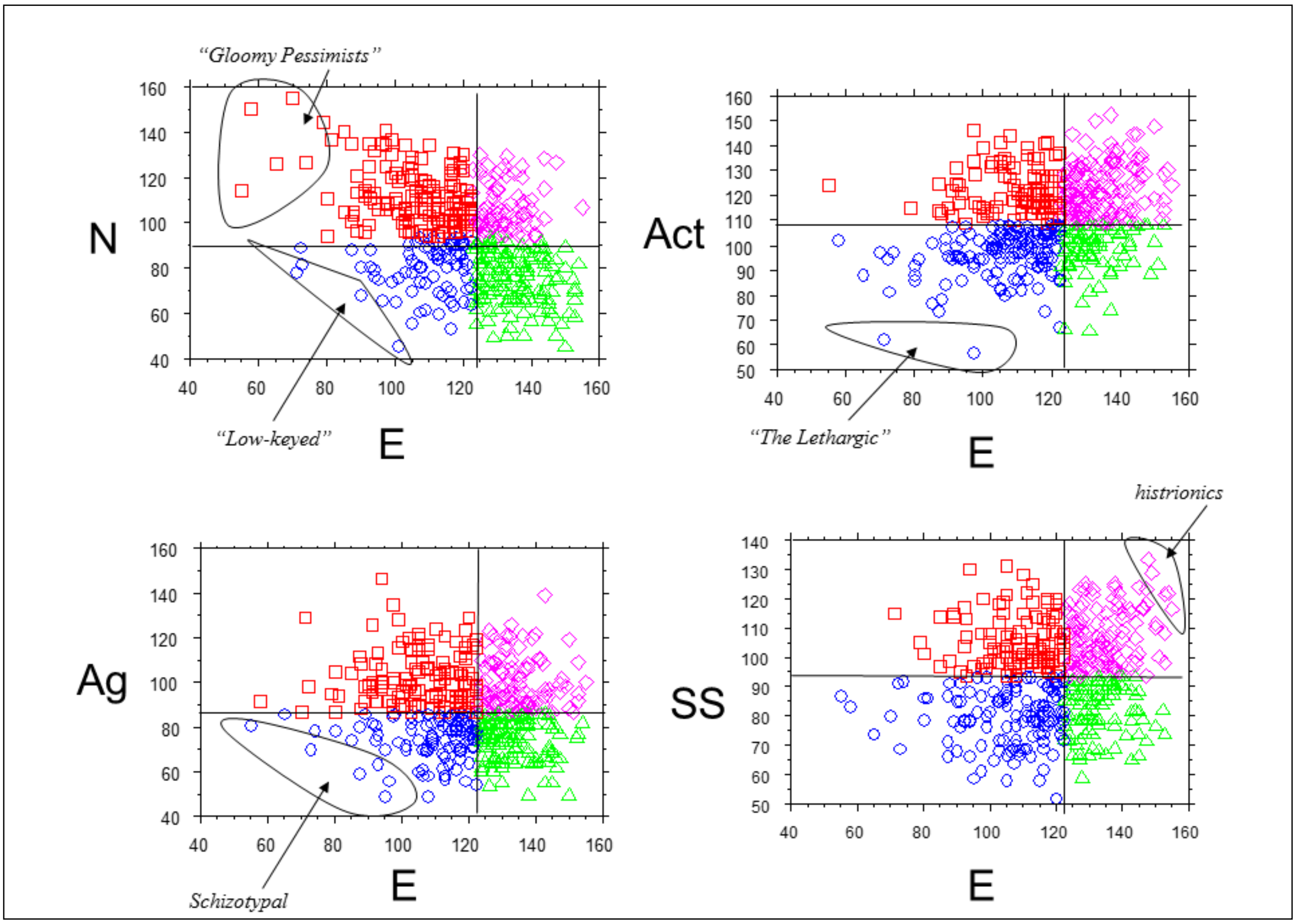
Effect	%	Appearing in real data set?
E × *N*	98.75	✓
E × *SS*	98.25	✓
E × *Ag*	96.25	✓
E × *Act*	96.00	✓
N × *SS*	100.00	✓
N × *Ag*	100.00	✓
N × *Act*	99.75	✓
SS × *Ag*	100.00	✓
SS × *Act*	99.00	✓
Ag × *Act*	98.75	✓
E × *N* × *SS*	56.25	✓
E × *N* × *Ag*	57.75	
E × *N* × *Act*	23.50	
E × *SS* × *Ag*	62.00	
E × *SS* × *Act*	18.00	
E × *Ag* × *Act*	12.75	
N × *SS* × *Ag*	85.50	✓
N × *SS* × *Act*	80.75	✓
N × *Ag* × *Act*	80.75	✓
SS × *Ag* × *Act*	81.00	✓
E × *N* × *SS* × *Ag*	08.75	
E × *N* × *SS* × *Act*	00.25	
E × *SS* × *Ag* × *Act*	00.50	
E × *N* × *Ag* × *Act*	00.75	
N × *SS* × *Ag*× *Act*	41.75	✓

such data set was then submitted to log-linear analysis. Table 4 presents descriptive statistics for each of the 10 pairwise correlations computed for this sampling distribution, obtained in Step 1. Clearly, while variability among the data sets was apparent, the match to the original correlation matrix was preserved on average. Table 5 presents percentages for the occurrence of each interaction (10 two-way, 10 three-way, and 5 four-way) across the 400 hierarchical models obtained in Step 3. Clearly, all 10 two-way interactions were required in the model, and these appeared in at least 96% of the simulations.

The presence of higher-order interactions might suggest to the reader that perhaps the ZKA-PQ factor structure itself is compromised in this sample. We ran a factor analysis using the ZKA-PQ facets (4 for each of the 5 dimensions). Inspecting the scree plot (indicating 5 factors), and employing a loading of .40 as criterion, we compared both Varimax and oblique factor solutions (which were very similar), with an eye for "simple structure." The orthogonal solution revealed the following: (1) factors E, Act, and SS were all clearly differentiated, with high loadings of their respective 4 facets; (2) factor Ag had high loadings of its own 4 facets, but also that of one of the facets of Act (hence, this facet had a split loading on both Ag and Act); (3) factor N had high loadings of its own 4 facets, but also that of one of the E facets (hence, this facet had a split loading on both N and E, and was in fact negatively loaded on N), and also that of one facet of Ag (hence, this facet also had a split loading on both N and Ag). We note a similar state of affairs in the results reported by Blanch, Aluja, and Gallart (2013, p. 109). Hence, the Ag × Act, E × N and N × Ag trait-trait interactions might very well be partly determined by this factorial structure. We suggest that while the ZKA-PQ space is basically orthogonal (given the results of the factor analysis), this space is not homogeneously populated (given the results of the log-linear analysis).

We stress that the complete set of 10 two-way trait-trait interactions should not be viewed in isolation, because they

Figure 1. Two-dimensional plots (continued next page)



are part of a more complex log-linear model involving higher-order interactions. Nevertheless, the two-way interaction, just like the bivariate correlation, can be informative of surface-level relationships. In this paper, we place primary focus on this level of interpretation. Let us now turn to these bivariate relationships.

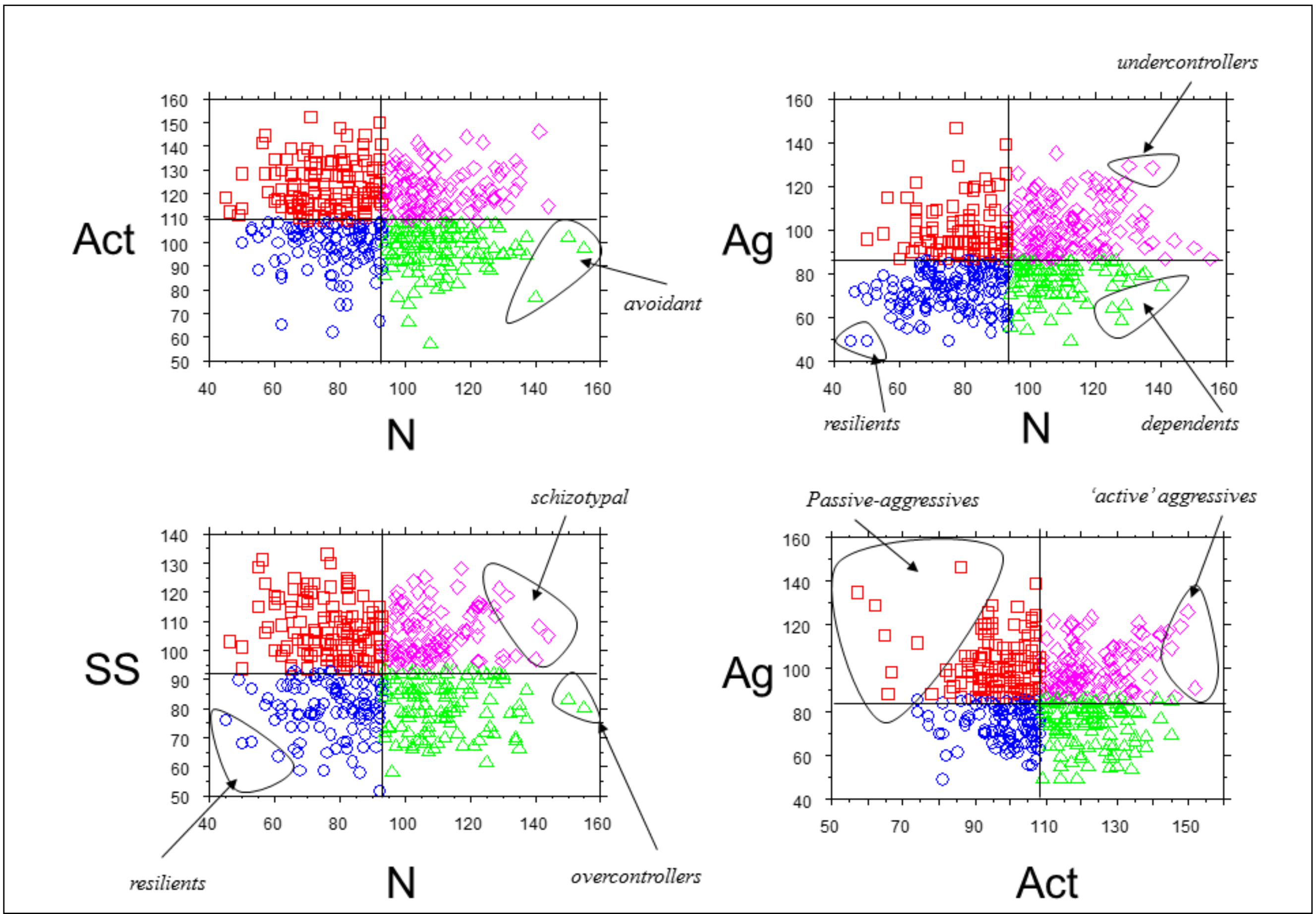
Two-dimensional plots

Figure 1 presents all 10 two-dimensional scatterplots, which correspond exactly with the correlations appearing in Table 1. In these plots, we combine a dimensional approach with our discrete approach, by plotting each participant within the plane, partitioning the plane following our median splits, and representing each participant accordingly. Note that in the log-linear analysis, participants lying within the same quadrant of the scatterplot are treated equally.

Where possible, we have labelled each quadrant using a suitable term from the framework of the Big Five (Wiggins, 2003, pp. 270-275). Here are some observations regarding a number of these planes. The E × N plane portrays the -.42 correlation between E and N, which following median splits becomes smaller, namely $\phi = .31$. Note that there is no evidence for discrete clusters in this space, hence a search for a personality type here would be unproductive. Nevertheless, in the quadrant labelled "Gloomy Pessimists", we note what might well be such a discrete cluster, worthy of further study. Turning to the E × Act interaction, we note that in the quadrant marked "The Lethargic", there might again be a cluster worthy of further investigation. As noted above, all the other two-way interactions are not strong. For example, this can be seen in the E × Ag interaction, which displays practically homogenous dispersion around the center of this plane. Nevertheless, in the quadrant labelled "Schizotypal", there might well be the beginning of a discrete cluster here. In line with footnote 2, above, schizotypal personality should have an E-Ag- N+SS+ profile; thus the E-Ag- quadrant ("Schizotypal") is only partly predictive here. We note from this E × Ag scatterplot just where to investigate, and further why our own use of median splits would not enable us to pinpoint such a personality type.

We further note that both bimodality and asymmetry of the trait distributions would be indicative of subgrouping (Fleiss, Lawlor, Platman, & Fieve, 1971), hence of the feasibility for conducting cluster analysis, or some other technique relying on continuous variables. Our data, however, revealed no bimodality, and apart from E also no asymmetry. Hence, we can safely rule out that option. Indeed, as Fleiss et al. (1971, p. 127) stated, "If the univariate and multivariate distributions on all variables for a sample are unimodal and symmetric, then the sample is most likely homogeneous as far as the variables employed are concerned, and it would be hard to justify using the given data for generating types." What we do suggest, however, is that the use of two-dimensional scatterplots, with superimposed median

Figure 1. Two-dimensional plots (continued next page)



splits, as in the present paper, is a practical and convenient means for visualizing personality space, and for suggesting particular regions of the space in which one can identify personality types.

Is there evidence for any of the types noted previously? The antisocial personality might have some representatives here in the SS+Ag+ quadrant of the SS × Ag plane; the avoidant personality might be seen in the N+Act- quadrant of the N × Act plane; and in the Ag × Act plane, there might well be some 'passive-aggressives' in our sample. Of course, given that we did not actively recruit clinical populations, the fact that major personality disorders are not clearly seen in our data is more reflective of our choice of sample, and less of our method of data analysis.

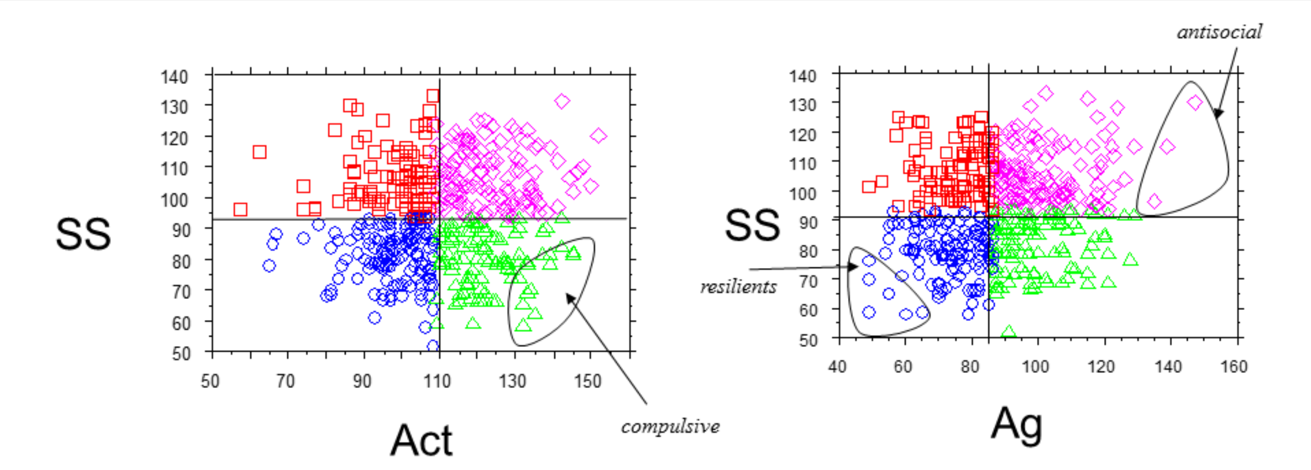
We can also see whether we can identify the three personality types, reported in the literature (Asendorpf, Borkenau, Ostendorf, & van Aken, 2001; Costa, Herbst, McCrae, Samuels, & Ozer, 2002; De Fruyt, Mervielde, & Van Leeuwen, 2002; Rammstedt, Riemann, Angleitner, & Borkenau, 2004), that have been termed 'resilients', 'undercontrollers' and 'overcontrollers'. In the Alternative Big Five personality space, resilients should be N-Ag- (Surányi, Rózsa, Kasek, & Aluja, 2014), undercontrollers should be N+Ag+ (Claes et al., 2006; that is, given what should be a negative correlation between Ag (aggression) and A (agreeableness)—see Aluja et al., 2002), and overcontrollers, who in the personality space of the Big Five are N+C+O- (Claes et al., 2006), should in the present space be N+SS-, given that C-O+ should be indicative of sensation seeking, as reported by Connelly, Ones, Davies, and Birkland (2014). In Figure 1, we have indicated what might be clusters worthy of further investigation (that is, given a wider sampling of individuals, including from clinical populations) that may reflect these particular types. Such individuals can then be further investigated using person-centered approaches (Asendorpf, 2006; Hofstee, 2002; McCrae et al., 2006b).

We stress, however, that these surface-level relationships cannot possibly resolve the complexity of the log-linear model that fits this personality space. Beyond the two-way relationships, there are also higher-order interactions in the model. Nevertheless, in the present paper we shall leave our analysis at the two-dimensional level, as do others (Burns et al., 2014; Hofstee et al., 1992; Markey & Markey, 2006).

DISCUSSION

Our major contribution to investigating multidimensional personality space involves plotting all 10 two-dimensional scatterplots, with superimposed median splits, as a visual aid in interpreting the two-way interactions, which are all required by the log-linear model. Previous studies have employed similar plots ('style graphs') for investigating types within the Big Five (Fang, Heisel, Duberstein, & Zhang, 2012; Weiss et al., 2009). In our plots, we see both the non-

Figure 1. Two-dimensional plots (continued)



homogeneity of personality space (indicative of a gestalt[8]) captured in these two-dimensional projections, but also areas in which personality types (again, indicative of a gestalt[9]) might well be found. We note here a technical problem stressed by Merz and Roesch (2011, p. 916), that "… it is often impractical to model all higher-order interactions of interest…." We suggest that a close inspection of the 10 two-dimensional scatterplots is a necessary first step in studying a high-dimensional personality space.

Investigating the structure of personality space

How would Allport or Eysenck view our approach to investigating the internal structure of personality space? Allport's (1937, p. 347) attack on 'factorial psychology' with its additive model for personality clashed with Eysenck's (1952) advocacy for such a view. As Eysenck (1952, p. 18) proclaimed, explicitly in response to Allport (and in italics), "*To the scientist, the unique individual is simply the point of intersection of a number of quantitative variables*." And, further on (p. 278): "The elementaristic method of *adding* scores along well-known lines of multiple prediction is shown to be conspicuously superior to the organismic method of *organizing* data into a meaningful dynamic pattern for each subject." And yet, the internal structure of Eysenckian space might well reveal that once one goes beyond a standard 2^3 (= 8) sector partitioning of this space, not all profiles actually arise in one's data set. For example, the familiar negative correlation between E and N, uncovered both here and by others (Buckingham et al., 2001), was found in one study to be "due to a lack of individuals in the low N, low E quadrant" (Crookes, 1979, p. 63).

Be that as it may, Eysenck's argument regarding personality as being 'the point of intersection', cited above, has been rejected by contemporary authors advocating a person-oriented view on personality (Uher, 2015, p. 601). Indeed, Allport (1961, p. 8) came out very strongly in response to this statement by Eysenck, writing:

> "What does this statement mean? It means that the scientist is not interested in the mutual interdependence of part-systems within the whole system of personality. He is interested only in separate dimensions whereby he can compare many persons.... The person is left as mere 'point of intersection' with no internal structure, coherence, or animation. I cannot agree with this view."

In this respect, we feel that Allport would welcome our approach, though perhaps would be wary of our focus on what today is considered to be a variable-oriented study (e.g., von Eye & Bogat, 2006).

Limitations and other considerations

Our choice of median splits to partition personality space is an accepted procedure (Krauth, 1985, 2003), though its limitations are readily acknowledged (Garcia, MacDonald, & Archer, 2015; Krauth, 2003). Let us, however, mention a

[8] In a letter to his then doctoral student, Molly Harrower, dated March, 1933, the renowned Gestalt psychologist Kurt Koffka writes that he has some exciting ideas about the Ego: "… the real, psychophysical Ego is not identical with the phenomenal Ego, but it is permanent… this makes a theory of personality possible" (Harrower, 1983, p. 31). Two years later, with the publication of Koffka's (1935) classic book, *Principles of Gestalt psychology*, his enthusiasm is given full voice:

> The question, therefore, can be formulated: Is personality a gestalt, and if so, what kind of gestalt is it? These are concrete questions which can be investigated by scientific methods. What would it mean if personality were not a gestalt? That its different behaviour units or traits were independent of each other and could be united in any combination. If, on the other hand, personality is a gestalt, then there would be interdependence between its various manifestations, and a great number of combinations of traits would be excluded. (p. 677)

The question whether personality is a *gestalt*, is one which, of course, was also given voice by Gordon Allport (Allport, 1937). Following Koffka (1935), one would not expect a uniform distribution of individuals within a multidimensional personality space.

[9] Writing in the same years, Gardner Murphy (1932) suggests:

> In all probability there are certain stable kinds of interaction, constituting personality types, and it is the business of the psychologist to help find these…. But if this new view is sound, as can only be proved by further quantitative measurement, it means that there are a finite number of possible kinds of personality types, and it is the business of the scientist to find out what those are in order that effort may be directed in useful directions. (p. 318)

Following Murphy (1932), one would expect to uncover such personality types, especially if there is a wide sampling of populations (both normal and clinical) within this personality space.

limitation that might be raised with respect to the present analysis, that "interactions may be caused which do not seem to be present in the original data" (Krauth, 2003, p. 324). The two-way interactions, such as E × Ag and E × Act, found using the log-linear approach, are consistent with the negative correlation found for E and Ag, and the positive correlation found for E and Act (see Table 1). Furthermore, our simulation study suggests that the two-way interactions that we report are quite characteristic of the sample of multivariate normal data sets generated. Hence, the spectre of this type of artifact can be ruled out.[10]

A limitation of our analysis is that we have looked at 32 cells based on median splits. Given our sample size of 460 participants, this seems to be a reasonable choice. But, consider the option of categorizing our participants along each dimension based on quartiles. On the one hand, this would certainly provide for a more refined partitioning of personality space. Instead of $2^5 = 32$ regions, one would be considering $4^5 = 1024$ regions. On the other hand, sample size would now need to be in excess of 14,720 individuals in order to achieve the same ratio of individuals-to-regions, as in the present sample.

In this first pass at looking at the internal structure of multidimensional personality space, we must raise a major limitation of the present study: We cannot possibly completely disentangle the nature of this space from the nature of our particular sample of participants. While we can effectively rule out the possibility that age and/or gender played a major role in determining the interactions uncovered,[11] we must consider the fact that a more heterogeneous sample might better uncover the non-homogeneity of personality space. Hence, it is of paramount importance to replicate this study, using the same questionnaire for assessing the five dimensions of the Alternative 5, but with a completely different sample. One option, of course, would be to see how log-linear modelling reveals both similarities and differences in the underlying structure of the ZKA-PQ personality space, as one moves from one culture and language to another. Our colleagues from around the world (Rossier et al., 2016) are welcome to check this in their own data. Another option would be to move out of the space defined by the Alternative 5, and to look at the results of such log-linear modelling for the Big Five (Aluja, García, & García, 2004; Zuckerman et al., 1993). Of course, one could also look at the Big 3 (Zuckerman, Kuhlman & Camac, 1988). There is much to explore here.

Implications and conclusions

What are the implications of our results for personality assessment? Three practical considerations come to mind. First, in addition to assessing personality using a standard questionnaire, one should plot these data, and thereby locate the individual with respect to the whole sample within personality space. Much can be gained regarding personality assessment when inspecting the two-dimensional plots. Second, personality typology, personality dimensions, personality assessment, and personality space are all part and parcel of adopting a *Gestalt* approach to the study of the structure of this space. Third, trait-trait interactions should be intensively assessed. A strictly additive approach to personality assessment might have been convenient in the past (Markey & Markey, 2006, p. 170); future research should be engaged with a more interactive view of what is required for personality assessment. Log-linear modelling of these trait-trait interactions is one tool that should be useful in this endeavor.

We stress that the two-dimensional plots, their corresponding bivariate correlations, and their associated two-way interactions in the log-linear model, while all being informative on their own, are also somewhat redundant in that they all depict the same surface-level, two-way relationships. The contribution of a log-linear model here is to go beyond these surface-level, two-way relationships, and to take into account the higher-order interactions present in the model. How to relate the complexity of the analysis (model) while achieving an understanding of the nature of this personality space is worthy of further study.

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[10] In the recent cross-cultural study of the ZKA-PQ (Rossier et al., 2016), sample means for both male and female participants, in separate, in each country are reported. We looked at the median values for these means, in comparison to the cut-off points (medians) employed in the present study. These are as follows: E—117; N—94; SS—94; Ag—90; and Act—110. Even given the wide dispersion of mean values across country (e.g., for N, these means range from 82.07 and 104.97), our own median values seem quite reasonable. Hence, even though we are not able to cross-validate our results on an independent sample, we would not expect to see vastly different differences within our own cultural setting.

[11] A preliminary test indicated that the distribution of participants appearing in Table 2 was not uniform ($\chi^2 = 60.3$, $df = 31$, $p < .005$). Analysis of the residuals pinpoints those cells with a significantly larger-than-expected *n*, namely (SS+Ag+Act+N-E+; *n* = 30), (SS+Ag+Act-N+E-; *n* = 30), and (SS-Ag+Act-N+E-; *n* = 34), and those cells with a significantly lower-than-expected *n*, namely (SS+Ag-Act-N+E+; *n* = 3) and (SS-Ag+Act+N-E-; *n* = 4). Could these aberrant cells reflect perhaps younger or older participants? We ran a five-way ANOVA, having these grouping factors, with age as dependent variable. For those 3 cells having larger-than-expected cell counts, mean age ranged between 24.8 and 30.2; for those 2 cells having a lower-than-expected cell count, mean age ranged between 30.0 and 35.2. Of the 31 significance tests incorporated in the five-way ANOVA, only 1 was significant at the .05 level (a main effect for N). Hence, the age of the participants does not seem to impact on their place within this personality space. Looking at gender, we did find that for one cell having a significantly lower-than-expected cell count, all 3 participants were female. But, this was also the case for three other cells. Thus, gender also does not seem to play a critical role here.

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