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Gray's Model of Personality and Aggregate Level Factor Analysis

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Abstract

Previous research shows that correlations tend to increase in magnitude when individuals are aggregated across groups. This suggests that uncorrelated constellations of personality variables (such as the primary scales of Extraversion and Neuroticism) may display much higher correlations in aggregate factor analysis. We hypothesize and report that individual level factor analysis can be explained in terms of Giant Three (or Big Five) descriptions of personality, whereas aggregate level factor analysis can be explained in terms of Gray's physiological based model. Although alternative interpretations exist, aggregate level factor analysis may correctly identify the basis of an individual's personality as a result of better reliability of measures due to aggregation. We discuss the implications of this form of analysis in terms of construct validity, personality theory, and its applicability in general. Copyright © 2003 John Wiley & Sons, Ltd.

INTRODUCTION

The development of a universal trait based model of personality centres upon the number of broad or super factors of personality. Most debates discuss differences between the 'Big Five' of Costa and McCrae (1985, 1992) and Eysenck's 'Giant Three' factor model (see e.g. Eysenck, 1967; Eysenck & Eysenck, 1985), although many others have contributed to the discussion (Block, 1995; Brand, 1994; Cattell, 1995; Digman, 1990; Goldberg, 1993; Kline, 1993; McAdams, 1992; Salgado, 1997; Zuckerman, 1992). In an effort to determine a universal model of personality, researchers generally use factor analysis to identify varying numbers of factors within different personality questionnaires.

It is possible to distinguish models of personality in terms of whether they are based on descriptions of people (e.g. the linguistic model based on adjectives, exemplified by

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Goldberg, 1993) or theoretically based (e.g. the biological model of Gray, 1982, 1987). Seen this way, we would expect the five factor model to provide a better description of people, whereas Gray's model might be expected to offer a superior explanation of the basis of personality. According to Gray's model, impulsivity has a biological basis in the Behavioural Activation System (BAS), and anxiety has a basis in the Behavioural Inhibition System (BIS). The BAS is associated with impulsivity, such that highly impulsive people learn best from, and are motivated by, reward. On the other hand, people with heightened reactivity to the BIS are sensitive to fear and punishment, and therefore high scorers on anxiety are thought to learn best from, and be motivated by, punishment. A third aspect of the theory labelled Fight/Flight is less well understood but relates to aggressive responses to threats or escape from threats (Corr, 2001; Matthews & Gilliland, 1999). This model is most often thought to be a 45° rotation of Eysenck's model, but recent clarification suggests that Impulsivity is aligned at 30° to Extraversion, and Anxiety is aligned at 30° to Neuroticism (Pickering, Corr, & Gray, 1999). The importance of Gray's model is summed up by the following sentence. 'Gray's personality model could be considered one of the most powerful frameworks for the study of human disinhibition' (Avila, 2001, p. 311).

Despite providing a behaviourally and physiologically based explanation of personality, as yet there is no factor analytical support of Gray's model (Wilson, Barrett, & Gray, 1989; Wilson, Gray, & Barrett, 1990). One study (Jackson, 2002) determines how well Gray's scales explain each of the 21 Eysenck Personality Profiler (EPP) primary scales, as well as the higher order Extraversion, Neuroticism, and Psychoticism scales of the short version of the EPQ-R (Eysenck & Eysenck, 1985). Eysenck's model of personality is interesting in that it is primarily based on factor analytical description like the five factor model, but also possesses a biological basis. Jackson argues that if Gray's model of personality explains the personality scales of the EPP and EPQ-R (which are argued to represent the surface or observable components of personality), then one could also regard it as being a reasonably complete model of the basis of personality. Alternatively, if Gray's model were unable to explain the EPP and EPQ-R scales very well, then it would seem as though it is, at best, only a partial explanation of the whole domain of personality, since other factors must be operating. At the individual level of analysis, Jackson reports that Gray's scales of personality generally provided a weak explanation of the EPP primary scales, suggesting that Gray's model has little utility in explaining personality at the individual level of analysis.

Aggregation of data tends to increase the magnitude of correlations between variables, because they increase weak linear relationships by eliminating within-group, individual error (see e.g. Angle & Perry, 1981; Dansereau, Alluto, & Yammarino, 1984; Glick, 1985; Glick & Roberts, 1984; Jackson & Corr, 1998; James, 1982; Mossholder & Bedeian, 1983; Ostroff, 1992; Schmitt, Colligan, & Fitzgerald, 1980, and see Ostroff, 1993, for a very thorough discussion of the theoretical, methodological, and statistical bases of aggregate data). It therefore seems likely that aggregation may increase the strength of the relationship between surface scales of personality as measured by Giant Three or Big Five personality questionnaires.

One way to aggregate personality data is to shift the focus from individual scores to average scores of social groups, which is termed aggregation over subjects (Epstein, 1980). The resulting data consists of an average representing each social group (but containing no data representing within-group variance).

Why should we be interested in personality analysis of social groups instead of individuals? First, whilst the use of aggregation, as used in this study, is probably unique,

the more general use of aggregation is hardly new in personality psychology and has made an exceptional contribution to the discipline. Aggregation as a general methodology is not necessarily a strange thing to do, when it is remembered that individual level data are themselves based on aggregated item level data. The general reason why we aggregate across items is that we prefer to improve reliability by sampling a variety of similar items as opposed to simply correcting for attenuation at the item level. It may be that we can further improve reliability by sampling across similar individuals as opposed to correcting for attenuation at the individual level.

Four types of aggregation are identified, including: aggregation over stimuli or situations, aggregation over trials and/or occasions, aggregation over measures, and aggregation over subjects (Epstein, 1980). As noted earlier, our focus is purely on the last type, aggregation over subjects. Epstein (e.g. Epstein, 1980) presents evidence of the stability of behaviour across situations and over time by using aggregated measures and demonstrates that aggregated data are more reliable than individual measurements, as incidental factors cancel out and validity increases. Aggregation over subjects is widely used in social psychological research to compare experimental conditions. Jackson and Corr (1998) also demonstrate that aggregated personality scores across groups are excellent predictors of performance, whereas individual level analyses are poor predictors—in other words they found that the removal of within group variance emphasized a weak relationship that was otherwise not possible to detect.

Following Epstein's (1980) line of reasoning, it seems possible that aggregate level analysis might provide a better representation of the basic structure of personality than that provided by individual level analysis. Let us suppose that the basic or source structure is defined in terms of reward, punishment, and fight/flight processes as defined by Gray (1982, 1987). This structure might not be observable at the individual level of analysis, because of random error that leads to the under-estimation of correlations between scales (following the arguments summarized by Ostroff, 1993). As a result, surface scales of personality are observable only in terms of the Giant Three or Big Five models, as opposed to Gray's source structure, which is only revealed by utilizing the higher scale reliabilities achieved by aggregate analysis.

An alternative explanation of any possible differences between aggregate and individual level analysis is that within group variation is mainly the result of systematic differences between individuals and therefore its removal results in a faulty analysis, commonly known as the ecological fallacy (Robinson, 1950).

There is however, theoretical justification from the literature for supposing that individual differences in personality between people within the same social group are best understood in terms of their similar reward and punishment pathways. In fact, these issues are indirectly explored in a variety of contexts, which leads to some *convincing* support for this proposition.

First, research supports the idea that levels of reward and punishment may be similar within occupational and other social groups, and that it is maintained by the group. Havighurst (1970) reports wide ranging evidence in favour of similar reward and punishment amongst the same members of different social classes. Reward and punishment also seem to be widely regarded as descriptive of occupational groups in general. Seen this way results from work settings demonstrate that personality, affect, and behaviour may be understood at the group level of analysis (George, 1990). Theoretically, George (1990) proposes that people with similar personalities tend to be found in the same occupation through a process of attraction–selection–attrition, which operates at the group

level, in addition to the individual level, of analysis. Her findings demonstrate that individual affect is consistent within groups, implying that the affective tone of a group is a meaningful construct. Also negative group affect relates to the extent to which a group engages in prosocial behaviour, whereas positive affective tone relates to absenteeism, demonstrating criterion related validity. These findings together imply that anxiety and reward may operate legitimately at the group level of analysis and that homogeneity within groups is both high and descriptive in terms of sensitivity to rewards (salary, sources of satisfaction, opportunities, etc.) and sensitivity punishment (threats from superiors, stress, etc.).

Others also emphasize the reward and punishment characteristics of groups to ensure correct behaviour of individuals (Furnham, 1997). Indeed, O'Reilly and Puffer (1989) found that inappropriate rewards and punishment led to lower motivation, satisfaction, and equity amongst task group members. They concluded that individuals within a group monitor the rewards and punishments given to others.

Second, further support for the notion of individual conformity to the group comes from social identity theory. This is an inter-group theory that focuses on an individual's need to maintain and enhance the positively valued distinctiveness of their in-groups compared with out-groups in order to achieve a positive social identity (Tajfel & Turner, 1979; Turner, 1975). Social identity is defined by Tajfel (1978) as 'being that part of an individual's self-concept that is derived from their knowledge of their membership of a social group (or groups) together with the value and emotional significance attached to those memberships' (p. 63). Turner, Hogg, Oakes, Reicher, and Wetherell (1987) show that an individual reports him or herself as embodying characteristics deemed typical of the social group. Farwell and Weiner (1996) discuss the tendency for a group to maintain its social identity, such that individuals within a group achieve conformity by positive reward of in-group members and punishment of out-group members. Interestingly, Terry, Hogg, and McKimmie (2000) find evidence that conforming to social identity is predictive of behaviour, and trait theory of personality is also about the measurement of consistent behaviour.

Research also demonstrates that personality and ability predict both work team processes and effectiveness (Barrick, Stewart, Neubert, & Mount, 1998). These results show that work teams with higher levels of general mental ability receive higher supervisory ratings for team performance than groups with higher levels of conscientiousness, agreeableness, extraversion, and emotional stability. However, teams higher in general mental ability, extroversion, and emotional stability receive higher supervisory ratings for team viability. The relationship of extraversion and emotional stability with team viability is mediated by social cohesion (Barrick et al., 1998; for partial replications see also van Vianen & De Dreu, 2001; and for non-linear effects of personality in teams see Barry & Stewart, 1997). These results, and those of others (e.g. Levine & Jackson, 2002), examine the criterion related validity of aggregated personality without consideration of what constitutes aggregate personality. Given that these results suggest that team processes are reflected by personality, in terms of extroversion (which relates to Gray's notion of impulsivity) and emotional stability (which resembles Gray's notion of anxiety), this provides additional support for the notion that Gray's theory of personality may be identified at the aggregate level of analysis.

Third, a number of studies demonstrate the importance of understanding personality effects at even higher aggregate levels of analysis. For example, in a study of national crime levels in 37 countries, Eysenckian measures of Psychoticism, Extraversion, and

Neuroticism were aggregated to the country level of analysis. These findings demonstrate that national levels of criminal activity relate to extraversion (Kirkcaldy & Brown, 2000).

Finally, the only multi-level study of behavioural activation and inhibition that we have identified demonstrates the functions by which BIS and BAS processes differ by level of analysis (Gable, Reis, & Elliot, 2000), but does not address the issues raised in this paper. In sum, research suggests that there is reasonably strong evidence of similar reward and punishment pathways between individuals within groups.

The tested hypothesis is that aggregate personality analysis of groups will show a personality structure according to Gray's physiologically based personality theory, whereas individual factor analysis will show a more traditional three or five factor analytical structure. Such a result will suggest that differences in the personality of groups may be understood in terms of Gray's theory and will also provide the first factor analytical evidence in favour of Gray's model.

METHOD

Participants

A total of 3403 individuals participated in this study based on 22 different social and occupational groups (described in Table 1). Each group consisted of individuals from one single coherent social group or organisation (thus, for example, the bikers were all surveyed on a single tour, the physicists were all members of the Institute of Physics, and the IT workers were all members of the same organization). Groups were split by sex since it is known that there can be quite large mean differences between men and women in some of the neuroticism and psychoticism scales, at the individual level of analysis. Most of the groups used in this study have been more fully described elsewhere (Jackson, Furnham, & Lawty-Jones, 1999; Jackson & Wilson, 1993, 1994; Wilson & Jackson, 1994; Jackson, Furnham, Forde, & Cotter, 2000).

Procedure

Personality Questionnaire: Eysenck Personality Profiler (EPP)

The Eysenck Personality Profiler (EPP; Eysenck & Wilson, 2000)[1] is a 420 item questionnaire measuring 21 primary scales that provide a reasonable fit to the Giant Three model of Eysenck and the Big Five model of Costa and McCrae. The factor structure of the EPP has been investigated (Costa & McCrae, 1995; Eysenck, Barrett, Wilson, & Jackson, 1992; Jackson et al., 2000), specific groups have been studied (Jackson et al., 1999; Jackson & Wilson, 1993, 1994; Wilson & Jackson, 1994), and it has been the centre of theoretical work (e.g. Furnham, Forde, & Cotter, 1998a, 1998b; Jackson, 2002; Jackson & Corr, 1998; Jackson et al., 1999). Recently, Jackson et al. (2000) suggested that the EPP provides a reasonably complete description of personality and that either a three or five factor solution provides a good summary of its factor structure. It is therefore an ideal instrument for the purposes of the present study.

[1]The EPP is available from Chris Jackson.

Table 1. Summary descriptive statistics of the different social and occupational groups

	n	E	N	P
Area sales managers (males)	34	22.40 (3.19)	5.90 (3.64)	19.41 (4.21)
Area sales managers (females)	15	20.39 (3.87)	7.04 (2.68)	17.40 (2.73)
Computer engineers (males)	53	22.26 (3.93)	6.41 (3.67)	18.97 (4.04)
Engineers (males)	43	20.39 (3.49)	5.28 (3.55)	19.56 (3.32)
Recruitment consultants (males)	13	24.51 (3.53)	7.19 (3.38)	21.19 (3.66)
Physicists (males)	109	16.93 (4.39)	8.47 (4.58)	16.86 (3.41)
Physicists (females)	133	17.25 (4.31)	9.91 (4.56)	14.69 (3.40)
Voluntary workers (females)	15	15.93 (4.16)	9.62 (5.08)	15.22 (2.66)
Warehouse staff (males)	44	18.36 (4.74)	11.07 (6.05)	19.69 (4.77)
Cosmetic sales (males)	77	21.65 (3.43)	7.97 (4.56)	19.00 (3.85)
Cosmetic sales (females)	19	22.82 (3.58)	8.92 (2.50)	19.12 (3.86)
Solicitors (males)	41	21.99 (3.83)	7.12 (5.99)	18.93 (3.82)
Bikers (males)	22	19.55 (3.81)	9.90 (4.82)	23.43 (3.42)
Bikers (females)	7	16.39 (3.34)	12.16 (4.67)	20.24 (4.19)
IT workers (males)	1445	20.65 (4.12)	7.93 (5.35)	20.12 (3.77)
IT workers (females)	1108	19.98 (3.94)	9.01 (5.08)	17.39 (3.64)
Students (males)	35	20.87 (4.23)	11.27 (4.64)	22.89 (3.45)
Students (females)	58	17.73 (4.11)	12.82 (5.30)	18.16 (3.83)
Blue chip sales (males)	46	21.11 (4.12)	10.96 (6.09)	20.87 (4.21)
Blue chip sales (females)	29	19.43 (3.88)	12.75 (4.19)	18.69 (4.63)
Veterinary (males)	15	20.55 (4.22)	7.00 (3.57)	16.65 (2.47)
Veterinary (females)	42	17.57 (3.81)	9.62 (4.85)	15.38 (3.67)
Total	3403	20.01 (4.24)	8.57 (5.21)	18.68 (4.07)

Extraversion (E), Neuroticism (N), and Psychoticism (P) scales are calculated by averaging the E, N, and P primary scales respectively as shown in Table 2. This table provides a useful summary of differences between the groups using the Giant Three personality classification. Means and (standard deviations) are shown.

Statistical analysis

The multi-level modelling option of the LISREL software package (Jöreskog & Sorbom, 1996) was used. Level 1 was specified as the 21 EPP primary scales (which are nested within participants), level 2 was chosen to be the participants (who are nested within social and occupational groups), and level 3 was chosen to be the social and occupational groups as specified in Table 1. Level 2 therefore represented individuals and level 3 represented aggregated individuals within groups. A multivariate empty model was fitted. Although this is a model without explanatory variables, it is useful to decompose the raw variances and covariances into the parts explained by level 2 and level 3. The procedure used in this study closely follows the example of multivariate analysis of educational data reported by Jöreskog, Sörbom, du Toit, and du Toit (1999) and more generally explained by Snijders and Bosker (1999, Chapter 13).

The level 2 and level 3 matrices were then separately used in a maximum likelihood exploratory factor analysis with varimax rotation to determine the factor structure at these two different levels of analysis. Both Snijders and Bosker (1999) and du Toit, du Toit, Jöreskog, and Sörbom (1999) specifically remark that such analyses are both meaningful and useful. Exploratory rather than confirmatory factor analysis was chosen, as this is an original study and therefore we had no prior evidence that any model of personality would be more suitable than another at the aggregate level of analysis. At both the individual and aggregate levels of analysis, three factors were rotated orthogonally after extraction using

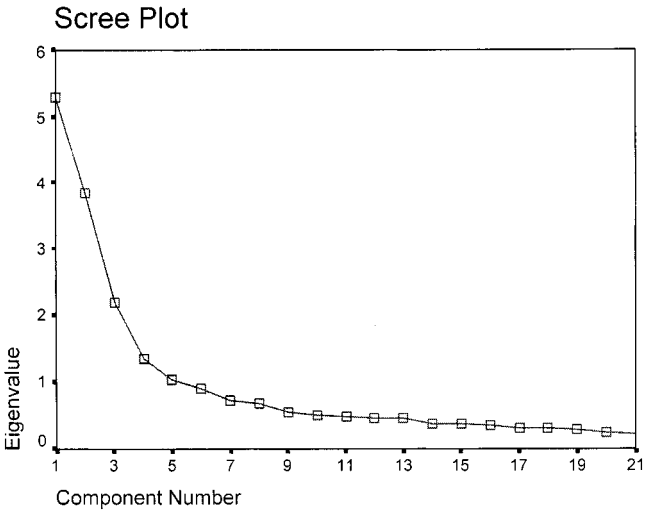

Figure 1. Scree plot of individual analysis of the EPP primary scales.

the scree slope methodology (see Figure 1 and Figure 2). Note that the number of EPP factors to be extracted at the individual level was discussed by Jackson et al. (2000) and is beyond the scope of this study.

RESULTS

Means and standard deviations of the EPP scales for the different social groups are shown in Table 1. Alpha reliabilities for the EPP scales are known to be at least reasonable and are summarized from results of several studies by Jackson et al. (2000).

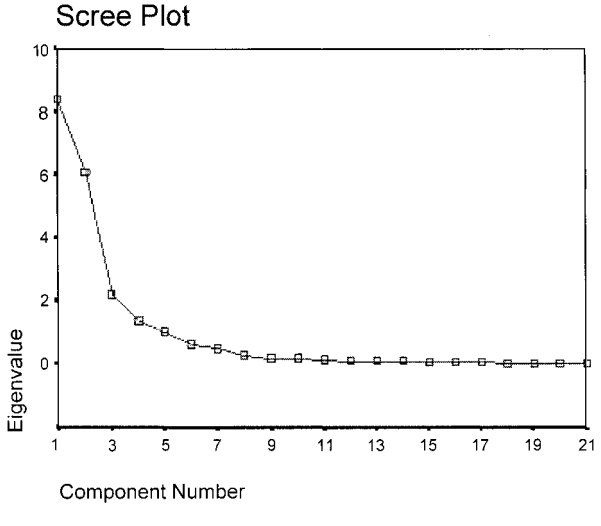

Figure 2. Scree plot of aggregate analysis of the EPP primary scales.

Table 2. Intra-class correlation coefficients

Scale name	ICC
E1 Activity	0.15
E2 Sociability	0.18
E3 Assertiveness	0.07
E4 Expressiveness	0.15
E5 Ambition	0.26
E6 Dogmatism	0.04
E7 Aggression	0.09
N1 Inferiority	0.14
N2 Unhappiness	0.11
N3 Anxiety	0.12
N4 Dependence	0.14
N5 Hypochondriasis	0.11
N6 Guilt	0.06
N7 Obsessiveness	0.05
P1 Risk-taking	0.10
P2 Impulsiveness	0.10
P3 Irresponsibility	0.17
P4 Manipulativeness	0.13
P5 Sensation-seeking	0.09
P6 Tough-mindedness	0.16
P7 Practicality	0.08

Table 2 presents the intra-class correlation coefficients, showing the amount of variance explained by individuals within the different social and occupational groups. Results indicate that, whilst a lot of variance does result from other sources, a useful amount of variance for most of the primary scales can be attributed to the effect of group level of analysis (ranging from 4 to 26%).

Table 3 presents varimax rotations of the maximum likelihood factor analyses at the individual and group levels of analysis. The percentage of variance in the solution accounted for by a factor is shown (following the methodology described by Tabachnick & Fiddell, 1989). Results indicate that a little more variance is explained by Factor I and Factor II at the group level compared with the individual level. The individual level analysis reflects the familiar Eysenckian scales of Extraversion, Neuroticism, and Psychoticism and has been reported elsewhere, although with a different dataset (Jackson et al., 2000). The aggregate level factor analysis presents a very different solution. Factor I consists of Activity, Expressiveness, Ambition, Dogmatism, Emotional stability (i.e. almost all the Neuroticism scales) and low irresponsibility. This factor reflects the inhibitory BIS (Anxiety) such that low scorers are anxious. Factor II consists of Sociability, Assertiveness, Risk taking, Impulsiveness, and Sensation seeking. This factor seems to reflect the activating nature of the BAS (Impulsiveness). Factor III consists of Aggression, Manipulativeness, and Tough-mindedness. This seems to reflect the Fight/Flight System proposed by Gray. Obsessiveness is the only EPP scale not to have any major loading on any of the three factors and contrasts with the individual level factor analysis, in which it loads on all three factors.

Other results of the multi-level analysis need only be summarized. One of the EPP scales (Irresponsibility) showed a significant fixed effect, indicating significant differences in the intercept of this scale across the groups. There was however generally significant

Table 3. Comparison of factor structure between individual and aggregate level analyses

	Individual level analysis			Group level analysis		
	I N	II P	III E	I BIS (Anx)	II BAS (Imp)	III FFS
% var. in solution	50.00	30.02	19.98	55.86	31.33	12.79
Cum. % var.	50.00	80.02	100.00	55.86	87.19	100.00
E1_ACT	0.28	0.25	0.51	0.95	0.19	0.09
E2_SOC	0.31	0.33	0.36	0.52	0.79	−0.05
E3_ASS	−0.22	0.49	0.32	−0.10	0.94	−0.15
E4_EXP	0.35	0.37	0.53	0.76	0.43	0.41
E5_AMB	0.07	0.02	0.69	0.91	0.34	−0.10
E6_DOG	−0.39	0.24	0.34	−0.60	0.24	0.46
E7_AGG	−0.35	0.50	0.20	−0.45	0.52	0.73
N1_INF	−0.81	−0.05	−0.26	−0.93	−0.08	−0.33
N2_UNH	−0.81	0.10	−0.11	−0.97	0.04	0.04
N3_ANX	−0.80	0.02	−0.05	−0.87	0.13	−0.30
N4_DEP	−0.79	0.09	−0.13	−0.97	−0.02	−0.04
N5_HYP	−0.70	0.06	0.12	−0.95	0.24	0.00
N6_GUI	−0.77	0.16	0.08	−0.67	0.32	−0.43
N7_OBS	−0.49	−0.27	0.48	−0.07	0.00	−0.29
P1_RIS	0.11	0.76	−0.09	−0.09	0.93	0.16
P2_IMP	−0.23	0.63	−0.03	−0.52	0.77	0.23
P3_IRR	−0.25	0.54	−0.42	−0.80	0.49	0.05
P4_MAN	−0.11	0.37	0.10	0.24	0.55	0.69
P5_SEN	0.08	0.65	0.18	0.23	0.85	0.29
P6_TOU	0.22	0.30	0.03	0.27	−0.04	0.90
P7_PRA	0.16	0.00	−0.23	−0.37	0.54	0.53

Maximum likelihood factor analysis with varimax rotation was used.
Factor loadings with absolute values above 0.35 are underlined for the individual analysis, and factor loadings greater than 0.66 are underlined for the aggregate analysis.
E = Extraversion, N = Neuroticism, P = Psychoticism, BIS = Behavioural Inhibition System (also known as Anxiety), BAS = Behavioural Activation System (also known as Impulsivity), FFS = Flight/Flight System.
E1 = Activity; E2 = Sociability; E3 = Assertiveness; E4 = Expressiveness; E5 = Ambition; E6 = Dogmatism; E7 = Aggression; N1 = Inferiority; N2 = Unhappiness; N3 = Anxiety; N4 = Dependence; N5 = Hypochondria; N6 = Guilt; N7 = Obsessiveness; P1 = Risk taking; P2 = Impulsiveness; P3 = Irresponsibility; P4 = Manipulativeness; P5 = Sensation seeking; P6 = Tough mindedness; P7 = Practical.

variation and covariation in the random components of the model at both level 2 and level 3. Level 2 random effects tended to be larger than level 3 random effects.

To determine the stability of our results using all our data, we randomly split each group of the dataset into two equally sized sub-sets. We then performed maximum likelihood factor analysis with varimax rotation on the two sets of aggregate data. Results (shown in Table 4) indicate considerable similarity to the overall solution and suggest that our aggregate level results are not obtained as a chance deviation from the individual level. The BAS and BIS scales in particular are well reproduced. The Fight/Flight System is represented clearly by Aggression in all solutions, but Tough-mindedness drops out of one to be replaced with Obsessiveness, and Manipulativeness seems to become more of a BAS scale.

Correlations between the factors for the overall aggregate factor analysis are shown in Table 5. Results suggest that the extracted factors are close to being orthogonal.

Table 4. Factor loadings of aggregate data when split into two random groups of equal size

	I BIS	II BAS	III Fight/Flight	I BIS	II BAS	III Fight/Flight
% var. in solution	47.24	34.59	18.17	50.95	32.30	16.74
Cum. % var.	47.24	81.83	100.00	50.95	83.25	100.00
E1_ACT	−0.85	0.36	−0.18	−0.89	0.34	−0.06
E2_SOC	−0.46	0.55	−0.12	−0.38	0.65	−0.11
E3_ASS	−0.06	0.71	−0.44	0.28	0.94	−0.19
E4_EXP	−0.77	0.54	−0.17	−0.62	0.58	0.16
E5_AMB	−0.72	0.34	−0.49	−0.76	0.35	−0.37
E6_DOG	0.10	0.66	0.00	−0.03	0.50	0.28
E7_AGG	0.16	0.69	0.62	0.32	0.50	0.71
N1_INF	0.91	−0.22	−0.03	0.88	−0.05	−0.14
N2_UNH	0.90	0.23	−0.15	0.95	0.07	−0.03
N3_ANX	0.90	0.06	−0.12	0.80	−0.03	−0.24
N4_DEP	0.96	−0.01	−0.01	0.92	−0.06	0.05
N5_HYP	0.71	0.23	0.27	0.80	−0.01	0.07
N6_GUI	0.71	0.18	−0.31	0.54	0.26	−0.17
N7_OBS	0.02	0.22	−0.94	0.07	−0.13	−0.27
P1_RIS	0.17	0.82	0.21	0.13	0.70	0.37
P2_IMP	0.44	0.56	0.45	0.37	0.68	0.31
P3_IRR	0.73	0.45	0.34	0.74	0.39	0.25
P4_MAN	−0.11	0.88	0.17	−0.29	0.61	0.48
P5_SEN	−0.11	0.89	0.03	−0.28	0.80	0.24
P6_TOU	−0.22	0.27	0.37	−0.27	0.04	0.70
P7_PRA	0.04	0.14	0.54	0.37	0.06	0.57

Each social and occupational group was randomly split into two groups of equal size. Factor loadings of both random groups are generally very similar to those reported in Table 2 and to each other.

Table 5. Correlations between the factors in aggregate factor analysis

	I BIS	II BAS
II BAS	−0.11	
III FFS	0.29	0.02

We also correlated the orthogonal factor scores derived from the aggregate factor analysis with sex and age effects. This might be a useful test to determine whether results reflect confounding effects based on simple group demographic differences. Results are shown in Table 6 and show that correlations are very low except for that between sex and the Fight/Flight System.

DISCUSSION

Consistent with our expectations, based on previous knowledge about the effects of aggregation and our literature review, the results demonstrate that personality correlations are substantially larger with aggregate data analysis in comparison with individual data analysis. Such inflation of correlation coefficients is not unexpected, as previous research

Table 6. Correlations between aggregate scales and age and sex effects

	Sex	Age
BAS	−0.098**	−0.22**
BIS	−0.11**	0.11**
Fight/Flight	−0.46**	−0.01

**$p < 0.01$.
$N = 3400$.

has demonstrated that they also exist for personality–performance relations across different occupations (Jackson & Corr, 1998), organizational teams (see e.g. Barrick et al., 1998; George, 1990), and in a wide variety of non-personality related areas (Ostroff, 1993). Nevertheless, and more specifically, our results demonstrate that aggregate level factor analysis produces results that support a factor model of personality that is psychometrically similar to that of Gray's model.

(i) The aggregate level analysis suggests that the BAS system comprises the excitement seeking and impulsive components of Psychoticism as well as the sociable components of Extraversion. The results therefore suggest that this factor seems highly related to BAS type activity.
(ii) The second factor comprises activity type Introversion scales, low Neuroticism and low Irresponsibility, and seems plausibly related to BIS type activity or Anxiety. The further suggestion that individuals who are high in BIS are also irresponsible seems quite explainable, as motivation by punishment is likely to be a poor reinforcer of socially responsible behaviour.
(iii) The third factor comprises Aggression, Manipulativeness, and Tough-mindedness. This seems to clearly indicate an orientation towards Gray's Fight/Flight higher order factor.

It is notable that the results demonstrate greater correlations between the primary scales, and this leads to strong psychometric support for Gray's personality model at the aggregate level of analysis. The lower correlations between the primary scales at the individual level indicate support for Eysenck's factor analytical model. (It is noteworthy that the individual level analysis may also support a five factor model, but comparisons between three and five factor models at the individual level were not the purpose of this study and have been specifically addressed elsewhere, Jackson et al., 2000.) We conclude that differences in the average personality of groups are explainable in terms of a factor analytical representation of Gray's model. This intriguing finding suggests that the personality of groups may be described in different terms to that of individuals.

At the aggregate level of analysis, results suggest a link between individual difference research on personality and social identity theory. Social identity theorists propose a link between group norms and behaviour (Terry et al., 2000), and from this it is a small step to propose that the link between social group and personality might be well defined in terms of Gray's model of personality at the aggregate level of analysis. One interpretation is that Gray's theory of personality provides an excellent description of a group's social identity from the perspective of personality. It may be that the common personality or behaviour of a group (defined in terms of its reward and punishment orientation) might be a major cause of social identity, as opposed to the opposite model tested by Terry et al. (2000), in which social identity is thought to be the cause of behaviour.

The finding of an aggregate personality that works at the group level akin to Gray's individual level model of personality is difficult to question, as it represents an aggregate finding based on aggregate analysis. Nevertheless, the mechanism by which a physiological based model might work at an aggregate level is questionable.

It therefore seems possible that our aggregate results reflect chance variation derived from the small number of groups available for analysis. To counter this argument, we divided each group into two equal samples and once again conducted aggregate factor analysis. Although results are not exactly the same, there is a great deal of similarity both across the two random sub-samples and with the overall analysis. In each case, there seems strong evidence of BAS, BIS, and Fight/Flight factors.

If we reject the possibility of random chance accounting for our aggregate level results, then we are left with two competing explanations. First, as discussed above, it seems possible that Gray's model helps us to understand groups in terms of general principles of reward and punishment, and that Gray's physiological explanation has no utility in understanding group psychology.

A second possibility is that our aggregate results inform us about the structure of personality at the individual level of analysis. That different levels of analysis produce different results is not surprising, considering what is known about individual and aggregate level analysis (see Kreft & De Leeuw, 1998; Ostroff, 1993; Snijders & Bosker, 1999). It is, however, surprising that the aggregate analysis produces factor analytical results remarkably *similar to Gray's model*. Such complex results, matching a highly regarded physiological model of personality, seem unlikely to be the result of chance relationships.

This leads to the question of whether the aggregate factor analytical results might, in fact, be a more accurate representation of personality structure at the individual level than the individual level factor analytical results. In other words, might explanations of individual differences be best found at the group level?

The answer appears to be that aggregate level analysis may provide support for Gray's model for individuals, but it depends upon the reasons for the differences between the scale intercorrelations at the individual and group levels. If the individual variance within each of the social groups is explained purely in terms of random error, which is reduced through aggregation, then the consequent improved reliability of the measures could provide a more accurate representation at the aggregate level.

Our satisfaction with this possibility depends upon how well we can accept the radical view that a group average represents the 'source' scales of personality and deviations from the average represent random effects. Although, at first sight, this seems unlikely, it is not so strange if personality is seen in terms of reward and punishment systems, as opposed to surface traits of personality. Evidence reviewed in the introduction implies that people with similar levels of reward and punishment gravitate towards the same group (see e.g. George, 1990; Havighurst, 1970) and group similarity is the basis of social identity theory.

To some extent, the literature on group psychology supports the view that reward and punishment pathways are very important at the individual level of analysis, with perhaps some further compelling evidence coming from results of meta-analyses suggesting that conscientiousness predicts work performance (Barrick & Mount, 1991). This is important as conscientiousness is widely regarded to be the opposite of impulsivity and BAS activity (see e.g. Zuckerman, Joireman, Kraft, & Kuhlman, 1999). If only BAS is predictive of work performance, then it seems possible that other personality scales exist merely as additional random error to that of the BAS system.

Such a radical explanation needs to be tempered, however, by noting that aggregate analysis is at the wrong level (see Robinson, 1950). Aggregate analysis partitions the within group variance into random error whereas, in fact, systematic differences between individuals within groups may need to be acknowledged. As soon as we acknowledge these systematic differences between people within groups then we can find no psychometric support for Gray's model of personality amongst the personality scales of the EPP, since the aggregate level analysis has no bearing on the individual level analysis. By accepting this conclusion, the supremacy of the Giant Three and Big Five models of personality at the individual level remains unchallenged, whilst still acknowledging the importance of finding BAS, BIS, and Fight/Flight explanations at the group level.

A final possibility that might explain the findings is that differences between group and individual level correlations result from an unmeasured variable that acts at the group level of analysis. It may be that intelligence (see e.g. Barrick et al., 1998), age, sex, salary, or various other differences operate at the group level. These possibilities seem unlikely considering how well the results at the different levels of analysis supported each of the two major competing theories of personality. Moreover, we were able to test and reject the effects of age and sex as possible confounding variables.

In summary, we find that group differences are well explained by a Gray type model of personality, utilizing the form of aggregation that Epstein (1980) terms aggregation over subjects. One explanation for these effects challenges traditional views concerning the structure of personality, just as Epstein challenged the views of his time regarding the continuity of behaviour.

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