Psychiatry Research 230 (2015) 553–560

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Population heterogeneity of trait anger and differential associations of trait anger facets with borderline personality features, neuroticism, depression, Attention Deficit Hyperactivity Disorder (ADHD), and alcohol problems

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ARTICLE INFO

Article history:
Received 6 October 2014
Received in revised form
15 September 2015
Accepted 1 October 2015
Available online 3 October 2015

Keywords:
Factor mixture modeling
Heterogeneity
Associations of anger factors with psychiatric outcomes

ABSTRACT

Anger is an emotion consisting of feelings of variable intensity ranging from mild irritation to intense fury. High levels of trait anger are associated with a range of psychiatric, interpersonal, and health problems. The objectives of this study were to explore heterogeneity of anger as measured by the Spielberger Trait Anger Scale (STAS), and to assess the association of the different anger facets with a selection of psychiatric disorders covering externalizing and internalizing problems, personality disorders, and substance use. Factor mixture models differentiated between a high and low scoring class (28% vs. 72%), and between three factors (anger-temperament, anger-reaction, and immediacy of an anger response). Whereas all psychiatric scales correlated significantly with the STAS total score, regressing the three STAS factors on psychiatric behaviors model showed a more detailed pattern. Only borderline affect instability and depression were significantly associated with all three factors in both classes whereas other problem behaviors were associated only with 1 or 2 of the factors. Alcohol problems were associated with immediacy only in the high scoring class, indicating a non-linear relation in the total sample. Taking into account these more specific associations is likely to be beneficial when investigating differential treatment strategies.

1. Introduction

Anger is an emotion consisting of feelings of variable intensity ranging from mild irritation to intense fury or rage (Spielberger et al., 1983). Anger can be either suppressed or directed at self (anger-in) or expressed outwardly through aggressive or confrontational behavior (anger-out). High levels of trait anger are associated with a range of psychiatric, interpersonal, and health problems, and in some cases anger can lead to aggression and violence (McDermut et al., 2009; Owen, 2011). Although clinically relevant in its own right, high levels of anger are significantly associated with a range of psychiatric disorders, including mood disorders, anxiety disorders, personality, and substance use disorders (DiGiuseppe et al., 2012; Kassinove and Tafrate, 2006; McDermut et al., 2009). Furthermore, anger is a central feature and diagnostic criterion for borderline personality disorder (American Psychiatric Association, 2013).

Anger has been described in terms of cognitive, emotional, and behavioral features, and several anger questionnaires attempt to capture these different aspects (Eckhardt et al., 2004; Owen, 2011; Smith et al., 2004). However, most investigations of the clinical correlates of anger have limited their focus to those correlates of aggregate measures of trait anger, failing to examine whether there are specific aspects of anger that show differential relations to common psychiatric problems. The present study focuses on aspects of anger measured by the Spielberger Trait Anger Scale (STAS, Spielberger et al., 1983). The STAS measures the disposition to have angry feelings. Factor analyses of the STAS have consistently shown that this scale is not unidimensional, but consists of two distinct facets, namely anger temperament and anger reaction. The STAS items measuring anger temperament are

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http://dx.doi.org/10.1016/j.psychres.2015.10.003
0165-1781/

designed to refer to more frequent and intense feelings of anger that occur in a broader range of situations whereas anger reaction more narrowly refers to experiencing anger when negatively evaluated or mistreated by others (Spielberger et al., 1983). Analyses of the Dutch version point to the possibility of a third factor measuring the immediacy of an anger response, which is most likely due to the fact that the Dutch version is not a literal translation (van der Ploeg et al., 1982). Three items of the English STAS have been replaced, and two of these items are designed to tap into the immediacy of an anger response (van der Ploeg et al., 1982). The developers report a two-factor structure of the Dutch STAS, with a distinction between anger-temperament and anger-reaction, and suggest the two items concerning the immediacy of an anger response to be part of anger-temperament for subjects with high levels of Trait Anger but part of anger-reaction for subjects with low levels Trait Anger (van der Ploeg et al., 1982). These differences between subgroups were not directly investigated since statistical methods designed for this purpose were not available at the time, however, this issue is addressed in the current study.

One aim of the present study is to explore potentially different associations of the different STAS anger factors with a selection of psychiatric problems that are known to co-occur with anger, or feature anger as a symptom. Specifically, we investigated whether the anger factors show differential associations to a range of psychiatric problems from each of the following domains: externalizing and internalizing problems (ADHD and depression, respectively), substance use (alcohol problems), and maladaptive personality (borderline personality affect instability, identity problems, self-harm, negative relations, and neuroticism). Although by no means comprehensive, this selection provides an excellent opportunity to investigate the potentially differential associations of anger temperament, anger reaction, and the immediacy of an anger response. Since neuroticism is highly associated with a total score of borderline personality features (Distel et al., 2009), we also included neuroticism to further explore similarities and differences in the association with anger factors compared to the different aspects of borderline personality features.

Our second goal was to investigate potential heterogeneity. Population heterogeneity refers to the presence of different clusters in the population that differ qualitatively (e.g., differential profiles on aspects of anger, differential comorbidities) and/or quantitatively (e.g., severity of symptomology) (Lubke and Muthén, 2005). Studies of population heterogeneity of anger are very limited (but see He et al. (2013)). Given the importance of anger as a health risk factor (Chida and Steptoe, 2009), a detailed understanding of the presentation of anger is critical for clinical research. To investigate population heterogeneity of the different aspects of anger it is necessary to carry out item-level analyses rather than using total scores. In this study we modeled item-level data of the Dutch version of the STAS with factor mixture models, and assessed differential associations of the different anger facets in each of the latent classes. Factor mixture modeling is a recently developed statistical framework that permits estimating a specific factor structure within different clusters (aka latent classes) of subjects in the population (Tueller and Lubke, 2010). Factor mixture modeling combines latent class analysis and factor analysis in a single modeling framework (Lubke and Muthén, 2005). Latent class analysis attributes overall covariation between questionnaire items entirely to mean differences between latent classes while constraining within class covariances of items to be zero. Factor analysis attributes overall covariation to continuous underlying factors that represent severity, and assumes a single homogeneous population. Factor mixture models are hybrids that permit mean differences between latent classes as well as severity differences in factors within each class. Most importantly, the clusters or classes reflect a grouping of subjects with similar response profiles that is data-driven. The factor structure and the response profiles of the items can differ across clusters. The classes can be compared with respect to qualitative differences (characteristic response profiles, differential associations with covariates), and quantitative differences (severity of symptomology).

In summary, in order to examine the differential associations of a range of psychiatric problems with different aspects of anger, we assessed the heterogeneity of anger, as measured by the STAS, using factor mixture modeling in a large population sample drawn from the Netherlands Twin Register (NTR) (Willemsen et al., 2013). We also addressed the question whether the Dutch version of the STAS is more adequately modeled with two or with three factors. Next, we investigated differences between classes regarding the association of the different STAS anger factors with borderline personality features, ADHD, depression, neuroticism, and alcohol problems.

2. Methods

2.1. Participants

The subjects were participants of the Netherlands Twin Register (NTR), a population-based sample, which is ascertained based on the presence of twins or higher-order multiples in the family (Willemsen et al., 2013). Data collection in 2 to 5-year intervals started 25 years ago. Most data included in the present study were collected between 2004 and 2005 (survey 7), with the exception of depression, which was collected in survey 8 (between 2009 and 2012, see below). The total number of participants with valid data for analysis was 3821 men, and 6451 women.

2.2. Measures and descriptives

Trait anger was measured with the Dutch adaptation of the STAS (Spielberger et al., 1983; van der Ploeg et al., 1982). As described by van der Ploeg et al. (1982), the scale items are formulated to explicitly tap into a more general disposition rather than into feelings of anger at a given time. Three items of the Dutch version are not literal translations of the English version. Based on factor analyses and validity studies during the adaptation of the STAS, items “angry when slowed by others”, “annoyed when not given recognition”, and “feel like hitting someone” were replaced by “I feel quickly angry”, “I am hot-tempered”, and “I am quickly irritated”. The developers report a two-factor structure distinguishing between anger-temperament (items 1, 2, 3, 5 and 6) and anger-reaction (items 7, 8 and 10), which mirrors the structure of the English version of the STAS. Items 4 and 9 (“I feel quickly angry”, “I am quickly irritated”)[1] measure the immediacy of an anger response. In our analyses we compared the suggested 2-factor structure as well as a 3-factor structure where items 4 and 9 load on a separate factor. By specifying 2 or, alternatively, 3 factors within each class, and leaving factor variances to be class-specific, we can obtain detailed information about this aspect of anger in the different latent classes.

Summary statistics of the ten items are presented in Tables 1 and 2. Responses were moderately skewed, and rates of the 4 response categories of each item were similar for males and females (see Table 1). The STAS has good discriminant and convergent validity as well as clinical utility, and has been administered across a wide range of subject populations and psychological

[1] Note that the Dutch wording is much less similar than implied by the English translation.

Table 1
Response rates on the 10 STAS items for males and females.

	Almost never	Sometimes	Often	Almost always	NA
1: "I am quick tempered"	0.569/0.611	0.381/0.342	0.044/0.041	0.003/0.003	0.002/0.003
2: "I have a fiery temper"	0.658/0.627	0.295/0.318	0.041/0.049	0.004/0.004	0.001/0.003
3: "I am a hotheaded person"	0.756/0.790	0.213/0.179	0.025/0.022	0.003/0.002	0.003/0.006
4: "I feel quickly angry"	0.365/0.313	0.532/0.573	0.094/0.104	0.006/0.007	0.003/0.004
5: "I am hot-tempered"	0.767/0.765	0.203/0.201	0.025/0.024	0.002/0.003	0.004/0.007
6: "I fly off the handle"	0.800/0.763	0.183/0.213	0.011/0.015	0.002/0.002	0.005/0.007
7: "when I get mad I say nasty things"	0.429/0.427	0.464/0.471	0.084/0.078	0.020/0.017	0.003/0.007
8: "it makes me furious when criticized in front of others"	0.465/0.422	0.464/0.501	0.056/0.057	0.011/0.013	0.003/0.007
9: "I am quickly irritated"	0.491/0.401	0.434/0.497	0.058/0.080	0.004/0.006	0.013/0.016
10: "I feel infuriated when I do a good job and get a poor evaluation"	0.335/0.287	0.527/0.572	0.104/0.105	0.033/0.032	0.002/0.004

Note: Male/female response rates are given in frequencies, and are separated by a slash. The content of items 4, 5, and 9 is different in the Dutch version of the STAS.

domains (Chida and Steptoe, 2009; Eckhardt et al., 2004; van der Ploeg et al., 1982). As suggested by the developers of the Dutch STAS our analyses are limited to subjects who had answered at least 7 of the 10 items although personality and health items in the NTR are relatively unbiased with respect to non-response (Distel et al., 2007; van der Ploeg et al., 1982).

Age ranged from 16 to 90 years in males (median 42 years), and from 16.5 to 88 years (median 42 years) for females. Correlations of the anger items with age were small but in our large sample nevertheless significant. On average, age explained 0.3% of the variance of anger items in males, and 6% of the variance in females. This is consistent with previous results (Hakulinen et al., 2014; Okuda et al., 2015; Phillips et al., 2006). Age was therefore included as a covariate in all analyses.

Borderline Personality Disorder (BPD) features were measured with the Personality Assessment Inventory Borderline Features Scale (PAI-BOR, Morey, 1991). The 24 PAI-BOR items are grouped into 4 subscales measuring affect instability (AI), identity problems (IP), negative relations (NR), and self-harm (SH). The test-retest reliability of the PAI-BOR in the Dutch data is 0.78 (Distel et al., 2009). We used the four subscales because BPD features are known to be heterogeneous (Hallquist and Pilkonis, 2012; Lenzenweger et al., 2008; Lubke et al., 2014; Skodol et al., 2002). ADHD was measured with the ADHD index, which aggregates the 12 items of the Conner's Adult ADHD Rating Scale corresponding to DSM symptoms. The 6-week test-retest reliability is 0.67 (Boomsma et al., 2010). Neuroticism was measured with the neuroticism subscale of the NEO five-factor inventory (NEO-FFI), which consists of 12 items (Costa and MacCrae, 1992). Reliability of the NEO-FFI scales in a Dutch speaking population is between 0.68 and 0.86 (de Fryt and Mervielde, 1998). Alcohol Problems were assessed with the four CAGE items, which have a reported reliability of 0.85–0.95 (Mayfield et al., 1974, Dhalla and Kopec, 2007). We used a dichotomized version of the aggregate CAGE score, as a score of 2 or higher is indicative of alcoholism (Ewing, 1984; Geels et al., 2013). Finally, depression was measured with 10 items of the Adult Self Report that correspond to DSM depression symptoms (Achenbach, 1997). This measure was obtained during wave 8 of the NTR data collection, and has a reliability of 0.85 (de Moor et al., 2006).

Correlations between the 10 STAS items are shown in Table 2, and range between 0.22 and 0.62. Initial exploratory factor models fitted separately to data from males and females resulted in almost identical factor structures, and favored a 3-factor solution. The three factors also showed a very similar pattern of associations with the psychiatric problems for males and females. All models were therefore fitted to data of the two genders jointly.

The correlations among PAI-BOR scales, neuroticism, ADHD, depression, and alcohol problems were generally small to moderate, and, therefore, were not expected to cause multi-collinearity problems (see Table 3). The correlation table includes a sum-score of the 10 STAS items to show the overall association of anger with these behaviors. The mixture analyses described below aimed at providing a more detailed picture regarding aspects of anger as they relate to different psychopathology.

2.3. Analyses

2.3.1. Type 1 error control

The investigation of heterogeneity involved fitting multiple mixture models to the data, and the association assessment involved estimating multiple regression coefficients. Although in the area of mixture modeling it is not yet widely recognized, type 1 error is inflated if coefficients are estimated in a selected model (Hurvich and Tsai, 1990). The inflation of type 1 error due to model selection is comparable to multiple stage clinical trials, where well-performing drugs are selected for subsequent stages of a study. Not accounting for the selection implies capitalizing on chance, which in turn leads to type 1 error inflation. The model selection has therefore to be taken into account to keep type 1 error under control. We therefore adopted the following analytic strategy. Benefitting from our extremely large sample, we

Table 2
Correlations between the 10 STAS items.

	STAS1	STAS2	STAS3	STAS4	STAS5	STAS6	STAS7	STAS8	STAS9	STAS10
STAS1	1									
STAS2	0.61	1								
STAS3	0.62	0.59	1							
STAS4	0.43	0.43	0.38	1						
STAS5	0.50	0.56	0.58	0.45	1					
STAS6	0.43	0.44	0.43	0.35	0.46	1				
STAS7	0.26	0.27	0.24	0.28	0.26	0.29	1			
STAS8	0.22	0.23	0.21	0.29	0.25	0.24	0.33	1		
STAS9	0.43	0.43	0.38	0.62	0.43	0.36	0.29	0.30	1	
STAS10	0.25	0.24	0.23	0.30	0.25	0.24	0.31	0.44	0.3	1

Table 3
Data exploration: correlations of neuroticism, PAI-BOR subscales, ADHD index, DSM-depression, and CAGE alcohol problems for male and females prior to model fitting.

	Ang	Neurot	bor_ai	bor_ip	bor_nr	bor_sh	Adhd	Depres	Alcohol
Ang	–	0.42	0.548	0.379	0.344	0.259	0.485	0.278	0.111
Neurot	0.37	–	0.601	0.643	0.457	0.185	0.554	0.552	0.095
bor_ai	0.564	0.562	–	0.564	0.516	0.29	0.539	0.482	0.143
bor_ip	0.35	0.588	0.507	–	0.497	0.277	0.517	0.475	0.096
bor_nr	0.322	0.431	0.507	0.463	–	0.275	0.385	0.362	0.124
bor_sh	0.311	0.213	0.349	0.286	0.31	–	0.341	0.195	0.1
Adhd	0.51	0.475	0.495	0.454	0.34	0.36	–	0.468	0.135
Depres	0.265	0.495	0.397	0.422	0.302	0.165	0.432	–	0.103
Alcohol	0.151	0.104	0.148	0.129	0.133	0.162	0.155	0.134	–

Note: Female correlations are shown in the upper triangular, and male correlations in the lower triangular. Abbreviations are as follows: ang=anger total STAS score, neurot=NEO neuroticism, bor_ai=borderline affect instability, bor_ip=borderline identity problems, bor_nr=borderline negative relations, bor_sh=borderline self-harm, adhd=CAARS ADHD index, depress=DSM depression symptoms, alcohol=CAGE alcohol problems.

randomly selected $N=2499$ individuals, and fitted a series of alternative latent class and factor mixture models with 1–3 factors within class and an increasing number of classes. The best-fitting model was selected, and then fitted to the data in the remaining sample in order to estimate the regression coefficients of the factors on the psychiatric behaviors. The Bayesian Information Criterion, BIC, has been shown to be one of the best indices to compare alternative mixture models (Schwarz, 1978; Nylund et al., 2007). We note that model selection based on fit indices such as the BIC is to some extent arbitrary since all fit indices depend on sample size, and hard cut-offs therefore do not exist (Joreskog, 1993). Our model selection is based on extensive prior simulation work of our team (Lubke and Neale, 2008, 2006; Tueller and Lubke, 2010) as power simulations using the current models and sample size are beyond computational feasibility. Model selection and estimation of regression coefficients was done after splitting the data into two separate sets, thus avoiding capitalizing on chance. We controlled for testing multiple covariates by using a more stringent significance level. A procedure to obtain an adequate significance level for correlated tests was implemented in the freely available program matSpD (Nyholt, 2004). Non-independence of observations due to family membership (e.g., our data included twins) was taken into account by using a sandwich estimator in all analyses (Freedman, 2006). This is implemented in Mplus with option "mixture complex", and using a family indicator as grouping variable, Muthén and Muthén (1998–2012). Age was used as class-predicting covariate to correct for age influence on class membership (Phillips et al., 2006; Hakulinen et al., 2014; Okuda et al., 2015).

2.3.2. Analysis Part 1: Assessment of population heterogeneity of anger using a random subsample of the data (N=2499)

The analysis plan comprised of fitting latent class models and factor mixture models to the 10 Dutch STAS items observed in male and female participants. The 2-factor structure was based on previous studies using the Dutch version of the STAS, and the 3-factor structure, which was based on initial exploratory factor analyses, had items 4 and 9 ("quickly angry", and "quickly irritated") load on a separate additional factor. The number of random starts was set to 200, with 20 sets iterating to final convergence. If the likelihood was not replicated we increased the number of starts.

2.3.3. Analysis Part 2: Associations between anger factors and BPD features, ADHD, neuroticism, depression, and alcohol problems in the remaining sample with available covariate data

We planned to fit the best fitting model from step 1 of our analysis to the remaining sample to investigate the associations with covariates while keeping Type 1 error under control. In this model, the factors were regressed on the selected psychiatric behaviors within each class. Regression coefficients were estimated specific for each class. The sample with data for BPD features, neuroticism, ADHD, and alcohol problems was $N=9763$. The sample with available data for depression was smaller, $N=5384$. Note that we did not correct for potential item overlap (e.g., between anger, borderline features, and neuroticism scales) because the aim was to investigate whether different aspects of anger are differentially associated with behaviors such as neuroticism *as commonly defined and measured*.

All models were fitted in Mplus 7.11 (Muthén and Muthén, 1998–2013). We conducted appropriate Wald tests to assess whether the class differences in the associations of anger factors and covariates were significant.

3. Results

3.1. Analysis part 1: Population heterogeneity of anger

The results of the models that were fitted to select the best fitting model using a subset of the data ($N=2499$) are presented in Table 4. As expected, latent class analysis models (LCA models) did not fit the data as well as the factor mixture models, which allow for severity differences in anger.

All factor mixture models were fitted with class-specific factor variances and covariances. We also permitted class-specific loadings and thresholds to allow for deviations from measurement invariance, which is difficult to test in the context of mixture

Table 4
Model fit results.

	Log likelihood	#parameters	BIC	saBIC
LCA C2	−18259.270	62	37003.581	36806.592
LCA C3	−17690.645	94	36116.675	35818.013
LCA C4	−17365.716	126	35717.161	35316.827
F1C1	−17376.632	41	35074.033	34943.766
F2C1	−17164.978	45	34558.756	34415.780
F2C2	−16945.583	78	34360.309	34112.483
F2C3	−16845.291	113	34603.874	34244.845
F2C4	−16784.063	148	34723.727	34253.494
F3C1	**−16947.075**	**46**	**34254.038**	**34107.885**
F3C2	**−16816.382**	**81**	**34266.480**	**34009.122**
F3C3	−16822.285	119	34482.748	34104.655
F3C4	−16818.046	157	34698.028	34199.199

Note: Models were fitted to a subsample of $N=2499$ to separate model selection from the estimation of regressions on comorbid behaviors in order to avoid inflated type 1 error. LCA C# indicates results for latent class models with # latent classes. F#C# are factor mixture models where # indicates the number of factors within class and the number of classes (e.g., F2C3 is a 2-factor 3-class model). BIC stands for Bayesian Information Criterion, with smaller values indicating better model fit. SaBIC is a BIC with a different sample size adjustment.

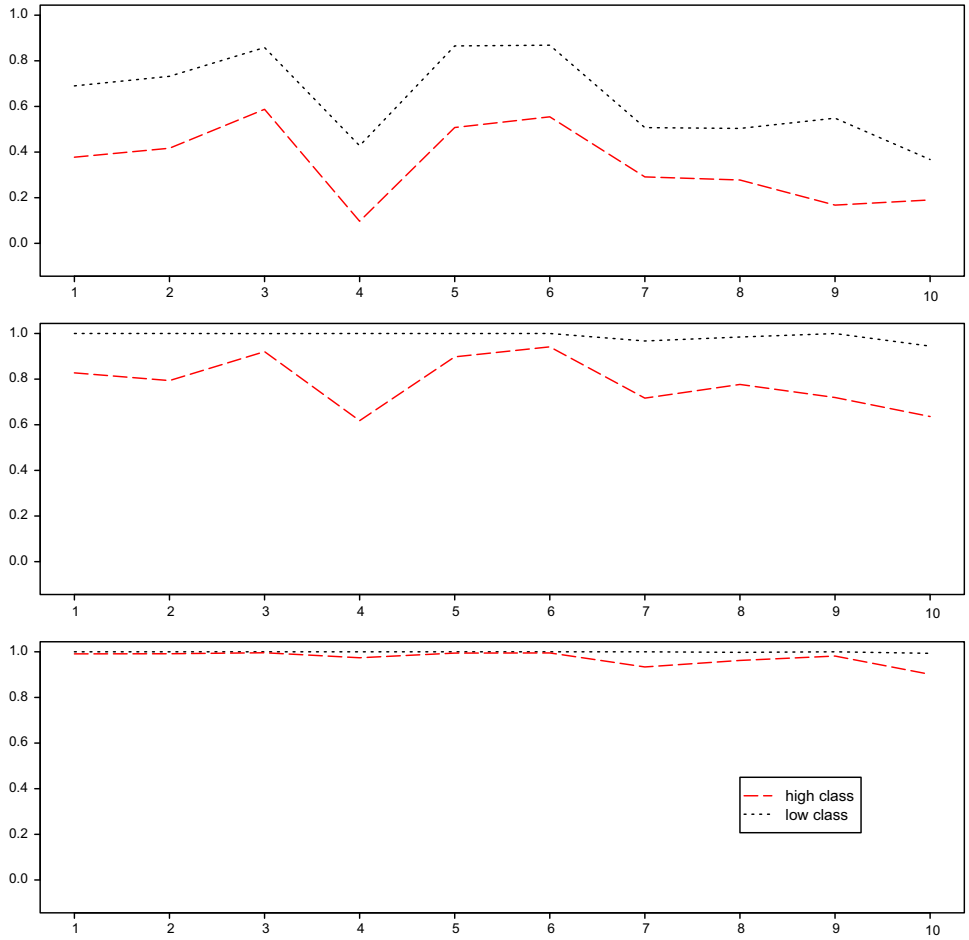

Fig. 1. Response Profiles of the two classes on the 10 STAS Items *Note:* The three panels depict the cumulative probabilities of scoring zero (upper panel), zero or one (middle panel), and zero, one or two (lower panel), respectively. The 10 STAS items are on the *x*-axis. The probability of scoring zero has a similar pattern for the two classes, but the higher scoring class endorses zero less often (see upper panel). Almost all participants in the lower scoring class have answered either zero or one on all items (see middle panel, probabilities for the low scoring class depicted in black are all close to 1). The higher scoring class also endorses higher response categories, and shows a differential response pattern across items. The lower panel shows that the higher scoring class scores higher than two especially on items 4, 7, 8, and 10.

models (Millsap and Tein, 2004, Lubke and Neale, 2008). We found that factor mixture models with 3 factors provided a better fit than 2-factor models, thus separating the facets anger temperament, anger reaction, and immediacy of an anger response. The best fitting models were 3-factor single class and 3-factor 2-class models. Although the BIC was somewhat smaller for the single class model we expected the 2-class model to have superior fit in the larger confirmatory sample due to the much better resolution for the detection of classes in larger samples (see Lubke and Neale (2008) and Lubke and Neale (2006)). We therefore selected the 3-factor 2-class model as the more adequate final model. This model was then fitted to the data not used for model selection in analysis Part 2 (see below).

The class proportions were 28% for the smaller high scoring class, and 72% for the lower scoring majority class. The response profiles on the ten items are presented in Fig. 1, which shows that the profiles are reasonably parallel for the probability of scoring zero. However, the probability of scoring either zero or one differs across classes (see Fig. 1, middle panel). This is the result of differences in item thresholds, which were estimated as class-specific. The higher scoring class provides more information concerning a differential pattern across the ten items for the higher response categories as the lower scoring class does not endorse categories higher than 1 on any of the items. There were no substantial differences in factor variances and covariances across the two classes. Factor correlations within class ranged between 0.35 and 0.68, with the lowest correlation being between temperament and reaction, and the highest between temperament and immediacy. The regression on age was significant (standardized regression coefficient $\beta = 8.399$, p-value < 0.001); younger participants were more likely members of the higher scoring class.

3.2. Analysis Part 2: Differences between classes regarding BPD features, ADHD, neuroticism, alcohol problems, and depression

A 2-class 3-factor model was fitted to the remaining data. In this model the three factors were regressed on the covariates in both classes. Although factor variances and covariances showed only small differences between classes in the first part of the analysis, these parameters were kept as class-specific to avoid unnecessary bias in the estimation of regression coefficients. All reported regression coefficients were estimated simultaneously in this model. The resulting class proportions and within class parameters of this model were very similar to the model fit using $N = 2499$. (e.g., loadings correlated 0.95, see Table 5).

The results of the regression of the three anger factors on the psychiatric behaviors are shown in Table 6. The estimated effects were selected based on initial exploratory analyses in the smaller sample where the three factors were regressed on all covariates. The cutoff was a regression coefficient of 0.05. The selection was done to avoid the risk of including many non-significant covariate effects, which can lead to instability and unreliable results (Tueller

Table 5
Standardized factor loadings of the 3-factor 2-class model.

	Temperament					Reaction			Immediacy	
	STAS_1	STAS_2	STAS_3	STAS_5	STAS_6	STAS_7	STAS_8	STAS_10	STAS_4	STAS_9
high c 1	0.835	0.841	0.860	0.809	0.710	0.671	0.526	0.649	0.880	0.884
lowc 2	0.846	0.851	0.869	0.821	0.725	0.738	0.598	0.717	0.839	0.845

Note: The loadings for the higher scoring class are provided in row 1. The general pattern is similar for the two classes. Loadings were also very similar in the models fitted to the smaller model selection sample and the larger sample used to investigate associations (i.e., loadings correlated 0.95).

Table 6
Standardized regression coefficients of the three anger factors on comorbid behaviors within the high scoring minority class and within the low scoring majority class of the best fitting 3-factor 2-class model.

	Anger temperament	Anger reaction	Anger immediacy
	High scoring minority class		
BOR-AI	**0.484 (<0.001)**	**0.369 (<0.001)**	**0.484 (<0.001)**
BOR-NR	–	0.126 (0.004)	−0.009 (0.751)
BOR-IP	0.004 (0.914)	0.082 (0.099)	–
BOR-SH	**0.100 (0.001)**	–	−0.028 (0.379)
Neuroticism	–	–	**0.221 (<0.001)**
ADHD	–	**0.168 (0.003)**	**0.107 (0.003)**
Alcohol problems	–	–	**0.080 (0.001)**
Depression	**0.173 (<0.001)**	**0.306 (<0.001)**	**0.394 (<0.001)**
	Low scoring majority class		
BOR-AI	**0.508 (<0.001)**	**0.238 (<0.001)**	**0.398 (<0.001)**
BOR-NR	–	**0.100 (<0.001)**	−0.046 (0.012)
BOR-IP	−0.044 (0.007)	0.073 (0.006)	–
BOR-SH	**0.112 (<0.001)**	–	0.015 (0.420)
Neuroticism	–	–	**0.073 (<0.001)**
ADHD	–	**0.233 (<0.001)**	**0.209 (<0.001)**
Alcohol problems	–	–	0.026 (0.111)
Depression	**0.204 (<0.001)**	**0.221 (<0.001)**	**0.326 (<0.001)**

Note: Presented are standardized regression coefficients of the regression of the factors on the comorbid behaviors and their *p*-values (between brackets). All regression coefficients were estimated simultaneously by fitting a 3-factor 2-class model. Blanks indicate that effects were not included in the model because coefficients were below 0.05 in initial exploratory analyses (see text). Significant effects are in bold, the significance level was determined after correction for multiple testing at $\alpha=0.0036$ (see text). Abbreviations are bor-ai=borderline affect instability, bor-ip=borderline identity problems, bor-nr=borderline negative relations, bor-sh=borderline self-harm, adhd=CAARS ADHD index, depression=DSM depression symptoms, alcohol=dichotomized CAGE alcohol problems.

and Lubke, 2010). The significance level was adjusted for multiple testing as implemented in the freely available program matSpD to $\alpha=0.0036$ (Nyholt, 2004). With the exception of alcohol problems and borderline negative relations (see below), the *differential pattern of associations* was the same in the high scoring minority class and the lower scoring majority class.

Only borderline affect instability and depression had consistent effects across the three anger factors. All other behaviors showed specific pattern of associations with the three different anger factors. Borderline self-harm was associated with anger temperament in both classes, whereas borderline negative relations was associated with anger reaction. The latter effect was observed only in the lower scoring majority class, but it should be noted that the low scoring class was about three times as large, thus affording higher statistical power. Borderline identity problems were not significantly associated with any anger facets. Neuroticism was only associated with the immediacy of an anger response, and the effect was somewhat more pronounced in the high scoring class. ADHD was related to anger reaction in both classes, and also to anger immediacy in the lower scoring majority class. Alcohol problems were related to the immediacy of an anger response. This effect was observed in the high scoring class, but was absent in the low scoring majority class. This result indicates that the overall effect is non-linear, that is, the effect varies with severity of the immediacy of an anger response.

We conducted Wald tests to investigate whether the class differences in associations of the three anger factors were significant. This was done using the Mplus option “Model Test”, which evaluates whether constraining the regression coefficients to be the same across classes is tenable. For the immediacy factor, regression coefficients were significantly different across classes (Wald statistic=21.68, *p*-value=0.0014). For the other two factors the differences were not significant, which is consistent with the more similar pattern of associations shown in Table 6. We also tested whether class was moderating the associations, and found that the regressions of class on the covariates were all close to zero and non-significant. Therefore we can conclude that class is not moderating the associations.

4. Discussion

To our knowledge this is the first study that explores the associations between the different STAS anger factors and PAI-BOR subscales, neuroticism, depression, ADHD, and alcohol problems in more detail in a population sample. These behaviors are known to be associated with anger, and were chosen as examples of personality problems, externalizing and internalizing problems, and substance use problems. Comparing the overall correlations of these behaviors with the STAS total score (see Table 3) with the more detailed results from our analysis (see Table 6) reveals a more distinct structure of associations that is hidden when considering anger as a total score.

4.1. Anger presents as a heterogeneous phenotype

The factor mixture analysis of the 10 STAS items revealed two latent classes. The classes differed quantitatively with respect to the severity of the scores on the 10 STAS items. The smaller, higher-scoring class comprised about 28% of the sample. The classes differed qualitatively with respect to the within class associations of the STAS anger factors with the psychiatric behaviors. In addition to replicating the two factors anger temperament and anger reaction that are known to the STAS items, we found that separating a third factor measured by the two items concerning the immediacy of an anger response (“I feel angry quickly”, “I am quickly irritated”) benefitted the model fit. It should be noted that the selection of a best fitting model is a matter of power. Especially when analyzing categorical outcomes a model with an additional class requires the estimation of a much larger number of parameters, which can lead to rejection when using the BIC for model comparisons (Lubke and Neale, 2008). Given that with respect to anger severity the classes differed mainly quantitatively, it will depend on the goals of future research whether it is useful to account for the apparent grouping into higher and lower scoring participants. In this context it is noteworthy that the response profiles on the 10 STAS items in the two classes showed that the higher scoring class differed especially with respect to one of the anger immediacy items (see Fig. 1), and that the classes differed

significantly with respect to the associations of the immediacy factor (see below).

4.2. Anger factors are differentially related to multiple psychiatric problems

The patterns of associations shown in Table 6 are consistent with both clinical observations and empirical findings for these psychiatric problems. First, the PAI_BOR affect instability scale and the depression scale reflecting DSM depression symptoms were the only scales with consistent effects across all three anger factors. Anger is central feature of Borderline Personality Disorder (BPD), and is a core emotion that manifests itself in the affective instability characterizing BPD (Trull et al., 2008). Furthermore, angry temperament, angry reactions to others, and the immediacy of anger expression are all common clinical features of BPD. Concerning depression, psychodynamic theories posit that depression can be conceptualized as chronic anger turned inward (Busch, 2009), and anger and irritability are often abruptly and intensely expressed by depressed individuals in their interpersonal relationships (perhaps due to high levels of rejection sensitivity) often leading to social dysfunction.

All other scales measuring personality and psychiatric problems showed more specific patterns of interrelations with the different aspects of anger. Notably, the NEO neuroticism scale, which correlates highly with borderline affect instability, was associated only with the immediacy of an anger response rather than showing a broader association with anger. This is likely due to the NEO scale's assessment of a range of negative affects (e.g., anxiety, dysphoria) in addition to anger. ADHD was not related to anger temperament, but rather to anger reaction, and also anger immediacy. This suggests that anger among those with ADHD is most likely to manifest itself in interpersonal contexts, and that the impulsivity associated with ADHD may lead to very abrupt and intense anger expressions. The latter may reflect some deficits in cognitive control and in emotion regulation amongst those with ADHD (Shaw et al., 2014). Interestingly, alcohol problems were associated with immediacy only in the high scoring class. Clearly, this result contradicts a simple linear relation between anger and alcohol problems where increasing anger symptoms are accompanied by increasing alcohol problems. This result is noteworthy because the high scoring class differed significantly from the lower scoring class only with respect to the associations of the immediacy factor, and is interesting in the context of previous findings that in individuals with low levels of trait anger the relation between alcohol and aggression was less pronounced than in individuals with higher levels of trait anger (Parrot and Zeichner, 2002).

The differential pattern of associations of the studied comorbid behaviors with the different aspects of anger is an important finding that can inform future studies in clinical samples to investigate differential treatment strategies (e.g., anger management, cognitive-behavioral treatment, relaxation therapy; Del Vecchio and O'Leary, 2004). Our results indicate that taking into account specific patterns of associations at the level of more narrow defined factors rather than the level of broader domains is likely to be beneficial when defining symptom profiles.

4.3. Strength and limitations

This study is the first to investigate population heterogeneity of anger and the association of the different clusters to a number of related psychiatric disorders. An important strength of the current study is the large population based sample drawn from the Netherlands Twin Register (NTR) used for the analyses (Willemsen et al., 2013). A limitation of our study is that all measures are self-reports, and do not take into consideration possible psychiatric diagnoses or treatments. In addition, cluster solutions concerning self-reports of anger may at least to some extent be culture dependent, and generalizations beyond the Dutch population should be made with caution.

Acknowledgments

GH Lubke was supported by NIH DA-018673. MHM de Moor was supported by the Netherlands Organization for Scientific Research (NWO) (VENI-016-115-035). We acknowledge funding for data collection from the Netherlands Organization for Scientific Research (NWO) and MagW/ZonMW: Twin family database for behavior genomics studies (480-04-004); Genetic determinants of risk behavior in relation to alcohol use and alcohol use disorder (ZonMw Addiction-31160008); Genotype/phenotype database for behavior genetic and genetic epidemiological studies (ZonMw Middelgroot 911-09-032); Spinozapremie (SPI 56-464-14192); CMSB: Center for Medical Systems Biology (NWO Genomics); NBIC/BioAssist (RK/2008.024); BBMRI–NL (184.021.007): Biobanking and Biomolecular Resources Research Infrastructure; the VU University: Institute for Health and Care Research (EMGO+) and Neuroscience Campus Amsterdam (NCA); the European Science Council (ERC Advanced, 230374)

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