A twin study on humor appreciation: The importance of separating structure and content

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A twin study on humor appreciation: The importance of separating structure and content

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Abstract

The present study focused on genetic and environmental influences on appreciation of structure and content of humor. Monozygotic (*n* = 135) and dizygotic (*n* = 60) adult twin pairs rated their trait-like humor appreciation using the 3 WD humor test (Ruch, 1992) which assesses three basic humor stimuli (incongruity-resolution humor; nonsense humor; sexual humor), and two basic components of responses to humor (funniness; aversiveness). Additionally, two indices were derived from these scales, namely structure preference and liking of sexual content (i.e., controlled for humor structure). Intraclass correlations and behavior genetic model-fitting analyses indicated a moderate genetic effect for funniness ratings of liking the sexual content. The remaining funniness scales seemed entirely influenced by environmental effects. Aversiveness scales mainly showed environmental effects represented in reduced CE models, although twin similarity coefficients showed hints of genetic influences as well, which needs to be unraveled in future research. The results demonstrated clearly that funniness ratings should be separated for structure and content, to obtain detailed information about heritability of humor appreciation. Future research should validate these promising initial findings by utilizing larger samples.

Keywords: humor appreciation, twin study, incongruity-resolution humor, nonsense humor, sexual humor

A twin study on humor appreciation: The importance of separating structure and content

Introduction

Over the last decades there has been an increase in publications (scientific and non-scientific) showing that humor is an important topic. For example, humor impacts individuals' good mood, and humor shields against the consequences of life stress and daily hassles (Ruch, 2004). As such effects might be relevant to individuals, it is of importance to understand genetic and environmental influences on humor appreciation. Previous research has yielded inconsistent findings; hence, the present study aims at adding further knowledge by introducing an important structural distinction provided by the two-mode model of humor appreciation.

An approach to humor appreciation

Ruch (1992; Platt & Ruch, 2014; Ruch & Hehl, 2007) presented a two-mode model of humor appreciation composed of a stimulus mode and a response mode. The stimulus mode refers to a taxonomy of jokes and cartoons comprising the dimensions of *incongruity-resolution* humor (INC-RES), *nonsense* humor (NON), and *sexual* humor (SEX). In the response mode two orthogonal components in humor appreciation are distinguished: *funniness* ($_f$) and *aversiveness* ($_a$).

Funniness of humor. Studies of responses to humor show that all positively toned ratings tend to intercorrelate highly and positively, independent of whether they refer to the perceived properties of the stimuli (funny, witty, original), or to the recipients' feelings (exhilarated, amused). This positive response factor also covers both cognitive (clever, original) and affective (funny, amused) evaluations.

Aversiveness of humor. Negative responses to humor, like indignation, embarrassment, or boredom were neglected for a long time. However, a humor response factor of negative affect consistently emerged from the intercorrelations among the negatively toned response scales (like embarrassing, plain, childish, aggressive) that is orthogonal to the funniness dimension. In studies of humor appreciation a rating of “aversiveness” best represents this factor.

Factor analyses aimed at establishing a taxonomy of jokes and cartoons revealed that both *structure* and *content* of humor have to be considered in the classification of humor (Platt & Ruch, 2014). More specifically, two factors relate to structural properties of the jokes and cartoons and one to their content. Jokes and cartoons of the structure-dominated INC-RES humor category are characterized by punch lines in which the surprising incongruity can be completely resolved. The common element in this type of humor is that the recipient first discovers an incongruity, which is then fully resolvable upon consideration of information available elsewhere in the joke or cartoon. The other consistently emerging structural factor is NON humor, which also has a surprising or incongruous punch line. However, the punch line may (1) provide no resolution at all, (2) provide only a partial resolution, or (3) actually create new absurdities or incongruities. In nonsense humor the resolution information gives the appearance of making sense out of incongruities without actually doing so.

The third factor (SEX humor) is characterized by the salient content. There are a variety of sexual themes involved, and only the sex jokes and cartoons load on this factor. However, SEX humor does not consist of pure content, but is embedded in a joke framework. Both the incongruity-resolution and the nonsense structure can provide the basis of SEX humor as they do for non-tendentious content. A factor of sexual humor has consistently been found since the first factor analytic study of humor (Eysenck, 1942). It is likely that more content factors will be found once a simultaneous control of both content and structure becomes a standard procedure (Ruch & Platt, 2012).

The two-mode model provides an exhaustive taxonomy for the classification of both humor responses and humor stimuli. A subject's humor appreciation is described by his/her response profile in this 2 x 3 (response dimensions x humor stimulus factors) model. The validity of the two-mode model of humor appreciation is supported by the results of several personality studies (e.g., Carretero-Dios & Ruch, 2010; Ruch, 1992, 2008; Ruch & Hehl, 2007; Ruch & Malcherek, 2009). For example, the 3WD scales were found as meaningful predictors of characteristics like *conservatism* (positively related to INC-RES_f), *openness to experience* (negatively related to INC-RES_f, positively to NON_f, and negatively to NON_a), *agreeableness* (positively related to INC-RES_f), and *sensation seeking* (negatively related to INC-RES_f, positively to NON_f, and negatively to NON_a and SEX_a).

Prior behavior genetic investigations on humor appreciation

At present, there are only a few behavior genetic studies on humor appreciation. Wilson and colleagues (e.g., Nias & Wilson, 1977) were the first to attend to genetic and environmental influences on humor appreciation. They analyzed ratings of funniness of 48 cartoons, representing four groups (i.e., nonsense, satirical, aggressive, and sexual). Results indicated environmental influences predominantly, although liking of aggressive humor tended to be partly genetically determined as monozygotic twins showed a numerically higher intraclass correlation than dizygotic twins, but the coefficients did not differ significantly. More current research regarding humor appreciation was presented from Cherkas and colleagues (Cherkas, Hochberg, MacGregor, Snieder, & Spector, 2000). They used a five-item cartoon test (consisting of “Far Side”-Larson cartoons). Results of a multivariate behavior genetic analysis suggested no genetic influences on humor appreciation.

Thus, in both studies, monozygotic twins were *not* more similar than dizygotic twins. The correlations between both groups of twin pairs (all reared together) showed that shared environmental influences were most relevant, followed by non-shared (i.e., unique) environmental influences. As a result, one might conclude that familial and peer influences predominantly determine what we consider to be funny. This is noteworthy, as a finding of *no* genetic influences on a reliably measured psychological trait characteristic is a rare exception (cf. Turkheimer, 2000). Furthermore, the contents of humor (aggression, sex), and major predictors of humor appreciation (extraversion, conservatism, sensation seeking) are known to have a strong genetic basis.

Ruch (2008) argued that it would be premature to conclude from these studies that humor appreciation is exclusively determined by environmental factors. The study by Cherkas et al. (2000), for example, used only five cartoons. This is exactly the number of cartoons that appears to be affected by a "warm-up-effect" that introduces a considerable amount of state variance (Ruch, 1992). For this reason, the first five cartoons are often excluded from scoring in humor appreciation tests. Furthermore, the aforementioned studies used humor scales that did not undergo an explicit construction and hence it is uncertain what they actually measure. Most importantly, these studies did not differentiate between structure and content. For example, while the study by Nias and Wilson (1977) examined content categories, they did not consider that funniness of both sexual and aggressive cartoons also represents liking of the structural properties of humor.

The present study

Therefore, the purpose of the present study was to estimate genetic and environmental influences on humor appreciation using a twin-design, and using a more sophisticated, well-validated, and reliable inventory that is based on a comprehensive model of humor appreciation (Platt & Ruch, 2014; Ruch, 1992). The 3 WD scales allow both the structure and the content of humor appreciation to be accounted for, and the 3 WD humor test is the only humor appreciation measure that yields a *content score* for sexual humor. Hence, the present study aimed to clarify the issue of a possible genetic basis of humor appreciation.

Method

Participants

A total of 390 adult twins embedded in the Bielefeld Longitudinal Study of Adult Twins (BiLSAT; e.g., Spinath, Wolf, Angleitner, Borkenau, & Riemann, 2005) were investigated. The sample was comprised of 135 monozygotic (MZ) pairs and 60 dizygotic

(DZ) pairs. Their ages varied from 28 to 81 years with a mean of 47.9 years (*SD* = 13.6 years). Women (84.9%) participated more frequently than men (15.1%).

Measure

3 WD. The 3 WD ("3 Witz-Dimensionen") humor test (Ruch, 1992) assesses funniness and aversiveness of three humor stimuli: *incongruity-resolution humor*, *nonsense humor*, and *sexual humor*. The 3 WD presents 29 jokes and cartoons utilizing a 7-point rating scale for each response mode (i.e., "0" = not at all funny to "6" = very funny; "0" = not at all aversive to "-6" = very aversive). The first five items are "warm up" items, which are not analyzed. Scale scores (i.e., $INC\text{-}RES_f$, NON_f, SEX_f, $INC\text{-}RES_a$, NON_a, SEX_a) were computed by summing up the eight items per scale. For both funniness and aversiveness of the content of sexual humor, additional indices can be derived via regressing each SEX scale (SEX_f, SEX_a) for INC-RES and NON, and the standardized residual scores were used as indicators of liking of the content in sexual humor (SEX_f-resid, SEX_a-resid). The structure preference indices (i.e., SPI_f, SPI_a) were obtained by subtracting INC-RES from NON, and they reflect the relative dominance of liking of incongruity over resolution. Two sum scores (SUM_f, SUM_a) were computed by summing up all 24 items for each of the two response modes (for an overview see Table 1). Previous studies regarding the psychometric properties of the 3 WD showed that the reliability estimates are satisfactory for all computed scales (cf. Ruch, 1992).

Insert Table 1 about here

Procedure

In the BiLSAT, test-booklets including several personality tests were mailed to the participants. To minimize participants' effort, short versions were used whenever existing. Therefore, an abbreviated version of the 3 WD was generated that reduced the number of items per scale from ten to eight. Participants were instructed to complete the questionnaires independently from each other in a non-distracting setting, and without comparing item responses with their twin-sibling. Participants returned the completed material free of charge within a period of five weeks.

Analyses

Zygosity was derived from a physical similarity questionnaire (Oniszczenko, Angleitner, Strelau, & Angert, 1993) in which participants were asked to describe and compare themselves with their twin-sibling on selected physical characteristics. Prior to the calculation of twin similarities and univariate behavior genetic analyses, all variables were controlled for age and gender using the standardized residual scores of regression analyses (cf. McGue & Bouchard, 1984). Twin similarity was calculated as intraclass correlations (ICC 1.1; Shrout & Fleiss, 1979), and genetic and environmental influences were estimated using the software package Mx (Neale, Boken, Xie, & Maes, 2003). For all investigated variables variance-covariance matrices were analyzed. The estimated models (i.e., ACE, AE, CE) specified additive genetic effects (A), *shared* environmental effects (C), and *non-shared* environmental effects (E). In the analysis of manifest variables E confounds variance of both non-shared effects and measurement error.

Results

Preliminary analyses

Means, standard deviations, and internal consistencies (Cronbach's alpha) for all 3 WD scales as well as correlations between 3 WD scales, and age and gender were computed (see Table 2).

Insert Table 2 about here

Table 2 shows that means of INC-RES$_f$, NON$_a$, and SEX$_a$ were higher than expected, whereas the mean of NON$_f$ was lower than expected (cf. Ruch, 1992). Reliability coefficients of the abbreviated version were satisfying for all scales (see Table 2). Funniness of incongruity-resolution humor (INC-RES$_f$) and aversiveness of nonsense humor (NON$_a$) yielded positive correlations with age. No relationship was found between NON$_f$ and age. Female participants found sexual humor more aversive than men did (see Table 2).

Twin analysis of 3 WD scales and derived indices

To estimate genetic and environmental effects on different aspects of humor appreciation intraclass correlations (ICC), as indicators of twin similarity, and twin analyses including full ACE models and reduced models (AE, CE) were carried out. Due to low sample size, we carefully explored the results in three steps: Followed by an inspection of the ICCs, in the second step we focused on the full ACE models when exploring the results (although confidence intervals included zero). Finally, to validate these results, we inspected the reduced CE models in case the ICC of the dizygotic twins exceeded the halved ICC of the monozygotic twins, indicating mainly environmental influences, and we inspected the reduced AE models in case the ICC of the dizygotic twins was lower than the halved ICC of the monozygotic twins, indicating both genetic and environmental influences (see Table 3 for funniness and Table 4 for aversiveness).

Insert Table 3 about here

Table 3 shows that intraclass correlations (ICC) for liking the content of sexual humor (SEX$_f$-resid) suggested moderate genetic influences, and considerable non-shared environmental influences, because correlations for MZ were numerically higher than correlations for DZ twins. Also INC-RES$_f$ seemed to be slightly affected by genetic effects. The correlation pattern for nonsense humor (NON$_f$), sexual humor (SEX$_f$), total funniness score (SUM_f), and structure preference (SPI_f) suggested substantial environmental influences as the ICC coefficients for MZ and DZ were nearly identical or even DZ correlations were considerably higher (e.g., NON_f). These suggestions were mostly detected in the full ACE models, and after a careful inspection of the reduced models (see Table 3). E followed by A seemed to be the most relevant influential factors for SEX_f-resid and INC-RES_f, although C has a small impact on INC-RES_f as well. NON_f was mostly influenced by effects of E and C. For SEX_f, SUM_f, and SPI_f E was mostly influential followed by effects of C, and small effects of A. Both the full ACE model and the reduced CE model of SUM_f fell below a p-level of 0.05; thus, it should be rejected as the data significantly did not fit to the tested models. The careful examination of the reduced models showed that only for SEX_f-resid the AE model seemed to be meaningful; for all remaining funniness variables the CE models appeared to best fit our data.

Insert Table 4 about here

Table 4 shows that intraclass correlations (ICC) of aversiveness ratings suggested for incongruity-resolution humor (INC-RES_a), sexual humor (SEX_a), total aversiveness score (SUM_a), and content of sexual humor (SEX_a-resid) small to moderate genetic and substantial environmental influences, because correlations for MZ were numerically higher than correlations for DZ twins. For nonsense humor (NON_a) and structure preference (SPI_a) only environmental influences were suggested as the ICC coefficients for MZ and DZ were nearly identical or even DZ correlations were considerably higher (e.g., SPI_a).

Examining the above-mentioned suggestions for aversiveness variables, estimates of A, C, and E influences were inspected in the full ACE models and in the reduced models. Table 4 shows for the full models that INC-RES_a was mostly influenced by effects of E and A. SEX_a-resid, SEX_a, and SUM_a were mostly influenced by E, followed by A, and small effects of C. In contrast, for NON_a and SPI_a only effects of C and E mattered. After a careful inspection of the reduced models, CE models appeared to be most meaningful for all aversiveness variables, although INC-RES_a might be also affected by genetic influences, which needs to be studied further.

Discussion

This study investigated genetic and environmental influences on humor appreciation *separated* for structure and content. Prior studies did not pay attention to the fact that both content and structure contribute to appreciation of humorous material, and that the assessment of appreciation of humor contents is typically contaminated with liking of structural features of jokes (e.g., cleverness, complexity, surprisingness etc.). Also in the present study the 3 WD standard sexual humor (SEX_f, SEX_a) scales represent mixtures of liking of both structure and content features, but the two indices (SEX_f-resid, SEX_a-resid) represent only appreciation of the sexual content in humor, because they are corrected for humor structure (INC-RES, NON). This separation of the structure categories allows to estimate the heritability of liking of content features, and these initial results underscore the importance of this separation.

Humorous content

Funniness of sexual humor (SEX_f; i.e., the standard scale including structure and content) showed in the full ACE models only a small tendency to be impacted by genetic effects (just as in the study by Nias & Wilson, 1977), and was mostly influenced by non-shared, and shared environmental factors, but funniness of the content in sexual humor (SEX_f-resid; i.e., the structure-corrected content scale) presents an unambiguous genetic component (accounting for 35% of variance). This goes along with prior findings as, for example, Eysenck (1976) found a substantial genetic basis for libido in male participants. Kirk, Bailey, Dunne, and Martin (2000) reported additive genetic effects for orientation of sexual fantasies, attitudes to heterosexual or homosexual sex, and number of partners of the opposite sex, as accounting for between 34% and 53% of the variation. Appreciation of content in sexual humor was exactly related to such variables in prior studies (i.e., correlated with sexual libido, behaviors and attitudes; Ruch & Hehl, 1988). It appears that higher libido will make sexual topics in humor more attractive; they will be processed more deeply, the incongruity will be perceived as stronger which, in turn, will lead to a quicker resolution or partial resolution of the incongruity, and thereby also to higher appreciation (higher funniness, lower aversiveness).

Structural humor components

Variance estimates for the pure structural component incongruity-resolution humor (INC-RES) showed the tendency of both funniness and aversiveness ratings to be slightly affected by genetic and mainly by environmental effects. Incongruity was one of the first ingredients of humor to be discussed as it has been mentioned more than 2000 years ago (cf. Deckers, 1993; Schmidt-Hidding, 1963), and INC-RES humor is the most popular humor type (i.e., it underlies most humor in the German culture). As noted above, individuals who score high on INC-RES show a need for structured, stable, and unambiguous stimuli (Ruch, 1992), just as conservatives do, and conservatism is known for its heritability (e.g., Bouchard, 2004).

Contrary to INC-RES, both funniness and aversiveness of nonsense humor (NON) seem to be best represented in environmental models. NON humor involves the appreciation of residual incongruity (i.e., the initial incongruity in a punch line that can not be fully resolved, or the [new] incongruity that is brought about by a partial resolution of the initial incongruity). Nonsense humor is historically more recent, and is mentioned in literature since the middle of the 19th century (cf. Schmidt-Hidding, 1963). It is not mainstream humor, and is found more often in the alternative culture. It should also be noted that neither Cherkas et al. (2000) nor Nias and Wilson (1977) found any evidence for heritability of nonsense humor. Cherkas et al. (2000) studied “Far Side”-Larson cartoons that have been clearly subsumed under nonsense humor (Ruch, 2008). It is not clear from the descriptions by Nias and Wilson (1977) whether they studied nonsense humor in the sense of unresolvable incongruity or merely “harmless” (i.e., non-tendentious) humor. However, nonsense humor is predicted by openness to experience, and the experience seeking subscale of sensation seeking, and individuals liking nonsense often display a preference for complexity and grotesque literature (Ruch & Malcherek, 2009). Thus, as sensation seeking is a highly heritable trait it is noticeable that appreciation of nonsense humor did not yield any genetic effect. The preference of humor structure (INC-RES vs. NON) shows, in both funniness and aversiveness ratings, mostly environmental influences (shared and non-shared effects).

Future research

The present results seem to be a meaningful step in analyzing humor appreciation based on twin data, but there is a need for further behavior genetic evidence in this field. First, as a main limitation of the present research, future studies should utilize larger samples to enhance the statistical power when estimating behavior genetic models. Second, to get detailed information about genetic and environmental influences on humor appreciation, future studies might think about splitting the humorous data into two components: their structure and their content (cf. Platt & Ruch, 2014; Ruch & Platt, 2012). A first candidate for such an approach is aggressive humor. Nias and Wilson (1977) failed to find a clear genetic effect, but in their study structure and content were not separated. As for the sexual, so for the aggressive content in humor, genetic effects may be expected (e.g., Eley, Lichtenstein, & Moffitt, 2003). Third, research on humor appreciation thus far was restricted to printed material (e.g., jokes and cartoons). Movies or short clips were not utilized, but such new media allows for efficient presentation of humor, and this has not been used yet. Contents like aggression, sexuality, or disgust might be more salient in such material, and hence, content might get a higher share of the individual differences compared to the cognitive processes. Fourth, future research should study the genetic effects of humor appreciation and of major predictors of humor (e.g., conservatism) jointly to see whether the two sets of data can be explained by the same latent genetic effect. For example, the simultaneous study of sensation seeking and nonsense will also illuminate why sensation seeking is highly heritable but appreciation of nonsense humor is not. Furthermore, because individuals with higher neuroticism (N) scores dislike things principally more than N low-scorer and N is known as a trait that is substantially genetically influenced (e.g., Bouchard, 2004), the simultaneous study of 3 WD aversiveness ratings and N might unravel the link between a genetic base of aversiveness ratings in this humor context and individuals' N levels.

All in all, we know too little about the relative contribution of genetics and environment to humor appreciation and further research is requested. This should also entail the illumination of the different environmental factors that make humor more funny or more aversive.

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Table 1

Model of Humor Appreciation as Measured by the 3 WD Including Six Regular Scales and Six Derived Indices

	Response mode in the 3 WD	
Variables	Funniness (f)	Aversiveness (a)
3 WD regular scales (8 items each)		
Incongruity-resolution humor (INC-RES)	INC-RES_f	INC-RES_a
Nonsense humor (NON)	NON_f	NON_a
Sexual humor (SEX; incl. INC-RES or NON)	SEX_f	SEX_a
Derived Indices		
Sum scores over 24 items (SUM)	SUM_f	SUM_a
Structure preference index (SPI; NON minus INC-RES)	SPI_f	SPI_a
Liking of sexual content in humor (SEX excl. INC-RES or NON)	SEX_f-resid	SEX_a-resid

Table 2

3 WD Humor Test: Means, Standard Deviations, Internal Consistencies, and Correlations With Age and Gender

	Descriptives			Correlations	
Variables	*M*	*SD*	α	Age	Gender
3 WD funniness					
$INC\text{-}RES_f$	23.55	9.85	.84	.29***	.06
NON_f	12.10	8.66	.79	.07	-.08
SEX_f	15.22	9.70	.81	.11*	-.10
3 WD aversiveness					
$INC\text{-}RES_a$	6.99	8.82	.89	.11*	-.02
NON_a	14.02	12.21	.88	.22***	.04
SEX_a	21.06	13.21	.88	.10	.17***

Note. Analyses are based on an abbreviated version of the 3 WD (8 items per scale). N = 371-378. Gender: male = 1, female = 2.
*p < .05; ***p < .001 (two-tailed)

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Table 3

Twin Similarities and Univariate Model-Fitting (ACE, AE, CE) Results for 3 WD Funniness Scales and Indices[a]

	ICC			Parameter estimates			Model fit[b]	
Variables	MZ	DZ	Model	a^2	c^2	e^2	χ^2	*p*
$INC\text{-}RES_f$	.34	.28	ACE	.28 (.00; .52)	.09 (.00; .41)	.63 (.48; .80)	7.52	.06
			CE	0	.31 (.17; .43)	.69 (.57; .83)	8.73	.07
NON_f	.37	.46	ACE	.00 (.00; .44)	.39 (.00; .51)	.61 (.48; .74)	6.68	.08
			CE	0	.39 (.26; .51)	.61 (.49; .74)	6.68	.15
SEX_f	.31	.32	ACE	.15 (.00; .49)	.20 (.00; .43)	.65 (.51; .81)	4.64	.20
			CE	0	.31 (.18; .44)	.69 (.56; .82)	4.98	.29
SUM_f	.30	.40	ACE	.05 (.00; .49)	.30 (.00; .46)	.65 (.50; .79)	10.08	.02
			CE	0	.34 (.21; .46)	.66 (.54; .79)	10.12	.04
SPI_f	.41	.37	ACE	.09 (.00; .52)	.31 (.00; .51)	.59 (.46; .73)	1.75	.63
			CE	0	.39 (.27; .51)	.61 (.49; .73)	1.89	.76
SEX_f-resid	.35	.10	ACE	.35 (.00; .48)	.00 (.00; .33)	.65 (.52; .81)	1.25	.74
			AE	.35 (.19; .48)	0	.65 (.52; .81)	1.25	.87

Note. ICC = intraclass correlation (type 1.1). MZ = monozygotic twins. DZ = dizygotic twins. a^2 = genetic variance. c^2 = shared environmental variance. e^2 = non-shared environmental variance (incl. measurement error). 95% confidence intervals are shown in parentheses.

[a] The analyses are based on corrected data for age and sex from MZ (*n* = 131 - 134) and DZ (*n* = 54 - 56) twin pairs. [b] Estimates of full ACE-models are based on *d.f.* = 3; estimates of reduced models (CE, AE) are based on *d.f.* = 4. All p-values are two-tailed.

Table 4
Twin Similarities and Univariate Model-Fitting (ACE, AE, CE) Results for 3 WD Aversiveness Scales and Indices[a]

	ICC		Parameter estimates				Model fit[b]	
Variables	MZ	DZ	Model	a^2	c^2	e^2	χ^2	p
INC-RES$_a$	.29	.16	ACE	.30 (.00; .45)	.00 (.00; .35)	.70 (.55; .87)	1.75	.63
			AE	.30 (.14; .45)	0	.70 (.55; .86)	1.75	.78
			CE	0	.25 (.11; .38)	.75 (.62; .89)	2.97	.56
NON$_a$	.28	.27	ACE	.00 (.00; .40)	.27 (.00; .40)	.73 (.59; .86)	0.93	.82
			CE	0	.27 (.14; .40)	.73 (.60; .86)	0.93	.92
SEX$_a$	.38	.29	ACE	.22 (.00; .52)	.16 (.00; .45)	.62 (.48; .78)	1.08	.78
			CE	0	.34 (.21; .46)	.66 (.54; .79)	1.79	.77
SUM$_a$	.32	.23	ACE	.19 (.00; .46)	.13 (.00; .41)	.68 (.54; .84)	0.12	.99
			CE	0	.29 (.15; .42)	.71 (.58; .85)	0.56	.97
SPI$_a$	.13	.28	ACE	.00 (.00; .28)	.18 (.00; .31)	.82 (.69; .97)	1.50	.68
			CE	0	.18 (.03; .31)	.82 (.69; .97)	1.50	.83
SEX$_a$-resid	.39	.30	ACE	.33 (.00; .56)	.10 (.00; .45)	.57 (.44; .74)	3.35	.34
			CE	0	.36 (.23; .48)	.64 (.52; .77)	5.13	.28

Note. ICC = intraclass correlation (type 1.1). MZ = monozygotic twins. DZ = dizygotic twins. a^2 = genetic variance. c^2 = shared environmental variance. e^2 = non-shared environmental variance (incl. measurement error). 95% confidence intervals are shown in parentheses.
[a] The analyses are based on corrected data for age and sex from MZ (n = 128 - 130) and DZ (n = 59) twin pairs. [b] Estimates of full ACE-models are based on *d.f.* = 3; estimates of reduced models (CE, AE) are based on *d.f.* = 4. All p-values are two-tailed.