

Undue influence of weight and shape: is it distinct from body dissatisfaction and concern about weight and shape?

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Background. Three cognitive constructs are risk factors for eating disorders: undue influence of weight and shape, concern about weight and shape, and body dissatisfaction (BD). Undue influence, a diagnostic criterion for eating disorders, is postulated to be closely associated with self-esteem whereas BD is postulated to be closely associated with body mass index (BMI). We understand less about the relationships with concern about weight and shape. The aim of the current investigation was to examine the degree of overlap across these five phenotypes in terms of latent genetic and environmental risk factors in order to draw some conclusions about the similarities and differences across the three cognitive variables.

Method. A sample of female Australian twins ($n = 1056$, including 348 complete pairs), mean age 35 years (*s.d.* = 2.11, range 28–40), completed a semi-structured interview about eating pathology and self-report questionnaires. An independent pathways model was used to investigate the overlap of genetic and environmental risk factors for the five phenotypes.

Results. In terms of variance that was not shared with other phenotypes, self-esteem emerged as being separate, with 100% of its variance unshared with the other phenotypes, followed by undue influence (51%) and then concern (34%), BD (28%) and BMI (32%).

Conclusions. In terms of shared genetic risk, undue influence and concern were more closely related than BD, whereas BMI and BD were found to share common sources of risk. With respect to environmental risk factors, concern, BMI and BD were more closely related to each other than to undue influence.

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Introduction

Three cognitive constructs related to weight and shape have been shown to be risk factors for disordered eating. The first is body dissatisfaction (BD), the subjective negative evaluation of one's body, a robust risk and maintenance factor for bulimic symptomatology (Stice, 2002). The second is concern about weight and shape, which predicts the onset of partial syndrome eating disorders (Killen *et al.* 1996). This measure typically consists predominantly of items that relate to body image (e.g. how often have you worried about having fat on your body?) in addition to an item that assesses the degree to which weight influences feelings of self-worth (e.g. how much has your weight

made a difference in how you feel about yourself?). The third cognitive construct relates to this latter item, namely the undue influence of body weight and shape on how a person feels about, or evaluates, themselves as a person (Fairburn & Cooper, 1993), which predicts the onset of disordered eating behaviours (Wilksch & Wade, 2010).

This latter construct has been differentiated from the other two. It is categorized as an overvalued idea (Veale, 2002), defined as 'an unreasonable and sustained belief that is maintained with less than delusional intensity ... not ordinarily accepted by other members of the person's culture or sub-culture' (APA, 1994). It is the only one of the three constructs to be encapsulated as a diagnostic criteria for both bulimia nervosa and anorexia nervosa (APA, 1994), and has been referred to as the core psychopathology of eating disorders (Fairburn, 2008). It is a central target of cognitive behavioural treatment approaches (Fairburn, 2008).

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Theoretically, BD and undue influence are clearly differentiated. BD is seen as a widespread phenomenon in a Western sociocultural environment, the so-called normative discontent in females (Rodin *et al.* 1984) that is labile and largely responsive to changes in shape, weight or mood (Cooper & Fairburn, 1993). By contrast, undue influence is theorized to be less widespread, peculiar to bulimia nervosa and anorexia nervosa, stable, difficult to change in treatment, and closely tied to self-esteem (Cooper & Fairburn, 1993). This association with self-esteem represents a defining characteristic of an overvalued idea, which is the excessive identification of value with the self (Veale, 2002). There is a growing body of empirical support to suggest that BD is a distinct construct from undue influence. The phenotypic correlation between the two is 0.59, indicating shared variance of only 35% (Cooper & Fairburn, 1993). Longitudinal observations in clinical populations have shown undue influence to be related to changes in self-esteem but not negative affect, whereas BD was related to changes in both (Masheb & Grilo, 2003; Masheb *et al.* 2006). A study of pre-adolescent boys and girls showed that body mass index (BMI) predicted the growth of BD, but not undue influence (Allen *et al.* 2008).

However, the theory and evidence about concern about weight and shape is less clear. To date, only one previous study has directly compared all three constructs, where undue influence was shown to differentiate better between eating disordered and non-eating disordered groups than BD or concern (Goldfein *et al.* 2000). Twin studies also suggest a difference across the three constructs. Univariate estimates of BD measured with the Eating Disorder Inventory (EDI; Garner *et al.* 1983) show heritability of 59% in women (Keski-Rahkonen *et al.* 2005), similar to the 62% heritability of the shape concern subscale of the Eating Disorder Examination (EDE; Fairburn & Cooper, 1993; Wade *et al.* 1998). By contrast, the weight concern subscale of the EDE has been shown to be influenced only by environmental factors (Wade *et al.* 1998), although moderate heritability (54%) is indicated for the combined weight and shape concern subscales of the self-report version of the EDE for females aged 13 to 41 years (Klump *et al.* 2009). The undue influence items from the EDE show heritability of 25% as measured over a 3-month period (Wade & Bulik, 2007). However, factor analyses of the EDE with adults (self-report format) and adolescents (interview format) have found that the weight and shape concern subscales form one factor, including the two items relating to undue influence of weight and shape (Peterson *et al.* 2007; Wade *et al.* 2008).

Therefore, the main aim of the current research was to gain further understanding about the differences

and similarities among these three cognitive constructs. One approach that has not previously been utilized is to examine the degree to which risk factors for these phenotypes are shared. If there is a large degree of overlap in the risk factors, this argues for the constructs being more alike than different, whereas a small degree of overlap would suggest difference rather than similarity. The current research used a genetically informative design with a female adult twin population, a multivariate investigation of undue influence of weight and shape, concern over weight and shape, BD, self-esteem, and BMI. This design allowed us to examine any overlap across the constructs in terms of latent genetic and environmental risk factors. It was hypothesized that there would be little overlap between the risk factors for BD and undue influence. Furthermore, it was hypothesized that there would be a significant overlap in the latent genetic and environmental risk factors for BMI and BD whereas undue influence would share a significant overlap of risk factors with self-esteem. No hypotheses were posed for the relationship with concern about weight and shape because of the paucity and conflicting nature of the evidence to date.

Method

Participants

Participating twins were derived from a cohort of 8536 twins (4268 pairs) born 1964–1971, who were registered as children with the Australian Twin Registry (ATR) during 1980–1982, in response to media and systematic appeals through schools. Female–female twins who had participated in at least one of two waves of data collection (Heath *et al.* 2001), one during 1989–1992 when the twins were aged 18–25 years and the other during 1996–2000 when the median age of the sample was 30 years, were approached during 2001–2003 to participate in a third wave of data collection ($n=2320$); of these, 1083 individual twins (47%) actively consented to participate (Wade *et al.* 2006b). Of those consenting, 1002 (43%) completed a semi-structured interview over the telephone relating to current and lifetime eating, 1016 (44%) completed a mailed self-report questionnaire assessing various aspects of personality, where 962 women completed both (42%). In all, 1056 females (46%) participated in at least one of the data collection components.

The sample included 348 complete sister–sister pairs who completed the Wave 3 data collection, 226 monozygotic (MZ) pairs and 122 dizygotic (DZ) pairs, and 360 incomplete pairs (170 MZ and 190 DZ), where only one twin participated. Both interview and questionnaire were completed by 293 complete pairs.

Zygosity was determined on the basis of responses to standard questions about physical similarity and confusion of twins by parents, teachers and strangers, methods that give better than 95% agreement with genotyping (Eaves *et al.* 1989). The mean age of the women at the time of the data collection was 35 years (s.d.=2.11, range 28–40). The Flinders University Clinical Research Ethics Committee approved the study and written informed consent was obtained.

Measures

BMI

Self-reported weight and height were used to calculate BMI (kg/m^2).

Self-esteem

The Rosenberg Self-Esteem Scale (Rosenberg, 1965) is a 10-item self-report questionnaire that uses a four-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). Higher mean item scores indicate greater self-esteem. The scale has demonstrated good concurrent validity with the State Self-Esteem Scale (Heatherton & Polivy, 1991), $r=0.72$, $p<0.05$. Internal reliability in the current sample was good ($\alpha=0.87$).

Body dissatisfaction

The figural stimuli developed by Stunkard *et al.* (1983) and containing nine female schematic figures that range from underweight to overweight was used to measure BD. Subjects are asked to rate the figures based on their (i) current size ('which silhouette is closest to your usual appearance?') and (ii) ideal size ('which of these figures would you like to look like?'). The difference between the ratings is a discrepancy index and is considered to represent the individual's level of dissatisfaction with their current size. Studies indicate that the current and ideal size ratings meet acceptable standards of reliability (Thompson, 1995). The validity of the figural stimuli has been examined in a large twin cohort, where examination of BMI and current body size estimation using the figural stimuli have shown the stimuli to be effective in classifying individuals as thin or obese (Bulik *et al.* 2001). Genetic influences showed the largest impact on the individual variation in current body size measures, whereas non-shared environmental influences had the largest impact on ideal body size. There was a significant main effect of heritability on polychoric correlations for the derived BD measure (Wade *et al.* 2001). This method of deriving BD has been shown to correlate significantly with two continuous measures of BD in adult women, namely the

EDI BD scale (Garner *et al.* 1983) with $r=0.59$ and the Body Esteem Scale (Franzoi & Shields, 1984) with $r=0.44$ (Tiggemann & Lynch, 2001). It has demonstrated reliability and validity (Banasiak *et al.* 2001), with test–retest reliability of 0.59 over a 2-year period with 14-year-old girls (Tiggemann, 2005).

Concern about weight and shape

The EDE (Fairburn & Cooper, 1993) is a semi-structured interview that includes questions relating to behavioural features of DSM-IV eating disorders in addition to items that form subscales relating to dietary restraint (five items), eating concern (five items), shape concern (eight items) and weight concern (five items) over the previous 28 days. Each item is measured on a seven-point Likert scale, ranging from 0 to 6, where higher scores indicate greater psychopathology. The EDE has a high level of inter-rater reliability and it has been described as 'the most sensitive instrument for assessing the complex psychopathology of anorexia and bulimia nervosa' (Wilson, 1993). Consistent with previous factor analyses, the subscales were combined for the present investigation. One item is repeated in both subscales and so was used only once, and the items relating to undue influence were also removed. The resultant measure containing 10 items had good internal reliability ($\alpha=0.89$).

Undue influence of body weight or shape on self-evaluation

Two EDE items assess the diagnostic criterion of 'undue influence of body weight or shape on self-evaluation' over the previous month, one each for weight and shape. Each item was measured on a seven-point Likert scale, ranging from 0 to 6, where 4 is equivalent to moderate importance, which is considered to be clinically significant (Fairburn & Cooper, 1993). The mean score was calculated, producing good internal reliability ($\alpha=0.87$).

Statistical analyses

For the purpose of the following analyses, all data were treated as being continuous and a full information maximum likelihood (FIML) approach using the statistical package Mx (Neale, 1997) was used, which uses the raw data and incorporates complete and incomplete pairs of twins and those with missing data.

Correlations

Within-twin correlations between the variables were estimated using the FIML approach. The MZ and DZ correlations for each phenotype were also examined.

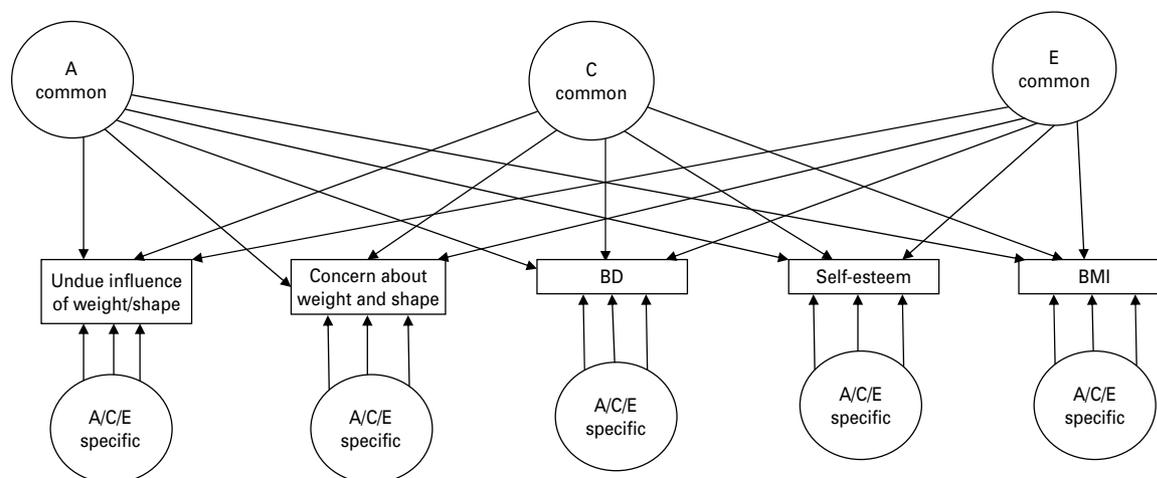


Fig. 1. Path diagram showing an ACE independent pathways model with common and specific risk factors.

Multivariate twin model

As previous analyses showed no relationship between participation in the current wave of data collection and variables from the previous two waves, including the number of eating problems, personality variables or lifetime depression (Wade *et al.* 2006a), FIML can reduce the impact of any respondent bias when the data are missing at random (Little & Rubin, 1987). FIML estimation has been found to be superior to the three *ad hoc* techniques (listwise deletion, pairwise deletion and mean imputation) in multiple regression models as FIML parameter estimates had less bias and sampling variability than the other three methods (Enders, 2001).

Although univariate twin analyses use data on co-twin similarity for a single trait, multivariate analyses use observed similarity between the same trait in co-twins, between one trait in a twin and a different trait in the co-twin, and between the various traits observed in individuals. The sources of variance in liability to a trait are divided into that proportion accounted for by four different influences: additive genetic (A), common or shared environmental (C), genetic dominance (D), and non-shared or unique environmental (E). This latter factor also contains the variance of any error measurement. Each factor is latent and not observed directly. D is rarely indicated as accounting for variance in phenotypes but has been found to be a significant contributor to the variance of BMI where an ADE model is suggested (Maes *et al.* 1997). Models can only contain a maximum of three sources of variance, so either an ACE or an ADE model must be chosen for examination.

Specifically, an independent pathways mode was used, where each of the three common latent factors (A, C/D and E) has their own paths to each of the five phenotypes, that is the five phenotypes have these

influences in common. The sources of unique variance to each phenotype from each latent source is also estimated, that is those sources unshared with the other phenotypes, known as specific pathways. This model allows us to divide genetic and environmental variance across the different phenotypes and also those specific to each phenotype. The general structure of the independent pathways model is shown in Fig. 1 with ACE factors.

Initially, a full model (ACE) was fit to the data, followed by an ADE model, an AE model, a CE model, and a model containing only non-shared environment (E). The aim of model fitting is to explain the observed data as an optimal combination of goodness-of-fit and parsimony. Akaike's Information Criterion (AIC; Akaike, 1987) reflects these criteria, where the more negative the value, the better the fit of the model. The fit of submodels can be tested by the difference between the $-2\ln(L)$ and the degrees of freedom (df) of the full model and the submodel, resulting in a χ^2 (df).

Results

Descriptives

BD, BMI and concern about weight and shape were significantly positively skewed ($p < 0.01$) and the \log_{10} transformation improved the distribution. There was no difference between the MZ and DZ twins for the respective values [mean (s.d.)] of influence of weight or shape [2.23 (1.55) and 2.13 (1.55), odds ratio (OR) 0.96, 95% confidence interval (CI) 0.88–1.04], concern about weight and shape [1.22 (1.34) and 1.22 (1.22), OR 1.18, 95% CI 0.66–2.10], BD [0.88 (1.05) and 0.87 (0.99), OR 0.85, 95% CI 0.22–3.35], self-esteem [3.15 (0.45) and 3.12 (0.44), OR 0.85, 95% CI 0.65–1.13] or BMI [24.21 (5.42) and 24.06 (5.16), OR 1.56, 95% CI 0.32–7.72]. Nor was there any indication that the variances differed

Table 1. Within-twin maximum likelihood correlations

Phenotype	BMI	Self-esteem	BD	Concern: weight and shape
Undue influence	0.23	-0.35	0.29	0.55
BMI		-0.19	0.68	0.47
Self-esteem			-0.26	-0.40
BD				0.54

BMI, Body mass index; BD, body dissatisfaction.

(*p* values for Levene's test of homogeneity of difference ranged from 0.24 to 0.76). On the whole, no cooperation bias detected, as there was no difference between complete and incomplete pairs for the respective values [mean (s.d.)] of concern [1.22 (1.29) and 1.22 (1.29), OR 0.94, 95% CI 0.51–1.72], BD [0.88 (1.00) and 0.87 (1.07), OR 0.73, 95% CI 0.17–3.08], self-esteem [3.14 (0.44) and 3.14 (0.45), OR 1.02, 95% CI 0.76–1.38] or BMI [24.10 (5.00) and 24.08 (4.72), OR 1.02, 95% CI 0.19–5.48]. However, cooperation status did predict a difference in the undue influence variable (OR 0.89, 95% CI 0.82–0.97), where complete twin pairs had a significantly higher importance rating [2.28 (1.52)] compared to incomplete twin pair respondents [2.00 (1.60)].

The averaged undue influence variable ranged from 0 to 6, with a mean of 2.19 (s.d. = 1.55). Concern over weight and shape ranged from 0 to 6 with a mean value of 1.22 (s.d. = 1.29). BD ranged from -3 to +7, with a mean value of 0.87 (s.d. = 1.02). The majority of women (*n* = 654, 64.7%) selected a body size smaller than they judged their current size, and could thus be categorized as body dissatisfied. Self-esteem ranged from an item average of 1 to 4 with a mean of 3.14 (s.d. = 0.45). BMI ranged from 14.20 to 63.98, with a mean of 24.09 (s.d. = 4.91). A BMI < 26 was reported by 75.1% of the women, and 8.2% had a BMI > 30. This is slightly lower than that obtained in a large demographically representative sample of Australian women aged 28 to 33 (Brown *et al.* 1998), where the mean BMI was 25.0 and the proportion of women who were overweight or obese was 38.9%.

Within-twin correlations

First, the fit statistics allowing the four within-twin correlation matrices to be different across both MZ and DZ twins, and also Twin 1 and Twin 2, were compared to the fit statistics when the four correlation matrices were constrained to be same across these four groups. The difference between these two approaches was not significant ($\chi^2 = 71.82$, *df* = 60, *p* = 0.14), indicating that

Table 2. Relative fit of the different independent pathways models

Model	-2ln(L)	df	AIC	Fit χ^2 (df) <i>p</i>
ACE	-960.017	4987	-10 934.018	-
ADE	-956.513	4987	-10 930.513	-
AE	-897.738	4997	-10 891.737	62.279 (10) < 0.001
CE	-846.912	4997	-10 840.912	113.105 (10) < 0.001
E	-424.265	5007	-10 438.266	535.752 (20) < 0.001

AIC, Akaike's Information Criterion; ln(L), log likelihood; df, degrees of freedom; A, additive genetic; C, common environment; E, unique environment.

there was no significant difference across correlations derived across the whole sample (i.e. treating twins as singletons) or those derived for each of the four subgroups. Thus only the within-twin correlations for the whole sample are reported in Table 1, which shows correlations in the expected directions, that is a higher undue influence is associated with a higher BMI, lower self-esteem, higher BD and higher concern over weight and shape. The highest correlation was between BMI and BD (*r* = 0.68), and the lowest correlation was between BMI and self-esteem (*r* = -0.19).

Twin correlations

The MZ and DZ twin correlations for each variable and are reported in Table 3. The MZ:DZ correlations across all the phenotypes indicated a substantial genetic contribution. All phenotypic correlations between the MZ and DZ twins were significantly different, as indicated by the *Z* statistic.

Multivariate model

First, the different models were tested against each other (Table 2). The ACE model was significantly better fitting than the AE, CE and E submodels, and the ACE model was considered to be more parsimonious than the ADE model given the lower AIC value. However, interpretation of this model needs to take into account that the ACE model is unlikely to represent BMI accurately given previous findings, and this may also extend to BD, which is a measure derived from figural stimuli representing BMI. The pathway estimates of the ACE model are presented in Table 3. The model was also examined with only complete twin pairs, showing no substantial difference in the estimates (Appendix 1). Examination of each phenotype suggests that the proportion of variance due to genetic influence is 48% (undue influence), 52% (concern) and 45% (self-esteem). More caution should

Table 3. Cross-twin correlations (MZ and DZ) and the common and independent pathway estimates and 95% CI for the ACE independent pathways model

Phenotypes	<i>r</i> MZ (95% CI) <i>r</i> DZ (95% CI) <i>Z</i> (<i>p</i>)	A common	A specific	C common	C specific	E common	E specific
Undue influence	0.42 (0.30–0.52) 0.06 (–0.14 to 0.25) 4.82 (<0.001)	48 (40–56)	0 (0–5)	0 (0–3)	0 (0–4)	1 (0–3)	51 (44–58)
Concern	0.47 (0.36–0.57) 0.25 (0.07–0.42) 3.19 (0.001)	52 (42–60)	0 (0–4)	2 (0–10)	0 (0–4)	12 (6–20)	34 (28–40)
Body dissatisfaction	0.56 (0.46–0.64) 0.24 (0.03–0.42) 4.82 (<0.001)	15 (5–23)	5 (0–15)	30 (21–43)	0 (0–7)	27 (18–39)	23 (13–33)
Self-esteem	0.48 (0.38–0.57) 0.04 (–0.16 to 0.23) 7.01 (<0.001)	0 (0–0)	45 (28–55)	0 (0–1)	0 (0–14)	0 (0–0)	55 (46–66)
BMI	0.74 (0.68–0.79) 0.45 (0.28–0.59) 5.82 (<0.001)	11 (2–17)	18 (5–28)	43 (30–57)	0 (0–8)	14 (9–21)	15 (10–21)

MZ, Monozygotic; DZ, dizygotic; CI, confidence interval; BMI, body mass index; A, additive genetic; C, common environment; E, unique environment; *Z* (*p*), *Z* statistic indicating whether a significant difference exists between the MZ and DZ correlations.

be exercised for interpreting heritability estimates for BD and BMI, given the likelihood of undetected dominance, where heritability was 20% and 29% respectively.

Informing the main aim of the current research was the division of the different types of variance across the different phenotypes. With respect to additive genetic variance, the common factor contributes most to the undue influence and concern phenotypes, three to four times less variance to BD and BMI, and none to self-esteem. The difference between undue influence and concern emerges when looking at the common unique environmental variance, which contributes similarly to concern (12%), BD (27%) and BMI (14%), but hardly at all to undue influence (1%) and none to self-esteem. With respect to the common C factor, BMI and BD are the only phenotypes to be substantially impacted. In terms of variance that is not shared with other phenotypes, self-esteem emerges as being separate, with 100% of its total variance unshared with the other phenotypes, followed by undue influence (51%), and then concern (34%), BD (28%) and BMI (32%).

Discussion

Although the current research cannot determine cause and effect, it can inform us as to the degree of overlap across latent genetic and environmental risk factors for

undue influence, concern about weight and shape, BD, self-esteem and BMI. Our first hypothesis, that there would be little overlap between the risk factors for BD and undue influence, was partially supported. The common additive genetic factor contributed to both undue influence and BD, 48% and 15% respectively, and the common non-shared environmental factor also contributed to both, 1% and 27% respectively. However, these figures do not indicate a high level of overlap between risk factors, especially with respect to environmental risk factors. We can only speculate as to the different environmental variables that contribute to these two phenotypes, but given BD is seen as a normative discontent, it may be that BD is more influenced by the sociocultural thin ideal whereas undue influence may be more influenced by adverse life events or family dysfunction. Greater overlap in the heritability of undue influence and concern was indicated, suggesting that concern about weight and shape may be an endophenotype candidate for undue influence. However, a difference between these two variables was indicated by little overlap in environmental risk factors. Also supportive of a difference between the two factors was the finding that undue influence had 51% of its total variance unshared with the other phenotypes, compared to 34% for concern. This difference supports the unique position of undue influence as a diagnostic criterion for eating disorders in contrast to concern, but further research is required

to understand which environmental risk factors differ between undue influence and concern. This different pattern between shared genetic and environmental risk factors may explain the contradictory evidence with respect to these two phenotypes, where they load onto the same factor (Wade *et al.* 2008) but where undue influence better differentiates between eating disordered and non-eating disordered groups than concern (Goldfein *et al.* 2000).

Supportive of our second hypothesis, BMI and BD had the highest phenotypic correlation and shared a moderate degree of the common C factor, 43% and 30% respectively, in contrast to the other phenotypes. They also shared a smaller overlap of common non-shared environment. Although variation in undue influence and variation in BMI were both influenced by the common A factor, this is only 11% of the variance for BMI compared to 48% for undue influence. Given that undue influence is a diagnostic criterion for both bulimia nervosa and anorexia nervosa, which are associated with healthy and underweight respectively, and there is some debate as to its inclusion as a diagnostic indicator for binge eating disorder (Mond *et al.* 2007; Grilo *et al.* 2009), which is associated with obesity, it is important that this construct is not too closely linked with BMI in order to have diagnostic validity across the different eating disorders. These findings support the diagnostic validity of undue influence in the DSM nomenclature (APA, 1994). However, in contradiction to our hypothesis, the risk factors for undue influence and self-esteem did not overlap. Self-esteem tends to be associated with a broad range of psychopathologies, whereas undue influence has been found to confer specific risk for the development of disordered eating (Wilksch & Wade, 2010). Further investigation of this relationship is required, using multidimensional operationalizations of self-esteem rather than the global measures that may not adequately capture the complexities of this construct.

Although the focus of the current research was the degree of overlap among the sources of risk for our phenotypes, the heritability estimates for each phenotype can be reported. However, this needs to be interpreted in the context of using one multivariate model to represent all phenotypes, where the inclusion of BMI presented a difficulty as it is affected by genetic dominance (Maes *et al.* 1997), which may also impact on our BD measure, which has been found to be closely associated with BMI (Bulik *et al.* 2001). A review of the literature on the familial resemblance of BMI found that twin studies suggest that between 50% and 90% of the variance in BMI is accounted for by genetic factors (Maes *et al.* 1997), and the BD measure has previously been found to be moderately heritable (Wade *et al.* 2001), as have other measures of

BD, with estimates of 60% (Keski-Rahkonen *et al.* 2005). Thus, with the exception of BMI and BD, our heritability estimates can be compared to those reported previously. Few studies have examined the heritability of undue influence, with a previous estimate for the current twin population over a 3-month period being 25%. The heritability for the 1-month period is higher, at 48%, indicating that further research is required to ascertain accurate estimates. Previous studies have examined weight concern and shape concern separately with respect to the EDE, with 0% and 62% heritability respectively (Wade *et al.* 1998), and therefore our moderate heritability in the current study for the combined scale (52%) can be seen to be between these two previous estimates, and similar to the 54% reported for the combined scale for the self-report version of the EDE (Klump *et al.* 2009). Self-esteem was moderately heritable, with an estimate of 45%, similar to the 52% heritability found in the Virginia Twin Registry (Roy *et al.* 1995).

There are limitations in the current research that should be taken into consideration when interpreting the results. First, we have a moderate response rate (47%), commensurate with another large Australian population study, where an initial response rate for mid-age women was 54% (Brown *et al.* 1998). Previously, no response bias due to a past history of disordered eating has been detected for this sample (Wade *et al.* 2006c), or other samples of Australian twins (Wade *et al.* 1997). Second, our community sample was drawn from a twin population, and there have been no investigations of whether eating- and body-related variables are similar between twin and non-twin groups. Third, we have used only one measure of BD, but there are several different measures of BD used in the literature and these may relate differently to our variables. Fourth, given the cooperation bias that was detected for the influence of the weight and shape variable, the analysis of complete and single twins together for this variable may not represent the most optimal strategy. Fifth, BMI was measured using self-report, which could introduce a small margin of error, given the κ between self-reported height and weight and BMI is 0.705 for women (Craig & Adams, 2009). Sixth, the relevance of the current findings to younger women and girls is unknown. The sample is beyond the period of risk for developing an eating disorder and thus the results of the study may not generalize to adolescents and young adult women, who are most at risk. Seventh, we have used the two-item undue influence of weight and shape measure as a continuous scale in analyses, but this approach is likely to limit the variation of this construct and may impact on the estimates derived.

In summary, the data suggest that BD is relatively different from both concerns and undue influence, and that concerns and undue influence are more closely related in terms of shared genetic risk. However, undue influence and concern are differentiated in terms of environmental risk factors, which may justify the inclusion of undue influence as a diagnostic criterion for eating disorders rather than concern. However, further research is required to explore the ways in which undue influence may be more clinically relevant than concern. The results of the current study also suggest a large overlap in risk factors between BMI and BD, affirming the successful focus on BMI in

current interventions for decreasing BD, that is challenging the thin ideal using cognitive dissonance (Stice *et al.* 2006), healthy eating (Stice *et al.* 2006), and accepting unpleasant thoughts and feelings about one's body (Wade *et al.* 2009). However, in light of the results, use of interventions to broaden one's criteria for judging self-worth in order to decrease disordered eating (Fairburn, 2008) may be relatively ineffective. Future research should investigate a variety of additional approaches to decreasing undue influence, such as tackling perfectionistic, all-or-nothing thinking styles (Steele & Wade, 2008), or character traits such as ineffectiveness or impulsivity (Wilksch & Wade, 2010).

Appendix 1. Common and independent pathway estimates and 95% CIs for the ACE independent pathways model: complete pairs only

	A common	A specific	C common	C specific	E common	E specific
Undue influence	44 (35–52)	0 (0–6)	0 (0–3)	0 (0–5)	1 (0–3)	56 (47–64)
Concern	50 (39–58)	0 (0–5)	2 (0–9)	0 (0–5)	13 (7–21)	36 (30–44)
Body dissatisfaction	19 (7–29)	4 (0–13)	27 (17–41)	0 (0–7)	29 (19–43)	22 (10–31)
Self-esteem	0 (0–0)	45 (28–54)	0 (0–1)	0 (0–14)	0 (0–0)	55 (46–66)
BMI	13 (3–21)	19 (6–30)	40 (26–55)	0 (0–7)	13 (8–19)	16 (11–22)

CI, Confidence interval; BMI, body mass index; A, additive genetic; C, common environment; E, unique environment.

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Declaration of Interest

None.

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