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"You see yourself like in a mirror": The effects of internet-mediated personal networks on body image and eating disorders[1]

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Abstract — Body image issues associated with eating disorders consist of attitudinal and perceptual components: individuals' dissatisfaction with body shape or weight, and inability to correctly assess body size. While prior research has mainly explored social pressure from media, fashion, and advertising, we aim to uncover how personal networks, also encompassing internet-mediated interactions, bear upon body image. We estimate these effects with data from a survey of users of websites on eating disorders, including indicators of their body size and body image, and maps of their networks of connections. A bivariate ordered probit accounts for the joint distribution of attitudinal and perceptual body image dimensions depending on network characteristics. Results, confirmed by in-depth interviews, provide evidence that personal networks affect body image concerns, and show that this influence varies significantly by body size. Personal networks, as may be formed also (but not only) online, can be conducive to positive body image development.

Keywords: Personal networks, health, eating disorders, body image, network density, social circles.

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Abstract

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INTRODUCTION

Eating disorders such as anorexia nervosa and bulimia nervosa are characterized by extreme behaviors with insufficient or excessive food intake, often accompanied by purging, self-induced vomiting, and problematic exercising affecting both physical and mental health. Eating disordered behaviors typically coexist with body image issues, and diagnostic criteria include disturbance in the way body size and shape are experienced, as well as over-emphasis on body weight in self-evaluation (American Psychiatric Association 2013). Research has highlighted the role of body image issues in the onset and maintenance of eating disorders (Stice and Shaw 2002). Both the *attitudinal* dimension of body image – i.e., individuals' dissatisfaction with their perceived body shape or weight – and the *perceptual* one – i.e., individuals' inability to correctly assess their own body size (Waldman et al. 2013) – are present in persons with eating disorders (Benninghoven et al. 2007), and can jointly trigger or sustain unhealthy eating behaviors.

The social environment in which individuals are embedded shapes body image and eating behaviors (Costa-i-Font and Jofre-Bonet 2013), though in ways that are still poorly understood. The mass media and fashion have often been held responsible for socio-cultural idealization of (especially female) thinness, but their effects are uneven and do not systematically result in dissatisfaction or pathological perceptions (Polivy and Herman 2004). Rather, the way in which women engage with responses to media images seems to be mediated by their daily-life contexts and their relationships with others, such as partners, friends, and health professionals (Paquette and Raine 2004). Family expectations and other social contacts in specific communities may attenuate the effects of media pressure (Odoms-Young 2008).

This evidence suggests that media effects on body image and body weight can be mediated by relationships, and more generally, by an individual's immediate social surroundings. But how do these effects occur? Current research offers hints, but no clear answers, by exploring the role of social influence, especially from friends (Christakis and Fowler 2007, Valente et al. 2009). Although most of these studies find evidence of social influence, the underlying social mechanisms remain unclear (Cunningham et al. 2012).

The literature on personal networks offers a promising direction of research. By mapping precisely the contacts ("alters") of a focal individual ("ego"), a personal-network approach can provide a reliable picture of the relational environment in which ego is embedded; and can illuminate the way networks channel norms, information, opportunities and constraints for action, thereby moderating the perception and possible internalization of bodily ideals. While Brewis, Hruschka and Wutich (2011) simply count the relationships of ego to alters to study vulnerability to fat-stigma in interpersonal relationships, other areas of health research demonstrate the usefulness of accounting for more complex aspects such as breadth of relationship types (Ellwardt, Van Tilburg and Aartsen 2014), existence of ties between alters (Reeves et al. 2014), organization of alters into social circles (Tubaro, Casilli and Mounier 2014), reciprocity and shared acquaintances (Valente et al. 2009).

A systematic personal networks approach may enlighten the specific effects of internet and online social networking sites on body image and eating disorders, as well as the extent to which they confirm patterns observed with traditional media. Extant correlational evidence of linkages between use of "new" media, body image issues, and disordered eating is rather thin. The focus of most existing studies on a generalist online service, *Facebook*, offers limited scope for generalization to the more controversial "pro-anorexia" (or "pro-ana") websites, whose alleged triggering effects have fueled press debates and ban attempts for over a decade (Casilli et al. 2013, Chang and Bazarova 2016, Knight 2006, Yeshua-Katz and Martins 2013). More

importantly, attention has been focused primarily on contents rather than on the underlying interpersonal interactions, so that little is known of the potential moderating role of personal ties. The combined effects of computer-mediated and face-to-face social relationships are also to be explored.

The present paper contributes to filling these gaps, using data on users of varied online media related to eating disorders, including both "pro-ana" pages, blogs and forums, and generalist services such as *Facebook*. Interestingly, this population encompasses not only recovering and diagnosed sufferers but also persons with sub-clinical symptoms, who would escape notice in medical study settings. They exhibit a wide range of body shapes and sizes – from severe thinness to obesity – corresponding to different body image issues and types of disorders. The data include maps of personal networks of connections, both online and in daily life – school, work, leisure, family. We can thus account for the deliberate effort of persons with eating disorders to shape their social networks through the internet, and shed further light on the linkages between online socialization, body image, and unhealthy eating.

We show that specific structural and compositional aspects of personal networks reduce attitudinal and perceptual distortions of body image. We also provide evidence that the relative strength, and significance, of network effects vary across individuals depending on their body size – a novel result. In comparison to previous literature, we draw a more nuanced picture, in which use of internet (even including debatable contents) may be conducive to positive body image development.

THEORY AND EVIDENCE

The health effects of social integration via personal networks have been widely recognized in the general population. Berkman and Syme's 1979 pioneering study of Alameda County, California, showed that individuals with no ties to others face higher mortality risk than

individuals with many contacts. Researchers have since extended this result to a broad range of health outcomes including people's capacity to cope with stress (Thoits 1995), hypertension (Cornwell and Waite 2012) and suicide attempts (Mueller and Abrutyn 2015). Networks offer the comfort of companionship, channel informational and emotional support, and provide access to resources and material goods (Berkman et al. 2000, Wellman and Frank 2001).

Most early studies used personal network *size* (i.e., number of alters of an ego) as proxy for social integration, the underlying idea being that larger networks offer more benefits. Recognizing that network size is only a coarse measure of connectedness, recent research tends to collect richer data so as to use additional indicators (Smith and Christakis 2008), also including network *structure*, that is, the pattern of ties between alters in a personal network, and *composition*, that is, the aggregated attributes of alters (Valente 2010). This general literature informs our reasoning on the specific case of eating disorders.

Network size

Secrecy about food intake, purging practices, and weight loss interferes with the formation of trusting relationships (Stice 2002) and is often associated to social isolation (Levine 2012). However, the advent of social networking services and online forums for communication has created new opportunities for socialization, allowing individuals with eating disorders to interact with peers (Casilli et al. 2013). Consequently, the size of personal networks of members of "pro-ana" communities may signal potential support. An individual with a larger network (including online ties) will obtain feedback from many people, and will be able to compare and contrast different views, so that any extreme opinions (e.g., pressure for thinness) will likely offset opposing ones (e.g., encouragement to gain weight after anorexia). We thus expect an association between number of alters and greater availability of useful feedback. Together, these factors can moderate the desire for thinness and correct inaccurate perceptions, leading to our

first hypothesis: *Network size will be positively associated with smaller attitudinal and perceptual distortions in body image (H1).*

Network structure

Beyond size, inclusion of more complex structural features derived from relations between alters can be useful, especially when personal networks are large (McCarthy 2002). One of the most important dimensions of structure is cohesion between alters in the personal network of ego. Cohesion can be interpreted in at least two ways. First, it can be the existence of ties between alters, as perceived by ego – what one would conventionally measure as personal network *density*. Second, it can be the existence of *social circles*, or contexts of interpersonal interaction (such as school, workplace, or sports club), known to ego and shared by two or more alters. Social circles are important as they link forms of sociability and forms of socialization, relating relationships to ego's life experiences (Bidart and Charbonneau 2011). Sharing a context creates opportunities for, and is the first step towards, the creation of a relationship – a tie is such when it becomes autonomous from the context in which it has first appeared and can survive its disappearance, for example in the case of classmates who remain friends after leaving school (Bidart, Degenne and Grossetti 2011).

Cohesive personal networks are more likely to convey less diverse feedback to ego, as alters will tend to share their views and be more similar to one another (Burt 1983, 1992). Further, cohesiveness may put pressure on individuals to conform to commonly accepted norms (Valente 2010). In our study, this may involve increased pressure from peers toward standards of beauty and thinness (Mundt 2011), a greater sense of bodily inadequacy, and a stronger drive for change. This leads us to our second hypothesis: *Network cohesiveness will be positively associated with larger attitudinal and perceptual distortions in body image (H2).*

Network composition

Network composition indicators shed light on the aggregate characteristics of alters in a personal network. One dimension is diversity, observed along relevant attributes such as gender, social role relative to ego (e.g., kin, friend, colleague), and channel through which the relationship is maintained (online, face-to-face, or both). For example, the proportion of same-sex alters in a network can capture the degree of homophily in ego's choices. In general, a diverse network is likely to provide the individual with a wide range of viewpoints (Burt 1983, 1992), where any extreme views are countered by opposite perspectives, thereby offering more scope for a balanced assessment and correction of any biases.

A second relevant dimension is the strength of a social tie, which Granovetter (1973) defined as a function of its duration, emotional intensity, intimacy, and exchange of services. Strong ties are more likely to generate social support (Wellman 1979), but also to increase the amount of social control exerted on ego (Valente and Vlahov 2001). Strong ties are more likely to provide feedback and help correct attitudinal or perceptual distortions.

Accordingly, we formulate our third set of hypotheses: *Network heterogeneity will be positively associated with smaller attitudinal and perceptual distortions in body image (H3a); Strength of social ties will be positively associated with smaller attitudinal and perceptual distortions in body image (H3b).*

DATA AND METHODS

We use data from the first social network study of users of websites related to eating disorders, fielded as a web survey in 2011 – 2012 and completed by 284 English- and French-speaking European respondents. The sample represents a large population, though with fuzzy boundaries. It is estimated that eating disorders affect at least 600,000 people in the UK (PwC and B-eat 2015) and just as many in France (AFDAS-TCA 2014); both countries have high internet

penetration with over 65% of adults (and a higher percentage of younger people, who are also more likely to have an eating disorder) using the internet daily in 2012 (INSEE 2013).

While the nature of this study drove the choice of a purposive rather than random sampling strategy, the data is informative of body dissatisfaction issues and their linkages to unhealthy eating in a relatively large and diverse population, not limited to recognized patients. The comparative dimension of the study accounts for key contextual aspects: while similar under many respects, the two countries differ in average observed BMI of women – 23.2 in France and 26.2 in UK, respectively the lowest and highest in Europe – as well as ideal BMI – 19.5 in France and 20.7 in UK (de Saint Pol 2009).

Most importantly, this survey collected rich data on respondents' broadly defined social environments, including face-to-face and internet-based personal networks. This information was elicited through a user-friendly graphical interface embedded in the online questionnaire to enable survey participants to draw their personal networks directly on their screens (Figure 1). This computer-based graphical tool was designed to facilitate data collection while improving the survey experience (Tubaro and Mounier 2014). In-depth interviews of 50-90 minutes each with a subset of this population (n = 37) offer further insight and contribute to bringing forth important discursive trends.

[FIGURE 1 ABOUT HERE]

Dependent variables: body image

To elicit information on body image, the survey used the Figure Rating Scale (FRS) developed by Albert J. Stunkard and co-authors in 1983, now widely used as self-reported measure (see e.g. Cardinal, Kaciroti and Lumeng 2006, Lynch et al. 2009). It requires participants to self-rate by choosing a figure from among nine stylized silhouettes ranging from emaciated to

corpulent. The scale was criticized for its ordinal and somewhat arbitrary nature, the restricted range of response options it offers, as well as an assumed Caucasian bias in the depiction of body shapes and complexions. However, it has been proven robust and highly correlated with self-reported height and weight in diverse samples (Bulik et al. 2001, Lo et al. 2012). A ROC (Receiver Operating Characteristics) analysis, not reported here, confirms that FRS accurately classifies respondents in our sample too.

Specifically in our study, the figure scale was used to assess the complex nature of body image issues through the following three questions: (1) how respondents *describe* (D) themselves ("If I had to describe myself, I would say that I look like..."); (2) how respondents would *choose* (C) to look ("If I could choose, I would like to look as..."); and (3) how respondents think *others* (O) see them ("People usually say that I look like..."). On this basis we created three variables (D, C, and O), each taking integer values ranging from 1 to 9.

These variables are then used to calculate, for each individual in the sample, two discrepancy scores, namely D - C (Described - Chosen body image) and D - O (Described – Other-mediated body image). In line with the literature, and similar to Bulik et al. (2001), the former operationalizes the *attitudinal* component of body image distortions, that is, weight and shape satisfaction/dissatisfaction; the latter stands for its *perceptual* component, that is, the inability to correctly assess body size. Zero attitudinal discrepancy ($D - C = 0$) denotes satisfaction, whereas positive discrepancy ($D - C > 0$) indicates that perceived body image is heavier than the individual's desired one, and negative discrepancy ($D - C < 0$) signals the opposite. Put differently, positive attitudinal discrepancy indicates an aspiration to *lose* weight, and negative discrepancy indicates an aspiration to *gain* weight.

The two discrepancy scores can theoretically vary between - 8 and + 8, taking only integer values. These scores cannot be taken as mere qualitative categories with no ordering. The literature (for example Bulik et al. 2011, Cororve Fingeret et al 2004) interprets differences

as discrepancy scores to assess the extent of body image dissatisfaction: higher (absolute) scores indicate higher dissatisfaction, and therefore potentially higher health risk. For example, Napolitano et al. (2010) study children with a genetic condition affecting body weight and notice a significant difference in mean dissatisfaction between males (mean = 3.07) and females (mean = 1.52). Of course, these differences are not continuous variables either, as they are derived from a scale with no direct numerical interpretation. What matters is the order of differences – whether they are smaller or larger – while their specific value is conventional and does not have a meaning *per se* (except of course the 0 value). For this reason, we interpret D - C as an ordered variable.

Figure 2 (left panel) plots D – C values by body-mass index (BMI) category, a widely-used measure computed as weight in kilograms divided by height in meters squared, allowing classification of adults as underweight (BMI < 18.5), normal weight (18.5 <= BMI < 25), and overweight (BMI >= 25) (World Health Organization 1995, 2000). The positive attitudinal discrepancy scores of most respondents indicate a desire to lose weight, while the negative scores of some underweight individuals indicate a desire to gain weight.

Positive perceptual discrepancies (D – O > 0) indicate that individuals over-estimate their body size compared to the views of others, and conversely, negative perceptual discrepancies indicate that individuals under-estimate their body size compared to others' views; again, these are ordered categories that are not numerically interpretable, though they are not mere categories either. Zero discrepancy denotes alignment with peers' perceptions. Note that non-zero perceptual discrepancies mean that respondents are aware of differences between their own and others' judgments, whether or not they accept to revise their views as a result. In the sample, most individuals have positive but small perceptual discrepancies (Figure 2, right panel); but all underweight individuals describe themselves as heavier than others perceive them to be, whilst the opposite is true for a small number of normal and overweight

individuals. Believing to be heavier in the eyes of others than in one's own may be a sign of stigma associated with weight in our societies (Carr and Friedman 2005).

[FIGURE 2 ABOUT HERE]

Independent variables: Network size, structure, composition

To test Hypothesis 1, we first consider ***network size***, measured as the count of all unique alters nominated by an ego. Globally, the size of these networks (15 alters per ego on average) is close to the size of networks elicited with similar methods in previous studies of non-pathological individuals (Tubaro and Mounier 2014); however, it would be smaller (10 alters per ego) if only face-to-face ties were taken into account. This suggests that if the networks of persons with eating disorders tend to shrink as a result of the illness, they may be actively endeavoring to re-create ties through the internet.

In light of Hypothesis 2, we include an indicator of network cohesiveness. A standard indicator would be density, defined as the number of existing ties relative to the number of possible ties (the latter depending on network size). Here, we enrich this measure through data on social circles, i.e., groups of alters sharing some affiliation: we compute an ***adjusted density*** which includes both regular ties and common affiliations to social circles. Because the latter can be construed as pre-conditions for the former to arise, we operationalize them as weaker ties, setting their weight operationally at 0.5. Adjusted density can thus be calculated as average strength across both types of ties (just as density in valued networks):

$$AD = (L + (0.5 * S)) / (0.5 * n * (n - 1))$$

where n = number of alters in a personal network, L = number of ties among them, S = number of their shared affiliations. Adjusted density can be equal to, or higher than, standard density.

Hypothesis 3 calls for the inclusion of network composition indicators. To test Hypothesis 3a, we use variables that capture heterogeneity of network members. To account for *media multiplexity* (i.e., the relative importance of online *versus* face-to-face ties as defined in Haythornthwaite 2000), we use Blau's (1977) index of diversity, a popular measure of categorical diversity among members of a group or network (Harrison and Klein 2007, Shen, Monge and Williams 2014), and calculated as:

$$1 - (p_1^2 + p_2^2 + ... + p_k^2)$$

where alters in a personal network are spread across k qualitatively different categories (here, three: face-to-face, online, and both), and p_k indicates the proportion of alters in the kth category. The value of the index can range from zero (when all alters are in the same category) to $(k\text{-}1)/k$ (when alters are distributed equally across all categories). We also use Blau's index to account for heterogeneity of alters as defined by their *social role* with respect to ego. There are eight categories including spouse/partner/significant other, friend, family member, classmate, colleague, teacher, health professional, and the residual category of "other". Regarding gender, we include two separate variables, the *proportion of females* in the network to account for homophily (as 95% of respondents are females), and *gender variance* to capture heterogeneity.

To test Hypothesis 3b, we distinguish strong and weak ties by using information on emotional closeness collected through this survey, as respondents were prompted to rank their alters as intimate, very close, close, and not-so-close. The literature recognizes that emotional closeness is the best predictor of tie strength (Marsden and Campbell 1984), even in the absence of details on other classical strength dimensions such as frequency of contact or duration of the relationship. We use a single indicator (*proportion of intimate*), measured as the ratio of intimate and very close alters (strong ties) relative to the close and not-so-close ones (weak

ties). We do not distinguish further between intimate and very close ties, and between close and not-so-close ones, as very few alters are in the first and last categories.

Control variables

To rule out other possible explanations for differences in attitudinal and perceptual body image distortions, we also use information on participants' socio-demographic characteristics, body measures and health status. Among socio-demographic variables, *age* has a lower bound at 16, imposed by the legal and ethical framework of the study, and reaches 42, with an average of 22. *English (vs. French)* is a binary indicator variable taking the value of 1 if the survey was administered in English, zero if French.

Respondents were prompted to declare their current weight and height on the basis of which we calculated their body-mass index (BMI), according to the definition outlined earlier. We use this variable in its category ordinal format to split the sample into three sub-groups (see above). In the model estimated on the full sample, the variable is introduced as a binary indicator taking the value of 1 for individuals who are either over- or underweight, and 0 otherwise (*BMI WHO*). Notice that 54% of respondents fall in the latter group, a high proportion that is explained by the diverse range of eating disorders, which are not limited to anorexia nervosa and do not always entail extreme weight loss: in our sample, bulimia nervosa was reported by more than 20% of respondents, and Eating Disorders Not Otherwise Specified (EDNOS) account for over 45%. Relative to the general population, underweight is over-represented in our sample (28%), while overweight (18%) is under-represented.

We also use the continuous measure of BMI to define a variable (*relative BMI*) measuring the gap between each individual's BMI and the average BMI of the individual's country of residence (retrieved from the WHO BMI database). This variable, however crude, is meant to account for people's worry about being fatter than others in their immediate physical

surroundings (Blanchflower, Oswald and Van Landeghem 2009). Due to the small size of our sample and its gender homogeneity, we limit the comparison to the country level, without breaking it down to smaller geographical units.

To distinguish attitudes and perceptions that are motivated by health-related concerns and those that are motivated mostly by beauty concerns, the questionnaire invited participants to rate on a scale of one to four the extent to which they are concerned about their *appearance*. It also included questions about frequency of exercise and *sports practice*, an ordered scale from "hardly ever" to "daily". This variable takes into account at the same time the known tendency of eating-disordered individuals to over-exercise (Bratland-Sanda and Sundgot-Borgen 2014) and the pressure on high-level and professional athletes toward weight control (Smolak et al. 2000). Finally, we include a binary variable indicating whether the individual is undergoing *treatment* for eating disorders.

For parsimony, we have not included variables that proved to be non-significant in all previous versions of the model (for example socio-economic information such as student or worker status; co-habitation and family structure; and type of eating disorder).

Table 1 provides a descriptive overview of our sample and summarizes essential information on the control variables included in our empirical model specifications.

[TABLE 1 ABOUT HERE]

Analysis

We proceed in two steps. First, we model discrepancies in attitudinal and perceptual body image for the whole sample. Second, we repeat the analysis separately for the three BMI categories of overweight, underweight and normal weight (as described above). We do so because an analysis of all individuals may mask variations in the determinants of attitudinal and perceptual

discrepancies across the weight and body mass spectrum. We distinguish by BMI rather than type of eating disorder because, especially in a non-clinical setting like ours, people may be at different stages of a disorder, so that problematic attitudes and perceptions may coexist with different levels of BMI, including those who are neither over- nor underweight. Indeed some extant research suggests that body image distortions and influence of social contacts on behaviors may operate differently depending on BMI (Eisenberg et al. 2005, Strauss and Pollack 2003).

Given the ordered nature of our dependent variables D – C and D – O, we use an ordered discrete choice model (probit). More precisely, taking into account the correlation between the two variables which are both based on D, we use a bivariate ordered probit. This model can be treated as an extension of a standard bivariate probit model where the number of categories of the dependent variables is greater than two (Kilkenny and Huffman 2003). The model estimates the correlated outcomes jointly, with the same set of covariates including individual attributes of ego and personal network (structural and compositional) characteristics. We use the bioprobit Stata program developed by Sajaia (2008). As our three sub-samples consist of a limited number of observations, we apply a stochastic re-sampling procedure based on bootstrapping (Efron 1979) to reduce the possible resulting bias.

RESULTS

Table 2 reports the results of our bivariate ordered probit regression for the whole sample (first column) and for the three BMI-related sub-samples (last three columns). The top panel reports parameter estimates for the effects of the covariates on attitudinal discrepancies (D – C); the bottom panel for perceptual discrepancies (D – O).

[TABLE 2 ABOUT HERE]

The effect of *network size* is always negative, as expected (except in the case of normal-weight individuals for whom it is not significant). This corroborates Hypothesis 1 and our expectation that larger personal networks convey more diverse information, so that opposing extreme views cancel out, and a more moderate opinion emerges. This effect is driven by individuals in the tails of the BMI distribution, and is particularly strong for those who are underweight, reducing both their attitudinal (D – C) and perceptual (D – O) body image discrepancies. This result suggests that underweight individuals are receptive of the views of others (O), and think that others see them as thinner than they perceive themselves to be: as a result, they adjust their description (D) downwards bringing it closer to C, so much so that D – C may even become negative as discussed in section 3.1. Overweight persons are also sensitive to network size but only insofar as D – C (attitudinal discrepancy) is concerned: D – O (which as shown in Figure 2, tends to be lower than for the underweight, and is occasionally negative) is not affected.

Adjusted density has a positive effect, in line with H2: more cohesive social environments exacerbate body image discrepancies. Indeed in a dense network, a person's social contacts interact with one another and mutually reinforce their views, so that they provide less diverse feedback to ego than would be the case in a sparser network (of the same size). Accordingly, an individual is under greater pressure to conform to bodily norms. However, this is statistically significant only for attitudinal discrepancies in body image (D – C), not for perceptual ones (D – O), and it is not significant for underweight individuals.

Network composition is differentially associated with discrepancies for the three BMI categories, offering some support to H3a and H3b. The qualification of contacts by social role (e.g. family, friends) is not significant; neither is *media multiplexity*, though it has the expected (negative) sign, suggesting that *internet use does not reinforce distorted body image*. Network gender effects are noteworthy, particularly in the case of underweight persons whose

discrepancies (both attitudinal and perceptual) in body image decrease with a greater *proportion of females* in their personal network, and increase with greater *gender variance*. It appears that underweight users of websites on eating disorders benefit most from gender-homogenous, mostly female personal networks, a result similar to what Wellman and Frank (2001) found for women in general. The same gender variance effect is also found among the overweight sub-sample, though only for attitudinal discrepancies, while the proportion of females has the opposite sign for the normal-weight group with respect to the perceptual component of body image. Emotional closeness (*proportion of intimate*) has a weak effect overall. A small, yet significant exception is represented by the overweight sub-sample, for which emotional closeness has a strong negative effect on attitudinal discrepancies about body image. Whilst we expected strong ties to provide more help to correct distortions, this is not true at all levels of BMI and in particular, underweight individuals are not sensitive to such feedback, perhaps because they find it judgmental or inaccurate.

Regarding control variables, results show some variation across the English and French sub-samples, the former having larger attitudinal (but not perceptual) discrepancies than the latter, an effect driven by the normal-weight group. Larger gaps between individual BMI and average BMI of the country in which the individual lives (*Relative BMI*) result in larger attitudinal discrepancies. This result confirms previous findings that inter-personal comparisons matter even at such a general level – comparing oneself with one's country at large, beyond one's immediate circle of contacts (Blanchflower et al. 2009). *Age* has a negative effect, suggesting that older respondents have narrower attitudinal and perceptual gaps. *Sport practice* has a positive effect on both attitudinal and perceptual discrepancies over body image, presumably resulting from some degree of pressure on athletes (as the effect is driven by normal-weight individuals) and some form of problematic exercising among the underweight (for D - O). Finally, individuals under *treatment* have larger perceptual and attitudinal

discrepancies, an indication that those with the largest gaps are those who seek or are in treatment: *amongst our population, eating disorders are not normalized*.

Robustness checks

To strengthen inference we have conducted extensive robustness checks of sensitiveness of our conclusions to different assumptions about data generating mechanisms. First, we re-estimated the model by excluding from the sample 16 outlier observations of individuals with negative values in their attitudinal (D - C) or perceptual (D - O) body image gaps. Additional robustness checks involved: a) exclusion of males – representing only 6% of the whole sample; b) use of different values of adjusted density - one of our main theoretical variables of interest – computed using different weights (i.e., 0.1, 0.25, 0.75, and 1); c) replacement of the variables representing the compositional diversity of the personal networks that we measured by using the Blau index with variables computed using the Brillouin index, an alternative indicator of diversity. Both indices give similar comparative measures – consistently with the very high correlation coefficients (above 0.90) between them. Finally, we have included squared BMI to check for higher discrepancies scores for extreme BMI values. All these supplementary analyses support the results outlined above.

DISCUSSION

In line with a growing literature on the effects of social ties on health (Luke and Harris 2007, Valente 2010), we have explored the effects of personal networks on body image concerns and weight-related behaviors in persons with eating disorders. Insight from qualitative interviews can now help us give greater depth to our analytical results. Our choice to focus on BMI is motivated by the meaningfulness of this measure for the population under study:

I looked for information regarding things related to people's body shape or size […] websites that calculate various things, like, BMI (Resp. 612, English, BMI = 19).

Respondents' familiarity with BMI measures and standards suggests likely accuracy of the declarative weight and height data that we have collected, and sustains our choice of using them in the present analysis. These data can be taken as reasonably objective complements of subjective representations of body shape and size, which we have elicited with Stunkard's Figure Rating Scale. Taken together, these different pieces of information account for the fact that being fat or thin in the medical sense is not the same as feeling fat or thin, or appearing as such to others:

The doctor said I had anorexia […]. But, I still don't think that I get that, because I don't see myself as thin enough, but logically, I know that my BMI is low enough and I do match the criteria (Resp. 607, English, BMI = 15.6).

I know that I don't see myself as I am necessarily, and there's some element of body dysmorphia and… I might be able to look in the mirror and think that I'm fat even though I know I'm medically… not! (Resp. 641, English, BMI = 16.4).

With these data, we have examined the extent to which size, as well as structural and compositional aspects of personal networks affect the body image of individuals who use the internet (and in particular, self-styled websites on eating disorders, including "pro-ana" websites) to form, maintain and manage their relationships.

Our results confirm a tenet of the classical literature on social networks and health: that the size of personal networks matters (Valente 2010). In particular, larger size is associated with smaller body image distortions. Even controversial "pro-ana" websites may contribute to this beneficial outcome, by offering additional opportunities for socialization that counter the isolating effects of the illness:

[Online] I think people's barriers are often down and they're often less inhibited and more open to revealing personal information… that really creates a sense of community and it just feels that you're not alone. (Resp. 641, English, BMI = 13.6).

The mechanisms through which internet ties contribute to mitigating body image distortions have to do with the wide range of information and feedback received from peers:

When you read [the blogs of] other people, you see yourself like in a mirror and... you see what the illness involves (Resp. 12, French, BMI = 18.2).

On the forum… it's a bit like writing a diary, but with readers […], readers and answers. Sometimes relevant answers... ideas, intuitions, questions, that suggest new directions. This is enriching (Resp. 65, French, BMI = 21).

In terms of public-health and policy indications, online socialization should therefore be supported and encouraged – a finding that resonates with recent research on the effects of the internet on users' health practices and behaviors (Koteyoko, Hunt and Gunter 2015). This result is remarkably significant in the case of underweight individuals, whose attitudes towards, and perceptions of, body image are clearly responsive to larger network sizes. While the press often insists on restricting access to online resources in order to mitigate the dangers of promotion of thinness through "pro-ana" websites, ironically it is precisely this group (which includes many persons with, or recovering from, anorexia nervosa) that appears best positioned to benefit from use of the internet to nurture their social networks.

Our results show that network structures matter as well: high (adjusted) density would increase attitudinal body image gaps. Put differently, the positive effects of larger network sizes materialize to the extent that these networks remain sparse. In practice, this is achieved by keeping online spaces dedicated to eating disorders separate from other contexts of interaction – so as to access information and resources from others while minimizing reputational risk (Tubaro and Mounier 2014):

I am a different person on my blog and on Facebook. On Facebook, I am the one that everyone knows; on my blog, I am the one that nobody suspects (Resp. 23, French, BMI = 16.6).

I try to talk about it [the eating disorder] as little as possible in places that are not intended for this kind of things (Resp. 13, French, BMI = 17.3).

This result highlights that social networks may be detrimental: when they are highly cohesive, they increase attitudinal discrepancies, an effect that may offset the benefits of a larger size, especially in overweight individuals. Globally, the overweight are highly sensitive to network effects as far as their attitudes are concerned, though less so in their perception (but recall that the negative D – O of some of them may denote social stigma). Interviews suggest that overweight persons with eating disorders might be facing particular difficulties in light of social norms valuing thinness and of emphasis on "anti-obesity" measures in public policy, endorsed by their social surroundings and reflected in a greater sense of inadequacy:

You feel rejected because, beyond a certain weight, you cannot wear what you want […]. The others are perfect, they don't have the same problem as myself. When they go to a shop, they immediately find their size of trousers, dresses… and the clothes fit them wonderfully, while when I buy the same, one size larger, it doesn't give the same result (Resp. 123, French, BMI = 29.7).

Overweight persons may also suffer from a focus on anorexia nervosa and extreme thinness in public discourse on eating disorders, possibly leading to their situation being misinterpreted or not recognized as an illness:

Binge eating is … I've had this for eight years but it was only five years ago that it was recognized […]. Everybody blamed lack of will ... but it's not lack of will, it's more like bulimia […]. But when I told my GP 'I have bulimia', he didn't take me seriously (Resp. 103, French, BMI = 36.9).

One advantage of observing a population of online website users is to reveal the presence of this segment of the population, stressing how body image concerns and problematic eating behaviors may appear at all levels of BMI:

> *I feel like I was taken more seriously when, I mean, my weight dropped […]. When I was normal weight, there was actually a nurse who said to me that they didn't think it was an eating disorder (Resp. 607, English, BMI = 29.6).*

Overall, these findings invite closer inquiries of personal networks and network characteristics, and confirm the heuristic importance of BMI in mediating the effects of networks (and other factors) on persons with eating disorders.

Limitations and Conclusion

This research is not without limitations, and we address three important ones here. The first relates to lack of a probability sampling technique (the survey was administered to a purposive sample of eating-disordered users of dedicated websites), which entails potential for bias. A related limitation is the relatively small size of the sample, due to the difficulty to reach this sensitive and partly hidden population. Replication of the study with a larger sample, though hard to implement, would enable generalizability of the findings, perhaps also including non-eating disordered individuals who would serve as controls. The third limitation of the study is its cross-sectional design (motivated by the difficulty to track and re-interrogate persons affected by such disorders over time), implying that firm conclusions about the direction of causality cannot be drawn, and the reported relationships among variables must be interpreted with caution. This is especially important for a subject like body image that is not static but, rather, is a developmental process that changes over time.

The outcomes of this study may be used to guide public health and social policies aimed at supporting persons with eating disorders. Social networks affect the development of

attitudinal and perceptual biases that eventually affect behaviors and health. Opportunities for socialization, notably online, and for sharing experiences and information especially among peers, may be beneficial for correcting such biases. Instead of leaving it entirely to self-styled internet communities (such as the controversial "pro-ana" websites), healthcare providers and professional associations may exploit these opportunities and create appropriate environments, possibly online, to foster such forms of socialization. We hope that these ideas encourage additional work on this important area of academic and policy-oriented research.

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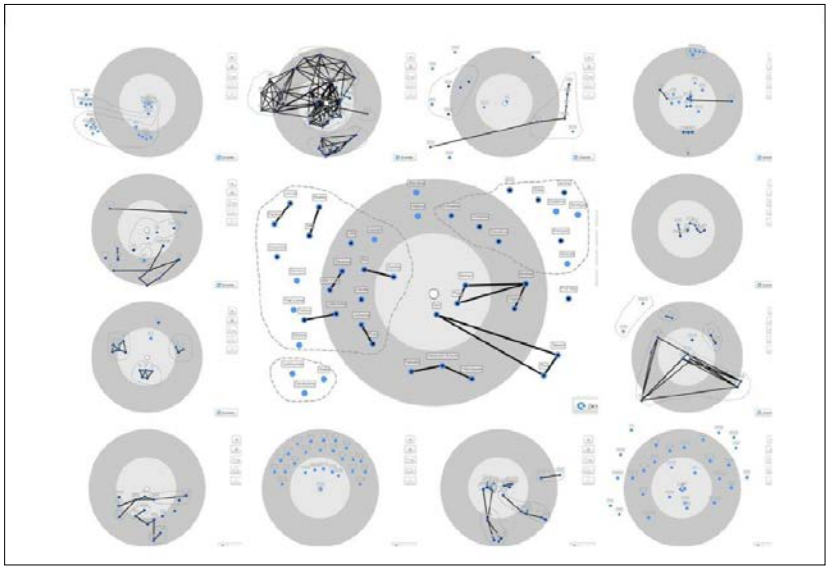

Figure 1 : Examples of networks drawn by survey participants. In each of them, the central white point is ego, black points around it represent alters, straight black lines are ties between alters, and dotted grey lines delimit social circles; distance of an alter from ego captures relational proximity.

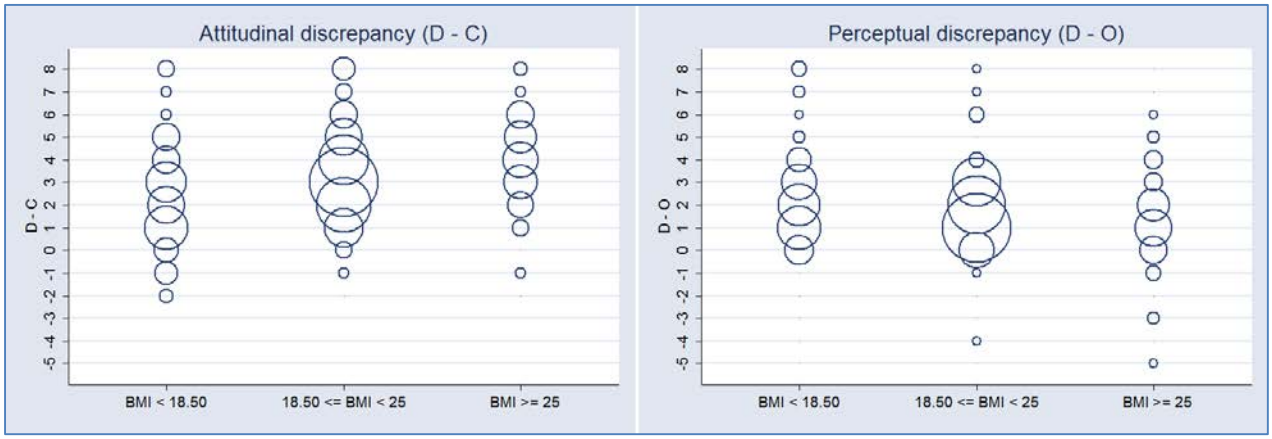

Figure 2: Scatterplot of attitudinal discrepancies, D - C (left panel) and perceptual discrepancies, D - O (right panel) in body image as a function of BMI, distinguishing individuals who are underweight (BMI < 18.5), normal weight (18.5<= BMI < 25) and overweight (BMI >=25). The size of each marker is proportional to the number of cases concerned.

Variable	Mean	Std.Dev.	Min	Max
Attitudinal discrepancy	3.162	1.915	-2	8
Perceptual discrepancy	1.819	1.695	-5	8
English (vs. French)	0.558	0.498	0	1
Age	21.691	4.869	16	42
In treatment	0.287	0.453	0	1
Appearance	3.683	0.607	1	4
Relative BMI	-3.582	5.712	-13.390	24.900
Sport practice	3.385	1.310	1	5
BMI WHO	0.460	0.499	0	1
Network Size	15.136	10.310	2	57
Adjusted density	0.201	0.230	0	1
Prop. of intimate	0.437	0.262	0	1
Prop. of females	0.654	0.198	0	1
Variance gender	3.901	4.258	0	24.042
Media multiplexity	0.394	0.190	0	0.656
Social role	0.532	0.171	0	0.808

Table 1: Sample characteristics (N = 265). The number of study subjects is lower than the original sample population due to missing items for network-related variables.

N=265	**ALL**	**UNDERWEIGHT**	**NORMAL**	**OVERWEIGHT**
Attitudinal Discrepancy (D - C)				
Individual (ego's) attributes				
English (vs. French)	0.296*	-0.076	0.502*	-0.230
Age	-0.041**	-0.070*	-0.050**	0.013
Treatment	0.343*	0.817**	0.196	1.388***
Appearance	0.032	-0.010	0.057	-0.049
Relative BMI	0.077***	0.129	0.051	0.085*
Sports practice	0.097*	0.123	0.148*	-0.095
BMI WHO	-0.281*			
Personal network characteristics				
Network size	-0.012	-0.053**	0.008	-0.119***
Adjusted density	1.054***	0.999	1.051*	1.946**
Prop. of intimate	-0.361	-0.824	0.197	-2.189***
Prop. of females	-0.129	-1.663*	0.350	-0.831
Variance gender	0.029	0.095*	0.011	0.126*
Media multiplexity	-0.211	-0.004	-0.052	-0.416
Social role	-0.017	-0.686	0.041	1.614
Perceptual Discrepancy (D - O)				
Individual (ego's) attributes				
English (vs. French)	0.106	-0.475	-0.062	0.420
Age	-0.035*	-0.081**	-0.034	-0.023
Treatment	0.320*	0.703*	0.257	0.447

Appearance	0.024	0.083	-0.007	0.166
Relative BMI	-0.014	0.013	-0.143**	0.030
Sports practice	0.172**	0.173*	0.251***	-0.117
BMI WHO	0.169			
Personal network characteristics				
Network size	-0.006	-0.038*	0.008	-0.033
Adjusted density	0.244	0.571	0.592	-0.213
Prop. of intimate	-0.155	0.204	0.270	-1.122
Prop. of females	0.028	-2.258**	1.252**	-1.726
Variance gender	0.018	0.096*	-0.012	0.045
Media multiplexity	-0.342	-0.363	0.323	-0.674
Social role	-0.022	-0.805	0.102	1.523
N	265	73	143	49
LR-test of Independent Equations [chi2(1)]	102.69*** (0.000)	85.43*** (0.000)	100.76*** (0.000)	3.890* (0.049)
Log likelihood	-873.648	-215.551	-411.519	-158.222
Wald chi2 [prob>chi2]	65.49*** (0.000)	35.94*** (0.001)	36.17*** (0.001)	52.27*** (0.000)
				*legend: * p<.05; ** p<.01; *** p<.001*

Table 2: Estimates of bivariate ordered probit models for attitudinal discrepancy D - C (top panel) and perceptual discrepancy D - O (bottom panel) for the whole sample (first column) and three sub-samples including, respectively, underweight, normal and overweight individuals (second, third and last column). All the variables are centered on the mean values.