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Mental and emotional representations of “weight loss”: free-word association networks in members of bariatric surgery-related social media communities

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Running title: Mental and emotional representations of weight loss

30

Abstract

Background: Mindset and communication barriers may hinder the acceptance of bariatric surgery (BS) by the eligible patient population.

35 **Objectives:** To improve the understanding of expectations, opinions, emotions and attitudes toward weight-loss among patients with obesity.

Setting: Switzerland, Germany, Austria.

40 **Methods:** Survey data collected from BS-related social media communities (N=1482). Participants were asked to write 5 words that first came to their mind about “weight loss”, and to select 2 emotions which best described their corresponding feelings. Demographic and obesity-related data were collected. Cognitive representations were constructed based on the co-occurrence network of associations, using validated data-driven methodology.

45 **Results:** Respondents were Caucasian (98%), female (94%), aged 42.5 ± 10.1 years, current/highest lifetime body mass index = $36.9 \pm 9 / 50.7 \pm 8.7$ kg/m². The association network analysis revealed two cognitive modules: benefit-focused (health, attractiveness, happiness, agility) and procedure-focused (effort, diet, sport, surgery). Patients willing to undergo BS were more benefit-focused (Odds ratio (OR)=2.4, P=0.02) and expressed more ‘hope’ (OR=142, P<0.001). History of BS was associated with higher adherence to the procedure-focused module (OR=2.3, P<0.001), and with increased use of the emotions ‘gratitude’ (OR=107, P<0.001), ‘pride’ (OR=15, P<0.001), and decreased mention of ‘hope’ (OR=0.03, P<0.001).

50 **Conclusion:** Patients with obesity in our study tend to think about weight loss along two cognitive schemes, either emphasizing its expected benefits or focusing on the process of achieving it. Benefit-focused respondents were more likely to consider BS, and to express hope rather than gratitude or pride. Novel communication strategies may increase the acceptance of BS by incorporating weight loss-related cognitive and emotional content stemming from patients’ free associations.

55 **Keywords**

Bariatric Surgery; Weight loss; Free-word Association; Network; Obesity; Emotional valence; Mindset; Motivation; Body image dissatisfaction

Introduction

Bariatric surgery (BS) is currently the most effective modality in the treatment of severe obesity and related diseases [1]. Despite its growing worldwide popularity as a treatment option, BS is rather underused by the eligible patient population [2]. Mindset and communication barriers seem to influence the diffusion of BS: lack of information, incorrect information, and stigmatization of individuals with obesity have proven to contribute to sub-optimal use of health care by the eligible patients and to insufficient cooperation between primary care physicians and BS centers [3, 4]. This may also hinder the identification and referral of eligible patients and undermine optimal postbariatric follow-up [4].

Available literature on motivational drivers in favor of seeking BS remains scarce and stems mainly from small cohorts [5-7]. Nevertheless, corroborative evidence shows that the willingness to improve health is the cornerstone for seeking BS, contextualized with psychological, emotional, environmental and social factors [8, 9]. Within the developing framework of person-centered care, the patients' narrative is a key factor in improving decision-making [10]. However, due to the sensitive, personal and private nature of patients' perception of their own body weight, direct questions from healthcare professional may be perceived as judgmental or scolding, and may rapidly close down communication [11]. In this sensitive context, an anonymized online survey with a free word association task seems to be an optimal approach to scope group opinion [12].

Free word association is a widely used technique in market research and psychology to encourage respondents to express openly their underlying motivations, beliefs, attitudes or feelings regarding a specific topic [13]. This technique enhances the unconstrained expressions of respondents and overcomes limitations of predefined questionnaires.

80 We aimed to map the mental and emotional representation of the term *weight loss* in patients
with obesity who had a documented interest in BS, using free word associations combined with a
novel data-driven associative analytical method [12]. Further, we aimed to investigate the
relationship between these representations and clinical parameters, such as stage of obesity and
previous or planned experience with BS. We hypothesized that BS had a “positive” impact on the
85 emotional labeling of *weight loss* related free word associations. Our findings may serve as basis to
improve patient-centered communication strategies, online and in clinical practice alike [14].

Methods

We conducted an anonymized online survey to understand how adults with severe obesity
90 (those who seek BS, postbariatric patients, and those who are not interested to undergo BS) perceive
weight loss. To ensure that participants are familiar with BS, respondents were recruited on a
voluntary basis from bariatric surgery-related German-speaking social media groups between
02/11/2018 and 04/04/2018. An invitation for participation and three reminders every two weeks
were posted on the ‘Adipositas Zürich’ (4100 followers) and ‘Adipositas Chirurgie - Fragen und
95 Antworten’ (1500 followers) Facebook© groups, and respondents were encouraged to share the
invitation within their own social networks. Thus, the survey was “open” to any respondents with a
presumed interest in BS. We aimed to enroll a convenience sample of >500 respondents. The survey
was administered via Typeform™ (Barcelona, Spain) (Supplemental Methods 1.), and only complete
questionnaires could be submitted. Respondents could not be backtracked to a specific Facebook©
100 profile. The Cantonal Ethics Committee of Zurich concluded that this study did not fall under the scope
of the Swiss Human Research Act, thus ethical approval was not required. The manuscript was

prepared according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines [15]. Network analyses were performed using Matlab 2017 (The Mathworks); logistic regressions and correlations were performed using R Software for Statistical Computing v3.5.2 (R Foundation, Vienna, Austria).

Building the dataset

Basic Demographics

Respondents were asked to self-report their age, sex, ethnicity, civil status, height, maximal and current body weight, past or planned bariatric operations, previous non-surgical weight loss attempts and their social interactions with bariatric patients. Body mass index (BMI) was calculated by the investigators based on the anthropometric data provided by the participants.

Free word associations

Participants were asked to write five words, which first came to their mind about “weight loss”. Further, they had to select two emotions from a list of 20 basic emotions (interest, anxiety, empathy, contempt, surprise, indifference, hope, fear, gratitude, anger, joy, sadness, calmness, frustration, pride, shame, generosity, envy, sympathy, antipathy) that best described their feelings about each of the five associations they provided [16, 17]. Emotional labeling was successfully applied in a recent study to improve the interpretation of free-word associations by the addition of affective content [12].

Body image dissatisfaction (BID)

The color version of the reliable and validated Stunkard Figure Rating Scale was used to assess current and ideal body size estimations [18]. This instrument uses a series of 9 gender-specific

silhouettes that gradually increase in body size. Although developed for normal weight adults with traditional eating disorders (e.g.: anorexia nervosa), this scale has been previously applied in the context of BS [19]. Respondents were instructed to select the figure that indicates (a) how they look currently and (b) how they would like to look like. A discrepancy score indicating *Body Image Dissatisfaction* (BID) was calculated by subtracting scores of the ideal figure (b) from the current (a) figure. Lower discrepancy scores were interpreted as lower body image dissatisfaction.

Data pre-processing

Response rate was calculated based on definitions and metrics proposed by the American Association for Public Opinion Research [20]. Respondents who provided incoherent data (i.e.: highest lifetime BMI < current BMI) or were found to be outside the target group (i.e.: highest lifetime BMI < 35 kg/m², history of gastric banding, etc.) were excluded from the study cohort in a step-wise manner (Supplemental Fig. 1). Free word associations to “weight loss” were first spellchecked and lemmatized (i.e.: to return the base of a word) by two independent native German speakers. Associations were merged if their English translation was identical. Idiosyncratic expressions (associations with <9 occurrences) were left out.

Association network analysis

In order to extract the most prominent mental representations from the numerous individual associations provided by the respondents, we applied an in-house developed algorithm, using a network-based methodology validated and described earlier by our group [12]. To create such a network, nodes (free word associations) and edges (statistical co-occurrences between two associations) were determined. Statistical co-occurrence was calculated by log-likelihood ratios (LLR).

The LLR value can denote attractive (when two associations are often mentioned together) and
145 repulsive connections (when two associations are rarely mentioned together) with a corresponding
level of significance. In the network of statistically related associations, modularity maximization
based consensus clustering algorithm was applied to explore any densely connected subnetworks
(i.e.: modules) [21]. We have previously demonstrated that these modules of associations - as
consistent patterns in individual association sequences – are able to capture the most prominent
150 cognitive representation of a given cue [12]. Associations with weak module attachment were
separately identified, since they may serve as bridges in future communicational strategies to
simultaneously address individuals with different cognitive modular membership.

Qualitative and quantitative analysis of the map

First, we used descriptive statistics to characterize the subgroups of interests, as well as the
155 members of the two cognitive modules. *Second*, we created explorative models by logistic regression
to describe the relationship between free-word associations (cognitive module membership,
emotional labels) and clinical parameters (stage of obesity, BS status, interest to undergo BS). The
cognitive module of respondents was determined by the association cluster to which the majority of
their associations belonged. Emotions were expressed as frequency (%) and the unfrequently (<4%)
160 mentioned emotions were not included in the models to decrease false discovery rate. Respondents'
current BMI status was dichotomized according to World Health Organisation obesity class II (\geq / $<$ 35
kg/m²), since this is the currently recommended cutoff for being eligible to BS [1]. We also created
subgroups based on the BS status of respondents: “underwent BS”, or in case of no previous BS,
“interested in BS” or “not interested in BS”. Other frequently used demographic parameters (age, sex,
165 ethnic origin) were not included in the explorative models, since they were equally distributed among

subgroups and >93% of all respondents were adult Caucasian females. Nagelkerke's R^2 was used to express the coefficient of determination of the models.

Results

Respondents

170 Out of 2387 unique visits at the landing page, 1601 respondents completed the study (completion rate: 67.1%). The survey was mostly filled in via smartphones (82.5%), and took in average 6min20sec to complete. The final study cohort included 1482 respondents (Supplemental Table 1.).

Free word associations

175 The total number of unique associations was 1793. After the spellcheck, lemmatization and merging, the number of associations decreased to 235, out of which 84 were non-idiosyncratic and represented the basis of the network analysis. The co-occurring network of associations is presented in Fig. 1. Fig 2. presents the respective emotional labels, whereas respondents' characteristics are shown in Table 1. Postbariatric patients had a significantly higher proportion of positive emotional
180 labels than non-operated adults with obesity (79% vs 75%, $t(1480)=1.82$; $P = 0.002$, $d=0.18$). We labeled the two cognitive modules as benefit- or procedure-focused, based on their most frequent associations. Significant attractive and repulsive connections between associations are presented visually in Supplemental Fig. 2. The associations with the lowest community attachment (measured by local modularity) were termed "bridging" associations, since they were frequently mentioned by
185 respondents of both groups (Supplemental Fig. 3). These included for example: "slim", "excess skin" and "pride". The association "new life" (most frequent emotional labels: joy, gratitude, hope, pride

200 BS. In the subgroup of respondents without previous BS, those who were interested in undergoing BS were more likely to express a benefit-focused mindset and use more frequently *hope* as emotional label.

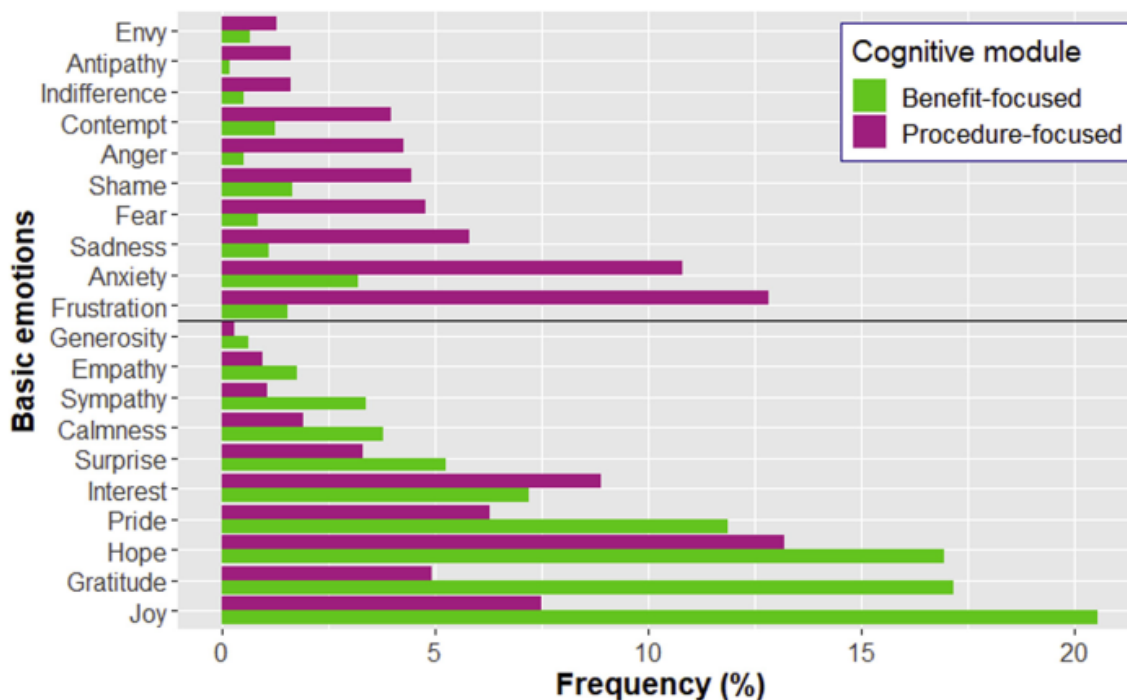


Fig. 2. Frequency of emotional labels assigned to the associations of each cognitive module

205 *Body Image Dissatisfaction*

The BID score is presented according to the cognitive module membership in Table 1. Overall, current BMI showed a) a strong correlation with BID (Pearson's $r = 0.6$, $P < 0.001$, Supplemental Fig. 4), b) an even stronger correlation with current body image ($r = 0.77$, $P < 0.001$) and c) a weaker correlation with the expected body image ($r = 0.42$, $P < 0.001$). Sex-related differences were not

210 identified (BID = 2.3±1.7 for females and 2.3±1.7 for males). Only 10.9% of all respondents (n = 162) were free of BID (score = 0).

	Module of associations		P
	Benefit-focused	Procedure-focused	
n	1174	253	
Age (mean, SD)	43.1 ± 10.8	40.4 ± 10.2	< 0.001
Female (%)	94.5	92.5	1
Relationship status (%)			0.22
<i>single</i>	15	17	
<i>divorced</i>	11	8	
<i>in relation</i>	22	26	
<i>married</i>	50	48	
<i>widow</i>	2	2	
Current BMI ≥35 kg/m² (%)	54.1	43.1	0.002
Maximal lifetime BMI (mean, SD)	50.7 ± 8.5	50.3 ± 9.2	0.51
Body Image Dissatisfaction (mean, SD)	2.3 ± 1.7	2.2 ± 1.5	0.52
Proportion of positive emotions (%)	86 ± 19	47 ± 27	< 0.001
Had bariatric surgery (%)	71.7	76.3	0.14
Among those who did not have BS:			
<i>Interested in undergoing BS (%)</i>	87	66.7	< 0.001
Most frequent associations (%)			
<i>1st</i>	health (54)	sport (17)	
<i>2nd</i>	agility (24)	diet (14)	
<i>3rd</i>	attractiveness (24)	effort (9)	
<i>4th</i>	happiness (21)	excess skin (5)	
<i>5th</i>	activity (21)	sacrifice (4)	
Most frequently associated emotions (%)			
<i>1st</i>	joy (21) *	hope (13) *	
<i>2nd</i>	gratitude (17) *	frustration (13) *	
<i>3rd</i>	hope (17) *	anxiety (11) *	
<i>4th</i>	pride (12) *	interest (9)	
<i>5th</i>	interest (7)	joy (7) *	

Table 1. Respondents' characteristics according to cognitive module membership. *BMI: Body Mass Index. BS: bariatric surgery. *: significant (P<0.01) difference in the frequency of the emotion between the two modules.*

215 *Respondents who would not consider to undergo BS*

Out of the 409 respondents without prior BS, 66 stated to have no interest to undergo BS. This subgroup had a mean age of 43.6 years and consisted of Caucasian (91%) females (92%) with a BID of 2.2 who managed to lose weight non-surgically (highest lifetime BMI: 45.4±8.3 kg/m², current BMI: 37.9±8.8 kg/m²). Only 53% of this group had regular contact with BS patients.

220 A. Respondents with ≥WHO Class II Obesity vs. Respondents with <WHO Class II Obesity (= reference). Based on the entire cohort [n = 1482; R² = 0.156]

	Respondents with ≥Class II obesity			
	<i>Odds ratio</i>	<i>95% CI</i>		<i>P</i>
Benefit-focused cognitive module	2.2	1.6	3.1	<0.001
Joy	1.4	0.5	4.2	0.5
Hope	76.6	25.7	227.8	<0.001
Gratitude	0.04	0.01	0.1	<0.001
Pride	0.2	0.06	0.7	0.01
Interest	0.4	0.1	1.4	0.14
Anxiety	0.7	0.2	4.9	0.96
Surprise	0.2	0.04	0.9	0.04
Frustration	1.6	0.3	9.4	0.63

225 B. Respondents who underwent bariatric surgery vs. Respondents without history of bariatric surgery (= reference). Based on the entire cohort [n = 1482, R² = 0.169]

	Respondents with prior bariatric surgery			
	<i>Odds ratio</i>	<i>95% CI</i>		<i>P</i>
Benefit-focused cognitive module	0.4	0.3	0.6	<0.001
Joy	0.5	0.2	1.8	0.3
Hope	0.03	0.01	0.1	<0.001
Gratitude	107.8	27.7	420.2	<0.001
Pride	15.6	3.4	69.2	<0.001
Interest	1	0.3	3.5	0.99

Anxiety	0.6	0.1	3.6	0.6
Surprise	7.2	1.2	45	0.04
Frustration	0.2	0.03	1.2	0.08

230

- C. Respondents with an interest to undergo bariatric surgery vs. Respondents not interested to undergo bariatric surgery (= reference). Within the subgroup of respondents without history of bariatric surgery [n = 409; R² = 0.142]

	Respondent with an interest to undergo bariatric surgery			
	Odds ratio	95% CI		P
Benefit-focused cognitive module	2.4	1.17	4.94	0.02
Joy	0.9	0.06	15.2	0.96
Hope	142.5	9.9	2047.1	<0.001
Gratitude	1.2	0.06	26	0.9
Pride	0.3	0.01	9.2	0.5
Interest	0.1	0.01	1.8	0.12
Anxiety	5.3	0.1	276.7	0.41
Surprise	4.3	0.06	328.7	0.51
Frustration	0.8	0.02	47	0.93

235 **Table 2.** Explorative models using logistic regression investigating the effect of the stage of obesity and of bariatric surgery status on cognitive module membership and use of different emotional labels. *CI: confidence interval, BMI: body mass index BS: bariatric surgery*

Discussion

240 This study achieved data-driven interpretation of the perception of weight loss in a large cohort of adults, mainly Caucasian women, with obesity and/or history of BS. This is the first application of this novel, network-analysis based methodology in the context of BS, where patients' mindset and emotional demeanor play a cardinal role in therapeutic decision-making.

245 A major finding was that the perception of "weight loss" in adults with obesity formed two distinct mental representations or modules. Some respondents predominantly mentioned associations related to the procedure of weight loss (i.e.: *sport, diet, surgery, effort* and *sacrifice*), while others provided associations related to the benefits of weight loss (i.e.: *health, activity, agility,*

attractiveness, happiness and quality or joy of life). In analogy to the latent class analysis of a recent study on patient preferences for BS [22], the larger module was labelled as *benefit-focused*, and the smaller as *procedure-focused*. The above-mentioned American study identified an additional, “cost-sensitive” mindset among BS candidates, however, in the current study, the financial burdens of BS were not mentioned. This is most likely explained by the inherent differences between the health-insurance systems of German-speaking European countries and the complex structure of health-insurance coverage in the United States of America, where private funding is often involved. The most frequently mentioned association was “*health*”, confirming from the patients’ perspective the utmost importance of the metabolic effects of weight loss. Several associations highlighted the social pressure related to weight loss (i.e.: *social life, employment, normality, friendship, confidence, new life*). This observation complements the findings of a previous free-word association study in the context of obesity, in which healthy students had to provide their impressions on *fatness*. Surprisingly, they linked the fatness-related bad feelings with social pressure rather than with the health or self-comfort of the people with obesity [23].

Explorative models were used to test whether cognitive module membership was associated with previous or planned BS. Respondents with a history of BS adhered more frequently to the procedure-focused cognitive module, mirroring their pragmatic approach to weight loss. In contrast, those with an interest to undergo BS belonged more likely to the abstract, benefit-focused cognitive module. It has been shown earlier that abstract (vs. concrete) representations of ideal end-states are likely to influence engagement in a specific goal-oriented behavior [24]. In the context of obesity, optimistic expectations were previously shown to favor higher rates of successful weight loss following behavioral weight reduction [25]. However, unrealistic expectations can be responsible for

270 the cycle of sub-optimal outcomes and renewed efforts to achieve self-change (i.e.: false-
hope syndrome, “yo-yo effect”)[26]. Therefore, the decision of undergoing BS may reflect a new
approach to weight loss by patients who already experienced several unsuccessful conservative
attempts to tackle obesity [1]. Although body image is an important indicator of patients’ wellbeing
after BS [27], BID ratings did not differ between the two cognitive modules, but showed a very
275 significant correlation with current BMI, and were higher in participants who planned to undergo BS,
compared to those who did not, or already had BS.

Based on our findings, the emotional component may play a more important role than the
cognitive component in the decision-making process of obese patients who seek to engage in new
health behaviors. In line with our hypothesis, history of BS favored the use of positive emotional
280 labels, however, the effect size was rather small. In fact, all respondents selected mainly positive
emotions to label their associations. Remarkably, patients willing to undergo BS were more likely to
express *hope*, while patients after BS expressed *gratitude* and *pride* more frequently, suggesting that
BS may fundamentally change the individuals’ affective connection with weight loss. The emotional
state of hope is forward-looking and may characterize both the procedures and the benefits related
285 to a planned action, reflected by its equal distribution between the two cognitive modules [28].
Respondents with a \geq Class II obesity mentioned *hope* more frequently, reflecting their unmet need of
achieving weight loss. In contrast, *gratitude* and *pride* were more frequently mentioned in the benefit-
focused module and by those who already had BS and had a current BMI <35 kg/m². The feeling of
gratitude is one of the most typical responses to perceived benevolence, which appears to foster
290 prosocial behaviors and correlates with other factors of psychological well-being and agreeableness
[29]. Pride is a subjective status-related emotion, which has a fundamental affective role in status

seeking, attainment, and signaling [30]. According to a Brazilian study in patients experiencing postbariatric weight regain, the feeling of gratitude toward BS remained, whereas pride was replaced by a feeling of sub-optimal outcomes and low self-esteem [31]. *Peacock et al.* also found that the extent of emotional component in bariatric candidates' motivation (by comparing desperate patients ("have to") with those who expressed sentiment of being tired ("don't want to") or of pragmatism ("want to")) was associated with better postbariatric weight loss [8]. Subsequently, postoperative weight loss was shown to have a strong positive impact on patients' psychological well-being (including: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance), and even on marital satisfaction [32].

We acknowledge that associations are determined by a variety of personal experiences and future projections, and are not necessarily anchored to one single factor (such as BMI or BS). Nevertheless, this study provided a comprehensive structure of adults' with obesity free expressions about weight loss, enhancing our understanding of patients' priorities and contributing to the improvement of health care-related communicational schemes. Discrepant expectations may significantly increase postoperative dissatisfaction with body image and decrease the extent of achievable weight loss (ref: <https://doi.org/10.1016/j.soard.2020.03.005> - not yet on pubmed), therefore setting realistic preoperative expectations and stepwise postoperative goals are crucial. Our findings also promote the collaborative approach between healthcare providers to support evidence-based treatments of obesity [33]. Focusing on the *consumer value* is the first principle of the *lean thinking* health care management method [34]. Association network models have been proven suitable for studying consumer-based brand equity by identifying relevant "character traits" which may assist the optimization of current processes [35]. In the context of BS, *Powell et al.* showed that

psychological skills interventions can be implemented successfully to improve postbariatric patients' participation in exercise programs [36]. Consequently, the network-based map of associations to weight loss presented in this study may serve as a navigational tool for caregivers, policy actors and researchers to better identify patients' implicit interest toward weight loss and to design new interventions aiming to tackle mindset barriers in the acceptance of BS among patients with obesity [37]. Our findings suggest that complementing factual information on BS with emotional experiences of postbariatric patients (i.e.: gratitude and pride) and emphasizing the benefits rather than the procedural aspects of achieving weight loss may be effective in changing perspectives on life-priorities of people with obesity. As there is a growing interest for health-related information on multiple digital platforms, including social media, the relevant positioning of "weight loss" can influence large groups of people with obesity and change social norms [38]. Once a mindset has been primed or activated, there is an increased likelihood that it will be used in upcoming tasks to interpret new information and to define subsequent actions [24]. A subgroup of the respondents stated not to be interested to undergo BS, nevertheless, by following BS-related social media they manifested interest towards BS and seem to be seeking facts and/or patient narratives to assist their health-related decisions. The main limitation of the study derives from the inherent methodologic bias of internet-based surveys: 1) the non-representative nature of the Internet population and 2) the self-selection of participants (volunteer effect) [15]. These factors may explain the very high proportion of Caucasian females with previous BS within all respondents. In the absence of longitudinal data collection, demographic parameters – especially current BMI – are likely to confound the relationship of BS and cognitive module membership. Although there are techniques to account for the effect of BMI (i.e.: propensity-score matching), we aimed to demonstrate real-world scenarios where the stage of obesity and BS

history are strongly interconnected. The lack of directly measured BMI values represent an additional imperfection. Nevertheless, self-reported height and weight were found to highly correlate with measured values ($R \geq 0.9$) in the Danish Health Survey [39].

Conclusion

340 The combination of research methods (data-driven cross-network analysis of free associations with emotional valence and use of validated psychologic questionnaire) was synergistic in mapping patients' motivational drivers, beliefs, attitudes or feelings towards weight loss. Respondents with severe obesity and those planning to undergo BS are more likely to be benefit-focused and to express "hope", compared to their slimmer postbariatric peers, who are more often procedure-focused, feel
345 "gratitude" and "pride" more often and suffer less from body image dissatisfaction. Emotional and mental schemes stemming from patients' free associations may enrich the informed consent process prior to BS and could serve as basis for the development of novel communicational strategies between health-care providers and patients with obesity.

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Ethical approval

The Cantonal Ethics Committee of Zurich stated that the study did not fall under the scope of the Swiss Human Research Act, and consequently, does not need ethical approval (BASEC-Nr. Req-2017-00903).

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