

THEORETICAL AND EMPIRICAL CONSIDERATIONS ON THE RELATION BETWEEN 'BODY IMAGE', BODY SCHEME AND SOMATOSENSATION

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Abstract—The authors first discuss possible interactions between the hitherto neglected neurophysiological and neuropsychological factors and the traditionally accepted cognitive and affective factors in 'body image' formation. They then report on a study of the relation between body size perception (video distortion technique, image marking procedure, kinaesthetic size estimation apparatus) and somatosensation (thermal, pain and vibration thresholds) in young women. Included in the study were questionnaires on eating behaviour and motivation, body attitude or body satisfaction, and depressive mood and thoughts. Neither the somatosensory nor the questionnaire variables explained the difference between 'overestimators' and 'underestimators' of body size. However, these variables did explain the difference between 'good perceivers' and 'poor perceivers' (degree of deviation from actual body size) in the video distortion technique, with a somewhat larger contribution by the somatosensory variables. The latter finding, although clearly preliminary, should stimulate further investigations of the relationship between somatosensory variables and body size perception.

INTRODUCTION

ALTHOUGH numerous experimental studies have addressed the issue of 'body image' disturbances in patients with eating disorders, the value of the concept 'body image' is still questionable (for differing appraisals, see [1, 2]). Most of the studies have assessed the pathological changes in a rather vaguely defined variable, and there have been few theoretical or empirical attempts to improve the concept of 'body image' or to develop more suitable alternatives. It has become increasingly clear that a distinction must be made between measures of body size perception and measures of body attitude or body satisfaction [3, 4]. The fact that these two groups of variables are often only weakly intercorrelated and that there is no theory of 'body image' to explain this finding has led at least one group to conclude that the concept of 'body image' is little more than a heading for research activities on perceptions, emotions and cognitions relating to one's own body [1]. Because we share this view, in what follows we address the issue of body size perception without using the term 'body image'.

But different measures of body size perception have also been found to intercorrelate only to a small degree [3, 5, 6] even though the measures are thought to reflect the same concept. Differences in methodology (task demands, availability of feedback, etc.) may explain some of these results [4, 7]. From a neuropsychological perspective, however, one can assume that different body schemes, originating from different sensory systems, underlie the different measures and that this explains the weak correlations.

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There is wide agreement that the psychological representation of one's body depends on how visual and somatosensory stimuli are processed and integrated [8–10]. Bruch [11], the founder of 'body image' research in eating disorder patients, was also amongst those who have pointed this out. There is a great deal of clinical evidence suggesting that under certain circumstances the visual input and the various somatosensory inputs are not well integrated into the body self. (We use the term body self to mean a unitary experience of body processes, as proposed by Melzack [12] when explaining phantom limb experiences.) Examples are asomatognosia resulting from certain kinds of brain damage, phantom limb experience after amputation, and bodily and somatic hallucinations in psychosis or in drug-induced states [8, 9, 13–16]. In everyday life, the integration appears to be successful. But what happens when people are asked to estimate their body size in tasks that clearly differ with regard to the sensory systems primarily involved?

One aim of this paper was to develop some theoretical proposals about the processes involved in body size perception, keeping in mind, however, that body size perception represents only one part of the entire body self.

The functional starting points in the formation of the body self are the different sensory (visual and somatosensory) systems contributing to it. It is known that the sensory inputs are not integrated into the body self in one step and that the first stage of integration results in multiple body schemes, some rather vague, some very precise, of a type widely known from the research on the mechanosensitive 'homunculi' [17]. The body schemes are built up in the primary and secondary sensory projection areas of the cortex. From studies on phantom limbs and on certain lesions of somatic nerves it is clear that the body schemes depend, at least partially, on the input from the corresponding sensory systems: A decrease in or an interruption of this input eventually leads to a shrinkage of the 'homunculi' [15, 18].

Let us assume that the second stage of integration of the multiple body schemes into one body self is also influenced by the degree of correspondence between the multiple body schemes. If there are marked contradictions then integration either fails to occur or is unstable. The brain areas involved in this step of the integration appear to be the temporal lobes [16].

Finally, cognitive and affective variables may either further or hinder stable integration. The latter may be the case if strong beliefs or emotions relating to one's own body exist that are at odds with the information in the body schemes [12]. At this final stage in the formation of the body self, a widespread cerebral network involving different cortical and subcortical areas seems to become active [16].

In addition, hemispheric specialization in the formation of the body self must also be considered because clinical evidence suggests that the process is disrupted more by right hemispheric than by left hemispheric dysfunctions [19].

If our assumptions are correct, persons at risk of developing disturbances of body self are those with:

- (a) somatosensory dysfunctions resulting in vague or contradictory body schemes;
- (b) beliefs about their body that are not in tune with the information contained in the body schemes;
- (c) dysfunctions in certain cerebral regions related to the formation of the body self, especially in the right hemisphere; or
- (d) a combination of these dysfunctions.

All this may be true for patients with anorexia or bulimia nervosa. Some such patients have somatosensory impairments [20–22], some experience themselves as being very fat even when their weight is normal or below normal [2] and some have a reduction in functions related to the right hemisphere [23, 24].

Let us further assume that if the sensory part of the integration process is affected body size perception will probably be inaccurate, i.e. there will be an increase in perceptual errors, whereas if the cognitive or affective parts are disturbed there will probably be a bias, leading to systematic over- or underestimation of body size. This makes it necessary to distinguish between the degree of deviation from the actual body size and the direction of this deviation.

The foregoing argumentation leads us to the view that somatosensory processes are of importance in 'body image' formation. But although this view is shared by other authors [8, 9, 13, 20], it has nevertheless been totally neglected in experimental research.

We studied body size perception in young women using three different standard methods: the video distortion technique (VDT), the image marking procedure (IMP) and the kinaesthetic size estimation apparatus (KSEA). As measures of somatosensation we assessed thermal (warmth and cold), pain and vibration thresholds. We expected the somatosensory variables to be more closely related to the accuracy of body size perception than to the direction of deviations, i.e. to over- or underestimation. Because cognitive and affective variables are thought to influence the direction of the deviation, we also administered a set of questionnaires on eating behaviour and motivation, on body attitude or body satisfaction, and on depressive mood and thoughts, variables that some authors think play a role in this context [2, 25].

METHODS

Subjects

Forty-one normal weight (BMI between 19 and 24, mean = 20.9, *sd* = 1.3) women between the ages of 20 and 30 yr (mean = 23.7, *sd* = 2.3) participated in the study. Their mean height was 168.7 cm (*sd* = 5.4) and mean weight 59.7 kg (*sd* = 5.3). All subjects gave written informed consent and stated that they had never had an eating disorder. The subjects were paid for their participation.

Apparatus and procedure

The session started at 9:30 a.m., 11:30 a.m. or 1:30 p.m. First the subject was asked to fill out the following questionnaires (German versions): the Eating Attitudes Test (26-item version [26]), with the scales Dieting, Bulimia and Food Preoccupation, and Oral Control; the Three-Factor Eating Questionnaire ([27], Fragebogen zum Eßverhalten [28]), with the scales Cognitive Restraint of Eating, Disinhibition, and Hunger; the Body Shape Questionnaire [29]; a short form of the Beck Depression Inventory [30] and the Depression Scale [31]. Thus a total of nine scales were administered.

Then four somatosensory thresholds were assessed, the pain, warmth, cold and vibration thresholds (in that order). The site of measurement was always the right foot (lateral dorsum pedis for thermal thresholds and dorsomedial aspect of the first metatarsal bone for vibratory threshold). Pain and thermal thresholds were assessed with a Peltier thermode (PATH-Tester MPI 100, Phywe Systeme GmbH, Göttingen; for details see [32]), and vibration thresholds were assessed with a VIBRA-Tester (Phywe Systeme GmbH, Göttingen).

For determination of the pain threshold, eight heat stimuli were applied with a rate of temperature change of 0.7°C/s, always beginning at 38°C. The subject was instructed to press a button as soon as she felt pain. The pain threshold was calculated as the mean of the peak temperatures of the last five stimuli.

For measurement of the warmth and cold thresholds, seven warmth stimuli and then seven cold stimuli were administered, always starting at a temperature of 32°C, with a rate of temperature change of

0.7°C/s. The subject had to press a button as soon as she noticed a change in temperature. The mean differences between the base temperature and the peak temperature in the two sets of seven trials were the measures of the warmth and cold thresholds.

The vibration perception threshold (VPT) was assessed in three trials by increasing the amplitude from zero, with a rate of change of 0.2 $\mu\text{m/s}$, until the subject felt the vibration and pressed a button. In three further trials, the vibration amplitude was decreased at the same rate of change from a clearly suprathreshold value until the sensation disappeared (vibration disappearance threshold, VDT). The vibration threshold (VT) was defined as the average of the VPTs and VDTs.

The body size perception tests (for details see [33]) were conducted with the subject wearing a leotard. For the video distortion technique (VDT), a video camera with a zoom lens scanned a Polaroid photograph of the subject in a frontal position and the signal was fed into a television monitor. The investigator could distort the picture on the screen in the horizontal plane from 60 to 140% of the original size by turning a dial. Ascending and descending trials alternated. The subject had to signal when the picture on the screen reflected her actual body size. Four trials were conducted and the average was taken as the measure of the VDT; this measure can be considered equivalent to the body perception index [BPI, (subjective body size/objective body size) \times 100].

For the subsequent image marking procedure (IMP), the subject stood in front of a white board with a marking pen in each hand. She was asked to mark her body width at the levels of the chest, waist, hips and thighs. The BPI was computed separately for each body site, and the average of the 4 BPIs was taken as the measure of the IMP.

The third test involved use of a modification of the kinaesthetic size estimation apparatus (KSEA) described by Gleghorn and co-workers [6]. It consists of a horizontal metal bar with two handles that can be slid along the bar. The blindfolded subject stood in front of the bar (adjusted initially to shoulder height) and was asked to estimate the width of her body at the chest, waist, hip and thigh level by moving the handles. There were four trials, alternating between 'ascending' and 'descending' trials. The average of the 16 BPIs was taken as the measure of the KSEA.

As a measure of the accuracy of perception in each body size estimation test, an error score (BPI-Error) was calculated by taking the absolute value of the difference between the individual BPI and 100.

Evaluation

Discriminant function analyses were performed to determine those variables having predictive value for the measures of body size perception. This statistical method was used because we did not know whether finer distinctions than 'over- vs underestimators' (BPI) and 'good vs poor perceivers' (BPI-Error) would be appropriate. The grouping was achieved by a median split for each perception measure. Analyses were done with all independent variables (13), questionnaire data only (9) and somatosensory data only (4) allowed to enter the function equation. The percentage of correct classifications and the *p*-value of the chi square test on Wilk's lambda are reported as the measures of the accuracy and importance of the discriminant functions. Pearson correlation coefficients were computed to evaluate the strength of the relation between two variables.

RESULTS

The body size perception measures BPI and BPI-Error obtained with the three different techniques (VDT, IMP and KSEA) are given in Table I. The BPIs for all three methods show a tendency to overestimation of body size. This tendency appears to be only slight for the VDT and marked for the IMP. Implied in this finding is that only in the VDT was there almost no bias due to the method itself. The BPI-Error, our measure of perceptual accuracy, was clearly lowest for the VDT and highest for the IMP. The similarity of the findings for BPI and BPI-Error may call into question our assumption that the two parameters measure different aspects of body size perception.

The correlations between the two parameters for a given method do not answer this question unequivocally (see Table II). For the VDT, the two parameters were clearly independent of each other, but this was not the case for the IMP or the KSEA. The correlations between different methods for a given parameter were close to zero in those cases where the BPIs of VDT were involved (see Table II). The correlation

TABLE I.—BODY PERCEPTION INDEX (BPI) AND BPI-ERROR FOR THE VIDEO DISTORTION TECHNIQUE (VDT), IMAGE MARKING PROCEDURE (IMP) AND KINAESTHETIC SIZE ESTIMATION APPARATUS (KSEA). VALUES ARE MEANS \pm SD ($N = 41$)

	VDT (%)	IMP (%)	KSEA (%)
BPI	101.4 \pm 7.6	105.1 \pm 12.7	103.6 \pm 11.3
BPI-Error	6.6 \pm 4.0	11.0 \pm 8.0	8.6 \pm 8.2

TABLE II.—INTERRELATIONS (PEARSON CORRELATIONS [R] WITH p -VALUES) BETWEEN THE BODY PERCEPTION INDEX (BPI) AND BPI-ERROR WITHIN AND ACROSS METHODS ($N = 41$)

	IMP (BPI)	KSEA (BPI)	VDT (BPI-E)	IMP (BPI-E)	KSEA (BPI-E)
VDT (BPI)	$R = 0.04$ $p = 0.817$	$R = -0.05$ $p = 0.736$	$R = 0.03$ $p = 0.861$	$R = -0.07$ $p = 0.662$	$R = 0.21$ $p = 0.197$
IMP (BPI)		$R = 0.37$ $p = 0.016$	$R = 0.16$ $p = 0.316$	$R = 0.49$ $p = 0.001$	$R = 0.10$ $p = 0.530$
KSEA (BPI)			$R = 0.36$ $p = 0.021$	$R = 0.06$ $p = 0.733$	$R = 0.66$ $p \leq 0.001$
VDT (BPI-E)				$R = 0.03$ $p = 0.833$	$R = 0.44$ $p = 0.004$
IMP (BPI-E)					$R = -0.09$ $p = 0.595$

VDT: video distortion technique, IMP: image marking procedure, KSEA: kinaesthetic size estimation apparatus.

between the BPIs of the IMP and the KSEA was also not very strong, although significant. For BPI-Errors, a significant correlation was found only between the VDT and the KSEA.

We conclude that there was no methodological bias in the VDT; the use of a BPI of 100 as the reference for a 'correct' perception appears to be appropriate. Moreover, in this method the accuracy of body size perception (BPI-Error) and the tendency to over- or underestimation (BPI) were unrelated. None of this was true for either IMP or KSEA.

The results of the discriminant function analyses are presented in Table III. 'Good' classification results (more than 80% 'correct') could be achieved for the BPI and BPI-Error of the IMP, and 'very good' ones (more than 90% 'correct') for the BPI-Error of the VDT using all the independent variables in the analysis. However, only in the case of the BPI-Error of the VDT was the chi square test on Wilk's lambda significant; in other words, the distinction of 'good vs poor perceivers' on the VDT accounted for a significant portion of the variance of the predicting variables (60%, with a lambda of 0.40). We conclude that of six discriminant function analyses only in the one with BPI-Error of VDT could a 'very good' classification result be obtained, based on a clearly meaningful discriminant model.

The contributions (increase in 'correct' classifications) of the different types of variables (questionnaire and somatosensory data) to this finding appeared not to be identical, as can be seen in Table III. The contribution of the four somatosensory variables was about 24%, whereas that of the nine questionnaire variables was only about 15%. In addition, for the somatosensory variables the distinction 'good vs poor perceivers' in VDT explained a significant portion of the variance of those variables (35%, with a lambda of 0.65).

TABLE III.—RESULTS OF THE DISCRIMINANT FUNCTION ANALYSES FOR THE DISTINCTION 'OVER- VS UNDERESTIMATORS' (MEDIAN SPLIT OF THE BODY PERCEPTION INDEX [BPI] VALUES) AND 'GOOD VS POOR PERCEIVERS' (MEDIAN SPLIT OF THE BPI-ERROR VALUES) WITH ALL VARIABLES OR ONLY SOMATOSENSORY OR ONLY QUESTIONNAIRE VARIABLES IN THE EQUATION: PERCENTAGE OF CORRECT CLASSIFICATIONS AND *p* VALUE OF THE CHI SQUARE TEST ON WILK'S LAMBDA (*N* = 41)

	All variables ¹		Somatosensory tests ²		Questionnaire data ³	
VDT (BPI)	65.9%	<i>p</i> = 0.557	65.9%	<i>p</i> = 0.560	63.4%	<i>p</i> = 0.609
IMP (BPI)	82.9%	<i>p</i> = 0.062	68.3%	<i>p</i> = 0.315	68.3%	<i>p</i> = 0.106
KSEA (BPI)	78.1%	<i>p</i> = 0.122	63.4%	<i>p</i> = 0.140	75.6%	<i>p</i> = 0.088
VDT (BPI-E)	92.7%	<i>p</i> = 0.006	78.1%	<i>p</i> = 0.003	68.3%	<i>p</i> = 0.217
IMP (BPI-E)	85.4%	<i>p</i> = 0.236	65.9%	<i>p</i> = 0.184	75.6%	<i>p</i> = 0.422
KSEA (BPI-E)	75.6%	<i>p</i> = 0.790	65.9%	<i>p</i> = 0.599	65.9%	<i>p</i> = 0.747

¹df = 13, ²df = 4, ³df = 9.

VDT: video distortion technique, IMP: image marking procedure, KSEA: kinaesthetic size estimation apparatus.

DISCUSSION

Our finding of only weak correlations between the body perception indexes (BPIs) of different methods is compatible with the results of other authors [3–6]. This suggests that the method used has an effect on this measure of over- and underestimation. Also consistent with the work of others is our finding that the BPIs of the body-site-specific methods (image marking procedure, IMP, and kinaesthetic size estimation apparatus, KSEA) correlate moderately and significantly with each other, whereas these methods have close-to-zero correlations with the BPI of the whole-body procedure used in the video distortion technique (VDT). But it is still unclear whether these findings reflect stable methodological differences or are indications that different body schemes underlie these measures.

Our data do not support the view that eating behaviour and motivation, body attitude and satisfaction, and depressive mood or thoughts are key variables in biasing a person to over- or underestimation of body size, a view held by other authors [2, 4, 25]. The distinction 'over- vs underestimators' according to the BPI in the VDT, IMP and KSEA can be explained only poorly by these variables, as the results of our discriminant function analyses show. Some of our questionnaire measures may have had a very small variance in our non-pathological sample of young women and, as a result, were not entirely appropriate for this kind of 'co-variance' analysis. However, this argument does not hold for all of the questionnaires used. Our results are in line with those of other authors, who also found that variables which are useful for the explanation of overestimation in eating disorder patients cannot be applied with the same result in non-eating disorder subjects [5, 34, 35].

We attempted to obtain a measure of the accuracy of body size perception (BPI-Error) by using the absolute deviation of the individual BPI from 100, the value at which perceived and actual body sizes are equal. On the one hand, this approach was suggested by findings that eating disorder patients are not necessarily biased to overestimation but are simply less accurate in body size perception (e.g. [36]). On the other hand, it was prompted by our idea that sensory dysfunctions and, as a consequence, vague or contradictory body schemes tend to produce perceptual

inaccuracy, whereas over- or underestimation are due to the biasing influences of cognitive and affective variables.

For the VDT, the BPI-Error approach can be considered successful because the correlation between BPI and BPI-Error is close to zero and the BPI group mean of 101.4 suggests that a BPI of 100 can be considered as a reference for a 'correct' perception. Neither condition was met using the other two methods, so the results obtained with them should be interpreted with caution.

And it was the 'good vs poor perceivers' distinction, using the BPI-Error of the VDT, which was the only one that could be explained to a marked degree (92.7% correct classifications) by our set of predictor variables in a discriminant function analysis. For prediction, we used four somatosensory tests (pain, warmth, cold, and vibration thresholds) and 9 questionnaire scales relating to eating behaviour and motivation, depressive mood and thoughts, and body attitudes. In an analysis with the somatosensory tests as the only variables included, 78.1% of the cases could still be correctly classified, which is more than could be achieved with the questionnaire data alone (68.3%). This suggests that in the VDT the somatosensory tests contribute more than the questionnaire data to the distinction 'goods vs poor perceivers'. The problems with the BPI-Errors of the IMP and KSEA mentioned earlier may be the reason that this was true for only one measure of accuracy of body size perception.

Our theoretical considerations led us to postulate that somatosensory functions may be of importance for body scheme formation and therefore also for the accuracy of body size perception. Our findings are clearly not conclusive evidence for this, but they do suggest that somatosensory variables have a weight at least similar to that of the variables traditionally used (data relating to eating behaviour and motivation, body satisfaction and body attitude, depressive cognitions and affects) to explain inaccuracies in body size perception. Hence, the claim that somatosensation has to be included in considerations on 'body image' disturbances [9, 20, 22] is certainly strengthened by our findings.

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