Body representation disturbances in anorexia nervosa

Lichaamsrepresentatie stoornissen in anorexia nervosa
(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht op gezag van de rector magnificus, prof.dr. G.J. van der Zwaan, ingevolge het besluit van het college voor promoties in het openbaar te verdedigen op vrijdag 21 maart 2014 des middags te 12.45 uur

door

Anouk Keizer
geboren op 16 januari 1986
te Losser

Promotoren: Prof. dr. H.C. Dijkerman
Prof. dr. M.A.M. Smeets
Prof. dr. A.A. Van Elburg

Dit proefschrift werd mede mogelijk gemaakt met financiële steun van Altrecht Eetstoornissen Rintveld te Zeist, Nederland.

Body representation disturbances in anorexia nervosa

Anouk Keizer

Body representation disturbances in anorexia nervosa

ISBN 978-90-6464-748-2

Cover design by Tom Kleijn
Photography by Allie Wimms
Printed by GVO Drukkers & Vormgevers B.V.

CHAPTER 8

Summary & conclusions

1.1. Background

One of the central symptoms of AN is a disturbance in how body weight and shape are experienced. AN patients are underweight, but have a persistent perception and experience of their own body as bigger than it objectively is (APA, 2000). Interpretation of traditional research on this topic (for reviews see e.g. Cash and Deagle, 1997; Farrell et al., 2005; Skrzypek et al., 2001; Smeets, 1997), mainly conducted by clinical psychologists and psychiatrists, is complicated by two main problems. First, the methodological paradigms (BSE tasks) that were used were inspired by perceptual psychology and psychophysics. In relation to this, perceptual representations of the body were regarded as similar to perceptual representations of objects. However, body representations as opposed to object representations do not form a neutral, static, percept or representation but are heavily influenced by emotions and attitudes. A second complicating factor is that most traditional body image research has focused on visual perception of the body and its size, rendering influences from other senses, such as touch, irrelevant.

In this thesis we approached the disturbed experience of body size from a theoretically and methodologically different perspective rooted in neuropsychology and cognitive neuroscience. This approach takes into account that 1) representations of the body are special, and fundamentally different from (neutral) object representations, and 2) that perception and experience of the body is rooted in a multisensory context. According to neuropsychological/cognitive neuroscientific views, body representations contain abstract, multimodal, bodily dimensions stored in a network of parietal, frontal and insular cortical areas (see e.g. de Vignemont, 2010; Dijkerman and de Haan, 2007; Gallagher, 2005; Haggard and Wolpert, 2005; Paillard, 1999; Serino and Haggard, 2010). Different body representations can be distinguished. For example, the body image, which is mainly involved in conscious body-related perception and cognition, and the body schema, which is mainly involved in relatively unconscious action guidance (see e.g. de Vignemont, 2010; Dijkerman and de Haan, 2007).

Previously it was shown that AN patients, on a behavioural and functional level, show differences compared to controls in terms of multisensory processing of bodily information (e.g. Case et al., 2012; Eshkevari et al., 2012; Grunwald et al., 2001; Guardia et al., 2012b; Mohr et al., 2010; Nico et al., 2010; van Kuyck et al., 2009). However, none of these studies directly focused on whether multimodal metric

aspects of body representation are disturbed in AN. We are among the first to directly investigate this adopting a neuropsychological approach.

The main aim of the present thesis was therefore to increase understanding of the disturbed experience of body size in AN, and specifically focusing on metric aspects of the mental representation of the body. The approach adopted here is rooted in neuropsychology and could be considered a paradigm shift. The present thesis consisted of three sections. In this chapter I will first summarize the findings from the studies presented in this thesis on a section by section basis, starting with body image studies, continuing with body schema studies, and ending with findings on plasticity of body representation. Subsequently I will discuss how the findings contribute to a more complete understanding of the nature and extent of the disturbed experience of body size in AN, and address suggestions for future research and clinical implications of the findings.

1.2. Section 1 – body image

Section 1 included three studies that focused on metric aspects of body image. First, in **Chapter 2**, a novel method for assessing metric tactile body representations was presented (based on Anema et al., 2008; Taylor-Clarke et al., 2004). As tactile representations of the body were largely ignored in relation to AN, we developed a method tailored to AN patients to assess a possible disturbance in this domain. To validate this method we tested a group of healthy participants. Specifically, blindfolded participants were asked to estimate the distance between two tactile stimuli presented to their forearm by separating their thumb and index finger. The results showed that healthy participants' performance on this paradigm was robust and unaffected by gender, stimulation-site (left or right arm), or response-hand (left or right hand). In accordance with previous studies (Spitoni et al., 2010), performance did not correlate with performance on a lower level tactile detection task, which indicates that different processes underlie size estimation and simple tactile detection.

The aim of **Chapter 3** was twofold. First, the visual mental representation of body size was assessed. In traditional BSE research the visual mental representation of body size was often assessed using tasks in which the stimuli itself consisted of visual information on body size (e.g. a (distorted) photograph of the body). Especially in the AN group such a priori visual information might bias their subsequent task response, making it an assessment of body attitudes more than the

visual mental image of body size (see e.g. Smeets, 1997; Smeets et al., 2009). Here the visual mental image of the body was assessed using a method (based on Smeets et al., 2009) in which stimuli consisted of body-related words instead of body-related images. As such, responses could not be a priori biased by visual information, but required generation of a visual mental image of the body. The results showed that AN patients made more errors in judging their body width, implying that AN patients' spontaneously generated visual mental representation of their body width is more inaccurate than that of healthy females. Second, we investigated tactile body representation disturbances in AN. With a method similar to the one presented in Chapter 2. AN patients were found to overestimate tactile distances on their forearm and abdomen compared to healthy females, but also compared to the actual applied distance, while healthy females underestimated distances. Overestimation of tactile distances in the AN group implies that AN patients process spatial aspects of touch stimuli differently than healthy females. They interpret a tactile distance as bigger than it actually is, i.e. as if a bigger surface of their skin is touched, which may be related to the experience of having a fat body that is characteristic for this clinical group. Most importantly, a disturbance in tactile body representation was identified in AN, implying that modalities other than vision and cognition are affected as well.

In **Chapter 4** we further explored the nature of tactile body representation disturbances in AN. Would overestimation of tactile distances in the AN group result from higher-order deficits, or instead be related to disturbances in lower level somatosensory processing (e.g. input on receptor level)? The results showed that, in accordance with findings from Chapter 3, again, AN patients and healthy females differed in tactile size estimations. However, in Chapter 4 we found an interaction effect between group and body part on which tactile stimuli were presented, indicating that the difference in size estimation between AN patients and healthy females was most pronounced for stimuli presented to the abdomen compared to the forearm. In other words, it appears that AN patients representation of body size is more disturbed for body parts that they worry about frequently, compared to less "sensitive" body parts. We further included two tasks assessing lower level somatosensory perception for which supposedly a body representation is not used (e.g. Spitoni et al., 2010). AN patients showed altered performance compared to healthy females on measures of tactile sensitivity as well as two point discrimination. Specifically, AN patients and HC differed in tactile sensitivity for the abdomen (AN were more sensitive), but not the arm, and overall AN patients showed decreased

tactile acuity. Regression analysis showed that tactile distance estimations on the arm were predicted by group membership (either AN or healthy female), and that distance estimations on the abdomen were predicted by group membership and two point discrimination (AN plus low tactile acuity predicted larger size estimations). These findings imply that AN patients tactile body image disturbance is most likely to result from a combination of higher order influences related to AN pathology, as well as lower level somatosensory disturbances.

In relation to the main aims of the present thesis, the findings from Section 1 show that body image disturbances in AN are not limited to distorted visual information processing, but also affect how touch is processed and perceived by this group. Disturbed perception of specifically tactile distance appears to result from deficits in basic somatosensory processing (i.e. tactile input arrives in the brain distorted) as well as higher order influences related general AN pathology (i.e. negative body attitudes and specific attentional processes).

1.3. Section 2 – body schema

From a neuropsychological perspective a distinction between different types of body representations can be made (see e.g. de Vignemont, 2010; Dijkerman and de Haan, 2007). Section 1 focused on multimodal body image, Section 2 includes two chapters that focus on body schema.

First, in **Chapter 5** we presented a methodological study in which a new method for assessing body schema (based on Warren and Whang, 1987) was evaluated in a group of healthy participants. In traditional literature on body size experience in AN, body schema, or how the body is used in action (guidance), is a largely overlooked aspect of body representation, and not investigated. Therefore we developed a method to assess this. Given that body schema is defined as a relatively unconscious representation of the body (e.g. Dijkerman and de Haan, 2007) it is important that body schema is measured whilst participants perform actions relatively automatically, i.e. without focusing conscious attention on the task. Therefore we asked healthy participants to walk through apertures varying in size, either being aware of the purpose of the study (i.e. measuring shoulder rotation when crossing the aperture) or being unaware (i.e. being told that they participated in a haptic memory experiment). We found that both groups started to rotate their shoulders as soon as an aperture was about 1.2 times as wide as their own shoulders. We found a marginally significant difference between the groups in terms of amount

of shoulder rotation, with unaware participants making smaller shoulder rotations at the opening width for which they started rotating than aware participants. It thus seems that performing actions without focusing conscious attention on the task increases efficiency of performing the action, but does not influence action-planning.

In **Chapter 6** we investigated body schema disturbances directly in an AN population. Although it was previously assumed that AN patients do not have problems regarding body schema, they do often report that they experience feelings of taking up too much space in a room, or being too big. Could this affect, or result from, how they move around in space? Locomotion in AN was assessed, using an aperture task similar to the one presented in Chapter 5. All participants were unaware of the purpose of the study. The results showed a group difference in terms of the opening width for which participants started rotating in order to fit through. Healthy females rotated their shoulders as soon as an opening was 1.25 times their shoulder width, or smaller, replicating the findings from Chapter 5. However, AN patients already started rotating as soon as the opening was 1.40 times as wide as their own shoulders. No other relevant differences on measures of locomotion were found between the groups (e.g. onset of rotation, amount of rotation). Interestingly, we found that AN patients and healthy females no longer differed in critical aperture as soon as this was calculated using their estimated shoulder size divided by the opening width for which they started rotating, compared to their actual shoulder width. This implies that AN patients' body schema is disturbed and that they unconsciously engage in whole-body actions and locomotion on basis of an enlarged internal modal of body size.

The main aim of the present thesis was deepening insight in the disturbed experience of body size in AN. Taken together the findings from Section 2 show for the first time that body representation disturbances in AN extend to the body schema. AN patients move around in space as if their body is bigger than it actually is, without being aware of doing so. In other words, their actions are, relatively unconsciously, guided by a representation of body size that is bigger than their body actually is.

1.4. Section 3 – plasticity of body representation

Section 1 and 2 focused on body image and body schema respectively. Both were found to be disturbed in AN. A next logical step would be assessing whether

this enlarged representation of body size can be changed. Therefore, we address the plasticity of body representation in AN in Section 3, with a specific focus on metrics, i.e. on how the body is experienced in terms of size and whether this can be changed.

In **Chapter 7** we assessed changeability of body representation in AN. A method rooted in cognitive neuroscience to assess malleability of body representation is the Rubber Hand Illusion (RHI, see e.g. Botvinick and Cohen, 1998). This method is particularly interesting in an AN group, as during the illusion a fake rubber hand is experienced as belonging to the own body. AN patients show no deficits when estimating the size of objects, but they do estimate their own body size in a disturbed way. We adapted traditional the traditional RHI method by including a size estimation of the rubber hand and own hand before and after induction of the illusion. This helps determining whether AN patients estimate an object (rubber hand) differently once it becomes incorporated in their body representation (i.e. after induction of the illusion). The results first showed that AN patients have a stronger experience of ownership over the rubber hand than healthy females, implying increased malleability of body representation. Interestingly, AN patients size estimations of their *own* hand, but not the rubber hand, changed after induction of the rubber hand illusion. After both the experimental and control condition of the RHI AN patients estimated the size of their hand as more accurate, and no longer showed overestimation of own hand size. It thus appears that the advantage of estimating the size of an external objects transfers to estimating the size of the own body. This transfer seems to be unrelated to experiencing ownership over the rubber hand. Although the exact mechanisms behind a change in body size estimation in the AN group cannot be inferred from the present results, they do indicate that body representation distortions in AN are not static, but *can* be corrected.

1.5. What do the findings tell us?

At the beginning of this chapter two main problems with traditional BSE research were addressed. First, traditionally body percepts/representations were not regarded as different from neutral object percepts/representations. Second, there was an almost exclusive focus on how body size perception/representation in the visual domain. In the present thesis the disturbed experience of body size in AN was investigated using an approach rooted in neuropsychology, taking the previously

mentioned problems into account. In short, the most important conclusions from the studies presented in this thesis are that:

- a paradigm shift allowed for testing of new hypotheses related to the disturbed experience of body size in AN;
- body representation disturbances in AN are more severe and widespread than previously assumed;
- AN patients have an inaccurate visual mental representation of body size;
- AN patients process and perceive tactile information differently (bigger) than healthy females;
- AN patients perform actions based on an enlarged internal representation of body size;
- AN patients' disturbed experience of body size can be changed.

1.6. Body representations in AN – a revisited perspective

The results from the present thesis have deepened and broadened the understanding of the disturbed experience of body size in AN. A paradigm shift enabled testing of previously unaddressed hypotheses, which in turn has resulted in novel perspectives on body representation disturbances in AN. Although it was traditionally assumed that AN patients merely thought of their bodies as fat, and visually perceived them as such, we have shown here that the disturbance in body size experience in AN extends beyond the visual and cognitive modality. Specifically, *multimodal* body image disturbances have been identified, including a disturbance in processing of tactile input, as well as body schema disturbances. These new insights imply that the disturbed experience of body size in AN is more severe than was previously thought. This has interesting implications for theory on body representation disturbances in AN, as well as for treatment of this disturbance.

1.6.1. Theoretical implications

Figure 1 depicts the traditional perspective on body representation disturbance in AN (left) as well as the revisited perspective based on the results of the studies described in the present thesis (right). According to the traditional perspective, two representations of the body were involved in the disturbed experience of body size in AN, an affective body representation (body attitudes) and a perceptual body representation (body image). It was generally thought that these two representations were independent from each other, and that the main problem

concerned a top-down influence of negative body attitudes (e.g. thinking that the body is fat) on visual representations of the body (defined as body image, see e.g. Smeets, 1995). Body schema was acknowledged as an existing construct, but it was assumed to be irrelevant to the disturbed experience of body size in AN. Adopting a different point of view, rooted in cognitive neuroscience, in the present thesis, led to the formulation of novel hypotheses and methods. Testing of these hypotheses provided new insights into the disturbed representation of body size in AN. As depicted in the revisited perspective (Figure 1, right) we propose that body representation disturbances in AN should be regarded as multimodal, including distortions at the level of body image (visual, tactile, and affective modality) as well as body schema (action guidance/performance).

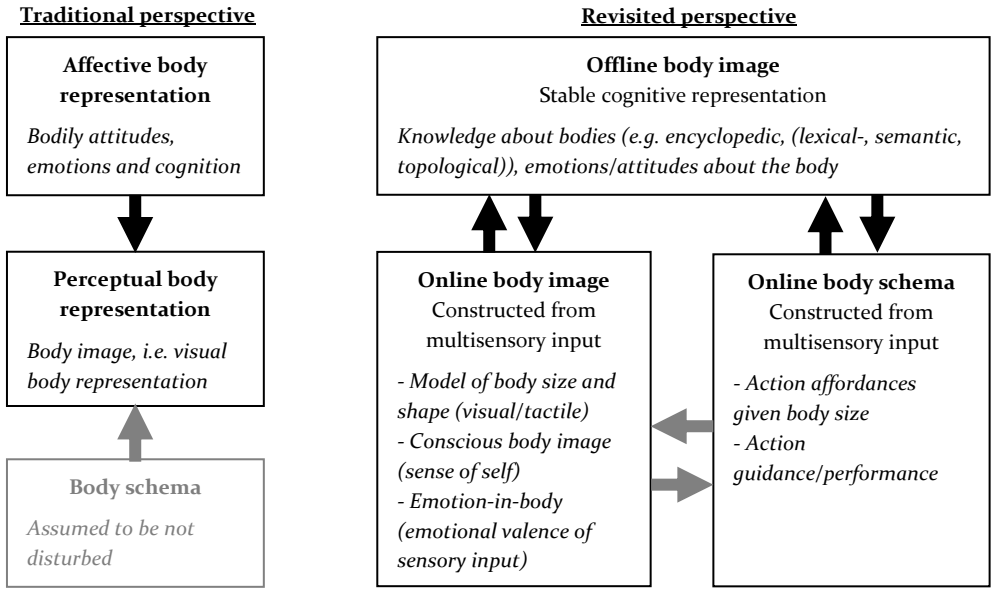

Figure 1. Traditional versus revisited perspective on body representation disturbances in AN.

A first important difference is that the new perspective includes the concept body schema. From traditional literature we may infer that the shared opinion seemed to be that body schema was not of relevance to the disturbed experience of body size in AN (Figure 1, left, in grey). In other words, it was assumed that with regard to performing actions, AN patients showed no disturbances. Results from the present thesis however show that the disturbed experience of body size in AN

patients also affects how they move in space, rendering the inclusion of body schema disturbances appropriate.

A second difference between the traditional and revisited perspective is the role that is ascribed to higher order affective/emotional bodily information in the disturbed experience of body size in AN. In the traditional perspective bodily emotions supposedly had an unidirectional influence on how the body was (visually) perceived (e.g. Smeets, 1995). In contrast, here we propose that AN patients' emotions related to the body are strongly entwined with, and interact with the online body image and body schema. According to theories rooted in cognitive neuroscience the online body image and body schema are invoked during processing of (multi)sensory input to construct representations of the body that reflect the present state the body is in (e.g. Longo et al., 2010). The online body image is supposedly related to conscious bodily perception, and the online body schema aids unconscious bodily actions (e.g. de Vignemont, 2010; Dijkerman and de Haan, 2007; Longo et al., 2010). Both representations of the body can be further divided into "sub-representations" that each have their own specific function (see Figure 1, right). Note however that the lists of sub-representations in Figure 1 (right) are not exhaustive (e.g. de Vignemont, 2010; Dijkerman and de Haan, 2007; Longo et al., 2010), only the sub-representations relevant to the present thesis (i.e. relevant to distorted experience of body size in AN) are included here. The online body image for example includes sub-representations that allow for the construction of an internal model of the shape and size of the body, as well as a so-called conscious body image, which is important in maintaining a coherent sense of self. Importantly, the online body image also includes an emotional component, which is related to the emotional valence that is ascribed to sensory input. When a healthy individual for example perceives touch on their body, they are almost instantly able assign emotional valence to what they perceive. As such body related perception and body related emotional information are suggested to be strongly linked, most likely due to connections between brain areas important in (higher order) processing of sensory input (here, e.g. secondary somatosensory area (SII)) and the insula, see e.g. Dijkerman and de Haan, 2007). In addition it is quite adaptive that a strong link between bodily perception and the associated affective state of the body exists, as it helps to avoid unpleasant, or even harmful, stimuli.

As the body schema is a mainly unconscious representation of the body, it does not include an emotional component. However, it is suggested that it can be

influenced by affective/emotional information about the body stored in the offline body image (e.g. de Vignemont, 2010; Longo et al., 2010). We believe that especially in AN patients it is highly likely that higher order emotional aspects of body representation as stored in the offline body image exert an influence on how the body is perceived and used in action. What is important about AN pathology is that the experience of body size and the appearance of the body take up a central role in the disorder (APA, 2000). As such, all input that is body-related is likely to be heavily laden with emotions/attitudes in this group. AN patients are overly aware of their body and have an excessive focus on body-related information (see e.g. Lee and Shafran, 2004; Shafran et al., 2007; Smeets et al., 2008). I believe it is therefore virtually impossible to separate for example an emotional evaluation of the body or body related attitudes from how sensory input is processed and used in AN patients.

The emotional evaluation of the body in AN might serve as a maintaining factor of disturbed experience of body size. On the one hand emotional aspects of offline body representation are very negative in AN, which can influence bodily perception and action. On the other hand, the emotional component of the offline body representation is based upon general evaluations of appearance, for example by comparing own body size to body size of someone else. In order to make such a comparison, information on own body size is required. Internal models of body size are is stored in the online body image and body schema. Indirectly, information on own body size is thus inferred from how body related sensory input is processed (e.g. how the body is perceived in terms of size (online body image) or how the body is used in action (online body schema)). In other words, as long as AN patients process body related sensory input in a disturbed way (e.g. perceive touch to their skin as enlarged), a distorted (enlarged) internal model of body size will affect the outcome of emotional evaluations stored in the offline body image, resulting in a negative downward spiral.

Third, in contrast to the traditional perspective, the revisited perspective is multimodal. It includes disturbances of body representation at the level of visual and tactile perception, attitudes/emotions, as well as guidance and performance of actions. The disturbed representation of body size in AN is thus viewed as a distortion that affects multiple modalities in conscious body-related perception as well as relatively unconscious body-related action.

A multimodal perspective on body representation disturbance in AN has two main advantages. A first advantage is that it takes into account that representations

of the body are fundamentally different from object representations. Generally, object representations are constructed from external information. That information is not by definition only visual, as individuals for example can manually explore an object. However, an important difference in constructing object representations and body representations is that for object representations the actor and the object are independent from each other: The actor gathers external input about the object. In contrast, body representations are constructed from external as well as internal input: The body can serve as both the actor and the object. For example, when constructing a representation of a bunny an individual has access to visual input and perhaps tactile input, but when constructing a representation of the own body the individual also has access to internally generated input (i.e. interoceptive perception), such as proprioception, or emotions and has a sense of ownership/agency. In case of the former the actor is unaware of the internal physical state of object (the bunny), while in case of the latter, the actor does have this information, as it concerns his/her own body. The new perspective does not only include input from visual perception, but also touch related input, emotional input, and action-related input, taking into account that representations of the own body are based on different input compared to object representations.

A second advantage of a multimodal perspective on the disturbed experience of body size in AN is that it more accurately matches clinical observations, and patients' own experience of their disturbed experience of body size (Espeset et al., 2011). Patients themselves indicate that feeling fat is in their experience not limited to how they think about their body or how they visually perceive it, but that it rather is something that they feel from their body. In addition patients note that the feeling of having a big body can persist, even though treatment has resulted in more accurate visual perception of their body and more positive bodily cognitions.

A fourth difference between the traditional and revisited perspective is that the new perspective includes a possible (Figure 1, right, in grey) interaction between body image and body schema. In the traditional perspective this interaction is absent. This is mainly related to the general assumption that body schema would not be disturbed in AN. In neuropsychology the dominant view exists that body image and body schema are dissociated from each other (see e.g. Dijkerman and de Haan, 2007; Gallagher, 2005; Head and Holmes, 1911; Paillard, 1999), however there are also some researchers that suggest an interplay between the two (see e.g. de Vignemont,

2010; Longo et al., 2010). Although it is beyond the scope of this thesis so resolve the ongoing debate on the body image – body schema dissociation, it should be noted that although different representations of the body may exist and serve different functions, they might not necessarily operate in strict independence from each other. For example, in one study a bodily illusion was induced in healthy participants. The illusion affected perceptual responses (judgment of location of the body, body image), but not motor responses (reaching movement, body schema, Kammers et al., 2009). However, in another study, using the same bodily illusion but a slightly different motor response (grasping movement), it was shown that now the motor response *was* affected by the illusion (Kammers et al., 2010). These results indicate that in certain tasks the body image and body schema appear to interact. In other words, the interaction between body image and body schema might be dependent upon the function that either representation in a given situation has. It is possible that some aspects of the online body image and body schema are more likely to interact than others.

Following this line of reasoning, the present thesis also suggests an interaction between body image and body schema in AN. The focus was specifically on actions in which the size of the body plays a central role. For such actions an internal model of the size of the body is required, which is assumed to be stored in the online body image (see Figure 1, right, Longo et al., 2010). Therefore, it is plausible that in the light of AN pathology the online body image and body schema interact in certain contexts. Nevertheless, in the current thesis we have found little evidence for a direct association between body image and body schema measures. This absence of significant correlations between the two constructs might however have resulted from a power issue. Sample sizes were big enough to detect changes on separate tasks between AN patients and healthy females, however they might have been too small to be able to detect a correlation between body image and body schema within either group.

Taken together, AN patients are at first glance different from the neuro(psycho)logical (lesion) patients and healthy participants on which body representations theories in cognitive neuroscience and neuropsychology have been built. For example, AN patients suffer from a psychiatric disorder that is likely to affect brain functioning, but they do not suffer from acquired brain lesions that are observed in e.g. stroke patients. Furthermore, AN patients show disturbances on perceptual as well as action related tasks, while in studies on lesion patients double

dissociations between e.g. perception and action are of specific interest. Nevertheless these theories have shown to provide a useful basis from which the disturbed experience of body size in AN can be investigated, as well as be placed in a theoretical framework. As indicated earlier, the body representations as specified in Figure 1 (right) are not exhaustive. Future studies in the field of body representation disturbances in AN can take advantage of the large body of literature from cognitive neuroscience and neuropsychology, to explore other (sub)representations of the body in the brain that may be affected in AN.

1.6.2 Clinical implications

Given that disturbed experience of body size has been linked to relapse and unfavorable prognosis in AN (see e.g. Farrell and Shafran, 2006; Freeman et al., 1985; Killen et al., 1996), it is important that treatment approaches are developed that successfully improve body size experience. Moreover, the present thesis has shown that body representation disturbances in AN are not limited to cognitions and visual perception of the body. These new insights should also be taken into account during treatment, so that the full spectrum of body representation disturbances is addressed.

In current treatment of AN pathology there is usually a specific focus on the disturbed experience of body size, for example during psychomotor therapy. What is mainly addressed are cognitions in relation to body size and the visual experience of body size. Research has shown that such approaches are not highly effective in reducing the experience of having a big body (Exterkate et al., 2009). This is also apparent from clinical observations (Espeset et al., 2011). Patients approaching the end of their treatment, who have attained a healthy weight and eating pattern, still indicate that they continue to experience feelings of fatness. They report that during treatment they have learned cognitively that they are not fat, and have developed strategies that help them deal with such feelings. However, most patients indicate that the strong sense of having a (too) big body remains. It thus seems that therapeutic interventions are successful in helping AN patients *cope* with feeling big, but are unsuccessful in actually changing the internal representation of body size stored in their brain. Perhaps the revisited view on body representation disturbances in AN offers possibilities for designing novel therapeutic interventions.

An example of a new treatment approach that follows directly from the research presented in this thesis is related to how participants use their body in

action, and the possible beneficial effects of intervening on the level of the body in action. What seems to be important for changing AN patients' vast conviction as well as experience of being bigger than they actually are is receiving undeniable evidence on their true body size and directly experience their actual body size. In Chapter 6 AN patients were found to already rotate their body for an opening that they could objectively walk straight through without bumping in to the sides of the aperture. Generalizing these findings, it could be that AN patients lack direct feedback on their true body size, as they behave and move around as if they are bigger than their actual body dimensions. The brain thus never receives the signal that it is guiding actions wrong, with a too big margin in terms of space. An example illustrating the opposite effect is that pregnant females learn their new, bigger, body dimensions through experience: As their belly grows they often start bumping in to things. Such direct feedback signals the brain that the mental representation of body (belly) size should be adjusted to avoid collisions in the future. For AN patients the opposite happens: They rarely bump in to things and thus do not receive feedback that can facilitate a change in the abstract representation of body size in the brain. Thus, while pregnant women need to incorporate their new, bigger, body size into the mental representation of their body, AN patients should "excorperate" excessive, and non-existent, body volume from their body representation. In AN patients it may therefore be important to offer a treatment approach in which they *do* receive direct feedback on their body size. This might be beneficial for two reasons. First, the brain receives feedback on actual body dimensions and can adjust the mental representation of body size accordingly. Second, due to feedback on actual body size patients will consciously experience that they are smaller than how they usually experience their own body. For example, they might profit from being able to navigate their body through a small space, even though they would not have thought this to be possible when looking at the space beforehand. In treatment exercises involving for example drawing the own body and comparing it to actual body size, patients only see a difference, but do not actually *experience* that they are indeed smaller than their drawing. During the latter exercise it may be relatively easy to deny (the impact of) the difference in estimated and actual body size. However when patients actively performs actions that, according to them, should be impossible given their body size, there is no way to refute the evidence of their actual, small, body dimensions.