Anorexia Nervosa and Body Representation

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Abstract

Research has shown that anorexia nervosa patients represent their bodies in a distorted manner, as *larger* than reality. This distortion is seen in three kinds of body representations: the *body percept* (the mental image we have of our bodies), the *body schema* (used for motor control and simulation) and a representation I call the *tactile form* (used for certain kinds of tactile perception).

In this thesis I fit this evidence into a broader framework for understanding how the spatial content of the body is tracked and stored. I do so by first discussing O'Shaughnessy's (1980) long-term body image hypothesis. This hypothesis posits a representation that tracks changes in the spatial content of the body and supplies this content to other body representations. I argue that a similar kind of body representation might exist, supplying spatial content to the body percept, body schema and tactile form. I then explain the evidence of distortion in patients' body representations by suggesting it *arises* in in this long-term representation.

I also discuss what role this distortion plays in maintaining the disease. I suggest that body percept and body schema distortion causes patients to have *oversized experiences* of their bodies. Along with socio-cultural influences, these oversized experiences help ground patients' propositional attitudes about their own body size. These propositional attitudes, in turn, motivate harmful dieting behaviour. As such, I show that distorted body representations play an important role in maintaining the disease.

Statement of Candidate

I certify that the work in this thesis entitled "Anorexia Nervosa and Body Representation" has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged. All information sources and literature used are indicated in the thesis.

Stephen Gadsby (42474175)

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Introduction

The focus of this thesis is *body representations*. These can be defined (minimally) as internal cognitive structures that "function to track the state of the body and encode it, that can misrepresent it and that can be decoupled from it" (de Vignemont, 2016). Body representations are integral to many of our cognitive abilities. In order to perform different cognitive tasks, our brains must represent features of our bodies. In order to mentally picture what our body looks like, we rely on a representation of it in the form of a mental image. In order to reach towards and flick on a light switch, our brain relies on a representation of how long our arm is (de Vignemont, 2010, p. 672). In order to localize where a sound is coming from, our brain relies on a representation of the distance between our two ears and the shape of the pinna (the visible part of the ear) (Aslin, Pisoni, & Jusczyk, 1983; Clifton et al., 1988).

Representations of our bodies can also determine how our bodies *feel* to us, how we *experience* them. Because of this, psychopathologies which involve distortions in the way people experience their bodies allow us to better understand how the brain represents the body (Schilder, 1935). For example, in phantom limb disorder, patients still *feel* the presence of a limb that has been amputated. This experience can be explained with the hypothesis that their brain is, somehow, still representing the missing limb (Hilti & Brugger, 2010). Another example is xenomelia, whereby a limb is said to be *missing* from a patient's body representation (Brang et al., 2008).[1] This

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[1] Xenomelia is often referred to as 'apotemnophilia' or 'body integrity identity disorder' (Sedda & Bottini, 2014).

causes the patient to have an extreme desire to amputate the limb. By studying disorders that appear to be caused by *distortions* or *deficits* in body representations, we can better understand the way body representation works—how our brains represent our bodies and what these representations are used for.

In this thesis I focus on a disorder that isn't discussed much in the body representation literature, anorexia nervosa (AN). AN is a complex eating disorder, with multiple biological, psychological, developmental, and sociocultural etiologies (Rikani et al., 2013). As such, my aim in this essay isn't to offer a complete account of the cause and effects of this disease. Instead, my focus is on just one element of it, how patients cognitively represent their bodies.

Because of the narrow focus of this thesis I will also only be discussing one sub-type of AN: AN involving a *fat-phobic* component. There are some types of AN that don't involve this component—patients have no fear of being fat (Lee, 1991; 2001; Lee et al., 1993; Ngai, Lee & Lee, 2000; Lee & Kwok, 2005; Becker et al., 2009; Wildes et al., 2013, p.1032). Their reasons for starving themselves generally involve complaints of gastric pain rather than fear of gaining weight. Because non-fat phobic AN does not seem to involve distorted body representations, I will avoid discussing it in this thesis.

The aim of this thesis is to understand how distorted body representations function in fat-phobic AN (herein, simply AN) patients and what relationship they have to the disease. The research I discuss and the claims I make are (for the most part) empirical. As my background is in philosophy rather than psychology or cognitive science, this paper will not present any novel empirical research. Instead I will adopt a more philosophical approach. There is ample precedent for this. As Bortolotti writes:

> Psychopathology has become of extreme interest to philosophers, but mainstream philosophers rarely stop and think about how they can contribute to a scientific or medical understanding of mental disorders, or about the implications of the experiences of people affected by such disorders … (p. 4)

For philosophers (such as myself) who do stop to think about how they can contribute to the scientific understanding of mental disorders, Bortolotti suggests the following:

> Philosophers have something to offer to the development of the empirical literature if they work in collaboration with psychologists and psychiatrists in order to gain a better understanding of psychiatric disorders and other relevant phenomena. … One example of a beneficial contribution that philosophers can make is to attempt to place single findings and interpretations of localised phenomena into a bigger picture which inspires new experimental questions and hypotheses. (p. 6-7)

This thesis is an attempt to contribute to a scientific understanding of AN by adopting Bortolotti's 'collaborative methodology'. Following Bortolotti, I believe this approach provides the best chance for a philosopher doing purely theoretical research to contribute to empirical literature. By placing single findings into bigger pictures, philosophers can help understand the significance of empirical data and elucidate possible directions for future research.

Furthermore, this methodology is well suited to the current state of research on body representation in AN. There has been an impressive influx of recent research bringing to light insights about how AN patients cognitively represent their bodies. However, there remains a distinct lack of theoretical structure tying these insights together and matching them up with other areas of research. This thesis aims to rectify that.

The outline of the thesis is as follows:

In Chapter 1 I review the literature on distorted body representations in AN. From this review I conclude that AN patients exhibit distortion in three different body representations: the *body percept* (the mental image we have of our bodies), the *body schema* (used for motor control and simulation) and a representation I call the *tactile form* (used for certain kinds of tactile processing).

In Chapter 2 I introduce a representational framework for understanding how spatial content on the body is stored and updated. This framework is based on work by O'Shaughnessy (1980), who claimed a representation (the 'long-term body image') tracks changes in the spatial content of the body and supplies this content to other body representations. My framework posits a similar kind of long-term body representation, supplying spatial content to the body percept, body schema and tactile form.

In Chapter 3 I apply this framework to understanding the evidence of distorted body representations in AN. Under this model, AN patients' long-term body representations become distorted and this distortion is transferred to the body percept, body schema and tactile form. I discuss different hypotheses for how AN patients' long-term body representations come to be distorted, ultimately suggesting affect plays a role. I also address the question of why patients' long-term body representations don't properly update when they view themselves in a mirror.

In Chapter 4 I turn to understanding what relationship distorted body representations have to the disease. To do so I introduce *the body affect*, a collection of propositional attitudes about the body. Specifically, I focus on two kinds of propositional attitudes: dissatisfaction with body size and beliefs about being 'fat'. I claim that mentally picturing the body as oversized (arising from body percept distortion) constitutes an *oversized experience* of the body. I then present a causal model whereby oversized experiences, along with socio-cultural factors, ground negative body affect.

In Chapter 5 I expand this causal model. I suggest that AN patients' distorted body schemas lead them to have a distorted perception of their ability to act within an environment. Just like mentally picturing the body as oversized, this faulty perception also creates oversized experiences of the body. I suggest that these *affordance based* oversized experiences might also play a role in grounding negative body affect.

In Chapter 6 I conclude the thesis by reflecting on how this project fits within my broader methodological goals and offering some suggestions for future research directions. As a first step in guiding future research, I propose a range of experimental paradigms to test some of the claims I make throughout the thesis.

Chapter 1 Anorexia Nervosa and Distorted Body Representations

1.1 Introduction

In this chapter I will review the literature on distorted body representations in AN. Evidence points to distortion in the spatial content of three different body representations: the *body percept* (the mental image we have of our bodies), the *body schema* (used for motor control and simulation) and what I call the *tactile form* (used for certain kinds of tactile processing). This distortion also takes on a particular qualitative nature: representations are *larger* than reality.

1.2 The Body Percept

1.2.1 The Body Percept—One Component of the Body Image

The first kind of body representation I will discuss is one aspect of what is referred to as *the body image*. Gallagher and Cole write, "the body image consists of a complex set of intentional states—perceptions, mental representations, beliefs, and attitudes—in which the intentional object of such states is one's own body" (1995, p. 371). Following Bruch (1962), AN patients are said to suffer from a *body image disturbance*. Within this complex set of states two sub-components are considered 'disturbed'. One component is referred to as *the body affect* (Gallagher, 2005, p. 25). I will discuss this component later in the thesis.

The other disturbed component can be referred to as *the body percept* (Gallagher, 2005, p. 25).[2] Following Schilder, this representation can be defined as "the picture of our own body which we form in our mind, that is to say the way in which the body appears to ourselves" (1935, p. 11).[3] AN patients' body percepts are said to be disturbed because they represent their bodies as larger than reality, causing them to mentally picture themselves as larger.

1.2.2 Anorexia Nervosa and Body Percept Distortion

Evidence that AN patients exhibit oversized body percepts comes from *body size estimate* (BSE) tasks. They involve a variety of different methods such as modifying distance between light points on a wall to match the width of one's body part, drawing one's body size on a wall or selecting a silhouette that best matches one's body size (Skrzypek, Wehmeier & Remschmidt, 2001; Gardner, 2011). While there has been a good deal of disagreement in the past regarding the reliability and usefulness of the many different BSE methods, independent critical evaluation of

[2] Gallagher uses the term 'body percept' to refer to a broad category of perceptual experiences of the body. Instead I am using this term as a shortened version for what AN researchers call 'the perceptual component of the body image'. This refers to a specific body representation, rather than a group of kinds of experiences.

[3] Following Bruch (1973) and Slade & Russell (1973), most AN researchers have adopted this definition of the perceptual component of the body image (Smeets, 1997, p. 79). While the definition given here suffices to capture the nature of the body percept, Schilder's book conflates two different body representations—the body percept and body schema. Gallagher claims, "a large amount of the historical confusion (surrounding the two terms) can be traced back to Schilder" (2005, p. 19). As such, one must be careful about how much of Schilder's characterisation is taken on board.

BSE methods and meta-analysis of previous studies have concluded that AN patients do overestimate their own body size (Smeets et al., 1997; Smeets, 1997; Cash & Deagle, 1997; Farrell, Lee & Shafran 2005; Gardner & Brown, 2014). Overestimation of body size has been suggested as a risk factor and relapse predictor for AN (Striegel-Moore et al., 2004; Slade & Russell, 1973).

Overestimation in BSE tasks appears to result from over-representation rather than a distortion in perceptual abilities. AN patients show no overestimation in evaluation of inanimate objects (Slade & Russell, 1973; Bowden et al., 1989). Furthermore, Smeets and colleagues (1999) found AN patients show no difference in sensitivity of size perception tests when showed photographs of their own and others bodies (also see: Gardner & Moncrieff, 1988).[4] Finally, as Smeets and colleagues point out, BSE tasks require patients to estimate their size without looking at their body either directly or in a mirror (1999, p. 466).[5] Therefore the size information informing these tasks must be stored (i.e. it must come from the body percept). As such, we can conclude AN patients' body percepts represent their bodies as larger than reality, causing them to mentally picture their bodies as larger.

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[4] See Goldzak-Kunik (2012) for a fairly comprehensive study of AN patients' perceptual abilities.

[5] However, recently some BSE experiments have adopted 'perceptual' conditions, I will discuss these later in the thesis (section 3.3.2).

1.3 The Body Schema

1.3.1 Defining the Body Schema

The definition of the body schema varies greatly between different research areas.[6] A good starting point for this thesis is to look at the definition used in the AN literature. This definition is "an unconscious, sensorimotor, representation of the body that is invoked in action" (Keizer et al., 2013, p.1). However, the body schema isn't *only* unconscious or *only* invoked in action. It is also used for offline motor *simulation*, including conscious motor simulation (motor imagery) (de Vignemont, 2010, p. 673).

We can understand the nature of this representation by considering an earlier definition given by de Vignemont: "a dynamic sensori-motor representation based on the continuous flow of somesthesic and visual information", necessary because, "if you want to move, you indeed need to know very quickly the position of your limbs at every movement" (2004, p. 145). This quote presents the idea of a consistently updated representation of the body, bearing content relating to its size, shape and current postural configuration. For now, this is the characterization of the body schema that I will adopt. When referring to the sensori-motor system that makes use of this representation, I will sometimes use the term body schema *system*.[7]

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[6] The term body schema is used interchangeably to refer to a particular sensori-motor representation, a group of kinds of representations, a cognitive system used for motor control that may or may not make use of representations and a kind of pre-reflective bodily awareness (see: Gallagher, 2005; 2008; Gallagher & Zahavi, 2008, p. 146; de Vignemont, 2010).

[7] This idea of a body schema *system* is a close fit to Gallagher's definition of the body schema as "the close-to-automatic system of processes that constantly regulates posture and movement to serve intentional action" (Gallagher & Zahavi, 2008, p. 146; see also Gallagher, 2005).

1.3.2 Anorexia Nervosa and Body Schema Distortion

A large trend in AN research focuses on what general deficits in cognitive ability accompany the disease (Pendleton-Jones et al., 1991; Bradley et al., 1997; Grunwald et al., 2002; Goldzak-Kunik, 2012). As such, it was discovered that AN did not result in any *general* decrease of ability at tasks that rely on the body schema system (Epstein et al. 2001). However, it was eventually suggested that although AN patients might not have a general deficit in their body schema abilities, they nevertheless might exhibit an *altered* body schema (Nico et al., 2010).

Guardia and colleagues (2010) conducted an experiment that required AN patients to mentally simulate an action: walking through an aperture. Participants were asked to imagine themselves passing through different sized apertures and answer whether it was possible without turning sideways. A previous study by Warren and Wang (1987) showed that visual judgments of passability operated according to an invariable ratio (π_p) between perceived aperture width and shoulder width. They found that in normal subjects π_p is around 1.16, regardless of body size. In Guardia and colleagues study, the median π_p value of their control group did not differ significantly from Warren & Wang's value. However, the median π_p for their AN group was significantly higher (1.34). In a later study, researchers found that this bias in passability estimation was not present in conditions where patients were asked to imagine an experimenter walking through the aperture (Guardia et al., 2012).

Keizer and colleagues (2013) modified the experiment to involve AN patients actually walking through apertures, measuring the ratio at which participants started to turn their shoulders. Participants were told to walk towards a table (through an aperture) while attempting to remember a haptic pattern. The aperture was created with moveable panels so the width could be manipulated. Patients were unaware of the goal of the experiment, being told experimenters were measuring the effect of walking on haptic memory. It was found that while healthy controls started rotating their shoulders for openings 25% the width of their shoulders (π_p = 1.25), AN patients started rotating at 40% the width (π_p = 1.40) (Keizer et al., 2013).[8]

Metral and colleagues (2014) also confirmed that AN patients turn their shoulders at a higher π_p compared to healthy controls. In their experiment participants were given an aperture-passing motor imagery condition similar to the one in Guardia and colleagues' study (p. 4). After this, an action condition required them to walk through the aperture, stop on the other side, turn around and walk through again. They confirmed the previous findings that AN patients have a higher π_p compared to healthy controls in both action and motor imagery aperture-passing tasks. This evidence all suggests that AN patients' body schemas are distorted, representing their shoulders as wider than reality. This distortion affects their motor control and motor simulation abilities.

[8] Warren & Wang originally noted a difference between passability ratios in motor imagery and action conditions (1987, p. 376). It makes sense that we are much more conservative when actually walking through apertures compared to when judging our ability to do so.

1.4 The Tactile Form

1.4.1 Introducing the Tactile Form

Apart from evidence that AN patients exhibit an oversized body percept and body schema, they also appear to have an oversized representation of the body used for tactile processing, what Medina and Coslett (2009) call a ‘body form representation’. To emphasise its specific cognitive role and distinguish it from other body representations, I will refer to this representation as *the tactile form*. In order to explain what function the tactile form plays, I’ll briefly discuss how touch perception functions.

When the body surface is touched, afferent signals are transmitted from mechanoreceptors on the skin to the somatosensory cortex. The primary somatosensory cortex of each hemisphere contains a topographically organised representation of the contralateral side of the body. This somatotopic representation is inverted, with legs represented medially and face and hands laterally. The size of representations of skin regions depends on the density of mechanoreceptors on that portion of the skin, which in turn determines spatial tactile acuity for that area (Penfield and Boldrey, 1937). For example, skin regions such as the fingers have large representations in the somatotopic map while the back and torso have small representations. As such, tactile spatial acuity is twenty times greater on the finger than the back (Serino & Haggard, 2010, p. 225).

I will now introduce what Spitoni and colleagues (2010) refer to as a *primary* property of touch. An example of this kind of touch perception is pressure. For example, de Lafuente and Romo (2005) showed (on monkeys) that pressure from tactile stimulus on the skin can be directly read off the firing of neurons in the somatosensory cortex. As such, the physiological resources needed for the coding of pressure are supplied by the somatosensory system (Spitoni et al. 2010, p. 185).

Secondary properties of touch cannot be processed at the same first level of somatosensory processing. An example of this is perception of tactile distance on the skin. It is claimed that tactile distances are measured by first localising points of contact on the body. Localising points of tactile input on the body surface (topognosis) is said to require mapping onto a body representation distinct from the somatotopic cortical map (Dijkerman & de Haan, 2007; Longo, Azanon & Haggard, 2009; Spitoni et al. 2010; Medina & Coslett, 2009; Serino & Haggard, 2010). Only after the points are localised onto a body representation can the distance between them be estimated. As Taylor-Clarke, Jacobsen & Haggard write:

> judging tactile distance requires a rescaling of neural signals, from a distorted, primary [somotototopic] representation based on receptor density, to an object-centred space. This rescaling requires a representation of the physical size of the simulated body part. (2004, p. 219)

This 'distortion'[9] of the somatotopic map does carry over somewhat to the perception of tactile distances, as shown by the Weber illusion. Weber (1834/1996) showed that the perceived distance between two tactile points is larger when presented on a region of high tactile acuity. However, Taylor-Clarke, Jacobsen & Haggard estimate that the

[9] It is worth noting that this representation is not distorted in a normative sense. The shape of the cortical map is appropriate for the function it serves (processing tactile pressure).

magnitude of this illusion is only 10% of what it would be if we relied on the somatotopic map alone (2004, p. 219). The distortions of the primary somototopic map must be corrected by a second process, which maps them to a more realistically scaled body representation (Longo, Azanon & Haggard, 2009, p. 659).[10] This more realistically scaled body representation is what I refer to as *the tactile form*.

The tactile form has its roots in Head and Holme's (1911) original body representation taxonomy. Their model involved a three-way distinction between the postural schema (body schema), body image and a body representation called the superficial schema — specifically responsible for localization of tactile stimulation. However, the superficial schema isn't often spoken of and there is some confusion in current body representation literature over which body representations are used for localisation of tactile input.[11] Despite this confusion, there is a wealth of evidence supporting the existence of the tactile form and dissociating it from other known body representations

[10] Research by Spitoni and colleagues (2010) further supports the claim that tactile distance estimation tasks require a second stage of processing. They found that these tasks not only produce higher reaction times than tactile pressure tasks but also produce increased activation of the anterior portion of the intraparietal sulcus, the inferior parietal lobule, the superior parietal lobule, and the superior postcentral gyrus and above baseline activation in the parieto-occipito-temporal junction, which is not present for pressure tasks.

[11] There is also confusion about what the term superficial schema ever referred to. It is sometimes claimed that this was the original name for the body schema and other times it's claimed that the superficial schema is now referred to as the body image (e.g. Cardinali et al., 2011).

Before distinguishing the tactile form from the other two (more well known) representations I have been discussing (body percept and body schema), I will address a relevant issue in the literature on body representations and tactile processing. I have claimed that tactile distance estimation (TDE) (sometimes referred to as 'tactile size perception') involves a first step that localises the tactile input to a more accurate body representation, the tactile form. However, there is an objection to this view of how TDE cognitively functions. It is sometimes hinted that different representations are used for tactile localisation and TDE (e.g. Mancini et al., 2010, p. 1200; Longo, 2015a, p. 9). If this is the case then a different cognitive story needs to be offered for how TDE functions and what relationship it has to tactile localisation.

One thing that might motivate a distinction between representations used for localisation and distance estimation is differences in the apparent distortion of these representations. While there has been a wealth of research into errors in TDE (suggestive of a distorted representation), less has been discovered using tactile localisation tasks in healthy subjects. In the experiments where consistent tactile localisation errors have been found, it's not clear how these error patterns match up with those from TDE tasks (e.g. Mancini et al., 2011).

However, it must be remembered that tactile localisation tasks actually involve two localisation steps. After a point is localised on the tactile form, participants must demonstrate this to the experimenter, generally by pointing out the location on an accurate pictorial representation of the body.[12] This second localisation step could account for the heightened accuracy in localisation, as opposed to distance estimation. Imagine a situation where the tactile form represents the hand in a distorted manner but the picture used to indicate localisation is accurate (see fig. 1 below).

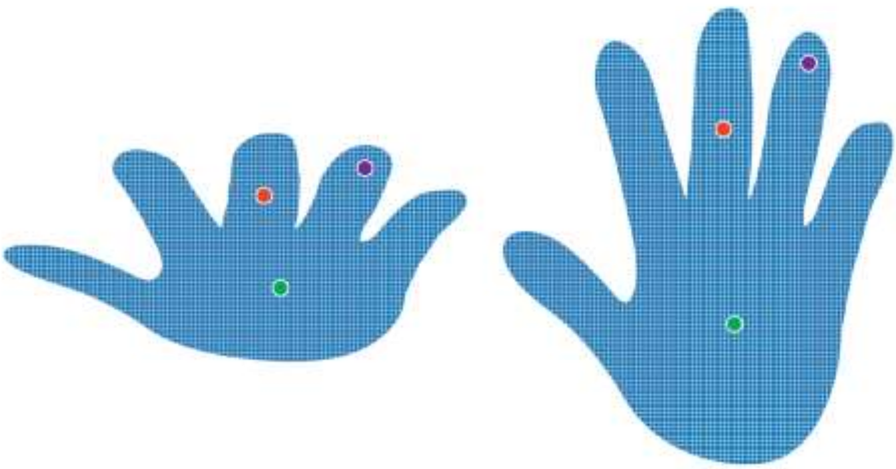

Figure 1: Points on a distorted representation of the hand's surface are remapped onto an accurate representation.

When mapping the localised points from the distorted representation to the accurate representation, we can imagine that many of the errors in localisation would be improved through this second step.[13] TDE tasks do not undergo any second step of referencing points to a different representation. After localisation, the distance

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[12] For example Mancini and colleagues (2011) used a life-size silhouette outline based on a photograph of the participants hand. Steenbergen and colleagues (2012) used an actual photograph of the participants arm shown on a computer monitor.

[13] It might also be this second step that introduces the patterns of localisation errors that have been discovered.

between the two points is directly estimated and indicated. This fact could account for the qualitative difference in errors between each of these kinds of tasks.[14]

While there has been a wealth of research establishing a dissociation between body schema and body percept, dissociating the tactile form has largely been overlooked (de Vignemont, 2010). One relevant body of research comes from Longo & Haggard, who showed dissociations between body percept, body schema and tactile form by investigating how each represents the hand (for review, see: Longo, 2015a). I will discuss these experiments at greater length in section 2.5. For now it suffices to say that although both the tactile form and body schema represent the back of the hand in a distorted manner, these spatial distortions are quite different (Longo & Haggard, 2010; 2011). Using a BSE task, they also discovered that participant's body percepts represent their hands quite accurately, in comparison to the body schema and tactile form (Longo & Haggard, 2010). As such we can distinguish between the body percept, body schema and tactile form.[15]

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[14] By asking participants to localise two points, Green (1982) found localisation errors did, in-fact, bear similarity to patterns of tactile distance underestimation found on the forearm i.e. participants underestimated distances *and* localised two points as closer together. However, like all localisation tests this involved a second step (localising on to the arm itself). As such, we can't be certain what effect this second step had on the final location.

[15] There is evidence to suggest that *immediate* mapping of tactile input onto a representation of the body's surface *in external space* (i.e. the body schema), without conscious detection of the input is possible. This is shown in cases of numbsense, where patients can physically point to tactile targets that they cannot consciously detect. In this case, an intermediate step (mapping the tactile input from the somatosensory cortex to the tactile form) might not be necessary. However, the kinds of touch

However, the tactile form does appear to have *some* connection with the body schema and body percept. Take the example of tool use. Tool use is generally regarded as involving the *incorporation* of the tool into the body schema (de Vignemont & Farnè, 2010). However, this incorporation has an effect on tactile localisation also. Not only do we localise tactile input onto tools that we use, this localisation follows the same principles as localisation of tactile input on hands (Yamamoto and Kitazawa, 2001). Changes in localisation of touch even remain for some time after tool use (Cardinali et al., 2009). Likewise it has been shown that particular illusions caused by aberrant proprioceptive input can cause alterations of both the body percept and tactile form (de Vignemont, Ehrsson & Haggard, 2005; see section 2.3.2). This ambiguity surrounding the relationship between tactile perception and the body schema/percept likely contributes to the uncertainty regarding tactile perception and body representation.

1.4.2 Anorexia Nervosa and Tactile Form Distortion

Turning to the AN literature on tactile perception, Keizer and colleagues (2011) showed that patients significantly overestimate tactile distances compared to controls. This seems to suggest that AN patients not only have an enlarged body percept and body schema but also an enlarged tactile form. In a follow up study, the results were replicated and, additionally, it was found that patients' tactile distance overestimation

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perception tasks AN patients show differences in all require conscious perception. Therefore I won't discuss this unconscious touch-processing route (see: Dijkerman & De Haan, 2007).

was more profound for the abdomen area (Keizer et al., 2012).[16] This suggests that AN patients, rather than having a *generally* oversized tactile form, might exhibit a specifically distorted representation that coheres with cultural ideas about how overweight bodies look (i.e. specifically wider abdomens) (p. 535).

The specific nature of AN patients' tactile form distortions was further explored by Spitoni and colleagues (2015). They ran TDE tasks on the thigh, abdomen and sternum of AN patients, replicating the results of overestimation in tactile distance but only for the thigh and abdomen, not for the sternum. Furthermore, they compared TDE tasks along the horizontal and vertical axes and discovered that tactile distance overestimation only occurred over the horizontal axis. This is further evidence that rather than having a generally oversized tactile form, AN patients exhibit a specifically distorted body representation, one that coheres with the particular dimensions of an overweight body: wider, specifically in areas that are known to put on weight (thighs and abdomen).

The specific dimensions of this tactile form distortion also generally cohere with distortion seen in patients' body percepts. Using a tile placement BSE task, Spitoni and colleagues measured patients' body percepts, discovering that (like the tactile

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[16] This experiment also found differences in primary tactile perception tasks (two point discrimination and pressure detection) between AN and control groups. However, they rule out the possibility that distorted primary tactile perception could result in tactile distance overestimation. Instead, they suggest that a heightened affective response to the experimental setup (blindfolded, abdomen exposed to the experimenter) on behalf of the AN group might explain this finding (p. 535 – 536). A later study also contradicts findings of distorted primary tactile perception (Spitoni et al., 2015).

form) they were wider, specifically around the abdomen, rather than simply being larger *in general* (p. 187).[17] This finding lines up with previous work in BSE experiments (Slade & Russell, 1973; Molinari, 1995).

1.5 Conclusion

In this chapter I have reviewed the literature on distorted body representations in AN. I have introduced three different body representations: the body percept (a mental picture of the body), the body schema (used for motor control and simulation) and the tactile form (used for tactile distance estimation). I have also discussed evidence which shows each of these representations are oversized in AN patients.

[17] Researchers used the Daurat-Hmeljak BSE task. This involves placing rectangular tiles on a board to reconstruct the spatial organisation of the body percept (Daurat-Hmeljiak et al., 1978; Fuentes et al., 2013; Cimmino et al., 2013; Di Russo et al., 2006)

Chapter 2 The Long Term Body Representation Hypothesis

2.1 Introduction

I have discussed findings that show AN patients exhibit distortion in the spatial content of three different kinds of representations: the body percept, body schema and tactile form. I also stated that the methodology of this thesis was to fit particular empirical findings into a bigger picture. In this chapter I will start to draw the picture I plan to fit these findings in to.

To do so, I will discuss a hypothesis that is rarely mentioned in today's body representation literature: O'Shaughnessy's (1980) long-term body image hypothesis. O'Shaughnessy claimed a body representation called the long-term body image tracks changes in the spatial content of the body and supplies this content to other representations. I will attempt to modernise this hypothesis, bringing it in line with current body representation research. Once the specifics of this modernised hypothesis are laid out, the stage will be set for chapter 3, where I apply it to understanding how AN patients' body percepts, body schemas and tactile forms become distorted.

2.2 O'Shaughnessy's Long-Term Body Image

O'Shaughnessy claimed the long-term body image is a representation that contains spatial information about one's body (1980, 1998). This spatial information is combined with postural sensation (e.g. proprioception) to generate short-term body images (1998, p. 187). O'Shaughnessy's justification for positing this long-term body image is that all short-term body images share a common spatial content and "while the content of proprioception is spatial and while postural (etc.) sensations cause proprioception, postural sensations cannot be *the original bearer* of spatial content in proprioception" (p. 195).[18]

This is because proprioception and the somatosensory system in general are not capable of independently supplying spatial content regarding the body. The somatosensory system relies on a range of different receptors that provide information about limb position, movement, tension, force, effort, and sense of balance. These receptors have evolved to supply afferent signals with very specific content. For example, muscle spindles monitor muscle stretch, golgi tendon organs monitor tendon tension and joint receptors monitor joint position (de Vignemont, 2014a, p. 990). However, no specific receptors exist to supply size and shape information regarding the body (Proske & Gandevia, 2012; de Vignemont, 2014a, p. 991).

While we probably rely on vision the most to gain information about our body size, it's clear that we don't have consistent visual access to the spatial content of the body. Due to head position, the body is rarely in the visual field. Furthermore, if we relied on a constant stream of visual perception to supply spatial information regarding the body then movement, tactile localisation and mental perception of one's own body with the eyes closed would be impossible. Given that there is no constant sensory input delivering the spatial dimensions of the body, processes that rely on spatial information about the body are what Clark and Toribio (1994) call a

[18] I won't go into a description of O'Shaughnessy's three different short-term body images, as they aren't relevant to my thesis.

‘representationally hungry domain’. Body size content cannot be reliably plucked from the sensory systems, so this information must be stored internally.

O’Shaughnessy’s solution to this problem was to claim that the spatial content of proprioceptive experience originates from a body representation called the long-term body image (LTB). The LTB determines how we experience the spatial properties of our body. So much so that were we to flex our arm while having a LTB that isn’t human (e.g. one that represents an octopus), “then despite having a human shape and despite the presence of posture-caused phenomena like sensations of posture, one could not have the experience of seeming to be in the presence of a flexed (very roughly) arm-shaped thing” (p. 184). So for O’Shaughnessy, experience of the spatiality of our own bodies is representationally mediated, by spatial content derived from the LTB.

O’Shaughnessy writes:

> The contents of this [representation] tend to change very slowly, generally paralleling changes in actual body size and shape: the image may be presumed to change its dimensions during the time of our life when we are growing, and to change its shape during adolescence or maybe somewhat during pregnancy and very likely over the decade in which we become hugely fat (p. 192).

O’Shaughnessy identifies three origins for the spatial content of the long-term body image: changeless-innate (e.g. fingers), developmental-innate (e.g. growing) and experience acquired (p. 193).[19] Incorporation of experience-acquired spatial content allows for appropriate additions (or subtractions) that could not have been genetically anticipated (e.g. losing an arm or gaining an unexpected hump).[20]

2.3 Dynamic Body Representations

A wealth of research into body representations has happened since O'Shaughnessy first introduced his distinction between short-term and long-term body images and his model is rarely still talked about. One modern treatment of the hypothesis comes from de Vignemont (2014). She claims the LTB is essentially the same notion as other representations such as Head & Holmes (1911) 'superficial schema' or Schwoebel & Coslett's (2005) 'body structural description' (2014, p. 992). However, I believe that rather than referring to the same general notions as other body representations, we can

[19] It's not completely clear why the developmental-innate source of content is necessary if it is possible to incorporate content via experience. O'Shaughnessy doesn't offer any argument other than: "it seems … unlikely that natural development alterations, such as growing or the changes of adolescence, are going to find themselves represented in the [long-term] body image *solely* as a result of coordinated motor-perceptual experience" (p. 193). It might be that anticipatory-developmental content is necessary in order to ensure children's LTBs are veridically updated, despite a lack of fully developed perceptual abilities. However, what role, if any, a developmental-innate channel plays isn't extremely important for the current discussion.

[20] It's noteworthy that, for O'Shaughnessy, the role experience plays in updating the long-term body image is minimal and mostly based on proprioceptive and tactile feedback. De Vignemont (2014) argues against this view, stressing the primacy of visual experience, in particular, in updating the LTB.

think of the LTB as playing a unique role in conjunction with the representations I have already discussed in this thesis.[21]

In order to show that there is a role for the LTB to play in conjunction with the body percept, body schema and tactile form I will discuss evidence regarding the *spatial plasticity* of these representations. This evidence shows that they are highly *dynamic*, i.e. they can rapidly modify their spatial content according to online sensory input. I will claim that this dynamic nature requires the role of a more *stable* LTB to maintain the default spatial parameters of the body.

2.3.1 Tool Use and the Body Schema

The most obvious and well-known example of sensory-driven modification of the spatial content of a dynamic representation is the case of tool use and the body schema. Consider our ability to use tools:

> Humans are proficient tool-users, it would make an obvious phylogenic advantage to have developed a body representation that allows one to immediately "tune" the motor control requirements to the physical and mechanical characteristics of a novel tool. (de Vignemont & Farnè, 2010, p. 14)

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[21] The association of the LTB with Schwoebel and Coslett's (2005) 'body structural description' is especially inappropriate. While the LTB specifically represents the spatial content of *our* body, the body structural description is a representation of the structure of human bodies *in general* (p. 544). A deficit in this representation is used to explain why autotopagnosic patients have difficulty naming and identifying body parts on themselves *and others* (Buxbaum and Coslett, 2001).

With the help of a highly adaptable body schema representation, this is exactly what we can do. It has been shown that tool use incorporates the tool in to the body schema (Berlucchi and Aglioti, 1997; Johnson-Frey, 2003; Maravita & Iriki, 2004; de Vinemont & Farnè, 2010). Importantly, this includes modifying the spatial content of the body schema to include the dimensions of the tool (Cardinali et al., 2009).

However, after use of the tool is finished, the body schema must regain its default parameters. As de Vignemont & Massin put it, “We may think of [the body schema] in terms of plastic band: we can stretch it as much as we want but it always comes back to its default size” (2015, p. 17).[22] This is where the LTB might come in handy. It might store spatial information offline so that the body schema can shift its spatial content, without losing its veridical parameters. These stored default parameters could allow the schema to ‘snap back’ to its veridical (body-minus-tool) dimensions.[23] While the body schema is *dynamic*, allowing it to easily stretch its dimensions, the LTB would be more *stable*, only updating its spatial dimensions to match changes in the body’s actual structure.

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[22] This conceptualisation of the body schema as plastic dates back to Head and Holmes original definition of schemas as ’plastic models of oneself’, they even discussed the idea of incorporation of foreign objects: “Anything which participates in the conscious movement of our bodies is added to the model of ourselves and becomes part of those schemata” (1911, p. 151).

[23] This ‘snap-back’ might not be such a sudden occurrence. Cardinali and colleagues (2009) found the kinematic effects resulting from incorporation of a tool into the body schema last up to 10-15 minutes post-tool use.

It might also be that after tool use the body schema simply updates itself according to fresh sensory input, constantly re-updating its spatial dimensions to account for the current state of the body. The fact that it returns to its default dimensions doesn't count as strong evidence that these dimensions must be stored elsewhere. However, there are other phenomena that occur during tool use that suggest spatial information on *just* the body might be retained.

Even when tools are incorporated into our body schema, we don't truly *act* as if they are part of our body.[24] Povinelli, Reaux & Frey write:

> … tools are frequently used in ways that we would never employ our hands. For instance, we will readily use a stick to stoke the hot embers of a campfire, or stir a pot of boiling soup with a wooden spoon. (2010, p. 243)

They found that chimpanzees also exhibit this behaviour, opting to use a tool to open the container of a box that potentially contained aversive objects. They conclude that chimpanzees must maintain a representation of their hand, separate from the tool incorporated body schema (p. 246). Longo and Serino concur with this conclusion, they write:

> effective guidance of the tool may require it being treated as part of the body, even as safety considerations may necessitate it being strongly distinguished

[24] We also don't *feel* as if they are part of the body. As Botvinick writes, "the feeling of ownership that we have for our bodies clearly does not extend to, for example, the fork we use at dinner" (2004, p. 783). However, I won't delve into the possible reasons for this difference in experience.

> from the body. Such conflicting requirements highlight the need for *multiple body representations, maintaining parallel, and potentially inconsistent, representations of the body with or without the tool*. (2012, p. 229, my italics)

As such, there might be an ongoing need for a stable representation that doesn't update its content but rather maintains the default parameters of the body; a perfect job for the LTB.

Not only might the LTB's spatial content allow the body schema to snap back to its veridical dimensions after tool use has ended, this stored content could also play an *ongoing* role in tool use. Having two representations, one of the body-plus-tool system (in the body schema) and another of the default parameters of *just* the body (in the LTB) might allow us to easily distinguish between the body and the tool, ensuring we can easily and unconsciously make use of tools for tasks we wouldn't use our body for (e.g. poking fires).

2.3.2 The Plasticity of the Body Percept and Tactile Form

There has been a lot of work done exploring the plasticity of the body schema. However, when it comes to the body percept and tactile form, much less is understood. It has been shown that the spatial content of the body percept can be altered as a result of changes in online sensory input. When anesthesia of the thumb and lips is produced (disturbing afferent input from these locations) there is an illusion of increase in size that affects the body percept (as measured by a template matching BSE task) (Gandevia & Phegan, 1999; see also: Paqueron et al., 2003).

There is also evidence that the tactile form can shift according to proprioceptive input. In the Pinocchio illusion a vibrator is applied to the bicep tendon, stimulating a muscle spindle normally stimulated by the stretching of the muscle. If the participant is holding on to their nose at the same time then a sensation of the stretching of the nose can result, “there is a sense of wonder as the dimensions of the body are perceived to change; as one subject reported in test configuration 1A: Oh my gosh, my nose is a foot long! I feel like Pinocchio” (Lackner, 1988, p. 284).[25] De Vignemont, Ehrsson & Haggard (2005) showed that this illusion affects the tactile form by modifying the paradigm so that the illusion affected participant’s index finger (rather than nose). While maintaining vibration they conducted TDE tasks on the finger, finding a bias in overestimation.[26][27]

As in the case of modification of the spatial content of the body schema, after the aberrant sensory input (or lack thereof) in these tasks subsides, the dynamic representations ‘snap-back’ to their default body dimensions.[28] However, it’s not yet

[25] There is a similar illusion called ‘phantom nose’ which is achieved with synchronous tactile input rather than muscle stimulation. It causes participants to feel that their “nose has either been dislocated, or has been stretched out several feet forwards or off to the side” (Ramachandran & Hirstein, 1997, p. 452).

[26] A template matching BSE condition where patients were asked to point to a picture of a finger that best represents the perceived size of their own finger further suggests the body percept was modified.

[27] Also see Tajadura-JimØnez and colleagues (2012) for an experiment suggesting modification of the tactile form can occur as a result of integrated audio-tactile input.

[28] To ensure this ‘snapping back’ is the dynamic representation returning to default parameters supplied by the LTB, rather than re-updating as a result of new visual input regarding body size, an experiment could be conducted whereby participants are blindfolded during and after pinnochio illusion vibrations

clear what functional role the spatial plasticity of the body percept and tactile form plays. Although the specifics of the role that sensory systems play in influencing the spatial content of the dynamic representations isn't entirely clear, they certainly play some role. As such, I present the following model of how the spatial content of one's body is represented:

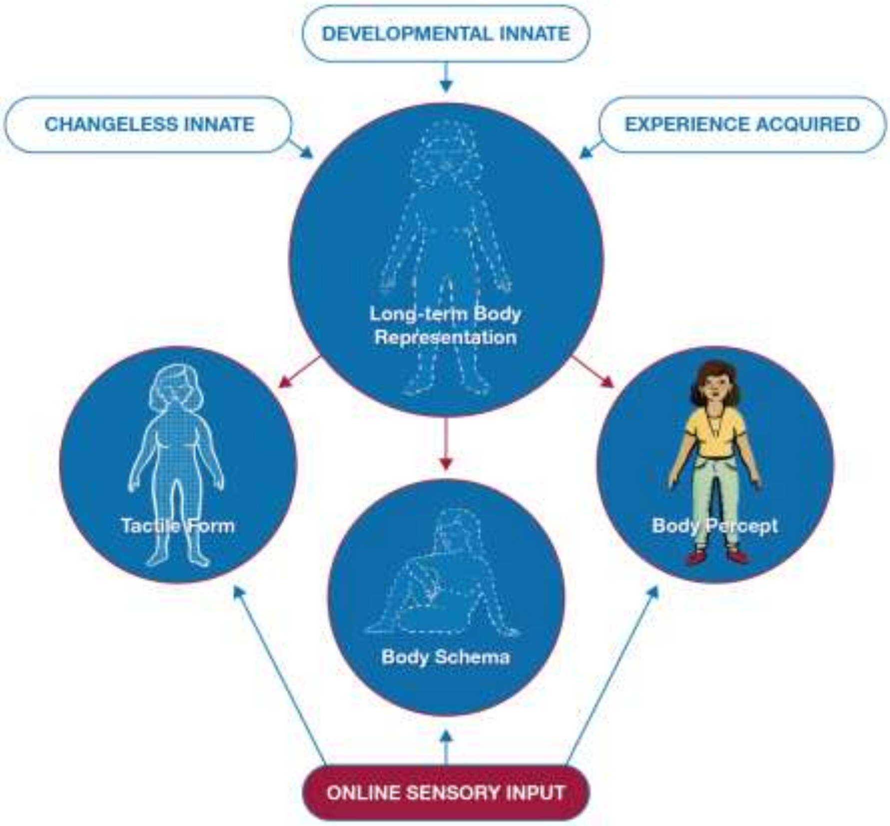

Figure 2: Flow chart of spatial content.

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are administered. If subjects' tactile forms snap back into default size (as verified by TDE tasks) without visual input supplying what this size is we can presume the 'snap back' hypothesis is true.

In this model, the LTB[29] tracks the spatial content of the body, using a combination of O'Shaughnessy's three routes. It then supplies this content (when needed) to the dynamic representations. Each dynamic representation's spatial content is jointly determined by the LTB and certain online sensory input.

2.4 Short-Term Body Representations

I have claimed that the body percept, body schema and tactile form can be thought of as *dynamic* representations, which can easily modify their spatial content according to online sensory input. This dynamic nature makes clear what role a more stable LTB can play. In this section I will go one step further, suggesting that not only are these representations dynamic, they might also be thought of as *short-term*. As we will see, this short-term classification makes the need for an LTB even clearer. Because of the comparative lack of research into the tactile form, I will focus my discussion here on the body percept and body schema.

De Vignemont defines short-term representations as "representations with a very short life-scale. [They are] built up at time t, stored in working memory, and erased at time t + 1 by the next one" (2010, p. 672). In contrast to this idea of a short-term representation we can think of a long-term representation as *storing* content.[30] This content is generally never erased, only *updated*.[31]

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[29] Although I will retain the abbreviation 'LTB', to distinguish it from the concept of a *body image*, this representation will be named the 'Long-Term Body *Representation*'.

[30] The long-term/short-term distinction bears some similarity to Carruthers' (2008) distinction between online and offline representations. Offline representations are relatively stable and represent what the body is *usually* like. While online representations represent how the body is currently, are newly

When reading the literature surrounding the body schema and hearing about how it is *updated* by multi-sensory information and tools are *incorporated* into it, it is natural to think of it as a long-term representation with content that constantly changes but is always present.[32] However, de Vignemont offers a more nuanced discussion of what the body schema is, particularly in relation to the motor system. In the motor system there are two kinds of models to consider: *inverse models* that compute the motor commands necessary to achieve the desired physical state (given the current physical state) and *forward (emulator) models* that predict the sensory feedback of these specific motor commands (2010, p. 673; Grush, 2004).

De Vignemont describes the relationship between the body schema and these models like so: the inverse model is "fed by the *initial body schema*, including long-term information like the size of the limbs, and short-term information like the joint angles and the hand position" (2010, p. 673). The forward model anticipates the sensori-motor consequences of the action based on motor commands resulting in *the*

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constructed (moment by moment) and are directly 'plugged into' current perception of the body (p. 1302). However, although the short-term/long-term distinction is similar, it isn't a perfect match. According to Carruthers, online representations are generated of *any* body we perceive (2013, p. 41). Because the representations I am discussing (body percept, body schema and tactile form) only represent *our* body, they do not classify as online representations (in Carruthers' sense).

[31] The content might become erased in death or through cognitive malfunction.

[32] Head and Holmes original classification seems to conceptualise the postural (body) schema as a constantly updated long-term representation, e.g. "we are always building up a postural model of ourselves which constantly changes. Every new posture or movement is recorded on this plastic schema" (1911, p. 151)

predicted body schema. This predicted body schema is used for motor imagery and it also allows anticipatory control of movements. Finally, sensory feedback from an action carrying information about which body parameters have been altered generates *the updated body schema*.

De Vignemont writes, “Consequently, both the predicted body schema and the updated body schema are dynamic short-term body representations, whereas only the initial body schema includes both short-term and long-term body representations” (p. 673). What we are interested in for the sake of this paper is the initial body schema.

De Vignemont is suggesting that the initial body schema is a *collection* of representations, some short-term and some long-term. However, I suggest that we think of the body schema as a single integrated, short-term representation of the current physical state of the body: one that is *generated* according to both short-term information from the sensory systems and long-term spatial dimensions from the LTB.[33]

Under this scenario, no initial body schema would exist until required by an inverse model. When we are inactive (e.g. during sleep), there is no body schema representation, just waiting to be made use of. Only when we are acting or assessing our ability to act, is information from the proprioceptive system and the LTB integrated to form a representation of the current state of the body, which can then be used to calculate the appropriate motor commands. Much like the predicted and

[33] The integration of multiple kinds of content to form single, unified representations has been discussed before (Carruthers, 2013; de Vignemont, 2014a, p. 1003; 2014b).

updated body schemas, this single integrated representation would be considered short-term, generated at time *t* to feed the inverse model but erased at time *t+1* once it has filled this role.

Throughout the day the generation of body schemas would likely be a constant process as a vast array of motor actions are simulated and carried out. During tool use, the content of these short-term body schemas would include the relevant tool.[34] Multiple body schemas might even be generated simultaneously and fed to multiple pairs of forward/inverse models (Wolpert & Kawato, 1998). These short-term initial body schema representations would also affect other representations ‘downstream’ (e.g. the predictive body schema).

This idea of dynamically generated short-term representations also fits nicely with the function of the body percept. As Smeets (1997) argues, we must think of the body percept not as the retrieval of an offline representation, as if we were retrieving a picture from a photo-album; rather, it must be thought of as the *construction* of a mental image. This becomes clear when you consider that mental imagery, including imagery of our own bodies, can be constructed however we like. I can readily construct a mental image of a grandmother on roller blades (p.88). Likewise, I can readily construct a mental image of myself on roller blades, wearing the wig of a grandmother.

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[34] A representation of the relevant tool would likely be generated and temporarily stored to aid in the generation of appropriate short-term body schemas in this case (see: Imamizu et al., 2000)

It wouldn't be correct to say this was a stored image of myself just waiting to be accessed. Rather, these mental images are constructed from stored information, albeit organized in whichever way we desire (p. 88). Presumably, information about the different elements (what rollerblades look like, for example) is stored somewhere, ready to be accessed if rollerblades are ever to be 'imaged'. Likewise, I claim, size information about the body is stored in the LTB, ready to be imaged when needed.

Thus the body percept, much like any other mental imagery, is constructed on the fly according to what the mental task requires. For some tasks (such as BSE tasks) a veridical picture of the body is needed, so information about the body (only size information, in this case) is constructed into a mental image as accurately as possible. Other mental imagery tasks require us to use the imagination to alter how our bodies look (e.g. imagining what I would look like with black hair). Just as we can consider the initial body schema as a short-term representation, erased at *t+1* after its task has been fulfilled, we can also consider these mental images (body percept(s)) as short-term representations.

When we think of the body schema and body percept as short-term representations, it's clear what role an LTB can play in relation to them. It stores spatial content on the body and this spatial content (along with other kinds of content, including from the online sensory systems) is used to generate these short-term representations.

This doesn't mean that different short-term representations can't have different spatial content. The generation of short-term representations doesn't mean that stored LTB content is *isomorphically* reproduced. However, under this framework, mismatches in content must be understood as arising from the *generation* of short-term representations, rather than as differences in *stored* content. This is an important point. As I will discuss in the next section, the body percept, tactile form and body schema represent the spatial properties of the hand differently.

2.5 Form and Spatial Content

I have mentioned that, even if we consider them short-term representations, the body percept, body schema and tactile form can differ in their spatial content. In this section I review evidence of differences in the spatial content of represented hand surfaces. I will discuss how this evidence sits with my modernised LTB hypothesis and the concept of short-term representations.

2.5.1 The Body Percept

The first evidence I will discuss investigates how the body percept represents the hand. Longo & Haggard (2010; 2012b; Longo, 2015b) modified a template matching BSE task to test whether the body percept represents hand shape accurately. They showed participants distorted images of hand surfaces (stretched in width or length) and asked them to pick the one they felt most closely matches the size and shape of their own hand. They found participants were quite accurate at matching hand shape and size for both sides of the hand (dorsal and palmar). This suggests the body percept represents the shape of both sides of the hand fairly accurately. Furthermore, the small amount of distortion they did find correlated heavily between both sides of the hand. They conclude from this that the body percept represents the hand as a coherent 3-D object (Longo, 2015b).

2.5.2 The Tactile Form

When introducing the tactile form, I suggested that it might exhibit patterns of distortion in its spatial content. This spatial distortion accounts for the Weber illusion, evident in TDE tasks. Longo & Haggard (2011) found that the distance between two tactile stimuli are perceived as 40% larger when running *across* the hand dorsum compared to the same distance running *along* it. From this they conclude that the tactile form represents the dorsal surface of the hand as fat and squat. However, they did not find *any* apparent bias on the palmar surface (Longo & Haggard, 2011). Longo concludes:

> representations of the dorsal and palmar sides of the hand appear to be stretched in different ways, a basic violation of 3-D geometry. Thus [sic] suggests that tactile size perception, like tactile localization, may rely on a set of fragmented, 2-D representations of individual skin surfaces. (2015a, p. 9)

The suggestion here is that the tactile form and body percept not only represent the spatial content of the hand differently, they both take quite different forms. Rather than being a single, integrated, 3d representation, the tactile form might be a *collection* of individual skin surface representations.[35]

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[35] It has also been argued that this collection is segmented into categorical body parts (e.g. hand and arm) (de Vignemont et al., 2009). This accounts for TDE biases that occur across functional borders (e.g. the wrist).

2.5.3 The Body Schema

Longo & Haggard (2010) also investigated the way the body schema represents the hand's surfaces. They placed participant's hands on a table palm down, covered from sight by a wooden board. They then asked participant's to indicate the location of their knuckles and tips of their fingers underneath the board, using a baton to indicate locations on the board above the hand. By mapping the identified landmarks in relation to one another the researchers constructed maps of how the hand's dorsal surface is represented.

Localisation of body points in external space is a task that relies on the body schema (Dijkerman & de Haan, 2007; Longo et al., 2009;). So we can presume that this experiment discovers how the body schema represents the hand's dorsum. However, Longo & Haggard have a specific view of what the body schema is and, as such, what this test is measuring. This specific view is worth teasing apart.

Longo & Haggard think of the postural (body) schema *only* as a representation of body posture made up of proprioceptive signals (2010, p. 11727). This postural model is *combined* with stored information about the body (what they call 'the body model') to arrive at a sense of position (p. 11729). So, according to them, their experiment indicates how this 'body model' represents the dorsal surface of the hand.

This description matches my own about how the body schema is generated. However, according to the model I am proposing, the *result* of this combination is the body schema. So this task shows us how the body schema represents the hand's dorsal surface. As discussed, this isn't necessarily how the LTB represents this surface, as shifts in spatial content can occur during the generation of a body schema.

In regards to how the hand surface is represented, the experimenters made the following finding:

> these maps were massively distorted in a highly consistent and stereotyped way across participants. In particular, there were three clear patterns of distortions: (1) overestimation of hand width, quantified as the distance between pairs of knuckles; (2) overall underestimation of finger length, quantified as the distance between the knuckle and tip of each finger; and (3) a radio-ulnar gradient, with underestimation of finger length increasing systematically from the thumb to the little finger. (Longo, 2015a, p. 10-11)

Longo & Haggard (2012a) were also interested in whether this representation, like the body percept, was a 3-D representation or whether it was (as they claimed with the tactile form) made up of independent representations of 2-D skin surfaces. As in the previous tactile form experiment, they tested both sides of the hand. Although distortions of each surface were qualitatively similar, the palmar surface was represented much more accurately, "overestimation of hand width was reduced on the palm, and underestimation of finger length was replaced by a near-accurate representation" (Longo & Haggard, 2012a, p. 12).

Because of these differences in magnitudes of distortion, Longo & Haggard conclude that the 'body model' (body schema) does not represent the hand as a fully unified, coherent, 3-D object, as this would be a violation of basic 3-D geometry. They also suggest that the strong correlation between distortions of the skin surfaces suggests that (unlike the tactile form), the body model is not a collection of 2-D representations of skin surfaces. Borrowing from Marr's (1982) concept of a 2[1/2]D visual sketch, they conclude that the body schema represents the hand as a 'hybrid' 2.5-D model. This representation is "intermediate between a purely local representation of individual skin surfaces and a fully volumetric 3-D body" (Longo & Haggard, 2012a, p. 11).

2.5.4 Differences in Spatial Content

There are two main conclusions that Longo & Haggard draw from these experiments. The first is that the body percept, body schema and tactile form each differ in spatial content. While the body percept's spatial content is fairly accurate, the tactile form and body schema's content is 'distorted', albeit in different ways.

The explanation they offer for the distortion in spatial content of the tactile form is that it arises from the geometry of tactile receptive fields (RFs) on the hand surface. While RFs on the palmar surface are generally smaller and more circular, RFs on the dorsum are usually oval-shaped, with the long axis running proximodistally. Longo & Haggard suggest that the tactile form codes surface size in terms of *number* of receptive fields, incorrectly coding all receptive fields as uniform in size/shape.

The number of RFs the tactile form represents as being between two simulated locations is then the *key information* for computing tactile distance:

> Tactile distance judgments, then, would be determined by essentially 'counting' the number of RFs between the stimulated RFs, without regard to their shape. Because more RFs intervene in a given tactile distance in a mediolateral direction than in a distal-proximal orientation, mediolateral distances appear correspondingly larger. (p. 725 – 726)

The researchers don't offer a complete explanation for the evident distortion in the body schema. Longo does, however, observe a link between it, RF geometry and somatosensory cortical representation:

> These biases appear to mirror known characteristics of primary somatosensory cortical maps. For example, the overestimation of hand width compared to length mirrors anisotropies in RF geometry and tactile size perception ... Similarly, the radial-ulnar gradient of finger size mirrors differences in tactile sensitivity and cortical magnification of the five fingers (Longo, 2015a, p. 11).

From this observation Longo suggests that generation of 'implicit representations' (body schema and tactile form) might happen as an operation of mutual interaction between bottom-up somatosensation: "represent[ing] the body surface as a mosaic of discrete receptive fields, which become progressively agglomerated into larger and larger units of organization" and top-down processes such as "vision … depicting the body as an undifferentiated whole" (2015a, p.12).

This general idea (which still seems to be in its infancy) about opposing forces of influence in the generation of body representations can cohere with my LTB hypothesis as long as we consider the top down influence as arising from the LTB. As I discussed in section 2.3, the spatial content of the dynamic representations can be influenced by multiple factors (e.g. online sensory input). The LTB, however, must be a *main* factor.

2.5.5 Differences in Form

The second conclusion Longo & Haggard draw from their experiments is that the tactile form, body schema and body percept take different *forms* (2D, 2.5D and 3D). The distinction between long-term and short-term representations throws some light on this issue. At one point Longo & Haggard indicate that they have considered the status of these representations in terms of a similar distinction. Speaking about the body schema, they write, "It is unclear from the present data, however, whether the 2.5-D representation is stored by the brain in some intermediate format or is built up in real-time from 2-D and 3-D representations, whether it is an "online" or an "offline" representation" (Long & Haggard, 2012a, p. 11). This 'building up in real time' (before being erased at time *t +1*) is exactly what is meant by the classification 'short-term'.

However, whether the body schema is short-term might have an effect on the issue of form. Consider the localisation in external space experiments used to test the body schema's representation of hand surfaces. To accomplish each of these kinds of tasks (localisation of points on the dorsal and palmar sides, respectively) only short-term representations of that *particular* hand surface's location in space need to be generated. In the same way that grasping for a mug wouldn't necessarily require a body schema with content about the size of my foot to be generated; these tasks wouldn't necessarily require generating a body schema that represented *both* hand surfaces, just the surface which is the target point of the task.

It might still be the case that short-term representations that include content on both hand surfaces are generated but this certainly doesn't seem necessary. If we suppose that the representations generated are *only* of the hand surface required by the task, there is no problem of form. The difference in accuracy between the hand surface representations is a characteristic of representation *generation* rather than stored content. Because they are not stored together, these incongruent surfaces are never a part of an integrated representation. Therefore, we don't have to worry about this stored content's form violating the rules of geometry; the problem of form simply never comes up.

2.6 Conclusion

In this chapter I discussed O'Shaughnessy's long-term body image hypothesis. I claimed that a similar kind of body representation might track changes in the spatial content of the body and supply this content to the body percept, body schema and tactile form. I claimed that the spatial content of these representations is dynamic, requiring this more stable LTB to store the default parameters of the body.

I went on to suggest that these dynamic representations might also be considered short-term. If this is the case, then the need for an LTB is even clearer, it stores the spatial content used to generate these short-term representations. Nevertheless, the existence of the LTB does not rest on this short-term characterisation. Even if empirical research shows that the body percept, body schema and tactile form *store* spatial content long-term, their dynamic nature (especially the body schema) still might require a more stable LTB.

The methodology of this thesis is to place the findings discussed in Chapter 1 into a bigger picture in order to gain a better scientific understanding of AN. This chapter was devoted to painting that bigger picture. This picture, the modernised LTB hypothesis, explains how spatial content on the body is stored and updated. The stage is now set for the next chapter: placing the findings.

Chapter 3 Anorexia Nervosa and the LTB

3.1 Introduction

When discussing the advantages of 'drawing big pictures', Bortolotti writes: "only when one takes some distance from the specific context in which some interesting data were found, can one identify previously neglected links with other areas of investigation" (2010, p. 7). In the previous chapter I introduced O'Shaughnessy's framework for understanding how spatial content on the body is represented, adapting it to fit with current body representation research. Under this modernised framework the LTB tracks the spatial content of the body and supplies this content (when needed) to the dynamic representations. We can now identify a previously neglected link between these two areas of investigation, applying this model to understanding the evidence of spatial distortion in AN patients' dynamic body representations.

To do so I suggest that AN patients' LTBs are distorted and *this* is what causes the distorted spatial parameters of the dynamic representations. First I will discuss how this proposal fits with evidence from AN research. I will then address two obvious questions: how do patients' LTBs become distorted and why, upon viewing themselves in the mirror, don't they correctly update? Although I won't offer definitive answers to these questions, I will discuss potentially relevant evidence and suggest some avenues worthy of further exploration.

3.2 Anorexia Nervosa and LTB Distortion

I have suggested that the LTB stores content regarding body size and this content is transferred to (or used to generate) the task-specific dynamic representations. If we accept this model then perhaps distortion of AN patients' dynamic representations originates in the LTB i.e. distorted content is imported from the LTB into the dynamic representations, causing the patterns of errors found in BSE, TDE and affordance tasks.

I will now explore how this claim fits with evidence from AN research. As discussed, it has been shown that AN patients' exhibit distortion in all of their dynamic body representations. Furthermore there are correlations between the different representations' degrees of distortion. Keizer and colleagues (2011) found that as body dissatisfaction increased, so did both body percept and tactile form distortion. Case also found a within-subject association between body dissatisfaction, body percept distortion and tactile form distortion (2013, p. 124). Her experimental setup (involving showing participants manipulated reflections of their bodies) saw body dissatisfaction and overestimation in BSE and TDE tasks all fluctuate within subjects. These two studies suggest that distortion of the body percept is linked with distortion of the tactile form and both are tied to body dissatisfaction. Although this correlational evidence doesn't provide *strong* support for the LTB distortion hypothesis, it does sit nicely with the more general idea that the different distortion shares a common cause.

Keizer and colleagues (2013) also found evidence suggesting a strong link between distortion of the body schema and body percept in AN patients. Not only did they test patients' body schemas with their aperture-passing paradigm, they also had patients complete a BSE task—drawing a line estimating the distance between their shoulders. As predicted, AN patients overestimated their shoulder width in this task. However, the experimenters made an even more interesting finding. Based on the participants estimated shoulder width and the width of the aperture they started to rotate their shoulders at, they discovered that "if AN patients' shoulders were as wide as they estimated them to be, they would perform equal to [healthy controls] on body-scaled action" (p. 5). So AN patients are, in-fact, moving their bodies with the same dynamics as healthy controls, albeit they are moving *as if* their body schema had the same shoulder width dimensions as their body percept.

What this shows is AN patients' body schemas and body percepts have matching spatial content (shoulder width), despite both representations being distorted. This exact dimensional could be due to the percept and schema having some *direct* causal relationship whereby they share spatial content. However, it might also be that these representations are gaining their spatial information from a single, distorted source. The experimenters make a similar suggestion, they write: "this [evidence] implies stored information on body size is disturbed in AN, which in turn affects perception-related body image as well as action-related body schema representations" (p. 5). This view fits nicely with my proposed model regarding the role of the LTB.

3.3 How Does the LTB Become Oversized?

If we accept that AN patients' LTBs become oversized, the question remains how this comes about. I will address three possibilities. The first is that the LTB has failed to update veridically after sudden weight loss. The second is that a perceptual deficit specifically related to perceiving one's own body is to blame. I will argue that the evidence counts against these two hypotheses. Instead, I will suggest that affect might play a role in distorting the LTB.

3.3.1 The Failed Update Hypothesis

One possible explanation for the oversized dimensions of AN patients' LTBs is that they have failed to update to new, thinner dimensions after sudden weight loss. Similarly, Guardia and colleagues have suggested that a failure to update might explain patients' oversized body schemas (2012, p. 7).[36] Metral and colleagues aimed to test this hypothesis. They "took account of the patients' weight before the onset of AN (as reported by the patients themselves), the weight one month and six months before the experiment and the weight at the date of the experiment" (p. 8). However, they found no significant positive correlation between body weight before the onset of AN and the dimensions of their oversized body schemas (represented by π_p).

Even more damning to this hypothesis is evidence from Keizer and colleagues' (2013) body schema study. In this experiment one group consisted of participants with EDNOS (eating disorder not otherwise specified). These participants had previously been diagnosed with AN but had regained their normal body size after a period of treatment. This is what classified them as having EDNOS rather than AN—they currently had healthy BMI and body sizes.

This group also showed an increased π_p, one that matched the AN group (p. 6). However, these EDNOS patients' bodies had returned to their normal sizes. This means they no longer had undersized body dimensions their body schemas could have

[36] There is some evidence to suggest that failure to properly update the body schema after massive weight loss is possible (Guardia et al., 2013)

failed to update to. This rules out the explanation that AN patients have representations (LTB or body schema) that haven't properly updated to reflect their new, smaller dimensions.

3.3.2 The Distorted Perception Hypothesis

I have discussed how AN patients don't have any *general* deficits in their perceptual abilities and how overestimation in BSE experiments results from oversized representations (the body percept). However, some recent BSE experiments have attempted to establish the existence of a certain kind of perceptual deficit by including 'perceptual' BSE conditions in their experiments (Shafran & Fairburn, 2002; Øverås et al., 2013).

These conditions involve exposing patients to a mirror, while next to the mirror a photo of themselves is projected. This photo is manipulated so that it is the same height as the mirror reflection of the patients but either wider or narrower. Patients are asked to modify the image's width until it represents the width of their body *as they perceive it in the mirror*. In both experiments done using a perceptual BSE condition, eating disorder groups overestimated body size in this 'perceptual' task (compared to healthy controls).[37] Furthermore, Øverås and colleagues (2013) discovered AN patients overestimate body size even more in this perception based task compared to a standard 'memory based' BSE task.

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[37] While Øverås and colleagues' group was only made up of AN patients, Shafran & Fairburn's group was a mix of AN, bulimia nervosa and EDNOS patients.

One might be tempted to interpret these results as showing that AN patients have a deficit in their perception, albeit one that is restricted to viewing themselves in a mirror. This interpretation sits nicely with patients' reports that, when looking in the mirror, they *see* themselves as fat (Smeets & Panhuysen, 1995, p. 109; Espeset et al., 2011). If this were the case then perhaps faulty self-perception is what updates the LTB to erroneous dimensions.

However, interpreting the results in this way would be falling for what is referred to as the El Greco fallacy (Rock, 1966; Anstis, 2002; Firestone, 2013). El Greco was a Spanish renaissance artist who famously painted subjects with elongated fingers. In the early 1900s it was suggested that El Greco might have been suffering from astigmatism, an ocular defect that distorts the perceived environment by vertically stretching it. However, this theory runs into an important conceptual problem. As Firestone & Scholl explain:

> If El Greco truly experienced a stretched-out world, then he would also have experienced a stretched-out canvas. In that case, the distortions should have canceled each other out: Just as El Greco would have seen real-word figures as elongated, so too would he have seen his paintings as elongated, and so the real-world distortions he experienced would never have transferred to his reproductions. The distortions in El Greco's paintings, then, must have some alternative explanation beyond a literal perceptual distortion. (2014, p. 39)

When we turn to BSE experiments involving a 'perceptual' condition, we are faced with a similar situation to interpreting El Greco's paintings. In these conditions BSE tasks are created so that the image participants manipulate appear to them just as an image in a mirror would; the digital photo used is manipulated to be exactly the same height as participants' body appears in the mirror.

If AN patients really perceived their mirror reflection in a distorted manner, this distorted perception should also apply to viewing images which are manipulated to look like mirror reflections. If both mirror reflections and the manipulated images are perceived in a distorted manner, then just as Firestone and Scholl argue with El Greco's paintings, the distortions should cancel each other out. However, no cancelling out is evident: oversized distortion *is* seen in the BSE results. This rules out distorted self-perception, suggesting the problem occurs elsewhere along the cognitive path.

3.3.3 The Influence by Affect Hypothesis

It's still too early to offer a complete answer for how the LTB becomes distorted in AN. However, I will discuss some evidence that suggests *affect* might play a role. A similar suggestion to the one I will make can be found in Metral and colleagues' (2014) paper. In response to finding a correlation between body schema size and weight recovery (i.e. the current BMI less the minimum BMI), they suggest the following explanation:

> In anorexic patients, weight regain (with calorie fear and false beliefs about being "obese") is associated with limbic and paralimbic activation and has consequences on emotional arousal (i.e. the presence of obsessive and depressive symptoms). During the weight recovery phase, the AN inpatient

> group's depression and anxiety scores were pathological. One could imagine that this emotional arousal interferes with visual and somesthetic sensory inputs that underpin body perception and motor expression. (2014, p. 9)

Metral and colleagues' particular interpretation of their finding is problematic. As discussed, AN patients do not have a general deficit in their visual inputs and there are no somesthetic sensory inputs that deliver consistent spatial content for emotional arousal to interfere with. However, the idea that affect plays some role in distorting the spatial content of the LTB is an interesting proposal.

This particular hypothesis blends nicely with a series of BSE experiments done in the 90s. Taylor and Cooper (1992) conducted the first of these experiments on a group of 85 healthy female college students. Participants first completed a BSE task. They were then split into groups and underwent either a positive or negative mood induction procedure involving reading statements with either miserable connotations (e.g. "I feel ashamed of things I've done") or pleasant connotations (e.g. "I feel that I am a nice person") and completing open-ended self-referent statement (e.g. "I feel a failure because…", "I feel proud of myself because...") (p. 55). Participants then re-estimated their body size using the same BSE method.

The researchers found that "compared with the induction of a positive mood state, the induction of a negative mood state led to greater disturbances in body size perception in the form of a tendency towards overestimating body size" (p. 57). Furthermore, they found:

> among the women who received the negative mood condition, compared with those with little or no concern with their body shape, for those with [high body conern] the induction of low mood led to greater disturbances in body size perception in the form of overestimating their body size significantly more … (p. 53)

This effect of negative mood induction on overestimation was not found to be statistically significant (p. 55). However, the study has since been replicated (with statistical significance reached) (Plies & Florin, 1992; Baker, Williamson, & Sylve, 1995; see also: McKenzie, Williamson & Cubic, 1993).

Relevant to the connection between body concern, negative mood induction and body size overestimation, Baker, Williamson, & Sylve (1995) compared subjects classified as either high or low in body dysphoria.[38] They found that negative mood induction *only* increased body size overestimation in their high body dysphoria group (p. 755).

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[38] Researchers screened 344 female undergraduate students to arrive at two groups, with 36 subjects in each. They write, "undergraduate females were screened for the presence and absence of body dysphoria using the *Body Shape Questionnaire* (BSQ; Cooper, Taylor, Cooper, & Fairburn, 1987). Subjects high in body dysphoria were defined by a score greater than one standard deviation above the mean (a score greater than 110) on the BSQ and subjects low in body dysphoria were defined by a score less than one standard deviation below the mean (a score less than 50) on the BSQ" (p. 749). The BSQ asks a range of questions, e.g. "Have you been afraid that you might become fat (or fatter)", "Have you avoided running because your flesh might wobble", "Has eating sweets, cakes, or other high calorie food made you feel fat", "Have you felt ashamed of your body?" and "Have you vomited in order to feel thinner" (Cooper et al., 1987).

Although no tactile form or body schema tests were conducted, these experiments might be an example of the spatial content of the LTB being altered. This would suggest that, even for healthy controls, the spatial information of the LTB can be altered through influence by affect. How much the LTB is susceptible to this influence through affect is possibly a product of how much body concern/body dysphoria someone has. AN patients' LTBs would be more highly susceptible to such alteration because, as a group, they have such high body concern/dysphoria.

Of-course this distortion of the body percept through affect might happen in a direct manner, leaving the dimensions of the LTB intact. It might even be that the evident shift in BSE results is caused by some other factor, not related to body percept size e.g. demand characteristics of the experimental setup. If either of these scenarios were the case, then we are still at a loss for an explanation for how AN patients' LTBs become distorted. The way to determine between these possibilities is, of-course, through experiment (see section 6.1.3).

3.4 Why Doesn't Self-Viewing Update the LTB?

I argued that AN patients don't have a perceptual deficit which causes them to actually *see* their bodies as wider when they look in a mirror. Given that vision undoubtedly plays a strong role in updating the LTB, one obvious question is why, upon viewing their thin bodies in the mirror, don't AN patients' LTBs update to reflect their true dimensions?

As in the case of answering how patients' LTBs become distorted in the first place, I won't be able to offer a complete solution. I will, however, discuss preliminary evidence that provides some insight into the issue. Using fMRI, Sachdev and colleagues (2008) investigated the brain processing of AN patients when viewing images of themselves. Patients processed non-self images similarly to the control group. However, when processing images of themselves, AN patients "do not appear to engage the attentional system or the insula, and suppress emotional and perceptual processing of the information" (2008, p. 2167). Previous studies have indicated that the insula is involved in processing images of oneself (Devue et al., 2007).

Sachdev and colleagues conclude from their findings:

> this differential processing … might explain why AN patients have a distorted view of their body image. The reduced perceptual processing may provide the basis for perceptual disturbance in relation to body shape which AN patients show, and the insula inactivity the basis of failure of feedback to correct their self-image disturbance. (2008, p. 2167)

It seems plausible that this distorted self-image processing also applies to instances of mirror exposure, helping explain why such experiences fail to properly update the LTB. Of course further investigation is needed to understand the exact nature and cause of this inhibited processing and what this means in terms of the LTB hypothesis, however Sachdev and colleagues' work is certainly a step in the right direction.

This altered processing of self-images might also explain why patients continue to overestimate body size in perceptual BSE conditions (while exposed to a mirror).

Perhaps patients continue to estimate their size based off the body percept rather than the mirror image. This body percept maintains its faulty dimensions, failing to update (via the LTB) due to aberrant processing of the mirror image.

We can also extend this explanation to account for evidence of AN patients overestimating body size *more* in perceptual BSE conditions than memory BSE conditions (Øverås et al., 2014). It's known that subjects with eating disorders respond to mirror exposure with a strong increase in negative affect (Vocks et al., 2007). So perhaps the size of the body percept increases in perceptual BSE conditions, due to increased negative affect (arising from mirror exposure) distorting the LTB (as hypothesized in section 3.3.4). This increase in the size of the body percept, in turn, causes even greater overestimation in the BSE task.

3.5 Conclusion

In this chapter I applied the modernised LTB hypothesis to understanding evidence of distorted body representations in AN, suggesting that AN patients have distorted LTBs. I discussed three different hypotheses for how the LTB becomes distorted, finally suggesting that affect might play a role. I also addressed the problem of why, during self-viewing in a mirror, the LTB does not correctly update, suggesting a differential processing of self-images might be to blame.

If the LTB distortion hypothesis is correct then the LTB, rather than any specific dynamic representation, is the most effective target for treatment of distorted body representations in AN. The first step, of-course, is to empirically verify the claims I have made in the preceding two chapters: that the LTB exists, that it causes the evident distortion in patients' dynamic body representations and that it becomes distorted through influence by affect.[39] After this, we must better understand how the LTB updates, how it can be manipulated and what *the specifics* of its relationship to affect are. Only then, will we be in a position to propose avenues for treatment.

[39] For first empirical steps towards this goal, see section 6.1.

Chapter 4 A Causal Model of Body Affect

4.1 Introduction

I have discussed evidence showing AN patients exhibit distorted body representations. I have also suggested that this is caused by distortion in patients' LTBs. This fits nicely with the methodological goal of placing "single findings and interpretations of localised phenomena into a bigger picture" (Bortolotti, 2010, p. 7). In this case, the big picture is a framework for understanding how spatial content on the body is stored. However, there is another picture to consider: the disease itself. The question to ask here is what role distorted body representations play in the *onset* and/or *maintenance* of the disease. The next two chapters will be devoted to answering this question.

In this chapter I will claim that body percept distortion plays a role in motivating harmful dieting behaviour. It does so through its influence on propositional attitudes about the body, referred to as *the body affect* (Gallagher, 2005, p. 25). I will first describe two categories of the body affect: attitudes of dissatisfaction about body size and beliefs about being 'fat'. I will then propose a causal model of body affect disturbance whereby mentally picturing their bodies as oversized along with influence from socio-cultural factors, grounds patients' negative size related propositional attitudes. These propositional attitudes motivate harmful dieting behaviour. As such, by grounding negative body affect, body percept distortion drives harmful dieting behaviour.

4.2 The Body Affect

The body affect is a group of propositional attitudes that reflect "the subject's emotional attitude toward his/her own body" (Gallagher & Cole, 1995, p. 371). The body affect is another component of the body image (apart from the body percept) that is considered 'disturbed' in AN (Skrzypek, Wehmeier & Remschmidt, 2001). It is considered disturbed due to the kinds of negative propositional attitudes AN patients have about their body size. I will discuss two kinds of these propositional attitudes: body size dissatisfaction and beliefs about being 'fat'.

4.2.1 Body Dissatisfaction

When discussing body affect disturbance, AN researchers have traditionally focused on *body dissatisfaction*.[40] Body dissatisfaction can be defined as "negative subjective evaluations of one's physical body, such as figure, weight, stomach and hips" (Stice & Shaw, 2002, p. 985). It involves holding propositional attitudes that reflect dissatisfaction with aspects of the body. In particular, AN research focuses on attitudes of dissatisfaction about the size or shape of body parts.

Body dissatisfaction is usually measured by structured interview or self-report questionnaire (Cash & Deagle, 1997). In some questionnaires, participants will be presented with statements such as "I think my abdomen is too large" and asked to respond with a measure of agreement or disagreement with the statement (Garner, Olmstead & Polivy, 1983). Alternatively, participants might be presented with the

[40] It should be noted that recently some researches have attempted to move away from focusing only on the body size dissatisfaction aspect of body affect in AN (Cash, 2002; Cash & Grasso, 2005).

names of body parts (e.g. hips, waist) and asked to rate their level of satisfaction with the size or shape of these parts (Menzel, Krawczyk & Thompson, 2011).

Other tests include *figural drawing scales*. These show different silhouettes of body sizes and participants are instructed to select which silhouette matches their current body and which represents their ideal body. Body dissatisfaction is then calculated as the discrepancy between these two figures (Altabe & Thompson, 1992; Menzel, Krawxcyk, Thompson, 2011).

4.2.2 Size Related Beliefs

Another group of propositional attitudes that have only recently garnered interest are *beliefs* about body size. It has been shown that, along with dissatisfied attitudes, AN patients hold false beliefs about their body size. These beliefs take forms such as "I am not thin now at 42kg", "I am fat now at 49kg" and "I am fat now at 49 kg and I must lose 5 kg to regain a normal weight" (Konstantakopoulos et al., 2012, p. 483).

The delusionality of beliefs is generally rated dimensionally with the hallmark feature of delusionality being 'conviction', i.e. how strongly a belief is held (Oulis et al., 1996; Jones and Watson, 1997). While some AN patients count as having completely delusional beliefs about appearance, the majority are considered 'insightful', i.e. aware of their mental illness as the cause of such beliefs (Steinglass et al., 2007; Konstantakopoulos et al., 2012; Hartmann et al., 2013; Mountjoy, Farhall & Rossell, 2014).

Beliefs about body size are sometimes categorised as a third component of body image disturbance, the ‘cognitive’ component (Menzel, Krawczyk & Thompson, 2011; Delinsky, 2011; Gaudio & Quattrocchi, 2012). However, this terminology isn’t common. Due to the similarities between body dissatisfaction and beliefs about body size, I will group them both together under the body affect category.

4.2.3 Body Affect and Motivational Force

As I stated in the introduction to this thesis, AN is a complicated disorder with multiple etiologies to consider. I am not attempting to offer a complete account of the causal factors involved in the onset and maintenance of the disease. However, we know that, in general, propositional attitudes have motivational force in regards to behaviour. For example, attitudes of dissatisfaction have *independent* motivational force. When people are dissatisfied with the width of their abdomens this motivates dieting behaviour (to make their abdomens thinner). This is why body dissatisfaction is generally considered to be a key factor in the development and maintenance of AN and other eating pathologies (Freeman et al., 1985; Stice, 2000; Striegel-Moore & Cachelin, 2001; Stice & Shaw; 2002; Striegel-Moore et al., 2004). Beliefs also have motivational force, when combined with desires. When people believe they are fat and also desire to be thin, this motivates them to diet.

Given that AN patients are dissatisfied with their body size and believe parts of their bodies are ‘fat’, it’s fair to presume that these attitudes play some motivational role in the harmful dieting behaviour associated with AN. If we can properly map out the etiology of these particular attitudes we are in a better position to change them.

Therefore modeling size related propositional attitude formation is an important step towards better understanding the disease as a whole.

4.3 Oversized Experiences

I have claimed that, given the motivational force propositional attitudes have, it seems likely the body affect plays a role in causing the harmful dieting behaviour associated with AN. An important question to ask then, is how these attitudes arise? To answer this question I will adopt an approach from the study of monothematic delusions.

Monothematic delusions are disorders where patients hold delusional beliefs related to one specific theme (e.g. Capgras patients believe their spouse has been replaced with an imposter). The empiricist approach to explaining monothematic delusions claims that *abnormal* beliefs are grounded in *abnormal* experiences (Bayne & Pacherie, 2004). Even if most AN patient's don't count as holding delusional beliefs, their propositional attitudes about body size are certainly abnormal—it's abnormal for someone to believe she is fat and be dissatisfied with how large she is when, in-fact, she is extremely thin. As such, I will adopt the empiricist approach and try to explain these propositional attitudes by looking for abnormal experiences that AN patients suffer from, ones related to the content of these attitudes.

AN patients do have abnormal experiences of their body size, I call these *oversized experiences*. One way that AN patients experience their bodies as oversized is by mentally picturing them as oversized. This experience is caused by body percept distortion. Following the empiricist approach, I claim that this abnormal experience of the body as oversized plays a role in grounding body affect.

4.3.1 Oversized Experiences and Body Affect Disturbance

A relationship between mentally picturing an oversized body percept and body affect disturbance seems plausible—patients might be basing their dissatisfied attitudes off their own mental picture of themselves. This possibility coheres with multiple studies showing a correlation between body percept distortion and body dissatisfaction (Gardner & Tockerman, 1993; Cash & Deagle, 1997; Sunday et al., 1992; Keizer et al., 2011; Waldman et al., 2013). The idea that AN patients are basing their attitudes of dissatisfaction on a (false) mental picture of their body size, rather than their actual size also explains why, unlike in healthy controls, body dissatisfaction in AN shows low correlation with BMI or body size (Ben-Tovim & Crisp, 1984; Ben-Tovim et al., 1990; Goldzak-Kunik et al., 2012). As Goldzak-Kunik and colleagues write, "AN patients are dissatisfied with their body image irrespective of its true dimensions and, hence, remain dissatisfied irrespective of their precipitous weight loss" (2012, p. 279).

Given how comparatively little research has been done into beliefs and AN, I'm unaware of any evidence linking body percept distortion and beliefs about body size. However, as in the case of body dissatisfaction, there is prima facie plausibility to the scenario that mentally picturing the body as oversized reinforces beliefs about being fat. For example, if every time we mentally pictured our body, it appeared to us as oversized, this might cause it to match our visual standard for what constitutes a 'fat' body. This could reinforce the belief 'I am fat'.

Another route through which mentally picturing the body as oversized might cause body affect disturbance is through social comparison (Wheeler & Miyake, 1992;

Leahey, Crowther & Mickelson, 2007; Myers, Crowther & Watson, 2009). If AN patients compared the size of others' bodies with their own body percept then, granted their body percept was distorted enough to be larger than average, they might conclude that they were bigger than most people. In support of this possibility, it has been suggested that comparison of body size is a behaviour that AN patients regularly engage in (Corning et al., 2006; Alleva et al., 2013, p. 99). In an analysis of interview transcripts from 32 AN patients, Espeset and colleagues write, "participants also said that they obsessively compared themselves with other people, especially other patients with eating disorders or women their own age" (2012, p. 524).

4.3.2 Socio-Cultural Processes and Body Affect Disturbance

If mentally picturing the body as oversized grounds negative body affect, it doesn't do so independently. Socio-cultural processes are also integral to explaining size related propositional attitudes in AN. They help explain the high prevalence of AN amongst women and in Western cultures that value thinness (Bulik et al., 2005; Makino, Tsuboi & Dennerstein, 2004). There is also extensive research drawing links between socio-cultural processes and body dissatisfaction (Wertheim et al., 1997; McCarthy, 1990; Stice, 2002; Stice & Shaw, 2002; Shroff & Thompson, 2006).

When combined with oversized experiences, socio-cultural processes can influence body affect in numerous ways. For example, they can cause subjects to internalise thin body ideals (Stice & Shaw, 2002). These thin body ideals, combined with mentally picturing the body as oversized (i.e. not matching these ideals) could cause body dissatisfaction.[41] Likewise, socio-cultural processes help define evaluative terms such as 'fat' and 'thin'. Mentally picturing the body as meeting (or not meeting) one's visual standards for these terms can reinforce beliefs such as 'I am fat' and 'I am not thin'. I won't address *exactly* which socio-cultural factors influence body affect and how they do so. Although this is an integral part of the puzzle, it has been given a lot of attention (Stice et al., 1994; Dimen, 1998; McKinley, 2011). Instead my goal is to understand what role distorted body representations play in the disease. Therefore, I will focus on the oversized experiences these distorted representations can cause.

4.4 A Causal Model of Body Affect Disturbance

I will now present an initial causal model of body affect whereby both socio-cultural processes and oversized experiences jointly cause body affect disturbance (see fig. 4 below).

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[41] Not only does this causal explanation for body dissatisfaction seem plausible, it is presupposed in figural drawing scale tests of body dissatisfaction. These measure body dissatisfaction as the discrepancy between how someone pictures their body size (body percept) and how they picture their ideal body size (normative body ideal) (Menzel, Krawczyk & Thompson, 2011, p. 155; Gardner, Jappe, & Gardner, 2009; Gardner & Brown, 2010).

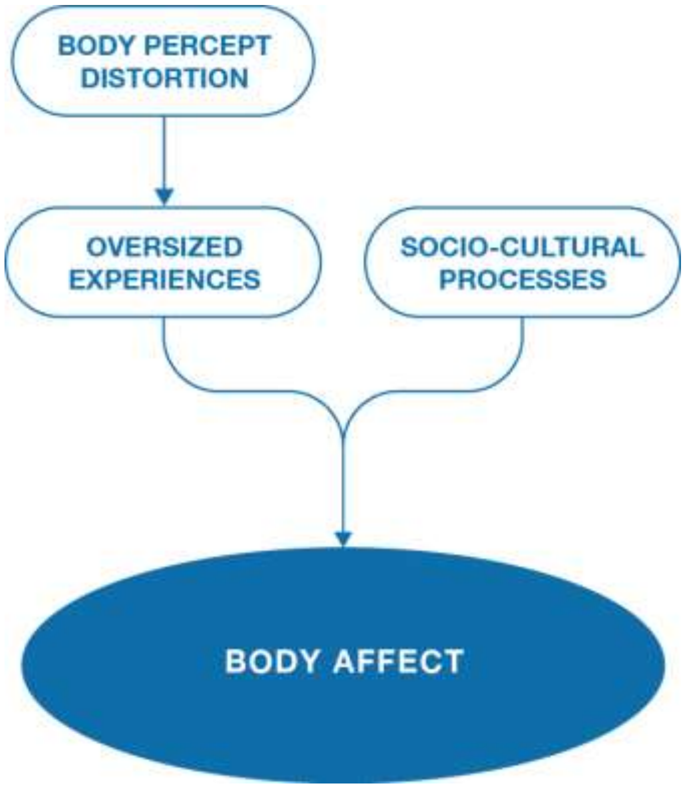

Figure 3: An initial causal model of body affect disturbance.

In this model, having a distorted body percept causes oversized experiences. These oversized experiences consist of mentally picturing the body as oversized. When combined with influence from socio-cultural processes they reinforce the size related propositional attitudes of AN patient's body affects. In Chater 5, I will expand this model by exploring what other kinds of oversized experiences can arise from distorted body representations.

4.5 The Role of Oversized Experiences: Onset or Maintenance?

The causal relationship between oversized experiences and body affect represented in this model might be classified in two different ways, in terms of *original* causation or *ongoing* causation. A model of original causation would explain which experiences *first* caused the attitudes under question (e.g. 'I am fat', 'I am dissatisfied with my body size'). A model of ongoing causation would only describe which factors serve to *maintain* and *reinforce* such attitudes.

In Section 3.3.4 I suggested that the LTB is susceptible to distortion through affect even in healthy subjects, especially those with high body concern. If this is the case then oversized experiences might be an original cause of these attitudes. Subjects with high body concern could exhibit LTB distortion, which (through body percept distortion) would cause oversized experiences. These oversized experiences would then cause negative body affect. This negative body affect could trigger the *onset* of the disease. If this were the case then distorted body representations would be a factor in the onset of AN.

However, without proper empirical verification of the influence by affect hypothesis, it is too early to make this claim.[42] It might be the case that neurological damage resulting from the starvation and chronic stress associated with AN causes distortion of body representations (Riva, 2011, p. 256). In this case patients could have these propositional attitudes prior to the onset of the disease, purely as a result of socio-cultural processes. Therefore I will remain neutral on the issue of original causation and instead present the above model as one of ongoing causation. As such, I only claim that distorted body representations are a factor in the *maintenance* of the disease.

[42] See section 6.1.3.

4.6 Links between the Causal Model and Anorexia Nervosa Literature

I will now draw some links between this causal model and other claims made in the AN literature. For example, this model coheres with the claim that body dissatisfaction is a more integral aspect of the disease than body percept distortion (Cash & Deagle, 1997; Sepulveda, Botella & Leon, 2002). In this model, distortion of the body percept only drives one causal component of negative body affect. So it's possible that, in many patients, it plays only a minor causal role (with socio-cultural processes playing the larger role). Because oversized experiences are only one causal component of negative body affect, body percept distortion cannot be a sole predictor for harmful dieting behaviour.

The above model is also compatible with theories that put the need for control as central to the disease (Fairburn, Shafran & Cooper, 1999). My focus is on the mismatch between how AN patients mentally represent their bodies and how their bodies actually are. This mismatch might result in a frustration of attempts for control because patients can't ever line up how they mentally picture their bodies with their ideal body size. This could lead to increasingly obsessive dieting behaviour. However, I remain neutral on where the need for control arises from or why it manifests in an attempt to control the size of the body.

Finally, I claim that the model I have proposed is superior to a *purely* socio-cultural model of body dissatisfaction. Tiggeman writes:

> At its simplest, the sociocultural model holds that (1) there exist societal ideals of beauty (within a particular culture) that are (2) transmitted via a variety of

> sociocultural channels. These ideals are then (3) internalized by individuals, so that (4) satisfaction (or dissatisfaction) with appearance will be a function of the extent to which individuals do (or do not) meet the ideal prescription. (2011, p. 13)

Although the socio-cultural model might account for body dissatisfaction in neurotypical subjects, it's unlikely that socio-cultural processes are the only causally relevant factor in AN. From BSE tasks, we know that AN patients exhibit oversized body percepts. It seems unlikely that mentally picturing the body as oversized would have no effect on propositional attitudes about body size. Furthermore, body percept distortion helps to explain why these propositional attitudes persist even after patients have achieved extremely thin body sizes.

One could argue that patients might have normative body size ideals and standards for what constitutes 'thin' that are so extreme that they can never physically attain them. If this were the case then negative body affect could be explained with a purely socio-cultural model. However, while this scenario might explain ongoing body dissatisfaction, it can't explain beliefs about body size.

Although normative ideals usually only apply to our own bodies, standards for what constitutes 'fat' and 'thin' bodies should be applied universally. If a patient's standard for 'thin' was so extreme that even she didn't match it then she should judge anybody that looked larger than her as 'fat'. Given how thin most AN patients are, she should come to the conclusion that almost everybody she saw was fat. This clearly isn't the case. In fact, some evidence shows that subjects high in eating disorder symptomatology are more likely to judge others as ‘thin’ (Alleva et al., 2013). Therefore, it seems AN patients only form these beliefs in regards to themselves; they don’t believe everyone they see is ‘fat’.

The importance of oversized experiences of one’s body is evident in the following excerpt from a structured interview with a patient:

> I know another girl with anorexia, we are exactly the same height and weight. But *we both feel three times as big* as the other. We have even taken pictures of ourselves. In fact, *I feel three or four times as big* as she is. … (Leah, BMI 15). (Espeset et al., 2011, p. 185, my italics)

Presumably Leah doesn’t believe her friend is ‘fat’, this is why she stresses the importance of *feeling* bigger than she is. If only socio-cultural forces were at play then Leah would simply consider herself, her friend and most other people she sees as ‘fat’. As such, my model is demonstrably superior to a purely socio-cultural model.

4.7 Conclusion

In this chapter I outlined two groups of propositional attitudes related to body size that AN patients hold: beliefs about body size and dissatisfaction with body size. Both these groups of propositional attitudes belong to the category of body affect.

I also discussed how body percept distortion causes oversized experiences, which consist of mentally picturing the body as oversized. I argued that these oversized experiences, along with influence from socio-cultural processes, ground negative body affect. In the next chapter I will expand this causal model, exploring what other kinds of oversized experiences can arise from distorted body representations.

Chapter 5 Expanding the Causal Model

5.1 Introduction

I have argued that AN patients experience their bodies as oversized by mentally picturing their bodies as larger than they are. When combined with socio-cultural influences, these oversized experiences ground the size related propositional attitudes of the body affect. However, I have also discussed evidence that shows AN patients exhibit oversized body schemas.

In this chapter I explore what kind of oversized experiences might arise from this body schema distortion. To do this I first discuss the concept of affordances. Affordances are what actions the environment offers an agent (Gibson, 1979). Perception of affordances is often determined by how the body schema represents the action capabilities of the body. Therefore, by having a distorted body schema, AN patients have a distorted perception of the affordances of their environments.

This distorted perception of affordances brings to awareness false information about the body: i.e. that it is too large for different features of its environment. Just as mentally picturing the body as oversized counts as an oversized experience of the body, so too does this distorted affordance perception. As such, these affordance based oversized experiences might also play a role in grounding negative body affect.

5.2 Affordances

5.2.1 Defining Affordances

In order to explain how body schema distortion can lead to oversized experiences, I will first discuss affordances. The term affordance was originally introduced by Gibson, who gave the following definition: "the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (1979, p. 127). To start with a simple example, a seat affords sitting on. 'Sitting on' is the affordance of that feature of the environment. While properties of the seat such as shape, size and material substance determine whether it affords sitting, there is still a piece of the puzzle missing: the relative properties of the agent.[43] As Heft explains:

> A seat's parameters as an affordance are delimited with reference to a specific individual of a particular weight, leg length, and girth. … The relative nature of seat affordances can be illustrated by the fact that a surface perceived as a seat by a young child may not be perceived as such by an adult. Specifically, a foot-stool may be perceived as a seat by a child and not by an adult as a function of leg length, and a cardboard box may be perceived as a potential seat by a child but not by an adult because of their differences in weight. (1989, p. 3)

The importance of properties of the agent in determining affordances has led many to propose *relational* theories of affordances (Heft, 1989; 2001; Reed, 1996; Stoffregen,

[43] Although discussion of affordances generally focuses on properties of the *animal,* I am specifically interested in affordances related to humans, therefore, I adopt the term *agent.*

2000; 2003; Turvey, 1992; Chemero, 2003). Although the specifics of the various relational accounts differ, what binds them together is that they all take into account properties of both the agent and the environment.[44] If we accept a relational account of affordances then the question is, what property of the agent are affordances relative to?

Following Chemero (2003), I believe the agent relata for affordances are *abilities*.[45] So a sitting affordance is relevant to the properties of the seat and the sitting ability of the agent. However, we must keep in mind that many factors make up an agent's abilities. Two obvious categories of properties that determine agent ability are *dimensional properties* and *kinetic properties*. Take the example of sitting: kinetic properties such as flexibility would determine submovement ability such as bending of the knees whilst relevant dimensional properties would include leg length and waist size.[46]

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[44] For example: affordances as animal relative properties of an environment (Stoffregen, 2000), properties of an animal-environment system (Stoffregen, 2003) or a relation between an animal's ability and a feature of an environment (Chemero, 2003).

[45] See Chemero for an argument on why agent relata are better though of as *abilities* rather than the often discussed notion of *effectivities* (2003, p. 189-190).

[46] Other agent properties such as epistemic states (i.e. knowledge of how to do the relevant action) and current mental states (e.g. anxiety) also determine affordances; however, these other properties aren't relevant to the case of AN. See Pijpers and colleagues (2006) for an empirical investigation into the role anxiety plays in determining affordances.

5.2.2 Primary Determining Factors for Agent Ability

Consider the ability related to the affordance for lifting a 200kg barbell. Given the importance of muscle strength (a kinetic property) for this action, I define it as the *primary determining factor* for this ability. Compare this against the example of passing through an aperture without turning one's shoulders. This seems like an activity where body width (a dimensional property) is the primary determining factor.

This can be extrapolated to most affordances that involve fitting through (or into) spaces. Affordances for passing through gaps sideways are primarily determined by depth of the body (i.e. abdomen size) (Franchack & Adolph, 2013). Many 'sitting on' affordances are primarily determined by waist size. All these examples belong to the category of affordances where body size makes up the primary determining factor for agent ability. Because AN patients misrepresent their dimensional properties, this is the category I am interested in.[47]

I also wish to narrow my discussion down to a subset of this category, what I call 'can't do' affordances. Affordances can be perceived not only in terms of what intentional actions the environment affords but also what actions the environment doesn't afford. For the purposes of understanding AN patients' oversized experiences, the relevant category of affordances is the category of 'can't do' affordances where body size is the primary determining factor.

[47] Multiple agent properties generally determine abilities; there often isn't a single primary determining factor. However, with cases where there is a primary determining factor (such as aperture-passing), this factor is usually obvious.

5.2.3 Perceiving Affordances

We don’t always perceive affordances. There are an infinite amount of ‘can do’ affordances given any agent/environment combination. Not only can I read a book, I can throw it in the air, put it on my head or lick it. Likewise there are an infinite amount of ‘can’t do’ affordances—I can’t fit the book in my mouth, bounce it like a basketball or snap it in two (unless I’m exceptionally strong). We clearly don’t perceive the infinite number of affordances of every environment we are in.

Whether we perceive an affordance or not depends on many factors. One necessary factor is that the environmental feature is currently available to our perceptual system. Simply put, I won’t perceive an affordance for chair sitting if I’m not perceiving the chair.

Another factor is current motivational state. Even if a book is the current object of my perception, I won’t perceive the infinite amount of affordances related to this book and my abilities, this would be far too demanding in terms of cognitive resources. Rather, I *usually* only perceive those affordances that are relevant to my current motivational state.[48] If I’m planning on eating the book I’ll perceive the ‘can’t do’ book eating affordance. If I feel like throwing a book in the air I’ll perceive the ‘can do’ air throwing affordance. These affordances would exist no matter what my current motivational state but this state helps determine whether I perceive them or not (Chemero, 2003, p. 193).

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[48] This is generally the case. However, I will argue later that some affordances *jump out* at us, despite not being relevant to our current motivational state.

5.2.4 Conscious Experience and Affordance Perception

I will now turn to the relationship between affordance perception and consciousness. In order to count as an oversized experience, AN patients must be conscious of these affordance perceptions. However, the vast majority of affordances relevant to our motivational states are perceived unconsciously. As we work towards our goals we usually utilise the affordances of our environments without conscious awareness. We do things like grasp mugs in just the right way or sit down correctly on chairs without first having to consciously recognise the affordances for doing so. Likewise, AN patients simply turn their shoulders at a higher π_p when walking through the apertures; they usually don't consciously *recognise* that they have to.

However, as we navigate our environments, from time to time an affordance will be consciously experienced. This most commonly involves 'can't do' affordances. For example, we reach for a mug and suddenly become aware that it has no handle.[49] If it had a handle we would have unconsciously gone through with the action (grasping). However, the unexpected 'can't do' affordance draws our attention, requiring us to consciously solve the problem it presents (how to grasp the mug).

[49] This scenario is an example of Heidegger's (1962) phenomenological category of *unreadiness-to-hand*. Usually mugs are *ready-to-hand*: we can easily use them without having to explicitly recognise and think about their function. However, when a tool (such as a mug) is broken it becomes *un-ready-to-hand* causing the subject to have to practically solve the problem this situation presents (see: Dotov et al., 2010; Wheeler, 2015).

When events are more cognitively difficult than expected an affordance becomes more *salient*. Salience can be defined as a property of affordances that determines how likely the relevant agent is to consciously perceive them.

5.2.5 Awareness of Constituent Relata

In order for perceiving an affordance to count as an oversized experience of the body, the experience must (in some way) be *about* the body. I have argued that facts about the body *determine* affordances but the question is: what role do these facts play in the *experience* of affordance perception? Chemero states, "an animal typically perceives only the affordance relation, though, and not the constituent relata … I am normally not aware of anything about my climbing abilities or riser heights when I perceive that I can climb a step" (2009, p. 146 – 147). In general, this statement seems correct. When we do become consciously aware of affordances, the content we become aware of is generally in the form of 'I can' or 'I can't'. The properties that determine this 'I can'/'I can't' aren't available to the perceiver.

However, there are exceptions to this. My claim is that in cases where specific properties make up the primary determining factor for an affordance relative ability then we necessarily become aware of these properties along with the affordance. Perceptions of these kinds of affordances relay information about the body, *body-relative* information (Legrand, 2006, p. 114). This information takes the form: *Rba*. Whereby *R* is a relation (e.g. too big, small, weak, inflexible etc.), *b* is a feature of the body and *a* is an action, relevant to an environmental feature (e.g. passing through the aperture).

Take the example of the ‘can’t do’ lifting 200kg barbell affordance. To perceive this affordance isn’t simply to become aware that one can’t lift the barbell but rather than one’s arms are too weak to lift the barbell. Likewise, perceiving the ‘can’t do’ aperture-passing affordance doesn’t cause one to only become aware that they can’t pass through the aperture. Rather, they become aware of content along the lines of ‘my shoulders are too wide to fit through this aperture’.

So awareness of certain kinds of content accompanies affordance perception. However, it is worth briefly discussing what relation this body relative, propositional content has to the affordance perception. To cash out this relationship we can borrow from Fulkerson’s (2014) concept of *inferential dependence*. He writes:

> [Inferential] dependence occurs when a state of indirect awareness results only from an inferential or similar cognitive process combined with an initial perceptual experience. Strictly speaking, it’s not the case that a separate experience arises from a cognitive act such as attending, judging, or inferring; instead, a state of indirect awareness is reliably and perhaps even automatically generated by an act of cognition in the appropriate perceptual circumstances. (2014, p. 86)

As a paradigmatic example of inferential dependence, Fulkerson suggests seeing a tank of gas is half empty by looking at a gauge: “it does not seem that we directly perceive the level of the gas in the tank, but we become aware of it in virtue of having a genuine visual experience of the gauge” (p. 86). Likewise we can say that indirect awareness of propositions that take the form *Rba* is inferentially dependent on certain kinds of affordance perception experiences. Patients don't directly perceive that they are too big for an aspect of the environment but they become aware of it in virtue of an affordance perception. Furthermore, as in the case of viewing the level of gas in the tank, this indirect awareness doesn't require reflection or conscious effort (p. 86).

5.2.6 Affordances and the Body Schema

Although I have been speaking about the body relative content conveyed by affordances, it's important to remember that the content under discussion isn't body relative content *per se*. Rather, it is content relative to how the body is *represented*, by the body schema. As Gallagher writes:

> What Gibsons calls affordances […] are defined as such for intentional consciousness *only on the possibilities projected by the body schema*. The floor affords walking, the chair affords sitting, and so forth, only in conjunction with the possibilities of particular postural models. All such features afforded by the environment, and evidenced in the implicit structure of noematic meaning, are predicated on the prenoetic functioning of the body schema. (1995, p. 234, my italics)

The predominant psychological theory here states that affordance perception involves motor simulation by the body schema system. By simulating an object relevant action, the body schema system determines whether it is possible (Jeannerod 1994; 2001; for an overview see: Declerk, 2015, p. 3-5). This is why AN patients with oversized body schemas perceive affordances for aperture-passing differently than controls, the relevant properties of their bodies are represented by their body schemas and their body schemas are distorted.[50]

5.3 Affordance Perception as an Oversized Experience

I can now explain how affordance perception for AN patients with distorted body schemas constitutes an oversized experience of their bodies. Let's consider an ecologically valid example. An AN patient suddenly becomes aware that the seat she planned to sit on is not wide enough to accommodate the (false) body schema dimensions of her waist. She experiences the perception of the 'can't do' chair sitting affordance and is forced to think the situation through. She double-checks her intuition that the chair will not support her width by consciously simulating herself sitting on the chair. Of-course this motor imagery task also relies on faulty body schema dimensions, so she's now *sure* she can't fit in the chair. She must consciously scan the environment for other options, perceiving the affordances of the nearby furniture to see if any will accommodate her body.

This drawn out, conscious event is an extended experience of her body as oversized—specifically as oversized in relation to features of her environment. It is a conscious

[50] I should note that there are some kinds of affordances that might not be handled by the body schema system. Declerk (2013) distinguishes between affordance perception for actions that are immediately feasible and possible actions which objects afford *in principle*, whereby motor simulation only calculates the former. This latter kind of affordance is more in line with the original Gibsonian view of affordances as being supplied solely by raw perceptual input, with no need for representations (Gibson & Adolph, 1992). We can avoid this dispute as the kinds of affordances we are interested in for the case of AN are ones that do require motor simulation.

reminder of false bodily limitations. This is clearly an example of an oversized experience of the body and these kinds of oversized experiences might arise in many different contexts e.g. fitting into or around furniture, or in between people in crowded spaces such as on public transport.

5.4 Expanding the Causal Model

I have already discussed how socio-cultural processes, along with mentally picturing the body as oversized might play a role in grounding size related propositional attitudes. However, the day-to-day perception of 'can't do' affordances that bring awareness to the content 'my body is too large for x' might also come into play.

In this picture, not only are propositional attitudes grounded by the experience of mentally picturing the body as oversized, this also happens throughout the day as patients interact with their environments. Being repeatedly made aware that they are too big for aspects of the environment grounds patients' propositional attitudes about body size. We can now modify our causal model to include body schema distortion as also causing oversized experiences (see fig 4).

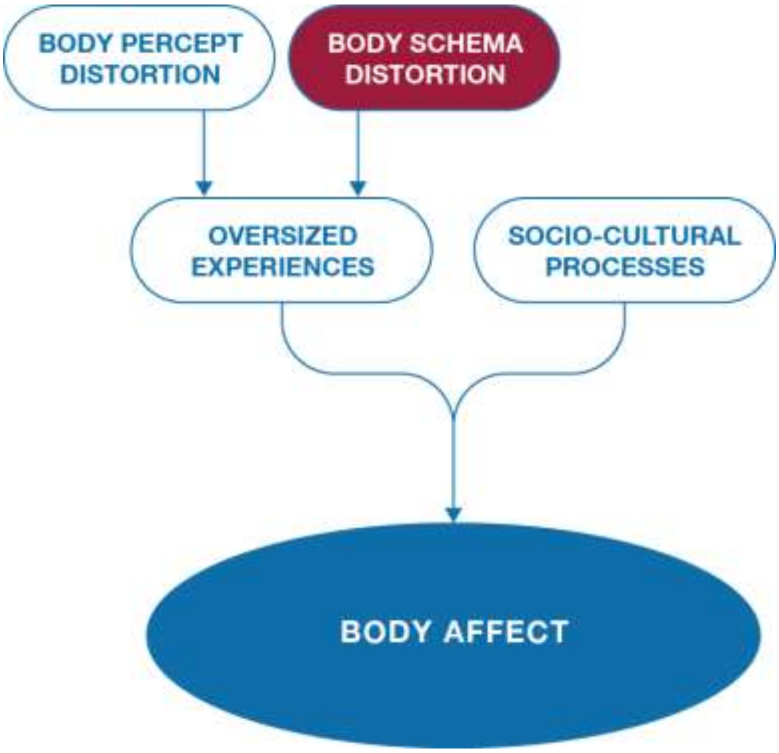

Figure 4: The updated causal model.

5.5 The Obvious Objection

One obvious objection to including body schema distortion in the above causal model is that these affordances would only rarely be consciously processed. Not only are our body schema systems incredibly efficient at unconscious motor control, man-made environmental features are usually designed to accommodate larger bodies. Therefore, unless their jobs involve a lot of movement around very unfamiliar environments, it seems unlikely AN patients would become consciously aware of many ‘can’t do’ affordances throughout the day. If this is the case then they mustn’t be able to play much of a grounding effect on the relevant propositional attitudes.

5.5.1 Clothes Fitting Affordances

However, take the example of perceiving affordances for fitting into clothing.[51] There are two obvious ways that visually assessing whether clothing would fit could cognitively function. The first is the same way most body size determined affordance-processing functions, via motor simulation. If this were the case then AN patients would underestimate what clothing could fit on them in the same way they underestimate which apertures they can fit through.

The other option is we simply look at who is wearing the clothing, evaluate their size and compare it against a mental picture of our own size. This alternative pathway for evaluating clothes fitting affordances would rely on the faulty dimensions of the body percept. Therefore, AN patients would still become aware of their false spatial dimensions in relation to the clothes.[52]

Fitting into clothes that are seen on other people or on mannequins in shop windows might be a 'can't do' affordance that is consciously experienced quite regularly.[53] Perhaps AN patients often mentally assess clothes they see for how well they would fit. Furthermore, the body relative content related to these kinds of affordance

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[51] Thanks to Colin Klein for this suggestion.

[52] Anecdotal support for patients' distorted perception of clothes fitting affordances comes from Casper and colleagues (1979). They write, "when anorectic patients buy clothes … [they] are usually surprised to discover that they can wear an even smaller size than they anticipated" (p. 60). Perhaps the (false) anticipation that causes this surprise is due to faulty clothes fitting affordance perception.

[53] Interestingly, this is an example of an affordance perception that isn't related to current motivational state i.e. the agent doesn't want to wear the clothes they see right now, they are simply assessing whether they could.

perceptions isn't only relative to a feature of the environment, it is relative to another body. The content isn't 'my body is too big for the door' but rather 'my body is too big for *her* top'.

This social dimension raises another interesting aspect of the clothes fitting affordance experience to consider. I have already mentioned that AN patients correctly estimate the size of other people's bodies. If they were to compare this size estimation with their 'can't do' affordance perception for fitting into other people's clothes, they might infer that they have bigger bodies than those whose size they are estimating.

5.5.2 Mental Preoccupation Determines Salience

I will make one more argument in favour of the regular frequency of affordance based oversized experiences. As discussed, the salience of an affordance determines how likely a particular agent is to consciously perceive the affordance. I will now develop the idea that mental preoccupation helps determine the salience of an affordance.

Consider the example of a skateboarder. Skateboarders are vastly more likely to perceive skateboarding related affordances in the environment around them. While most of us would look at a rail or a set of stairs and only perceive the skateboarding related affordances if prompted (or if, for some reason, skateboarding was on our mind), these affordances would *jump out* at skateboarders regularly. This jumping out is a result of affordance salience and isn't necessarily due to cognitive difficulty or current motivational state; the skateboarder might not want to skateboard at that time (perhaps they are tired or simply have other things to do). Nevertheless, because of this person's interest in skateboarding, their preoccupation with this general theme, skateboarding related affordances become more salient and are consciously perceived more often. Likewise we can presume that skateboarders who have a greater preoccupation with skateboarding (thinking about it more often) would perceive skateboarding related affordances much more than those who only think about it occasionally.

In the case of AN, patients have an extremely high preoccupation with ideas about their own body size. For example, Mountjoy and colleagues discovered that AN patients think about their size related beliefs more times and for longer periods at a time during the week than schizophrenia patients think about their own delusional beliefs (2014, p. 511). Because of this preoccupation with ideas related to body size, it is fair to presume that affordances primarily determined by body size (such as fitting into a shirt or fitting through a gap) would be more salient and, as such, more often consciously perceived.

There has also been a correlation found between public self-consciousness and heightened interest in clothing (Solomon & Schopler, 1982; Miller, Davis & Rowold, 1982). Although public self-consciousness is a quite broad category, body dissatisfaction has been linked to it (Kwon, 1992).[54] Given this possible heightened

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[54] In his paper Kwon calls his measure of body dissatisfaction 'body consciousness'. However, all the questionnaire questions under this category relate to body satisfaction, specifically satisfaction with weight, size and shape (1992, p. 301).

interest in clothing by those with more body dissatisfaction (i.e. AN patients), a heightened salience for clothing related affordances might also be expected.

In the same way that skateboarding affordances remind skateboarders of their related abilities (e.g. those stairs are too high for me to jump, that rail is low enough for me to slide), size related affordances would remind AN patients of their (false) oversized body dimensions. The increased salience of size related affordances for AN patients increases the likelihood that awareness of faulty relative body dimensions happens regularly enough to significantly reinforce negative body affect.

5.6 Conclusion

I have described how distortion of AN patients’ body schemas can result in oversized experiences of the body, arising through affordance perception. These oversized experiences involve awareness of false facts about the body—that it is too large for aspects of its environment. Along with mentally picturing the body as oversized, these affordance based oversized experiences might also play a role in reinforcing negative body affect.

I went on to suggest that this faulty affordance judgement might also apply to assessing whether clothing fits. I also claimed that due to their mental pre-occupation with ideas about body size, related affordances would have a higher salience for AN patients. This would increase the chance that AN patients perceive size related affordances (whether clothes fitting or environment navigation related), allowing this kind of experience to play a stronger role in grounding negative body affect.

The updated causal model makes clear why LTB distortion plays an important role in the maintenance of AN—it causes both the body percept and body schema to distort. In turn, this causes patients to have oversized experiences of their bodies. These oversized experiences ground propositional attitudes about body size, which, in turn, motivate harmful dieting behaviour. However, it's worth pointing out that the LTB doesn't *directly* cause any kind of experience relevant to the disease. Only through distorting the body percept and body schema, is the LTB causally relevant to maintaining the disease

The tactile form is also clearly missing from this causal model. This is because tactile form distortion doesn't cause oversized experiences of the body. Distortion of the tactile form does lead to a distorted experience of touch on the body but this does not deliver information *about* the body in the same way distorted experience of affordances delivers information about the body. This isn't to say information about the body can't be inferred from TDE tasks in tightly controlled settings but this scenario has no ecological relevance. There would be no everyday experiences where AN patients are made aware of faulty body dimensions due to tactile form distortion. Therefore tactile form distortion does not cause oversized experiences and does not reinforce negative body affect.

The point to take from this chapter is the importance of body schema distortion in the maintenance of AN. Body percept distortion has long been considered a relevant factor to the disease, with decades of empirical research poured into investigating it. However, it might turn out that body schema distortion and the affordance based oversized experiences it causes, is even more important.

To answer the question of which factor is more important, the differences between these two kinds of oversized experiences need to be explored. False mental imagery isn’t exclusive to AN, it is an aspect of common experience. Most people have had moments where they realise their mental picture of something (e.g. what an old acquaintance looks like) doesn’t match up to reality. As such, doubting the veracity of one’s mental imagery comes easily.

Furthermore, mentally picturing the body as oversized is a known symptom of AN. Patients might have been made aware of this from multiple sources (e.g. doctors, friends, the media, etc.). Therefore, it’s possible that patients don’t have much confidence in the veracity of their mental pictures of themselves.

Affordance based oversized experiences, however, come with a kind of *intuitive certainty*. Perceiving an affordance involves becoming intuitively certain of the ability (or inability) to act in a certain way; we just *know* we can’t fit through the gap or sit on the chair. When AN patients see clothes, for example, they might become not only aware but *intuitively certain* they won’t fit in them. The relative confidence given to this kind of experience might allow it to play a stronger role than mental imagery in grounding propositional attitudes.

Further differences between these two kinds of oversized experiences should be explored. Once we understand their qualitative differences, differences in the contexts in which they arise and their relative frequencies, we will be in a better position to judge which kind of oversized experience plays a stronger role in reinforcing negative body affect. This represents a promising direction for future research.

Chapter 6 Future Directions and Concluding Remarks

6.1 Future Directions

Before outlining some future directions for research suggested by this thesis, I will briefly mention a promising new area of research in AN and distorted body representations. This research relates to AN patients' susceptibility to the *rubber hand illusion* (RHI). During the RHI a participant sits with their left arm resting on a table in front of them, hidden from view by a screen (Botvinick & Cohen, 1998). A realistic life-sized rubber hand is placed in front of them. Whilst the subject looks at the rubber hand, the experimenter strokes both the rubber hand and the subject's hand simultaneously with two matching paintbrushes. After some time, participants report that they begin to feel a sense of bodily ownership over the rubber hand—they feel as if it belongs to them, or is a part of their body (Botvinick & Cohen, 1998; Longo et al., 2008).

The cognitive processes underlying the rubber hand illusion are widely considered to involve body representations (de Vignemont, 2007; de Preester & Tsakiris, 2009; Tsakiris, 2010; Carruthers, 2013). However, which representations are involved and how is still up for debate (Carruthers, 2009; Zopf et al., 2011; Apps & Tsakiris, 2014; Kilteni et al., 2015). Recent research seems to suggest that AN patients have a higher susceptibility to the RHI (Eshkevari et al., 2012; 2014; Keizer et al., 2014; Zopf et al., 2016; also see: Mussap & Salton, 2006). First and foremost, future research should explore what relationship the RHI has to the LTB. After this, the link between AN patients' LTB distortion and susceptibility to the RHI can, perhaps, be elucidated.

From the theoretical discussion in this thesis, future directions for research are clear. Given the role the LTB plays in causing dynamic representation distortion, targeting it is the most promising avenue for treatment of this distortion. The way forward then is to better understand how the LTB functions: how it updates, how it can be manipulated and what its exact relationship to affect is. Likewise, oversized experiences should be further explored. How often they arise, what exact role they play in propositional attitude grounding and how the two different kinds compare.

However, before future research is dedicated to understanding these areas, the claims I have made need empirical verification. It's no use trying to understand the LTB if we aren't sure it even exists or is distorted in AN patients. Likewise before further exploring oversized experiences, we need to be sure they actually occur and play a role in grounding negative body affect. In order to contribute to the task of verifying the empirical claims made in this thesis, I have included four suggestions for experiments. These experiments won't prove all the claims contained in this thesis. However, they are a step in the right direction.

6.1.1 Distortion of Alternative Body Schema Dimensions

The body schema experiments on AN patients have successfully shown that their shoulders are represented as wider. However, just as Spitoni and colleagues modified a TDE task to show that the tactile form had *specific* spatial distortions (i.e. wider hips and abdomen), alternative distorted spatial dimensions of the body schema should be explored.

I have suggested that different the body's dimensions determine different affordances. Just as shoulder width determines face-forward aperture-passing affordances, body depth (i.e. abdomen depth) determines side stepping through aperture ability and waist size determines sitting in-between aperture ability (e.g. on a chair with sides). Experimental setups that run motor imagery (or motor action) experiments on these alternative affordances would prove that AN patients' body schemas have distorted dimensions beyond shoulder width.[55] Furthermore, given that the waist and abdomen size is more distorted when it comes to the body percept, we should see a greater difference between controls and AN patients in these conditions (Molinari, 1995; Spitoni et al., 2015, p. 184).

If it can be determined that distortions are evident in these alternative body schema dimensions, then these results can be compared against BSE tasks asking participants to estimate these dimensions of their bodies. If a within-subject match is found between body schema dimensions and body percept dimensions, as Keizer and colleagues (2013) showed with shoulder width, then there is further support for my hypothesis that the spatial content of each representation is imported from a single source—the LTB.

6.1.2 Tool Extended Aperture-Passing Affordances

Perception of aperture-passing affordances coheres with the boundaries of the body schema. This includes when the body schema has incorporated tools or other objects.

[55] For example, Franchak & Adolph's (2013) paradigm for testing affordances for passing through apertures sideways could be adopted.

For example, Hackney, Cinelli & Frank (2014) showed that when walking through apertures while holding a serving tray that is wider than their shoulders, participants' π_p adapted to the width of the tray.

By adopting this experimental paradigm, one could conduct an experiment on AN patients where aperture-passing is tested using a condition that extends the body schema. If the overestimation seen in AN aperture-passing experiments reflects a *general* distortion of the body schema then this effect should remain even if the task involves holding an item that is wider than they estimate their shoulders to be (i.e. wider than their LTB's shoulder width). However if, as I have claimed, the distortion happens at the LTB and, as such, only applies to the dimensions of the *body* (rather than the person-plus-object schema), then during estimation of aperture-passing affordance in the tool holding condition, AN patients' π_p should decrease closer to the standard ratio found in healthy controls by Warren and Wang (1987).

6.1.3 Modification of the LTB Through Affect

Taylor and Cooper (1992) modified body size estimation on a group that didn't have eating disorders through negative mood induction. After inducing a negative mood they found that body percept size (as measured by a BSE task) increased, especially on those participants with high body concern.

If a similar experiment could be setup with additional tasks to test for tactile form and body schema size (i.e. TDE and affordance tasks), then this would lend support for the hypothesis that affect can distort the LTB, which then affects the spatial content of the dynamic body representations. By including conditions with tactile form and body schema tasks where the patients are unaware of the goal of the experiment, this helps to rule out the possibility that overestimation of body size after negative mood induction is a result of demand characteristics or a reflection of *attitude* rather than representation size.[56]

6.1.4 Clothes Fitting Affordances and Clothing Interest

Testing of clothes fitting affordances could be achieved by showing AN patients pictures of clothes on people and asking them to estimate if the clothes could fit them. Clothing interest could be measured by questionnaire (Solomon & Schopler, 1982). If AN patients do have a distorted perception of clothes fitting affordances and also a higher interest in clothing then this supports my hypothesis that everyday perception of 'can't do' clothes fitting affordances might serve to reinforce negative body affect.

6.2 Concluding Remarks

The goal of this thesis was to contribute to a greater scientific understanding of distorted body representation in AN. Following Bortolotti's advice for philosophers with such goals, I adopted her 'collaborative methodology' of placing empirical findings into bigger pictures. In chapter 1, I reviewed empirical research that shows AN patients have oversized body percepts, body schemas and tactile forms. In chapter 2, I presented a framework for how spatial content on the body is stored and updated: the modernised LTB hypothesis. In chapter 3, I placed the empirical findings

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[56] TDE and affordance tasks could be adopted from any of the previous AN experiments (e.g. Keizer et al., 2013; Spitoni et al., 2015)

discussed in chapter 1 into this framework. I did this by suggesting that distortion in patients' dynamic representations originates in the LTB.

This is an important claim. If I am correct, then targeting the LTB is the most effective avenue for treating distortion of AN patients' body representations. However, one could still ask whether this distortion is really worth treating—whether this would have much effect on the disease itself. To answer this question, I looked at what relationship distorted body representations have to the disease. Answering this question also fits into the methodology of understanding single findings in terms of bigger pictures. The bigger picture in this case, is the disease itself.

I did this by exploring what kind of experiences of the body can be caused by distorted body representations. In Chapters 4 and 5, I claimed that body percept and body schema distortion leads to oversized experiences of the body. These experiences consist of mentally picturing the body as oversized and falsely perceiving 'can't do' size related affordances. I claimed that, along with socio-cultural processes, these oversized experiences ground negative propositional attitudes (body affect). What this shows is that distorted body representations are an important aspect of the disease, they help ground propositional attitudes, which, in turn, motivate harmful behaviour.

As long as the claims I've made are correct, Bortolotti's methodology has provided us the greater scientific understanding she claimed it would. We have a better understanding of how distortion of body representations functions in AN: it arises through LTB distortion. We also have a better understanding of its relationship to the disease: it helps ground propositional attitudes, which motivate harmful behaviour.

However, the hard work has only begun. Bortolotti's methodology is a collaborative one. Whilst this work represents the philosophical side of that collaboration, the crucial next step involves developing the empirical side, keeping in mind the insights contained in this thesis.

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